ISSN 1598-5601

한국우주과학회보

Bulletin of The Korean Space Science Society

제27권 2호 2018년 10월

사단법인 한 국 우 주 과 학 회
The Korean Space Science Society

한 국 우 주 과 학 회

이 발표논문집은 2018년도 정부재원(과학기술진흥기금 및 복권기금)으로 한국과학기술단체총연합회의 지원을 받아 발간되었음

ISSN 1598-5601

한국우주과학회보

Bulletin of The Korean Space Science Society

제27권 2호 2018년 10월

사단법인 한 국 우 주 과 학 회
The Korean Space Science Society

차 례

<사단법인 한국우주과학회 입회 안내>

사단법인 한국우주과학회는 천문.우주과학 및 관련분야에 종사하는 여러분의 입회를 환영합니다. 우리 학회에 입회를 희망하시는 분은 입회원서 양식에 인적사항을 기재하시어 학회로 보내 주시거나 홈페이지에서 가입하시고 입회비와 연회비는 학회 은행계좌로 송금하시기 바랍니다.

▣ 보낼곳: 한국우주과학회
34055 대전광역시 유성구 대덕대로 776
한국천문연구원 내
전화 042-865-3391
팩스 042-865-3392

▣ 은행계좌:
국민은행 012-01-0603-888
우리은행 126-435843-01-001
예 금 주 한국우주과학회

▣ 회비납부안내

회원구분	입회비	연회비
학생회원(학부생)	10,000원	-
정회원	10,000원	50,000원
회장, 부회장	-	100,000원
이사, 감사	-	100,000원

※ 회원의 구분은 정관 제6조에 의거하며, 변경된 연회비는 학회운영에 대한 규정 제2조에 의거한 사항입니다.

※ 뒷면의 입회원서를 복사하여 사용해 주십시오.

[표지사진 설명]

차세대 태양코로나그래프 개발(Toward Next Generation Solar Coronagraph)

한국천문연구원은 2021년까지 NASA와 공동으로 차세대 태양코로나그래프를 개발하여 국제우주정거장에 설치하여 운영할 예정이다. 1단계로 2017년 개기일식 관측에서 코로나 관측기술을 시험하고 2단계는 성층권 기구에 실어 코로나그래프 관측기술을 시험하며 3단계에서 국제우주정거장용 코로나그래프를 개발한다.

입 회 원 서

<table>
<tr><td>성 명</td><td>한글
영문</td><td>성 별</td><td>남 여</td><td>생 년 월 일</td><td colspan="2">년 월 일</td></tr>
<tr><td>자택주소</td><td colspan="2"></td><td>우편번호</td><td></td><td>전 화</td><td></td></tr>
<tr><td>직장주소</td><td colspan="2"></td><td>우편번호</td><td></td><td>전 화</td><td></td></tr>
<tr><td>e-mail</td><td colspan="3"></td><td>이동전화</td><td></td></tr>
<tr><td>직 장 명</td><td colspan="2"></td><td>직 위</td><td colspan="3"></td></tr>
<tr><td rowspan="5">학 력</td><td>학위명</td><td>입학년도</td><td>학위취득일</td><td colspan="2">학교명</td><td>전 공</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>경 력</td><td colspan="6"></td></tr>
<tr><td>연구 업적</td><td colspan="6"></td></tr>
</table>

위 본인은 귀 학회의 설립 목적과 취지에 찬동하여 이에 회원 가입을 신청합니다.

년 월 일

신청인: (인)

위 사람을 귀 학회의 회원으로 추천합니다(참고: 정관 7조 1항에 따라 추천인은 우리 학회 정회원이면 누구나 가능합니다).

추천인 : 직장 및 직위	성명	(인)
추천인 : 직장 및 직위	성명	(인)

사단법인 한국우주과학회 귀중

한국우주과학회
2018년 가을 학술대회 일정표

일　　시 : 2018. 10. 24.(수) 14:00 - 26.(금) 11:00

장　　소 : 라마다 프라자 제주 호텔

발표논문 : 초청강연 5편, 구두발표 70편, 포스터발표 168편 총 243편

발표시간 : 초청강연(30분), 연구발표(15분~20분) 3세션 동시 진행

포스터 발표 : 1부　2018. 10. 24.(수)　16:40 – 17:40

2부　2018. 10. 25.(목)　13:30 – 14:30

사단법인 한국우주과학회

등록 및 교통 안내

1. 등록

회원의 등록비는 200,000원이며, 학생회원과 정회원 중 석.박사 과정(전일제) 학생은 100,000원입니다. 사전등록을 하신 회원은 등록자 명부에 서명 후 학회보, 명찰, 등록비 영수증(계산서)을 수령하시기 바랍니다.

2. 회원 가입

회원가입을 원하시는 분은 학회 홈페이지에서 회원가입신청 후 입회원서를 인쇄하여 추천인(2인) 서명을 받아 학회 사무국으로 송부하여 주시고 입회비와 연회비는 학회계좌로 송금하여 주시기 바랍니다.

입회비: 10,000원, 연회비: 50,000원
(학부학생회원은 입회비 10,000원, 연회비 면제)입니다.
학회계좌: 국민은행 012-01-0603-888
우리은행 126-435843-01-001
예금주 한국우주과학회

3. 발표자료 준비

구두발표: 발표자료는 파워포인트 파일로 준비하시기 바랍니다.
포스터발표: 포스터 발표 1부 세션은 10월 24일(수) 14시까지 지정된 장소에 게시하고, 25일(목) 10시에 수거하여 주시고, 2부 세션은 25일(목) 12시까지 게시하고, 26일(금) 10시에 수거하여 주시기 바랍니다. 집중발표 시간에 발표자는 자신의 포스터 앞에서 회원들의 질문에 답할 수 있도록 준비해 주시기 바랍니다. 포스터를 부착하지 않거나 학회 종료 후 수거하지 않은 회원은 추후 학회발표가 제한될 수 있습니다(2006년 3차 이사회 결정).

4. 발표장

발표형식	구분	분과명
구두발표	1발표장 (탐라홀)	-초청강연 -Sun/Space Environment I (Int'l) -Sun/Space Environment II, III, IV
	2발표장 (한라홀)	-Small Satellites -Toward the next generation solar coronagraph I, II (int'l) -Moon and Solar System
	3발표장 (아라홀)	-Korea Pathfinder Lunar Orbiter -Space Situational Awareness -Space Technology & Application I, II
포스터 발표	로비 (8층)	우주기술, 우주응용, 우주천문 태양 및 우주환경, 태양계 및 우주탐사, 기타

5. 교통

가. 주소 : 제주특별자치도 제주시 탑동로 66
라마다 프라자 제주 호텔 (Tel : 064-729-8100)

나. 찾아오시는 길
▶제주국제공항 : 총거리 3.8km / 택시 약5,000원(10분 소요)

2018년 가을 학술대회 일정표

세션별 발표장

발표일	구분	시간	제1발표장 (탐라홀)	제2발표장 (한라홀)	제3발표장 (아라홀)	포스터발표장 (로비)
10월 24일 (수)	세션 I	14:20~15:50	Sun/Space Environment I (Int'l)	Small Satellites	Korea Pathfinder Lunar Orbiter	1부 : 집중발표 16:40~17:40
	Invited Talk I	16:00~16:30	IS-1			
10월 25일 (목)	세션II	09:30~11:00	Sun/Space Environment II	Toward the next generation solar coronagraph I (int'l)	Space Situational Awareness	2부 : 집중발표 13:30~14:30
	Invited Talk II	11:10~11:40	IS-2			
	Invited Talk III	11:40~12:10	IS-3			
	세션III	14:30~16:00	Sun/Space Environment III	Toward the next generation solar coronagraph II (Int'l)	Space Technology & Applications I	
	Invited Talk IV	16:10~16:40	IS-4			
	Invited Talk V	16:40~17:10	IS-5			
10월 26일 (금)	세션IV	09:30~11:00	Sun/Space Environment IV	Moon and Solar System	Space Technology & Applications II	

구두발표
첫째날 10월 24일 (수요일)

시간	구분					
12:00~	등록		8층 로비			
14:00~14:20	개회식		제1발표장 (탐라홀)			
시간	**제1발표장 (탐라홀)**		**제2발표장 (한라홀)**		**제3발표장 (아라홀)**	
	Sun/Space Environment I (Int'l) 좌장: 이영숙 (충남대)		**Small Satellites 좌장: 김해동 (항우연)**		**Korea Pathfinder Lunar Orbiter 좌장: 김주현 (항우연)**	
14:20~14:35	I-1-1	K-I. Oyama	I-2-1	이상원	I-3-1	김영록
14:35~14:50	I-1-2	Miyashita Yukinaga	I-2-2	송영범	I-3-2	이현우
14:50~15:05	I-1-3	황정아	I-2-3	유광선	I-3-3	김인규
15:05~15:20	I-1-4	지은영	I-2-4	이재진	I-3-4	임조령
15:20~15:35	I-1-5	최경은	I-2-5	박설현	I-3-5	송민섭
15:35~15:50	I-1-6	Peter H. Yoon	I-2-6	최기혁	I-3-6	류동영
15:50~16:00	**휴 식**					
16:00~16:30	**Invited Talk I 장소 : 제1발표장(탐라홀) 좌장 : 문홍규 (천문연) Munetaka Ueno(Kobe University) / Solar system exploration missions in Japan**					
16:30~16:40	단체 사진 촬영					
16:40~17:40	**1부 포스터발표 (No.1 – No.84)**					
17:40~18:40	**제36차 정기총회 (한라홀)**					
18:40~20:30	만찬 (탐라홀)					

둘째날 10월 25일 (목요일)

시간	제1발표장 (탐라홀)		제2발표장 (한라홀)		제3발표장 (아라홀)	
	Sun/Space Environment Ⅱ 좌장: 김정한 (극지연)		Toward the next generation solar coronagraph Ⅰ (int'l) 좌장: 박영득 (천문연)		Space Situational Awareness 좌장: 임조령 (항우연)	
09:30~09:45	Ⅱ-1-1	이원석	Ⅱ-2-1	김연한	Ⅱ-3-1	김명진
09:45~10:00	Ⅱ-1-2	최종민	Ⅱ-2-2	최성환	Ⅱ-3-2	문현욱
10:00~10:15	Ⅱ-1-3	감호식	Ⅱ-2-3	봉수찬	Ⅱ-3-3	이은지
10:15~10:30	Ⅱ-1-4	김수인	Ⅱ-2-4	S. Yashiro	Ⅱ-3-4	최 진
10:30~10:45	Ⅱ-1-5	이환희	Ⅱ-2-5	조규현	Ⅱ-3-5	황혜원
10:45~11:00	Ⅱ-1-6	강지혜			Ⅱ-3-6	김수영
11:00~11:10	휴식					
11:10~11:40	**Invited Talk Ⅱ 장소 : 제1발표장(탐라홀) 좌장 : 조경석 (천문연)** **Arik Posner(NASA) / Science and Real-Time Observations with the 2024 Interstellar Mapping and Acceleration Probe (IMAP) Mission**					
11:40~12:10	**Invited Talk Ⅲ 장소 : 제1발표장(탐라홀) 좌장 : 조경석 (천문연)** **Nat. Gopalswamy(NASA) / Passband Ratio Imaging of the Solar Corona using the BITSE Mission**					
12:10~13:30	점심시간					
13:30~14:30	**2부 포스터발표 (No.85 - No.168)**					
	Sun/Space Environment Ⅲ 좌장: 박재흥 (천문연)		Toward the next generation solar coronagraph Ⅱ (Int'l) 좌장: 김연한 (천문연)		Space Technology & Application Ⅰ 좌장 : 송영주 (항우연)	
14:30~14:45	Ⅲ-1-1	양태용	Ⅲ-2-1	채종철	Ⅲ-3-1	Kewei Xia
14:45~15:00	Ⅲ-1-2	우창호	Ⅲ-2-2	Bo Li	Ⅲ-3-2	강호철
15:00~15:15	Ⅲ-1-3	김관혁	Ⅲ-2-3	서정준	Ⅲ-3-3	이현상
15:15~15:30	Ⅲ-1-4	김경찬	Ⅲ-2-4	R. Pinto	Ⅲ-3-4	김한돌
15:30~15:45	Ⅲ-1-5	김정헌	Ⅲ-2-5	조일현	Ⅲ-3-5	성재동
15:45~16:00	Ⅲ-1-6	전성경			Ⅲ-3-6	한조영
16:00~16:10	휴식					
16:10~16:40	**Invited Talk Ⅳ 장소 : 제1발표장(탐라홀) 좌장 : 한정열 (천문연)** **Ron Eng (NASA) / Future space telescope development at NASA**					
16:40~17:10	**Invited Talk Ⅴ 장소 : 제1발표장(탐라홀) 좌장 : 한정열 (천문연)** **Myung Cho (NOAO) / Development of Large optical systems and Sky Survey Programs**					

세째날 10월 26일 (금요일)

시간	제1발표장 (탐라홀)		제2발표장 (한라홀)		제3발표장 (아라홀)	
	Sun/Space Environment Ⅳ 좌장: 김록순 (천문연)		Moon and Solar System 좌장: 정민섭 (천문연)		Space Technology & Application Ⅱ 좌장: 이주희 (항우연)	
09:30~09:45	Ⅳ-1-1	임다예	Ⅳ-2-1	김진규	Ⅳ-3-1	윤재철
09:45~10:00	Ⅳ-1-2	문용재	Ⅳ-2-2	백슬민	Ⅳ-3-2	이종원
10:00~10:15	Ⅳ-1-3	박은수	Ⅳ-2-3	서행자	Ⅳ-3-3	신근웅
10:15~10:30	Ⅳ-1-4	이강우	Ⅳ-2-4	심채경	Ⅳ-3-4	이재민
10:30~10:45	Ⅳ-1-5	신슬기	Ⅳ-2-5	강태윤	Ⅳ-3-5	정민지
10:45~11:00	Ⅳ-1-6	김태영	Ⅳ-2-6	이상민	Ⅳ-3-6	함선영

1부 포스터 발표
게시기간 : 2018. 10. 24(수) 14:00 ~ 25(목) 10:00
집중발표시간 : 10. 24(수) 16:40 ~ 17:40

번호	분야	발표자	소속	번호	분야	발표자	소속
P-1	태양계 및 우주탐사	강금실1	항우연	P-43	태양 및 우주환경	유대중	경희대
P-2	우주기술	강금실2	항우연	P-44	태양 및 우주환경	윤아미	레이다앤스페이스
P-3	태양계 및 우주탐사	강범석	항우연	P-45	태양 및 우주환경	이대영	충북대
P-4	태양계 및 우주탐사	김동규1	항우연	P-46	태양 및 우주환경	이선호	항우연
P-5	태양계 및 우주탐사	김동규2	항우연	P-47	태양 및 우주환경	이종길	천문연
P-6	태양계 및 우주탐사	김성희1	항우연	P-48	태양 및 우주환경	이중기	천문연
P-7	우주응용	김성희2	항우연	P-49	태양 및 우주환경	이하림	경희대
P-8	태양계 및 우주탐사	김수연	충남대	P-50	태양 및 우주환경	장수정	천문연
P-9	태양계 및 우주탐사	김주현	항우연	P-51	태양 및 우주환경	정세헌	충남대
P-10	태양계 및 우주탐사	문상만	항우연	P-52	태양 및 우주환경	정종일	충남대
P-11	태양계 및 우주탐사	민승용	항우연	P-53	태양 및 우주환경	정현진	경희대
P-12	태양계 및 우주탐사	서행자	인스페이스	P-54	태양 및 우주환경	조경복	충남대
P-13	태양계 및 우주탐사	손승희1	항우연	P-55	우주기술	신재민1	항우연
P-14	태양계 및 우주탐사	손승희2	항우연	P-56	우주기술	신재민2	항우연
P-15	태양계 및 우주탐사	송영주	항우연	P-57	태양 및 우주환경	최규철	에스이랩
P-16	태양계 및 우주탐사	송재훈	항우연	P-58	태양 및 우주환경	이재옥	천문연
P-17	태양계 및 우주탐사	신재혁	경희대	P-59	우주감시	김시우	과기원
P-18	태양계 및 우주탐사	신현진	항우연	P-60	우주감시	오태봉	항우연
P-19	태양계 및 우주탐사	장수영1	항우연	P-61	우주감시	유성열	천문연
P-20	우주기술	장수영2	항우연	P-62	우주천문	강용우	천문연
P-21	태양계 및 우주탐사	조은진	천문연	P-63	우주천문	김수현	경북대
P-22	태양계 및 우주탐사	홍익선	충남대	P-64	우주천문	김윤종	천문연
P-23	태양 및 우주환경	김기문	경희대	P-65	우주천문	김혜영	충북대
P-24	태양 및 우주환경	김도현	인스페이스	P-66	우주천문	송민규	항우연
P-25	태양 및 우주환경	김수진	천문연	P-67	우주천문	정은정	천문연
P-26	태양 및 우주환경	김진현	천문연	P-68	우주천문	정의정	천문연
P-27	태양 및 우주환경	김향표	천문연	P-69	우주천문	조영수	천문연
P-28	태양 및 우주환경	나현옥	경희대	P-70	우주응용	공종필	항우연
P-29	태양 및 우주환경	노성준	충북대	P-71	우주응용	김연규	항우연
P-30	태양 및 우주환경	문수인	충남대	P-72	우주응용	김영선1	항우연
P-31	태양 및 우주환경	박경선	충북대	P-73	우주응용	김영선2	항우연
P-32	태양 및 우주환경	박근찬	충남대	P-74	우주응용	문귀원	항우연
P-33	태양 및 우주환경	박우연	천문연	P-75	우주응용	신상윤	항우연
P-34	우주기술	박성우1	항우연	P-76	우주응용	연정흠1	항우연
P-35	우주기술	박성우2	항우연	P-77	우주응용	연정흠2	항우연
P-36	태양 및 우주환경	박은수	경희대	P-78	우주응용	이원범1	항우연
P-37	태양 및 우주환경	박종엽	천문연	P-79	우주응용	이원범2	항우연
P-38	태양 및 우주환경	송호섭	천문연	P-80	우주응용	이일섭1	항우연
P-39	태양 및 우주환경	신경인	경희대	P-81	우주응용	이일섭2	항우연
P-40	태양 및 우주환경	신준호	경희대	P-82	우주응용	이주희	항우연
P-41	태양 및 우주환경	김주형	충북대	P-83	기타	이혜영	기초연
P-42	태양 및 우주환경	우창호	과기원	P-84	기타	허윤정	항우연

2부 포스터 발표
게시기간 : 2017. 10. 25(목) 12:00 ~ 26(금) 10:00
집중발표시간 : 10. 25(목) 13:30 ~ 14:30

번호	분야	발표자	소속	번호	분야	발표자	소속
P-85	우주기술	강상욱1	항우연	P-127	우주기술	우성현1	항우연
P-86	우주기술	강상욱2	항우연	P-128	우주기술	우성현2	항우연
P-87	우주기술	강수연	항우연	P-129	우주기술	원영진	항우연
P-88	우주기술	강우용	항우연	P-130	우주기술	윤형주	항우연
P-89	우주기술	강치호	항우연	P-131	우주기술	은희광	항우연
P-90	우주기술	구인회	항우연	P-132	우주기술	이나영1	항우연
P-91	우주기술	권재욱	항우연	P-133	우주기술	이나영2	항우연
P-92	우주기술	김규동	항우연	P-134	우주기술	이나영3	항우연
P-93	우주기술	김동오	항우연	P-135	우주기술	이동헌	항우연
P-94	우주기술	김명묵	항우연	P-136	우주기술	이상록1	항우연
P-95	우주기술	김영욱	항우연	P-137	우주기술	이상록2	항우연
P-96	우주기술	김의근	항우연	P-138	우주기술	이승욱	충북대
P-97	우주기술	김진광	항우연	P-139	우주기술	이승헌1	항우연
P-98	우주기술	김태윤1	항우연	P-140	우주기술	이승헌2	항우연
P-99	우주기술	김태윤2	항우연	P-141	우주기술	이재승	항우연
P-100	우주기술	김형완	항우연	P-142	우주기술	이주훈1	항우연
P-101	우주기술	김희경	항우연	P-143	우주기술	이주훈2	항우연
P-102	우주기술	문남진	항우연	P-144	우주기술	임정흠	항우연
P-103	우주기술	박덕종	항우연	P-145	우주기술	임종민1	항우연
P-104	우주기술	박봉규	항우연	P-146	우주기술	임종민2	항우연
P-105	우주기술	박수현	항우연	P-147	우주기술	장경덕1	항우연
P-106	우주기술	박영웅	항우연	P-148	우주기술	장경덕2	항우연
P-107	우주기술	박종범	항우연	P-149	우주기술	장성수	항우연
P-108	우주기술	박종석	항우연	P-150	우주기술	전현진	항우연
P-109	우주기술	박종오1	항우연	P-151	우주기술	정다운	항우연
P-110	우주기술	박종오2	항우연	P-152	우주기술	정병욱	경희대
P-111	우주기술	박진형	항우연	P-153	우주기술	정옥철	항우연
P-112	우주기술	박홍원	항우연	P-154	우주기술	조승원	항우연
P-113	우주기술	박희성1	항우연	P-155	우주기술	조창권	항우연
P-114	우주기술	박희성2	항우연	P-156	우주기술	조창래1	항우연
P-115	우주기술	방수완	항우연	P-157	우주기술	조창래2	항우연
P-116	우주기술	복준영	항우연	P-158	우주기술	최정수	항우연
P-117	우주기술	서석배1	항우연	P-159	우주기술	허성식1	항우연
P-118	우주기술	서석배2	항우연	P-160	우주기술	허성식2	항우연
P-119	태양 및 우주환경	채동석1	항우연	P-161	우주기술	허윤구	항우연
P-120	우주기술	채동석2	항우연	P-162	우주기술	강 철	항우연
P-121	우주기술	신현규1	항우연	P-163	우주기술	이서림	항우연
P-122	우주기술	신현규2	항우연	P-164	기타	육영춘1	항우연
P-123	우주기술	안상일1	항우연	P-165	기타	육영춘2	항우연
P-124	우주기술	안상일2	항우연	P-166	기타	이창은	항우연
P-125	우주기술	양승은1	항우연	P-167	기타	이훈희	항우연
P-126	우주기술	양승은2	항우연	P-168	기타	전종협	항우연

구두발표 논문 초록

10월 24일(수)

제1발표장 (탐라홀)

■ I-1 Sun/Space Environment I (Int'l)
좌장: 이영숙 (충남대)

14:20 [I-1-1]
Difficulty to apply DC Langmuir probe to Cubesat /small satellite for ionosphere study

K.- I. Oyama[1,2,3]

[1]*Institute of Space and Plasma Sciences, National Cheng Kung University, Tainan, Taiwan*
[2]*International Center for space weather study and education, Kyushu University, Fukuoka, Japan*
[3]*Asia Space Environment Research Consortium, Col.Ttd, Kanagawa, Japan*

Cubesat/small satellite will be more often used for science community, and its role will be further enhanced if the mission is planned as the constellation. One of the field is ionosphere study. So far basic plasma parameter (Ne, electron density and Te, electron temperature) has been measure by conventional DC Langmuir probe on board large satellite whose satellite frame is used as the reference electrode. However DC Langmuir probe can't be used in Cubesat/small satellite by fundamental reason: contamination of both satellite frame and the electrode to be used for DC probe. Problem of the contamination is further enhanced for Cube sat/small satellite which has a very small conductive reference surface. We stress here these problems by showing laboratory experiments. Finally we propose one instrument to measure Ne and Te, which is small in dimension, low electric power consumption, and low data rate, but still provides most reliable data in the world.

14:35 [I-1-2]
On verification of magnetosphere – ionosphere mapping

Yukinaga Miyashita, Jaejin Lee, Jaeheung Park

Korea Astronomy and Space Science Institute

Magnetosphere–Ionosphere coupling is essential for near–Earth disturbances, such as geomagnetic storm, substorm, and auroras, so mapping between the magnetosphere and the ionosphere is an important issue for understanding the mechanisms of these phenomena. We conventionally use magnetic field models for mapping, but the results are subject to some ambiguity, particularly during disturbed times. To verify magnetosphere–ionosphere connection, the NASA Magnetosphere–Ionosphere Connections Explorer (CONNEX) mission proposes an active experiment, where the mother spacecraft emits electron beams from the magnetosphere to the ionosphere. Ground–based instruments, such as all–sky cameras and radars, observe the signatures of the beams and the local ionospheric conditions, while the daughter spacecraft simultaneously observe plasmas and fields at the magnetospheric counterpart. In this presentation we will introduce the methodology of verifying magnetosphere–ionosphere connection and discuss potential science targets for this mission.

14:50 [I-1-3]
Current status of development of space physics payloads onboard Small scale magNetospheric Ionospheric Plasma Experiments (SNIPE)

Junga Hwang[1,2], Jongdae Sohn[1], Gyeongbok Jo[1, 3], Jaejin Lee[1,2], Young–Sil Kwak[1,2], Jaeheung Park[1,2], Uk–Won Nam[1], and Won–Kee Park[1], Hang–Pyo Kim[1,2] and Jongkil Lee[1,2]

[1]*Korea Astronomy and Space Science Institute, Rep. of Korea*
[2]*University of Science and Technology, Rep. of Korea*
[3]*Chungnam National University, Rep. of Korea*

We identified 411 Small–scale Magnetic Flux Ropes (SMFR) from 1998 to 2016 using ACE magnetic field data. The duration time of SMFRs ranges between 37 min and 12 hours with an average time of 144 min. Average strength of the magnetic field inside each SMFR interval ranges from 2 nT up to 47 nT with a mean value of about 7 nT. The average values of solar wind speed inside each SMFR are from 300 km/s to 950 km/s with a mean value of about 434 km/s. The proton number density ranges from 1 /cc to 70 /cc but the average density is about 8 /cc. The analysis results show that 130 (32%) of the SMFRs feature Alfven wave structure. 216 (53%) and 31 (7.5%) of SMFRs are related to substorm and storm. Also, we find no obvious correlation between the occurrence rate of the SMFRs and sunspot cycle. We do find a asymmetry in occurrence rate between cycle 23 and 24. In addition, we studied the response of the Earth's magnetosphere and ionosphere to SMFR conditions in solar wind by using a three–dimensional global MHD simulation. From the simulation results, the cross polar cap potential is mainly governed by IMF Bz as well as By/magnitude of B. Also, the cross polar cap potential increase over 20 kV for all of 4 types of SMFR. It possibly supports the growth phase conditions for substorm triggering despite the small–scale solar wind and IMF conditions.

15:05 [I-1-4]
Observations for the ionosphere using EISCAT Svalbard radar (ESR) in the dayside polar cap/cuso region

Eun-Young Ji[1], Geonhwa Jee[1], Young-Sil Kwak[2], Changsup Lee[1], Eunsol Kim[1]

[1]*Korea Polar Research Institute*
[2]*Korea Astronomy and Space Science Institute*

KOPRI (Korea Polar Research Institute) and KASI (Korea Astronomy and Space Institute) join the EISCAT Scientific Association as an affiliate institution starting in 2015. As an affiliated institution KORPI and KASI have observation time in the special programme category in accordance with the time share calculation of the Association. KOPRI and KASI jointly take an observation of ionosphere in the polar cap/cusp region by the EISCAT Svalbard Radar (ESR) at Longyearbyen. The observation is carried out twice from December 16 to 21, 2016 and from January 3 to 9, 2018. The purpose of observation is to look the characteristic of ionosphere in the dayside polar cap/cusp region for the winter. In this paper, we report on the observations obtained from ESR during KOPRI-KASI observation time. In addition, we also show ion upflow events found during the observation time.

15:20 [I-1-5]
Periodic properties of interplanetary magnetic field Bz near the Earth during solar cycle 23 and 24

Kyung-Eun Choi[1], Dae-Young Lee[1], Kyung Sun Park[1], Kyung-Chan Kim[2], Kyu-Cheol Choi[3], Jae-Hun Kim[4]

[1]*Chungbuk National University, Department of Astronomy and Space Science*
[2]*Daegu University, Department of Earth Science Education*
[3]*Research Institute, SELab, Inc.*
[4]*Korean Space Weather Center, National Radio Research Agency*

Variations in solar wind parameters are caused mainly by solar activities and may be also due to fluctuations in the solar wind. In this work, we examine periodic properties in the solar wind speed, interplanetary magnetic field (IMF) magnitude and components near the Earth using the observations from 1996 to 2017. We pay a particular attention to IMF Bz. For this examination, we perform the Continuous Wavelet Transform and FFT power spectrum analyses focusing on short term period less than 50 day. We identify the times when IMF Bz exhibits periodic changes with a period of the solar rotation and its harmonics. This is seen in GSM coordinates and clearer during spring and fall seasons than the other two seasons. We attribute this result to a combined effect between the Russell-McPherron effect and IMF sector structure. We will discuss how the IMF sector structure is in turn related to the magnetic sector structure near the solar surface and how the period for IMF Bz is dependent on solar cycle.

15:35 [I-1-6]
Solar Wind Isotropic Problem: Importance of Ion-Electron Kinetic Coupling

Peter H. Yoon[1,2,3]

[1]*Korea Astronomy and Space Science Institute, Korea*
[2]*School of Space Research, Kyung Hee University, Korea*
[3]*Institute for Physical Science and Technology, University of Maryland, USA*

Protons, electrons, and minor heavy ions measured in the solar wind possess varying degrees of temperature anisotropy. Apparently, the upper and lower bounds for the temperature ratio, $T_\perp / T_\parallel$ partially correspond to marginal stability conditions for various plasma instabilities such as the proton-cyclotron, mirror, electron-cyclotron, proton (parallel and oblique) fire-hose, and electron fire-hose instabilities. A substantial body of literature exists that address the origin of these upper/lower bounds. However, one crucial aspect that is often overlooked is the fact that, while the fringes of the solar wind data distributions in $(T_\perp / T_\parallel, \beta_\parallel)$ parameter space are partially described by the stability criteria, the bulk of data distribution is actually located in quasi-isotropic state. This is the "solar wind isotropy problem". In the expanding solar wind the plasma should inexorably evolve toward the stability boundary. However, when we consider dynamically coupled protons and electrons via collisional relaxation and instability excitation, it is possible to show that the protons and electrons remain largely isotropic despite the expansion effects, thus potentially resolving the solar wind isotropy problem. Of the two kinetic effects that couple the proton and electron dynamics, it will be shown that the instability excitation may account for proton isotropization but it is insufficiently tp isotropize the electrons. Isotropic electrons require the collisional temperature relaxation in addition to the instability excitation. This presentation will detail the findings.

제2발표장 (한라홀)

■ I-2 Small Satellites
좌장: 김해동 (항우연)

14:20 [I-2-1]
Attitude Determination and Control, Thrust Modulation Algorithm Development for the 4

Nano-satellites of the SNIPE mission

Sang-Won Lee, Sang-Young Park, Young-Bum Song, Seok-Ju Kang

Astrodynamics and Control lab, Department of Astronomy, Yonsei University, Seoul, Korea

The SNIPE mission is to observe spatial and temporal differences of the physical phenomena in the ionosphere. To observe spatial and temporal, the SNIPE mission uses formation flying of four nano-satellites. The four nano-satellites should control its orbit for formation maintenance and reconfiguration. Each nano-satellite has a single thruster so that it should control its attitude to align the desired thruster direction.

In this study, SNIPE nano-satellites attitude determination and control methods are developed for orbit control required for formation flying. In addition, the thrust modulation algorithm is developed to maintain the thrust direction while using thrusters.

14:35 [I-2-2]
Along-track formation control using multiple impulsives for the SNIPE mission

Youngbum Song, Sang-Young Park, Seokju Kang

Department of Astronomy, Yonsei University, Seoul, Korea

This study presents analysis of along-track formation flying in the SNIPE mission. The SNIPE mission observes temporal and spatial differences of physical phenomena in geomagnetic field using four nanosats. To satisfy scientific objectives, the mission has two formations; one is along-track foramtion to collect temporal science data and the other is cross-track formation to collect spatial science data.

The along-track formation consists of three orbit control phases. In the first phase, distance between nanosats will be naturally increased after ejected from a launch vehicle. This duration, the nanosats will not be controlled. In the second phase, nanosats will be controlled to recover the drift done during the first phase. This drift recovery will be performed for 60 days. In the third phase, after recovering the drift, the relative distance between nanosats will be kept to prepare for the cross-track formation. In this study, the simulations of orbit controls for the along-track formation are analyzed with thruster constraints and orbit knowledge errors.

14:50 [I-2-3]
Feasibility study on the ionospheric plasma monitoring by evenly distributed Cubesat constellation

Kwangsun Ryu[1], Kyungwook Min[2], K.-I. Oyama[3], Seong-Ho, Rhee[4], Sun Mie Park[5]

[1]*Satellite Technology Research Center, KAIST*
[2]*Dept. of Physics, KAIST*
[3]*International Center for space weather study and education, Kyushu University, Fukuoka, Japan*
[4]*Dream Spaceworld Ltd.*
[5]*Korea Academy of Science*

Limited local time observations by plasma instruments such as LP, RPA, and IDM can lead to the lack in complete understanding of the ionospheric plasma behavior under the solar activity and disturbances emerging from below, the neutral atmosphere, via ion-neutral collision, drag, chemical reaction, and recombination. Recent observations by small to large satellites such as CHAMP, DMSP, C/NOFS and DEMETER, lead to observational proof of the global-scale tidal wave appeared in the ionosphere as well as the neutral atmosphere. Since the above satellites were quite large satellites that can not be made in mass production, they could not completely overcome the limit of space and time in the in-situ observation. Recent progress of GPS receiver in the ionospheric survey even in 3 dimensional profiling, is limited by the critical weak point that the GPS receiving stations can not be built on the ocean. Evenly distributed cubesat constellation can be the promising solution to solve this puzzle. Feasibility studies on the possible configuration of constellation and plasma instruments optimized for the global ionospheric monitoring are introduced in terms of scientific and engineering issues.

15:05 [I-2-4]
SNIPE Mission Preliminary Design

Jaejin Lee, Young-Sil Kwak, Junga Hwang, Jaeheung Park, Jongdae Sohn

Korea Astronomy and Space Science Institute,

SNIPE mission consisted of four nanosatellites will do an ambitious mission, formation flying changing each satellite distance from 10 km to several hundred km. With such unique operation, we can measure the spatial and temporal variation of near-earth space plasma phenomena. The SNIPE mission will be launched into a polar orbit of the altitude of ~600 km in 2020. The SNIPE mission is equipped with scientific payloads which can measure the following geophysical parameters: density/temperature of cold ionospheric plasmas, energetic electron flux, and magnetic fields. In addition, this mission has enhanced communication equipment, UHF up/downlink, S-band up/downlink and Iridium module. For the attitude control, this mission will use three-axis reaction wheels with sun sensor, gyro, and star tracker. KASI, KARI and Yonsei university cooperates for this mission, and lots of domestic companies provide subsystems on the SNIPE mission. The SNIPE mission will pave way for the reliable CubeSat in Korea.

15:20 [I-2-5]
Combustion Experiments in Microgravity using a Nanosatellite

Seul Hyun Park

School of Mechanical System & Automotive Engineering, Chosun University

This study investigates the feasibility of nanosatellite (which was named as "Korea Microgravity Science Laboratory, KMSL") as a scientific platform for combustion experiments in space. The KMSL was selected as the final recipient satellite through a national CUBESAT competition in 2017 and has been funded by Korea Aerospace Research Institution (KARI) for implementation and fabrication. As shown in Figure 1, the KMSL is being designed to successfully facilitate combustion and biological experiments. In the present study, the focus of the preliminary design is on the assessment of systematic functionality of the KMSL as a platform for combustion experiments in space. Details on systematic and structural design as well as preliminary results obtained from ground-based combustion experiments will be presented and discussed in this study.

15:35 [I-2-6]
Future Scientific Payloads for Nano-Satellite; Underground Detecting Low frequency Sounder & Neutrino Instrument

Gi-Hyuk Choi, Hae-Dong Kim

Korea Aerospace Research Institute

Recently from 2000's nano satellites(<30kg) are actively used due to technology development and generalization. Even nowadays hundreds or thousands group of small satellites(<100kg) become realized for internet relay and earth monitoring with several tens of minutes interval. The companies of Planet labs, Oneweb and SpaceX are examples. Recently moreover nanosatellites are going to utilized for moon and Mars exploration as which boarded in mother spacecraft and released near the planet to monitor and relay communication between lander and the Earth. In this year NASA launched the Mars exploration spacecraft "INSIGHT" in which a nanosatellite "MARCO" boarded and released to relay communication between lander and the Earth. It is the typical example. So far majority payloads of nanosatellite are small optical cameras and ionosphere probes. However it is necessary to find new scientific missions to widen utility of nanosatellite. So, in this study we are suggesting new instruments such as low frequency radar and Neutrino instrument to observe underground. Low frequency radar uses the low frequency of VHF (30-300MHz) which could penetrate ~1,000m below moon and Mars soil because of perfect dryness. Moreover the Neutrino could penetrate ~1,000 km of whole planet crust. Therefore we could take a tomographic picture of planet including core. Such low frequency radar could detect a lot of domestic underground infrastructures, crustal faults which caused earthquakes in Gyungju in 2016 and Pohang 2017, and hidden military underground tunnels, buried land mines and explosives around DMZ. Also the Neutrino instrument gives us opportunity to observe directly inside of planet rather than indirect way of using seismic wave and gravity field.

제3발표장 (아라홀)

■ I-3 Korea Pathfinder Lunar Orbiter
좌장: 김주현 (항우연)

14:20 [I-3-1]
Orbit prediction error analysis for maneuver execution in translunar phase of Korea Pathfinder Lunar Orbiter mission

Young-Rok Kim, Young-Joo Song, Seok-Weon Choi

Korea Aerospace Research Institute

For successful mission planning and operation of Korea Pathfinder Lunar Orbiter (KPLO) in translunar phase, the orbit determination (OD) and orbit prediction (OP) are a significant flight dynamic procedure. The translunar phase of KPLO will use a 3.5 phasing loop which has an elliptical transfer orbit. During phasing loop, maneuver performance is essential for successful transfer and lunar orbit insertion. For stable maneuver execution, the timing of maneuver should be accurate. In this study, we performed the OP uncertainty analysis for perigee maneuver during phasing loop. AGI's STK 11 and ODTK 6 were utilized for true orbit generation and measurement simulation, respectively. OD and OP analysis were established by ODTK 6. For OP error analysis at maneuver time, the time of last tracking measurement was limited to 24 or 48 hours before maneuver execution. Finally, true anomaly uncertainty at maneuver time was calculated by using error covariance of the end of OD period. This study provides the preliminary analysis of mission operation in the translunar phase of KPLO.

14:35 [I-3-2]

The Structural Analysis and Vibration Test Result of KMAG : Korean Pathfinder Lunar Orbiter (KPLO) Payload

Hyunwoo Lee[1], Mangyu Lee[1], Seongwhan Lee[1,2] Dukhang Lee[3,4], Younghyeon Jeon[5], Ho Jin[1,6]

[1]*School of Space Research, Kyung Hee University*
[2]*Intorule Inc.*
[3]*York University*
[4]*Korea Astronomy and Space Science Institue*
[5]*Space Technology Synthesis Laboratory, Chosun University*
[6]*Department of Space Science, Kyung Hee University*

The KMAG (Kplo MAGnetometer) is one of science payload of the KPLO (Korea Pathfinder Lunar Orbiter) scheduled to be launched in 2020. The scientific objective is the magnetic field measurement of the moon. KMAG consists of a MAG (MAGnetometer) unit and a FCE (Fluxgate Control Electronics) unit. In this study, structural analysis and vibration test results carried out to verify the structural stability of KMAG Engineering Qualification Model (EQM) are presented. We carried out modal analysis and quasi-static analysis in the structural analysis. In the vibration test, We carried out sine sweep vibration, sinusoidal vibration, and random vibration tests. The result of the modal analysis show that the natural frequencies of the MAG unit and the FCE unit are 185.81Hz and 438.33Hz respectively. Both unit satisfy the requirement of above the limit frequency of 140 Hz. The result of vibration test, we confirmed that there are no mechanical and electrical defects. In this study, we had verified the stability of KMAG EQM. Especially, this result will contribute one of the good role of the future magnetic measurement mission using the boom structure.

14:50 [I-3-3]

The DTN Node Development status for the KPLO ground system

In-Kyu Kim, Seok-Weon Choi

Korea Aerospace Research Institute (KARI)

Interplanetary Disruption Tolerant Network (DTN) technology has more differences than terrestrial DTN technology. There are many limitations such as long delay, intermittent contact, high bit error rate, and asymmetric data bandwidth.

NASA JPL has been developing the DTN protocols to extend the space environment. it will work in environments where end-to-end connectivity cannot be assumed.

Interplanetary Overlay Network (ION) has the bundle protocols. It is open source, the modular, easy-to-modify, and can plug in user developing routing protocols.

In this paper shows and process the Interplanetary DTN node design, development, and verification about the DTN node.

15:05 [I-3-4]

Critical Design for Korea Pathfinder Lunar Orbiter Ancillary Data Generator Module

Jo Ryeong Yim, Dong-Kyu Kim, Seok-Weon Choi

Korea Aerospace Research Institute

Korea Aerospace Research Institute is developing the first Lunar Orbiter, Korea Pathfinder Lunar Orbiter (KPLO) in Korea. KPLO will be equipped with 6 Science Payloads: Lunar Terrain Imager (LUTI), Polarization Camera (PolCam), KPLO Magnetometer (KMAG), KPLO Gamma Ray Spectrometer (KGRS), Disruption Tolerant Network (DTN) from korean instrument developers and ShadowCam from NASA. The data reductions for the scientific observation data for the payloads require the position and velocity, attitude and alignment information and on-board spacecraft clock information and so on, called ancillary data. In order to help its scientific observation data processing, the ancillary data for KPLO will be provided as the SPICE kernels which is an observation geometry system for space science missions developed by NAIF (The Navigation and Ancillary Information Facility). The introduction to the SPICE kernels and the preliminary design concepts were presented in the previous research. The SPICE kernels will be generated in the Ancillary Data Generator Module of Mission Planning Subsystem for KPLO. In this paper, the detailed design concepts related to the generation for SPK (spacecraft ephemeris, given as a function of time), CK (orientation information, time tagged pointing angles for a spacecraft bus) and SCLK (spacecraft clock coefficients) will be briefly described including the input/output data interfaces.

15:20 [I-3-5]

Development of Kinematic Ephemeris Generator for KPLO : Algorithms and Performance verification

Min-Sup Song, Young-Kwang Kim, Sang-Young Park

Astrodynamics and Control Laboratory, Department of Astronomy, Yonsei University

Two methods of ephemeris generation algorithms for the Korea Pathfinder Lunar Orbiter (KPLO) are under development. One of these is dynamical method that calculates ephemeris in onboard propagation and the other is kinematical method that compress ephemeris in ground station and transmits it to onboard. In this study, kinematic ephemeris generation algorithm is presented and performance of it is verified. The core method of this algorithm is ephemeris compression using Chebyshev interpolation and it has advantages of calculating ephemeris with

small amount of data and having small maximum error. As a result of simulations on Lunar low orbit, which is the actual mission orbit, it is confirmed that the error of the ephemeris calculation satisfies the requirements for the specific interpolation degree and interpolation interval. Hence, the algorithm developed in this study can be utilized for the KPLO mission.

15:35 [I-3-6]
Survey results of candidate lunar terrain imaging sites by KPLO LUTI instruments

Dong-Young Rew, Joohee Lee, Seokweon Choi

Korea Aerospace Research Institute

Korea Pathfinder Lunar Orbiter (KPLO) will host a high resolution camera named Lunar Terrain Imager (LUTI). Images from LUTI operations will be used for preparing the future lunar landing mission which will be the Korean second lunar mission, lunar sciences, and public interest. Coverage of LUTI is limited to a few sites because of short LUTI operation duty and one year mission life of KPLO. Therefore selection of the imaging sites is necessary before the KPLO launch. Korea Aerospace Research Institute (KARI) has surveyed by receiving proposals for LUTI imaging sites from lunar scientific experts since July 2018. This paper summarizes proposed imaging sites and plan for the selection of the LUTI imaging sites.

제1발표장 (탐라홀)

■ Invited Talk I
좌장: 문홍규 (천문연)

16:00 [IS-I]
Solar system exploration missions in Japan

Munetaka UENO

Kobe University, Japan

Space science missions of JAXA is managed by its science institute ISAS and covers the science fields of space astronomy, heliophysics, planetary science, and development in space engineering. ISAS consists of astronomers, planetary scientists and space engineering researchers, about 150 in total, whose combination has led to cutting-edge missions that did something to be remarked despite the severe resource limitations in Japan. ISAS is based on a research institute with Inter-University research promotion system, which is a very unique system in the world, and with high degree-of-freedom in choosing research topics. ISAS is promoting not only doing research but doing flight and missions (complimentary in R&D) like "Idea into Flight Missions and Missions Stimulate Research". Here I introduce the steps of exploration missions of ISAS and some of their details.

16:30~16:40 기념 사진 촬영

16:40~17:40 1부 포스터 발표

10월 25일(목)

제1발표장 (탐라홀)

■ II-1 Sun/Space Environment II
좌장: 김정한 (극지연)

09:30 [II-1-1]
Discovery of pressure constancy at the turnaround altitude of meteor diffusion profiles observed from a meteor radar

Wonseok Lee[1], Yong Ha Kim[1], Changsup Lee[2], Hosik Kam[1]

[1]*Chungnam National University*
[2]*Korea Polar Research Institute*

Meteors are usually ablated in the mesosphere and lower thermosphere (MLT), and diffusion of meteor trails at specific altitudes can be measured by meteor radars. A meteor radar can thus provide profiles of meteor diffusion that are affected by both the conditions of background atmosphere and geomagnetic fields. Above ~95 km the diffusion of meteor trail is greatly hampered in perpendicular direction to the geomagnetic field, making average diffusion to be slow with increasing altitudes and thus resulting in turnaround altitude around 100 km in the diffusion profile. We derived turnaround altitudes of diffusion profiles observed by the meteor radar at King Sejong Station (62.22° S, 58.78° W), by using two methods. The first method is the quadratic fit to observed diffusion profiles and the second method used Dimant & Oppenheim [2006]'s model which calculates diffusion coefficients as a function of altitude and angle between magnetic field line and meteor trail. We found that the derived turnaround altitudes, which vary with seasons, match to a constant pressure level ($3.6*10^{-4}$ hPa) regardless of the season. This finding is the first observational confirmation of theoretical models in which diffusion coefficients of meteor trails are computed from collision frequency between electron and neutrals that are critically dependent on background atmospheric pressure. Utilizing the pressure constancy of the turnaround altitudes, one can routinely monitor the variation of atmospheric pressures in MLT from meteor diffusion profiles observed by meteor radars.

09:45 [II-1-2]

Statistical analysis of the distribution of broad plasma depletions in the equatorial F region observed by the C/NOFS satellite

Jong-Min Choi[1], Young-Sil Kwak[1], Hyosub Kil[2], Jaeheung Park[1], Woo Kyoung Lee[1], Yong Ha Kim[3], and Jae-Jin Lee[1]

[1]*Korea Astronomy and Space Science Institute, Daejeon, South Korea*
[2]*The Johns Hopkins University Applied Physics Laboratory, Laurel Maryland, USA*
[3]*Chungnam National University, Daejeon, South Korea*
hool of Space Research, Kyung Hee University

The broad plasma depletions (BPDs) is an ionospheric phenomenon that occurs over a wide spatial region in the equatorial F region. We analyzed the measurements of the plasma density on board the Communication/Navigation Outage Forecasting System satellite during 2008-2012 to investigate the statistical distribution of broad plasma depletions. The BPDs occurred mainly after midnight, and occurred more frequently around the geomagnetic equator. The BPDs occurrence rate increased as Kp increased and peaked at the lower altitudes. The BPDs occurred mainly in the solar minimum than in solar maximum, and seasonally they are observed in the June solstice. To identify the differences in BPDs characteristics over local time, we divided the BPDs into two groups before and after midnight. Post-midnight BPDs were mainly observed in the solar minimum and June solstice, whereas pre-midnight BPDs were detected frequently in solar maximum, equinox and December solstice. The occurrence rates of post-midnight BPDs are positively correlated with AE index and are inversely correlated with 10.7 cm solar radio flux. Low solar activity creates favorable conditions for generating BPDs by thinning the F region thickness. At the solar minimum, the density of the F region bottomside changes significantly even with slight altitude shifts, which can be recognized as a BPDs. When a geomagnetic disturbance occurs, the eastward electric field can be enhanced at the equatorial F region and the entire F layer can move upward.

10:00 [II-1-3]

Long-term oscillations of mesospheric winds and temperatures measured from meteor radars in Northern and Southern high-latitude regions

Hosik Kam[1], Yong Ha Kim[1], Nicholas Mitchell[2], Jeong-Han Kim[3], Changsup Lee[3]

[1]*Department of Astronomy, Space Science and Geology, Chungnam National University, Daejeon, South Korea*
[2]*Department of Electronic & Electrical Engineering, University of Bath, Bath, U.K.*
[3]*Division of Polar Climate Sciences, Korea Polar Research Institute, Incheon, South Korea*

Meteor echoes detected by a meteor radar (MR) can provide information on winds and temperatures in the mesosphere and lower thermosphere (MLT) region. In this study, we analyzed MR data observed at Esrange (67° 57 'N, 20°13' E) during the period from 2003 - 2014 and at King Sejong Station (KSS; 62° 13 'S, 58°47' E) during the period from 2007 - 2017. Using Lomb-Scargle periodogram analysis, we found the long-term oscillations of the neutral winds and temperatures int the MLT region at both sites. The components of Annual Oscillation (AO) and Semi-Annual Oscillation (SAO) appear to be significantly strong in the time series of the winds and temperatures. Especially, for zonal winds, the spectral power of SAO increases with altitude at both sites, whereas those of AO decreases. For KSS, the periodograms of the winds and temperatures show broaden and numerous peaks over periods of 2 year which might be induced by El Nino-Southern Oscillation (ENSO) and Quasi-Biennial Oscillation (QBO). For Esrange, components of periods over 2 year are rarely observed.

10:15 [II-1-4]

First identification of the high-latitude ionization trough from a low-Earth orbit satellite observations

Su-In Kim[1,2], Young-Sil Kwak[2,3], Hyosub Kil[4], Jaeheung Park[2,3], Khan-Hyuk Kim[1], and Jae-Jin Lee[2,3]

[1]*School of Space Research, Kyung Hee University, Korea*
[2]*Korea Astronomy and Space Science Institute, Korea*
[3]*University of Science and Technology, Korea*
[4]*Space Departments, the Johns Hopkins University Applied Physics Laboratory, USA*

Different ionization troughs develop in the sub-auroral and high-latitude F region by different physical processes. Mid-latitude trough at the sub-auroral region is a well-known phenomenon identified by many space-borne and ground-based observations, whereas the existence of a trough inside an auroral oval (we call it high-latitude trough) is identified by only a few radar observations. This study for the first time reports the detection of high-latitude trough from satellite observations. We distinguish mid- and high-latitude troughs by their locations relative to the auroral oval. Information of the auroral oval is obtained from the ionospheric radial current (IRC) derived with the SWARM magnetic field data and the DMSP particle data. Our preliminary results show that mid-latitude troughs are pronounced in the evening during local winter and high latitude troughs occur preferentially early in the morning during local summer. The location of the high-latitude trough coincides with the location of downward field-aligned current and significant eastward ion drift. These observations support the idea that

the formation of the high-latitude trough is associated with field-aligned plasma flow and heating of the upper atmosphere by the ion-neutral collision.

10:30 [II-1-5]
MHD simulation for the dynamic state transition in AR12158

Hwanhee Lee[1], Tetsuya Magara[1,2]

[1]*School of Space Research, Kyung Hee University*
[2]*Department of Astronomy and Space Science, Kyung Hee University*

We performed a magnetohydrodynamic (MHD) simulation of solar active region (AR) to demonstrate the dynamic state transition from a quasi-static state to the eruptive state involved in a solar eruption. The quasi-static state is caused by a continuously existing outward flow in the solar corona; that is, the solar wind making the coronal magnetic field deviate from mechanical equilibrium. The initial condition of the simulation is given by a nonlinear force-free field derived from a photospheric vector magnetic field of AR 12158. As a result, our simulation shows that a magnetic structure evolves toward an eruptive phase, as observed in this AR. The dynamic state transition is determined from the geometric shape of magnetic loops according to the κH-mechanism. This study suggests that the continuous outflow with the gravitational field plays a key role in solar eruptions.

10:45 [II-1-6]
Stability analysis of a flare-producing magnetic structure in the active region 12371

Jihye Kang[1], Satoshi Inoue[2], Kanya Kusano[2], Sung-Hong Park[2], Yong-Jae Moon[1]

[1]*Department of Astronomy and Space Science, Kyung Hee University*
[2]*Institute for Space-Earth Environmental, Nagoya University*

In this study, we analyzed a stabiltiy of a three-dimensional (3D) magnetic structure in the active region 12371 producing an M6.5 flare in June 22 2015. We first reconstructed time series of 3D magnetic fields derived from the photospheric magnetic fields using a nonlinear force-free field (NLFFF) extrapolation. The NLFFFs well reconstructed a sigmoidal structure in the active region, which is regard as a precursor of the solar flare, with the shape of a double arc magnetic structure. Next, we study the stability to clarify how the M6.5 flare is triggered in the double arc loops. As a result, the double arc structure is stable against a kink and torus instabilities. On the other hand, our analysis shows that the NLFFF before the flare occurrence becomes unstable against the double arc instability which was recently suggested by Ishiguro and Kusano (2017). We also discuss a possible process producing the M6.5 flare in view of ideal magnetohydrodynamic instability.

제2발표장 (한라홀)

■ II-2 Toward the next generation solar coronagraph I (int'l)

좌장: 박영득 (천문연)

09:30 [II-2-1]
Toward the next generation solar coronagraph: Development of a diagnostic solar coronagraph on ISS

Yeon-Han Kim[1,2], Seonghwan Choi[1], Su-Chan Bong[1,2], Kyungsuk Cho[1,2], Young-Deuk Park[1], Jeffrey Newmark[3], Nat. Gopalswamy[3], Seiji Yashiro[3], Nelson Reginald[3]

[1]*Korea Astronomy and Space Science Institute, Korea*
[2]*University of Science and Technology, Korea*
[3]*NASA Goddard Space Flight Center, USA*

The Korea Astronomy and Space Science Institute (KASI) plans to develop a coronagraph in collaboration with the National Aeronautics and Space Administration (NASA), to install it on the International Space Station (ISS). The coronagraph will utilize spectral information to simultaneously measure electron density, temperature, and velocity. For the purpose of technical demonstration, we observed the total solar eclipse in August 2017 with the photometric filter system and will perform a stratospheric balloon-borne experiment in 2019 with a new type of coronagraph. Finally, the coronagraph will be installed and operate on the ISS in 2021 to address a number of questions (e.g., source and acceleration of solar wind) that are both fundamental and practically important in the physics of the solar corona and of the heliosphere. In this presentation, we will introduce our plan and recent progress.

19:45 [II-2-2]
Progress Report of BITSE Electronics and Software

Seonghwan Choi[1], Jihun Kim[1], Jongyeob Park[1], Hee-Su Yang[1], Ji-Hye Baek[1], Jinhyun Kim[1,2], Su-Chan Bong[1], and Kyung-Suk Cho[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Kyung Hee University*

Korea Astronomy and Space Science Instiute (KASI) and Goddard Space Flight Center (GSFC) is developing a new type of solar coronagrpah, which is a high altitude balloon mission (about 40 km) designed to measure not only schematic features but also temperature and velocity of solar wind. The Balloon-borne Investigation of Temperature and Speed of Electrons in the

coronagraph (BITSE) uses a pixelated polarization mask on its CCD sensor. It can take a polarization image at once in specific filters with 393.5, 398.7, 405.0, and 423.4 nm respectively. In order to rotate the filters precisely, the filter wheel assembly uses Piezo motors and optical encoder. The flight software and the ground software is designed and developed based on Core Flight System (CFS) software framework and COSMOS developed by NASA. In this review, we report progresses of KASI responsibilities, which are a focal plane assembly, an electronics box, a flight software, and a ground software.

10:00 [II-2-3]
Science Goal of the Diagnostic Coronagraph on the International Space Station

Su-Chan Bong[1,2], Yeon-Han Kim[1,2], Kyung-Suk Cho[1,2], Jae-Ok Lee[1], Jungjoon Seough[1], Young-Deuk Park[1], Jeffrey S. Newmark[3], Natchimuthuk Gopalswamy[3], Nicholeen M. Viall[3], Spiro Antiochos[3], Charles N. Arge[3], Seiji Yashiro[3], Nelson L. Reginald[3], Silvano Fineschi[4], Leonard Strachan[5]

[1]*Korea Astronomy and Space Science Institute, Korea*
[2]*University of Science and Technology, Korea*
[3]*NASA Goddard Space Flight Center, USA*
[4]*INAF-Turin Astrophysical Observatory, Italy*
[5]*Naval Research Laboratory, USA*

The Korea Astronomy and Space Science Institute (KASI) plans to develop a coronagraph in collaboration with the National Aeronautics and Space Administration (NASA), to be installed on the International Space Station (ISS). It uses multiple filters to obtain simultaneous measurements of electron density, temperature, and velocity within a single instrument. The primary science goal is to understand the physical conditions in the solar wind acceleration region, and the secondary goal is to enable and validate the next generation of space weather science models. The planned launch in 2022 provides great potential for synergy with other solar space missions such as Solar Orbiter and Parker Solar Probe.

10:15 [II-2-4]
Total Solar Eclipse Observations obtained on 2017 August 21 Using a Polarization Camera: Data Analyses and Techniques

S. Yashiro[1,2], N. Gopalswamy[2], N. Reginald[1,2]

[1]*The Catholic University of America,*
[2]*NASA/Goddard Space Flight Center*

We observed the solar corona during the 2017 August 21 total solar eclipse using a polarization camera. The polarization camera had a polarization mask mounted on a CCD, which enable us to obtain total brightness (TB) and polarized brightness (PB) images of the corona simultaneously. The TB and PB images were obtained at four wavelengths (3850 Å, 3987 Å, 4100 Å, and 4233 Å) to diagnose the temperature and flow speed of the corona. We need to calibrate data to obtain the absolute temperature, but the TB image ratio at 4100 and 3850 Å shows the temperature distribution in the corona (hot streamers and cool coronal holes). We will present the details of data analyses and techniques used for the eclipse observations and discuss strategies for future coronagraph missions.

10:30 [II-2-5]
Determination of the three-dimensional coronal density structure using the solar rotational tomography

Kyuhyoun Cho, Jongchul Chae

Seoul National University

The determination of the solar coronal density structure will help to reduce the measurement error of coronal temperature and wind speed from the CODEX observations. We intend to estimate the three-dimensional coronal density structure using the tomographic method. The filtered backprojection algorithm which is widely used in radiology cannot be directly applicable to the solar rotational tomography because the coronal light behind the solar disk does not reach the observer. Thus we have developed a new algorithm which can successfully reconstruct in the solar coronal case, and have conducted the test using SDO/AIA data. We will present the results obtained by using this method and discuss its applicability to the CODEX observations in the future.

제3발표장 (아라홀)

■ II-3 Space Situational Awareness
좌장: 임조령 (항우연)

09:30 [II-3-1]
Optical lightcurves and shape model of PHA 3200 Phaethon during the 2017 apparition

Myung-Jin Kim[1], Hee-Jae Lee[1,2], Sang-Min Lee[1,2], Dong-Heun Kim[1,2], Fumi Yoshida[3], Przemyslaw Bartczak[4], Grzegorz Dudzinski[4], Jintae Park[1], Young-Jun Choi[1,5], Hong-Kyu Moon[1], Hong-Suh Yim[1], Jin Choi[1,5], Eun-Jung Choi[1], Joh-Na Yoon[6], Alexander Serebryanskiy[7], Maxim Krugov[7], Inna Reva[7], Kamoliddin E. Ergashev[8], Otabek Burkhonov[8], Shuhrat A. Ehgamberdiev[8], Yunus Turayev[8], Zhong-Yi Lin[9], Tomoko Arai[3], Katsuhito Ohtsuka[10], Takashi Ito[11], Seitaro Urakawa[12], Masateru Ishiguro[13]

[1]*Korea Astronomy and Space Science Institute*
[2]*Chungbuk National University, Korea*
[3]*Chiba Institute of Technology, Japan*

[4]*Adam Mickiewicz University, Poland*
[5]*University of Science and Technology, Korea*
[6]*Chungbuk National University Observatory, Korea*
[7]*Fesenkov Astrophysical Institute, Kazakhstan*
[8]*Ulugh Beg Astronomical Institute, Uzbekistan*
[9]*National Central University, Taiwan*
[10]*Tokyo Meteor Network, Japan*
[11]*National Astronomical Observatory of Japan, Japan*
[12]*Bisei Spaceguard Center, Japan*
[13]*Seoul National University, Korea*

The near-Earth asteroid (NEA) 3200 Phaethon (1983 TB) is the target of the JAXA's DESTINY+ mission which is currently under Phase-A study, and it is regarded as a parent body of the Geminids meteor shower that occurs every mid-December. Phaethon is also categorized as a potentially hazardous asteroid (PHA); the Earth minimum orbit intersection distance is 0.01945 AU. The spectral type of Phaethon is known as B-type, which is a sub-group of C-complex that is attributed to primitive volatile-rich remnants from early solar system. We investigated the rotational lightcurve and spin parameters from the ground-based observation campaign during the 2017 apparition using eight 1-2 m class telescopes. We obtained the unique solution for the ecliptic longitude and latitude of the pole orientation with two independent methods. With all available lightcurve data obtained via optical observations, as well as our time-series observation data, we derived a convex/non-convex 3D shape model that exhibits a concavity feature.

09:45 [II-3-2]
Analysis of FOV(Field-Of-View) of Space Surveillance Radar for Extraction of Radar Requirements

Hyun-Wook Moon[1], Eun-Jung Choi[2], Jaemeung Yeum[1], Sungki Cho[2], Jang-Hyun Park[2], Jung Hyun Jo[2]

[1]*Intelligence, Surveillance and Reconnaissance Laboratory, LIG Nex1*
[2]*Center of Space Situational Awareness, Korea Astronomy and Space Science Institute*

STK(System Tool Kit), which is a simulation tool developed by AGI, is able to give an access information of targets according to the radar design parameters such as maximum detection range and FOV(Field-Of-View). With this information, maximum target number of detection and target number of simultaneous tracking can be derived based on FOV analysis. In addition, with the extraction of CDF(Cumulative Distribution Function) for access duration, the probability for actual tracking targets over all access targets respect to the access duration is able to calculated. This analysis can be utilized to extract radar requirements in view of radar operation, Thus in this paper, FOV analysis results with STK are presented to extract radar requirements for space surveillance radar.

10:00 [II-3-3]
Improvement of Orbit Prediction for Cryosat-2 using OWL-Net Data through Elements-Fitting

Eunji Lee and Sang-Young Park

Astrodynamics and Control Lab., Depa

The orbit solution obtained from short and sparse optical tracking data is not proper to long-term prediction because the velocity error is relatively large due to the deficiency of dynamical information. In previous research, an element-fitting algorithm to improve the orbit prediction accuracy was developed and verified. In this research, practical optical data from OWL-Net is applied to the algorithm and the performance is analyzed. The target object is Cryosat-2, a low Earth orbit satellite with a laser reflecting mirror, so the results can be compared to the CPF (Consolidated Prediction Format) trajectory. The performance of element-fitting algorithm yields that the propagation errors between neighbored arcs are reduced from hundreds of kilometers to several kilometers. The orbit prediction error is under 30 km for 10 days, which means that the object can remain inside the 2 degrees of field of view from ground-based observatory without additional orbit update. Hence, the target can be continuously observed by the same optical system after its first element-fitting. Furthermore, the parameters related to the motion of spacecraft such as a drag coefficient can be optimized to improve the orbit prediction accuracy during the fitting. Using the optimized coefficient, the prediction error becomes several kilometers for 10 days.

10:15 [II-3-4]
Validation of the astrometric data of the OWL-Net during calibration phase

Jin Choi, Jung Hyun Jo, Eun-Jung Choi, Hong-Suh Yim, Myung-Jin Kim, Dong-Goo Rho, Jang-Hyun Park, Sungki Cho

Korea Astronomy and Space Science Institute

The OWL-Net (Optical Wide-field patroL-Network) is a global optical tracking network for SSA in South Korea. The OWL-Net system is under calibration phase in 2018. We had validation process of the observed time and angular position in celestial field for the astrometric measurements of LEO satellites from the OWL-Net. The astrometric measurements of LEO satellites were analyzed in each single observed image to find error source from the detection program. The analyzed errors were corrected with an inspection of the angular rates. We also had calibration for the effect of the chopper. The corrected astrometric data for LEO satellites were compared with the CPF (Consolidated Prediction File) by ILRS (International Laser Ranging Service). After correction for detection program and the effect of

the chopper system, an average error of the astrometric measurements from the OWL-Net was about five arc-seconds. However, the systematic validation process need to be done after calibration phase of the OWL-Net.

10:30 [II-3-5]
Precise Orbit Determination of Low Earth Orbit Satellite with Optical Observations Using Unscented Batch Filter

Hyewon Hwang, Sang-Young Park, Eunji Lee

Astrodynamics and Control lab., Department of Astronomy, Yonsei University, Seoul, Korea

In this study, a batch filter based on the unscented transform is used for the angles-only orbit determination. The unscented batch filter does not include any linearization process which can cause a large error or divergence. To verify the performance of the filter, simulation results are analyzed with various initial errors and measurement noises. Moreover, the optimal values of scaling parameters are chosen by simulating with various values within general range. The unscented batch filter is applied to real measurement data of Cryosat-2 from Optical Wide-field Patrol Network (OWL-Net). With measurements corrupted with large errors, the filter shows robustly converged results. Thus, the unscented batch filter is appropriate for highly nonlinear estimation problems. ed under the space environment.

10:45 [II-3-6]
Improving the quality and reliability of OWL-Net data during calibration phase

Sooyoung Kim, Hong-Suh Yim, Myung-Jin Kim, Dong-Goo Rho, Jin Choi, Jung Hyun Jo, Eun-Jung Choi, Jang-Hyun Park, Sungki Cho

Korea Astronomy and Space Science Institute

The optical wide-field patrol network (OWL-Net) has been developed and used for tracking and monitoring of low earth orbit satellites (LEO), and currently undergoes calibration procedures in 2018. We are improving the automated data reduction system in order to obtain high-quality, reliable data. The process involves revisiting the collected data from previous years and carefully testing various parameters that affect the outcome. We examine the cause of different mis-detection cases and implement the correction. We are working towards obtaining reliable OWL-Net data through finding best-fit data processing parameters and reducing error sources.

제1발표장 (탐라홀)

■ Invited Talk II
좌장: 조경석 (천문연)

11:15 [IS-II]
Science and Real-Time Observations with the 2024 Interstellar Mapping and Acceleration Probe (IMAP) Mission

Arik Posner

NASA Headquarters

The Interstellar Mapping and Acceleration Probe will help researchers better understand the boundary of the heliosphere, the heliosheath. This region is where the constant flow of particles from the Sun, the solar wind, collides with material from other stars in the galaxy. This interaction region, referred to as the heliosheath, is critical to understand as it limits the amount of harmful cosmic radiation entering the heliosphere. IMAP will collect and analyze neutral atoms and dust particles directly from the interstellar medium inflow and will determine many of their properties. By also analyzing energetic neutral atoms from the heliosheath, IMAP observations will provide detailed information on the three-dimensional structure of the interaction of the Sun with the local interstellar medium, and its dyamics from small to large scales. Another IMAP objective is to learn more about the generation of populations of energetic particles observed near Earth. The fundamental process of particle acceleration in space is not yet fully understood. After launch in 2024, the ten instruments on IMAP will collect plasma, particle, field, and other observations near the L1 Lagrangian point, about 1,500,000 km upstream from Earth. As proven by its predecessors, the International Sun-Earth Explorer (ISEE) 3, and the Advanced Composition Explorer, missions stationed at L1 can provide important information on changes in the space environment that may impact the Earth/moon system. IMAP will be equipped with the capability to downlink select observational data in near real time. This real-time data will be used for improving understanding of the science of space weather, and for testing new space weather forecasting techniques driven for the first time by real-time observations that have so far not been available. If successful, such observations could transition into operational use.

■ Invited Talk III
좌장: 조경석 (천문연)

11:40 [IS-III]
Passband Ratio Imaging of the Solar Corona using the BITSE Mission

Nat. Gopalswamy[1], Jeffrey Newmark[1], Nelson Reginald[1], Seiji Yashiro[1], P. Makela[1], A. Lara[1], Yeon-Han Kim[2], Kyungsuk Cho[2], Seonghwan Choi[2], Su-Chan Bong[2], Jong-Yeob Park[2], Heesu Yang[2], Ji-Hye Baek[2], Jihun Kim[2], Young-Deuk Park[2]

[1]*NASA Goddard Space Flight Center, Greenbelt, Maryland, USA*
[2]*Korea Astronomy and Space Science Institute (KASI), Daejeon, Korea*

Traditional coronagraphy from ground and space provides electron density in the corona. The passband ratio imaging (PRI) originally proposed by L. Cram in 1976 can be extended to provide information on the electron temperature and flow speed in the corona, especially in the solar wind acceleration region (2 – 10 solar radii). Spectroscopic observations from the Solar and Heliospheric Observatory (SOHO) provided electron temperature only around the inner edge of this window. We expect electron temperature and flow speed information from the outer edge of this window by the Parker Solar Probe launched recently. We show that the PRI technique can provide temperature, flow speed, and density information in the solar wind acceleration region using a coronagraph to be flown on a stratospheric balloon. The BITSE (Balloon-borne Investigation of Temperature and Speed of Electrons in the corona) mission will utilize the arc-second pointing capability available at NASA's Wallops Flight Facility to point a single-stage coronagraph at the Sun and use a polarization camera for PRI. The BITSE mission will use four passband filters between 380 and 460 nm for PRI and a broadband filter in the same wavelength range for traditional coronagraphy so that all the three physical quantities can be obtained in the solar wind acceleration region. This talk will describe the mission and provide the current status of the mission.

13:30~14:30 2부 포스터 발표

제1발표장 (탐라홀)

■ III-1 Sun/Space Environment III
좌장: 박재흥 (천문연)

14:30 [III-1-1]
Electron density and temperature characteristics observed by ISS and SWARM constellation in the equatorial F region

Tae-Yong Yang[1], Jae-heung Park[1,2], Young-Sil Kwak[1,2]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*

International Space Station (ISS) Floating Potential Measurements Unit (FPMU) and SWARM Electric field instrument (EFI) provide electron temperature and density information from 2006 and 2014, respectively. Both multiyear ISS and SWARM global and continuous electron temperature and density observations between 400 km and 530 km altitude provides a unique database. Using ISS and SWARM constellation observations of electron temperature and density, we investigate those seasonal and localtime variations at equatorial F region. Then, we will compare our results with model predictions.

14:45 [III-1-2]
Characteristics of parallel propagating electromagnetic waves in magnetized electron quantum plasma

Chang-Ho Woo[1], Min ho Woo[2], Cheongrim Choi[3] ,Kyoung-Wook Min[1]

[1]*Department of Physics, KAIST, Daejeon, Korea*
[2]*National Fusion Research Institute, Daejeon, Korea*
[3]*Chungbuk National University*

In this paper, we discuss the quantum effects on the electromagnetic waves in magnetized electron quantum plasma with zero temperature. We employed the quantum Vlasov equation (Wigner-Moyal equation in a differential form) and obtained the dispersion relations of the parallel propagating waves in degenerate plasma. The quantum effect is rather small for the upper branches of the L and R waves, with a stronger effect on the R wave than on the L wave. However, the effect on the lower branch of the R wave (whistler branch) is significant, showing termination of the branch at a finite wavenumber. It is also seen that Landau damping occurs due to the quantum effect near this termination point. We will discuss the physical origin of this damping in detail as well as the damping rate. We will also discuss the finite temperature effect on the dispersion relations.

15:00 [III-1-3]
Geomagnetic field oscillations in the nightside upper ionosphere during low-latitude Pi2 pulsations

Khan-Hyuk Kim[1], Jae-He Park[1], Dong-Hun Lee[1], and Junga Hwang[2]

[1]*School of Space Research, Kyung Hee University, Korea*
[2]*Korea Astronomy and Space Science Institute, Daejeon, Korea*

Pi2-associated geomagnetic oscillations in the nighside upper ionosphere are studied using magnetic field data acquired by low-Earth orbiting multispacecraft Swarm and at the

low-latitude Bohyun (BOH) station located at magnetic shell of L = 1.27 on 22 October 2014. Four Pi2 events were identified from the BOH data near midnight (MLT = 1.5) while Swarm A, B, and C spacecraft were orbiting on the nightside (MLT = 21-22) upper ionosphere from 70° to -60° in magnetic latitude (MLAT) at 450-500 km altitudes. It is found that the horizontal H component of BOH data is well correlated with the radial (B_x) and compressional (B_z) components of ionospheric magnetic fields when Swarm spacecraft were at |MLAT| < 40° . Both B_x and B_z components exhibit in phase or out of phase with the BOH H oscillations depending on the location of the spacecraft (i.e., in the Northern Hemisphere or in the Southern Hemisphere). This indicates that Pi2-associated magnetic oscillation in the ionosphere is the consequence of field line displacement that was symmetric or odd mode about the magnetic equator. We also find that stationary magnetic field perturbation, which is similar to Pi2 oscillation but not associated Pi2 signals, in the upper ionosphere near magnetic equator. A statistical analysis for the global distribution of static/spatial magnetic field perturbations using low-latitude Pi2 oscillation as a reference is a subject of future work.

15:15 [III-1-4]

Survey of the Favorable Conditions for Magnetosonic Wave Excitation

Kyung-Chan Kim[1], Yuri Shprits[2]

[1]*Daegu University, South Korea*
[2]*GFZ Gernam Research Center for Geosciences and University of Potsdam, Germany*

The ratio of the proton ring velocity (V_R) to the local Alfven speed (V_A), in addition to proton ring distributions, plays a key factor in the excitation of magnetosonic waves at frequencies between the proton cyclotron frequency f_{cp} and the lower hybrid resonance frequency f_{LHR} in the Earth' s magnetosphere. Here we investigate whether there is a statistically significant relationship between occurrences of proton rings and magnetosonic waves both outside and inside the plasmapause using particle and wave data from Van Allen Probe-A during the time period of October 2012 to December 2015. We also perform a statistical survey of the ratio of the ring energy (E_R, corresponding to V_R) to the Alfven energy (E_A, corresponding to V_A) to determine the favorable conditions under which magnetosonic waves in each of two frequency bands ($f_{cp} < f \leq 0.5\ f_{LHR}$ and $0.5\ f_{LHR} < f < f_{LHR}$) can be excited. The results show that the magnetosonic waves in both frequency bands occur around the post-noon (12-18 magnetic local time, MLT) sector outside the plasmapause when E_R is comparable to or lower than E_A, and those in lower frequency bands ($fcp < f \leq 0.5\ f_{LHR}$) occur around the post-noon sector inside the plasmapause when E_R/E_A > ~9. However, there is one discrepancy between occurrences of proton rings and magnetosonic waves in low frequency bands around the pre-noon sector (6-12 MLT) outside the plasmapause, which suggests either that the waves may have propagated during active time from the post-noon sector after being excited during quiet time, or they may have locally excited in the pre-noon sector during active time.

15:30 [III-1-5]

Developing a Data-assimilated Korean Ionospheric Prediction model with TIEGCM and IDA4D initial conditions

JeongHeon Kim[1], YongHa Kim[1], YoungSook Lee[1], SeHeon Jeong[1], Su-In Moon[1], YoungSil Kwak[2], JinWook Han[3]

[1]*Chungnam National University, Daejeon, Korea*
[2]*Korea Astronomy and Space science Institute, Daejeon, Korea*
[3]*Korea Space Weather Center (KSWC), Jeju, Korea*

In order to develop a regional ionospheric prediction model based on data measured at Korean peninsula and vicinities, we have evaluated various ionospheric and thermospheric models such as SAMI2, KIPM, TIEGCM, and IDA4D model. As a theoretical prediction model, we have developed a 3 dimensional (3-d) Korean Ionospheric Prediction Model (KIPM) by improving the SAMI2 model [Huba 2000; Kim et al., 2016]. To update initial conditions of the ionosphere in the KIPM, we use 3-d electron densities estimated from IDA4D with measured datasets of ionosondes, GNSS/TEC, and COSMIC satellite. The IDA4D model was originally developed by Bust et al. [2007] and has been applied to datasets of Korea [Chalachew et al., 2018]. As critical parameters that affect the prediction calculation we identified scale factors of O density and meridional wind relative to empirical values from MSIS and HWM models. These scale factors were derived by optimally matching with electron densities from IDA4D. As an alternative, we also calculated these scale factors by running global TIEGCM model with predicted F10.7 and Kp index. With each set of scale factors, we run KIPM to calculate 3-d electron densities over the prediction period (24 hrs). In the presentation we will present the comparison of predicted values with measured values in terms of peak densities and heights of the F2 peak and total electron contents.

15:45 [III-1-6]

Statistical study on the kinematic classification of CMEs in LASCO C3 field.

Seong-Gyeong Jeo[1] , Yong-Jae Moon[1 2] , Il-Hyun Cho[2] , Harim Lee[1] , Kangwoo Yi[1]

[1]*School of Space Research, Kyung Hee University*
[2]*Department of Astronomy and Space Science, Kyung Hee University*

In this study, we perform a statistical investigation on the kinematic classification of 4264 coronal mass ejections (CMEs) from 1996 to 2015 observed by *SOHO*/LASCO C3. Using the constant acceleration model, we classify these CMEs into three groups; deceleration, constant velocity, and acceleration motion. For this, we devise three different classification methods by fractional speed variation, height contribution, and visual inspection. First, the fractions of three groups depend on the method used. Second, about half of the events belong to the groups of acceleration and deceleration. Third, the fractions of three motion groups as a function of CME speed are consistent with one another. Fourth, the fraction of acceleration motion decreases as CME speed increases, while the fractions of other motions increase with speed. In addition, the acceleration motions are dominant in low speed CMEs whereas the constant velocity motions are dominant in high speed CMEs.

제2발표장 (한라홀)

■ III-2 Toward the next generation solar coronagraph II (Int'l)

좌장: 김연한 (천문연)

14:30 [III-2-1]
Plasma Outflows along Post-CME Rays

Jongchul Chae[1], Yoojung Kim[1], Kyuhyoun Cho[1], Ryun-Young Kwon[2]

[1]*Seoul National University*
[2]*Korea Astronomy and Space Science Institute*

Bright rays are often observed after coronal mass ejections (CMEs) erupt. These rays are dynamical structures along which plasmas move outward. We investigated the outflows along the post-CME rays observed by the COR2 on board STEREO Behind on 2013 September 21 and 22. We tracked two CMEs, two ray tips, and seven blobs using the NAVE optical flow technique. As a result, we found that the departure times of blobs and ray tips from the optimally chosen starting height of 0.5 $R_{\odot}$ coincided with the occurrence times of the corresponding recurrent small flares within 10 minutes. These small flares took place many hours after the major flares. Furthermore, we have examined the spatial configuration and the eruption process of the flares that are associated with the blobs by analyzing the EUV images taken by the SDO/AIA and the magnetograms taken by the SDO/HMI. As a result, we found that the flares occurred repeatedly, in a similar manner in the same magnetic configuration in which the main flare associated with CME erupted. Our results suggest that the CME and subsequent plasma outflows(rays and blobs) originate in the same region of magnetic reconnection, supporting the model that attributes the formation of the blobs to the recurrent magnetic reconnection in the corona.

14:45 [III-2-2]
Modeling the solar wind with a multi-fluid Magnetohydrodynamic approach

B. Li

Institute of Space Sciences, Shandong University, China

How the solar wind originates on the Sun remains an unresolved issue in solar physics. This issue comprises two inter-related aspects: what are the sources of the solar wind and how the nascent solar wind is accelerated to multi-million kilometers per hour within a couple of tens of solar radii. In this talk I will first give a brief summary of the observational features of the solar wind, thereby showing that the acceleration of the nascent wind is likely to be a result of coronal heating in magnetically open regions on the Sun. I will then move on to a computationally feasible scheme for modeling the large-scale solar wind, which is based on the moment equations of the Boltzmann equation and can readily handle the transition from the collision-dominated to the collisionless regime. With a handful of illustrative results, I will show how this multi-fluid magnetohydrodynamic approach can be employed to discriminate between different heating mechanisms of the solar wind. In addition, I will show how it can address such macrophysics as the gravitational settling of heavy ions in coronal streamers, the interaction between the multi-species solar wind and finite-wavelength (non-WKB) Alfven waves, and the angular momentum loss of the Sun due to a multi-component solar wind. I will conclude by showing the potential applications of our numerical framework to the solar wind physics to be addressed by the KASI-NASA coronagraph to be deployed on the International Space Station.

15:00 [III-2-3]
Solar Wind Modeling: Importance of Kinetic Effects and Parker Spiral IMF

Jungjoon Seough[1] and Peter H. Yoon[1,2,3]

[1]*Korea Astronomy and Space Science Institute, Korea*
[2]*School of Space Research, Kyung Hee University, Korea*
[3]*Institute for Physical Science and Technology, University of Maryland, USA*

Understanding the cause of million degree solar corona and relevant to solar wind acceleration as well as its dynamical evolution is an outstanding issue in solar physics. In order to resolve these issue, the space missions including the upcoming KASI-NASA coronagraph, Parker Solar Probe, and Solar Orbiter have been developed or preparing. Many viable theories relevant to the solar wind model based on a Magnetohydrodynamics or multi-fluid approach

have been developed to account for the heating and acceleration of solar wind and have successfully described the observational features adjacent to the Sun, such as the acceleration of both fast and slow winds, a preferential heating of ions and their temperature isotropy. In terms of theoretical aspect of solar wind modeling, nevertheless, there still remains the underlying physical mechanisms to be addressed for understanding what regulates the dynamical evolution of solar wind plasmas. In this talk, we will introduce the solar wind properties based on in situ measurements in solar wind and focus on the importance of Parker spiral configuration of the interplanetary magnetic field as well as kinetic effects, that is, instabilities and Coulomb collisions, responsible for the evolution of the expanding solar wind. Finally, I will discuss the possibility of incorporating these effects into the currently developed fluid model in view of the connection between the KASI-NASA coronagraph and inner heliosphere missions.

15:15 [III-2-4]
Models and observations of the solar wind: getting new insights into the acceleration region

R. Pinto, and colleagues

IRAP, U. Toulouse/CNRS

The solar wind is an uninterrupted flow of highly ionised plasma that is accelerated in the low solar corona and expands into the interplanetary space. Fast and slow wind streams develop at different places in the solar atmosphere, reflecting the global distribution of the coronal magnetic field during solar cycle, being the source of corotating density structures that perturb planetary atmospheres and affecting the propagation of impulsive perturbations (such as CME). Commonly used semi-empirical predictive laws for the solar wind speed use simple parameters describing the global geometry of the coronal magnetic field and require, in practice, ad-hoc corrections. Global numerical models of the solar wind, on the other hand, provide a fuller physical description of the wind, albeit requiring higher computational resources.
I will also present a new modeling approach based on a multiple flux-tube description of the solar wind (model MULTI-VP) allowing for very significant gains in computation time in respect to the full 3D MHD problem. The model reads a coronal magnetic field map as input (past data or forecast), and computes a collection of solar wind profiles spanning a region of interest of the solar atmosphere (up to a full synoptic map) at any instant desired in quasi-real time, while keeping a good description the plasma heating and cooling mechanisms. The model can provide continuously (nearly real time) a full set of bulk physical parameters of the solar wind (surface to ~1 AU) based solely on physical principles (wind speed, density, temperature, magnetic field, phase speeds) up to a few days in advance.
I will discuss the importance of future detailed coronographic measurements (e.g, ISS-COR, METIS/Solar Orbiter) of the dynamical and thermal properties of the wind flow in its region of acceleration and present preliminary studies using past data (e.g from the UVCS experiment).

15:30 [III-2-5]
2D solar wind speeds from 6 to 26 solar radii in solar cycle 24 by using Fourier filtering

Il-Hyun Cho[1], Yong-Jae Moon[1], Valery M. Nakariakov[1,2], Su-Chan, Bong[3,4] Jin-Yi Lee[1], Donguk Song[5] Harim Lee[1] and Kyung-Suk Cho[3,4]

[1]*Kyung Hee University*
[2]*University of Warwick*
[3]*Korea Astronomy and Space Science Institute*
[4]*University of Science and Technology*
[5]*National Institutes of Natural Sciences*

Measurement of the solar wind speed near the Sun is important for understanding the acceleration mechanism of the solar wind. In-situ and remote sensing observations with various instruments and methodologies developed up to date give knowledge to draw the global picture of solar winds, but hard to cover a broad ranges of time and space. Here we measure 2D solar wind speeds from 6 to 26 solar radii in timescales longer than a day, by applying the Fourier motion filter to the SOHO/LASCO C3 movies from 1999 to 2010. Our method successfully reproduces the original flow speeds in the artificially generated data as well as streamer blobs. Our measurements also generally consistent with the IPS and UVCS solar wind speeds. The spatial structure of solar wind speeds evolves from being uniform to bimodal in the solar cycle. The radial profile resembles the Parker's solar wind model.

제3발표장 (아라홀)

■ III-3 Space Technology & Application I
좌장: 송영주 (항우연)

14:30 [III-3-1]
Experimental Validation of Adaptive Saturated Controller for Spacecraft Formation

Kewei Xia[1,2], Youngho Eun[2], Sang-Young Park[1,2]

[1]*Yonsei University Observatory Yonsei University,*
[2]*Astrodynamics and Control Laboratory, Yonsei University*

The experimental validation of an adaptive saturated controller for spacecraft formation flying is investigated. By introducing a smooth switching auxiliary system, a novel adaptive controller is proposed for each spacecraft in the presence of unknown inertial parameters,

bounded external disturbances, and actuator saturation. The proposed controller is experimentally validated on the ground test facility, where a 3 degree-of-freedom (3DOF) floating simulator tracks a planar trajectory while synchronizing its rotation angle with the desired angle. Experimental results illustrate the effectiveness of the proposed controller.

14:45 [III-3-2]
Design and analysis of attitude system of Cubesat for CANYVAL-C Mission

Ho-Chul Kang, Dae-Eun Kang, Geuk-Nam Kim, Sang-Young Park

Department of Astronomy, Yonsei University

CANYVAL-C mission is aimed at scientific verification of the Sun's corona using inertial alignment technology. This study deals with the design and analysis of attitude systems for two cube satellites performing CANYVAL-C mission. Attitude determination algorithms are applied by using the Sun sensor and the Earth magnetic field sensor. The TRIAD method is used for the initial attitude determination algorithm and the extended Kalman filter is used for real time attitude determination. Attitude control algorithms are applied by using the magnetic torquer and the reaction wheel. Detumbling control uses B-dot control with magnetic torquer. Sliding mode control using magnetic torquer is used for 1U Sun/nadir-pointing control, and PD control using reaction wheel is used for 2U. The IGRF-12 model is used for the geomagnetic field vector and the Astronomical Almanac method is used for the sun vector. By comparing the results of the simulations with the given requirements, it is confirmed that the Cube satellites could successfully accomplish the mission.

15:00 [III-3-3]
Numerical simulation of β-ray measurement by space-borne charged particle detector in response to the electric field by using Geant4

Hyunsang Lee, Hoonkyu Seo, Yuchul Shin, Jongho Seon

School of Space Research, Kyung Hee University

Numerical simulation of β-ray measurement by space-borne charged particle detector in response to the electric field is performed by using Geant4. To take into account the specific geometry of telescope, mechanical structure of the detector considering material property is converted into a Geometry Description Markup Language (GDML). Approximated Fermi beta-function is solved to reproduce the β-ray spectrum emitted from 14C radioisotope. Individual electron is injected from the center of the aperture toward the detector. The instrument for simultaneous measurement of charged particles adopts an electrostatic field of 4,000 V/(3 × 10-3m) and particle flux attenuator. The results of energy spectra obtained in response to the electric field and attenuator are compared with the instrument test.

15:15 [III-3-4]
Current State of the Art and the Future Prospects of the INR System Technologies in Geostationary Remote Sensing Satellites

Han-Dol Kim

Korea Aerospace Research Institute

INR (Image Navigation and Registration) is an essential part of geostationary remote sensing satellites for their on-board instrument payloads to maximally perform their full function and utility, since it provides the knowledge and control of the geo-location of each image pixel relative to a fixed reference frame. INR is also a difficult subject since it is a multidisciplinary task closely related to the functions of AOCS, orbital mechanics, servo control, image processing, among others, and since its requirements are expressed in the order of micro-radians which in turn require thorough system analysis, careful space and ground segments design and testing as well as on-orbit testing and fine tuning to meet these tight requirements. In this paper, we try to provide a synthetic summary on the current state of the art and the envisioned future prospects of INR system technologies. In this trial, we intend to identify the core contents and the ultimate essence of INR systems, with its origin and evolution history laid out, its key areas of further development and expected evolution specified, and the areas of expanded application succinctly addressed.

15:30 [III-3-5]
Study of the Post Mission Disposal Maneuver for KOMPSAT-2

Jaedong Seong, Okchul Jung, Deawon Chung

Korea Aerospace Research Institute

Most space agencies established their own space debris mitigation guideline, which restrict orbital lifetime after end of mission, and try to comply the guideline for retired satellites and launch vehicles. Lifetime limitation guideline minimizes the probability of on orbit break-up situation so it can be one of the most effective activities not to deteriorate the space debris environment. Serious break-up event can be occurred when abandoned object has energy sources such as fuel or charged battery and retired object released in high spatial density area. More than millions of dollars are required to remove the these abandoned object in low earth orbit, therefore post mission disposal is rational and natural option if satellite or launch vehicle have maneuver capability and enough resources.

KOMPSAT-2 was launched in 2006 and

officially finished its entire mission after 3 extended mission. Nonetheless, it still has capability for continuous mission, which means precisely controllable, enough fuel and power supply capability. So, safe and effective post mission disposal maneuver should be designed before space and ground segment reach end of life. In this study, international guideline about post mission disposal and actual cases of other space agencies were surveyed and post mission disposal maneuver plan for KOMPSAT-2 was proposed to comply the international guideline. Furthermore, re-entry survivability analysis also performed to investigate ground impact casualty.

15:45 [III-3-6]
Commercial Launch Vehicles for LEO Satellite

Cho Young Han[1], In Ho Moon[2]

[1]*Korea Aerospace Research Institute*
[2]*Korea Aerospace Industries*

In the framework of CAS500 development program, two identical satellites will be developed. They are CAS500-1 and CAS500-2 satellites. The CAS500-2 satellite is identical to the CAS500-1 satellite, which is the replica of the CAS500-1 satellite. Korea Aerospace Research Institute is responsible for the development of the CAS500-1 satellite, which is scheduled for launch in 2019. As to the CAS500-2 satellite, it will be developed by Korea Aerospace Industries, Ltd. and scheduled for launch in 2020. In this context the commercial launch vehicles for a LEO satellite were surveyed and compared in connection with the launch of CAS500 satellites.

■ Invited Talk IV
좌장: 한정열 (천문연)

16:10 [IS-IV]
Future space telescope development at NASA

Ron Eng

NASA

Overview of the NASA Marshall Space Flight Center; space telescope development programs including balloon-borne telescope platforms. Discussion will focus on current technology development effort for detecting exoplanets. Topics will include mirror substrate material selection, optical metrology facility and instrumentation, cryogenic optical performance characterization, gravity sag, thermal gradient, and lessons learned.

■ Invited Talk V
좌장: 한정열 (천문연)

16:40 [IS-V]
Development of Large optical systems and Sky Survey Programs

Myung Cho

NOAO

Overview of the National Optical Astronomy Observatory (NOAO) and its programs are to be introduced. A sky survey program, the Large Synoptic Survey Telescope (LSST), will be addressed. Some key sub-assembly parts of LSST are under construction, and some details in the design and development of the key parts are to be addressed. This presentation includes the latest technology in mirror designs of M1/M3 and Secondary mirror (M2). It also includes active optics systems, and the optical performance predictions are discussed.

10월 26일(금)

제1발표장 (탐라홀)

■ IV-1 Sun/Space Environment IV
좌장: 김록순 (천문연)

09:30 [IV-1-1]
Sausage Oscillations in a Magnetic Flux Tube with a Surface Current

Daye Lim[1], Valery M. Nakariakov[1,2], and Yong-Jae Moon[1]

[1]*School of Space Research, Kyung Hee University, Korea*
[2]*Centre for Fusion, Space and Astrophysics, Department of Physics, University of Warwick, UK*

Linear sausage oscillations of a cylinder embedded in a plasma with an azimuthal magnetic field, created by a current on the surface of the cylinder, are studied. Such a plasma configuration could be applied to modelling demonstrate that the lowest radial harmonic of the sausage mode is in the trapped regime for all values of the parallel wave number. In the long-wavelength limit, phase and group speeds of this mode are equal to the Alfven speed in the external medium. It makes the oscillation period to be determined by the ratio of the parallel wavelength, e.g., double the length of an oscillating loop, to the external Alfven speed, allowing for its seismological estimations. The application of the results obtained to the interpretation of long-period (longer than 20-30 s) oscillations of emission intensity detected in solar coronal structure, gives reasonable estimations of the external Alfven speed. Cutoff

values of the parallel wavenumber for higher radial harmonics are determined analytically. Implications of this finding to the observational signatures of fast magnetoacoustic wave trains guided by the plasma non-uniformity are discussed.

09:45 [IV-1-2]
Application of Deep Learning to Solar and Geophysical Data: 1. Overview

Yong-Jae Moon, Eunsu Park, Taeyoung Kim, Harim Lee, Gyungin Shin, Kimoon Kim, Seulki Shin, and Kangwoo Yi

School of Space Research, Kyung Hee University

Multi-wavelength observations become very popular in astronomy and geophysics. Even though there are some correlations among different sensor images, it is not easy to translate from one to the other one. In this talk, we apply a deep learning method for image-to-image translation, based on conditional generative adversarial networks (cGANs), to solar and geophysical images. To examine the validity of the method for scientific data, we consider several different types of pairs: (1) Generation of SDO/EUV images from SDO/HMI magnetograms, (2) Generation of backside magnetograms from STEREO/EUVI images, (3) Generation of EUV & X-ray images from Carrington sunspot drawing, (4) Generation of solar magnetograms from Ca II images, and (5) Generation of COMS visible images from COMS IR images. It is very impressive that AI-generated ones are quite consistent with actual ones. In addition, we apply the convolution neural network to the forecast of solar flares and find that our method is better than the conventional method. Our study also shows that the forecast of solar proton flux profiles using Long and Short Term Memory method is better than the autoregressive method. We will discuss several applications of these methodologies for scientific research.

10:00 [IV-1-3]
Application of deep learning to solar and geophysical data: 2. Generation of SDO/AIA-like images from SDO/HMI magnetograms

Eunsu Park and Yong-Jae Moon

School of Space Research, Kyung Hee University

In this study, we apply an image-to-image translation model, based on conditional Generative Adversarial Networks (cGANs), to construct solar EUV images using solar magnetograms. For this, we train the model using pairs of SDO/AIA image and their corresponding SDO/HMI line-of-sight magnetogram for 9 wavelengths from 2011 to 2017 except September and October each year. We evaluate the model by comparing pairs of actual SDO/AIA images and corresponding AI-generated ones in September and October. Our results from this study are as follows. First, we find that both real and AI-generated images are quite consistent with each other in that it is difficult for one to distinguish solar EUV images from AI-generated ones. Second, 1600 and 1700 line images, which are photospheric or transition lines, have the best correlations (0.94 and 0.97) between actual AIA images and AI-generated ones. Third, 171, 193, and 211 line images, which are coronal lines, have good correlations (0.89, 0.91, and 0.91), which may be due to the fact that these lines are mainly heated by typical magnetic heating mechanisms such as nano-flare heating and MHD waves. Fourth, 304 line image, which is a chromospheric line, has a poorer result than the other lines, which seems to be caused by its complicated line formation mechanism and/or complex chromospheric structures such as filaments. Using this model, we have a plan to construct solar EUV images with Kitt peak magnetograms since 1974. This methodology can be applicable to many scientific fields that use several different filter images.

10:15 [IV-1-4]
Application of Deep Learning to Solar and Geophysical Data: 9. Real-time forecast of solar proton flux profiles using LSTM

Kang-Woo Yi[1], Yong-Jae Moon[1], Dohyeon Kim[2], Seung Bum Yang[2] and Taeyoung Kim[1,2]

[1]*School of Space Research, Kyung Hee University, Korea,* [2]*Inspace, Korea*

It is certainly believed that proton flux at geosynchronous orbit (GEO) is an important index to measure space weather risks. Solar activities are well-known sources of distinct proton flux enhancements. A solar proton event (SPE) is defined as an event that the >10 pfu (particle flux unit) of >10 MeV protons. In this study, we apply a Long short-Term Memory method to hourly proton peak flux prediction using GOES proton data from 2011 to 2015 for training and 2017 for test. To find better optional parameters for the LSTM model, we have tried two different structures (40 units with 1 LSTM layer and 6 units with 2 LSTM layers) and different hyper parameters (mean square error and mean absolute error loss functions; several epoch numbers to avoid over-fitting problem). We compare our LSTM predictions with the conventional autoregressive prediction. Our major results are as follows: First, root mean square error(RMSE) of next 24 hour proton flux prediction with LSTM model is 0.19 for whole year of 2017 and 0.52 for 2017 SPE duration while that with the autoregressive model is 0.19 and 0.55, respectively. Second, our LSTM model has similar prediction results with the autoregressive model for whole year of 2017. Third, our LSTM model has better prediction results than the autoregressive model from 1 hour forecasting to 24 hour forecasting for 2017 SPE duration.

10:30 [IV-1-5]

Application of Deep Learning to Solar and Geophysical Data: 8. Solar X-ray Flare forecast using full-disk magnetograms and flare history

Seulki Shin[1], Hyoungseok Chu[2], Yong-Jae Moon[1]

[1]*School of Space Research, Kyung Hee University*
[2]*Software Policy & Research Institute*

Convolutional neural network (ConvNet), one of deep learning methods, is specialized in image recognition. In this study, we apply the AlexNet and ResNet architecture, which is a winner of ILSVRC 2012 and 2015 respectively, to the forecast of solar flares. Our inputs are SDO/HMI longitudinal magnetograms from May 2010 to December 2017, and output ones are yes or no of flare occurrence. We select the training dataset from January 2010 to December 2013 and the testing dataset is chosen from January 2014 to December 2017. As a result, we find that True Skill Statsitics (TSS) of this model is 0.55. In order to improve our forecasting model, we apply the Supporting Vector Machine to the output of the first model and the flare occurrence of the previous day to predict the occurrence of flares for a given day. The second model greatly improve the TSS value (0.69). In addition, we are looking for a possibility to improve the model by using vertical current density derived from SDO/HMI vector magnetograms.

10:45 [IV-1-6]

Application of Deep Learning to Solar and Geophysical Data : 3. Generation of backside magnetograms from STEREO/EUVI images

Taeyoung Kim[1,2], Eunsu Park[1], Harim Lee[1], Yong-Jae Moon[1], Sung-Ho Bae[1], Daye Lim[1], Soojeong Jang[1], Lokwon Kim[1], Il-Hyun Cho[1], Myungjin Choi[2], and Kyung-Suk Cho[3]

[1]*Kyung Hee University*
[2]*InSpace Co., Ltd.*
[3]*Korea Astronomy and Space Science Institute*

Solar magnetograms are very important for studying solar activities and predicting space weather disturbances. Currently predicting space weather relies only on solar frontside magnetograms because STEREO satellites provide backside EUV images but not magnetograms. Here we first time successfully generate backside solar magnetograms from STEREO EUVI 304□ ˚A images using a deep learning model based on conditional generative adversarial networks(cGANs). We train and validate the model using pairs of SDO/AIA 304A images and their corresponding SDO/HMI line-of-sight magnetograms. Using this model with STEREO/EUVI 304A images, which are similar to SDO/AIA 304A images, we successfully produce AI-generated backside magnetograms without any magnetograph data.

제2발표장 (한라홀)

■ IV-2 Moon and Solar System
좌장: 정민섭 (천문연)

09:30 [IV-2-1]

Evaluation of speckle image quality measurement algorithms for the lunar surface

Jinkyu Kim, Chae Kyung Sim, Sungsoo S. Kim, Ho Jin

Kyung Hee University

We obtained images of the Moon using speckle-imaging technique through a 24-inch telescope installed at Sierra Remote Observatory (SRO) in California, USA. From a series of 100 images taken at a speed of 100 Hz, we evaluate the quality of each image and select the best one whose distortion by terrestrial atmosphere is minimal. Because traditional evaluation method based on Strehl ratio focuses on point objects, it cannot be applied to the large extended object as the Moon. Especially in this case, the Moon appears almost nine times larger than the field of view of our camera. Here, we study algorithms that are used to evaluate the quality of solar images (Popowicz et al., 2017) and apply them to our observational data of the Moon.

First, we simulate observational image of lunar disk with no atmospheric influence using data obtained by Terrain Camera (TC) onboard Kaguya spacecraft. Then we simulate speckle-patterns that can appear in various seeing conditions at SRO. Using these patterns as convolution kernels, we generate pseudo observation images considering various atmospheric influences. We compare the Strehl ratio of each speckle pattern with sharpness values that are evaluated by various algorithms in literature.

09:45 [IV-2-2]

Magnetic anomalies within Nectarian-aged basins: Evidence for a complex magnetic epoch on the Moon

Seul-Min Baek[1], Khan-Hyuk Kim[1], Ian Garrick-Bethell[1,2], and Ho Jin[1]

[1]*School of Space Research, Kyung Hee University,*
[2]*Earth and Planetary Sciences, UC Santa Cruz*

The nature and history of the Moon's extinct dynamo are poorly constrained. Crustal anomalies, such as those observed in the Nectarian-aged basins (e.g., Crisium, Moscoviense, and Mendel-Rydberg), provide clues to their history. Using the magnetic field data obtained from Lunar Prospector to model each anomaly' s source as a dipole, we find that the source' s depths and radial positions are located within basin's melt-pool, implying the

anomalies associated with a thermoremanent magnetization in a dynamo field at 3.7 Ga–4.0 Ga. We also find that the paleopole positions for the Nectarian anomalies are widely scattered and separated beyond their error ellipses. Their variable directions imply that the local field orientation was not fixed during the formation times of the anomalies. This suggests that the Moon may have experienced complex field geometries. A large spread of paleopole positions on the Moon may be due to true polar wander driven by impact basin formation or internal density changes, or from equatorial dynamo orientations produced by anomalous core heat flux conditions. The long cooling timescales of the anomalies also suggests they were not magnetized by more transient fields produced by impact–induced stirring of the core.

10:00 [IV–2–3]
Definition of Water Ice on Airless Body Images

Haingja Seo[1], Young–Jun Choi[2,4], Eunjin Cho[2,4], Ik–Seon Hong[2,3], Myungjin Choi[1]

[1]*InSpace (Intelligence in Space)*
[2]*Korea Astronomy and Space Science Institute*
[3]*Department of Astronomy, Space science and Geology, Chungnam National University*
[4]*Astronomy and Space Science, University of Science and Technology*

Analysis of airless body images can be another way for researching their surface. Water ice on surface especially is revealed brightly in the images. To confirm that the bright region in the image is water ice, it is necessary to define a reference value. We used Mercury images by MDIS/Messenger and Ceres images by FC/DAWN, and these data are images where the water ice had been found. Water ice on airless body is likely to be in Permanently Shadow Regions(PSRs), and we inferred that it caused brightness variation on PSRs' images. We defined the values of brightness variation and reflectance variation to identify the region of water ice in image. We also try to compute the value of temperature variation applying thermal model. The constructed value is acceptable to ShadowCam data to help water ice detection.

10:15 [IV–2–4]
Determination of polarization phase curve: sparse observation case

Chae Kyung Sim[1], Sukbum A. Hong[1], Sungsoo S. Kim[1], Minsup Jeong[2], Kilho Baek[1], Young–Jun Choi[2]

[1]*Kyung Hee University*
[2]*Korea Astronomy and Space Science Institute*

Polarimetry of the Moon allows us to study the size and composition of regolith grains on the lunar surface. This information is useful in understanding the surface properties and determining landing sites for future lunar missions. The wide–angle polarimetric camera (PolCam) onboard the Korea Pathfinder Lunar Orbiter (KPLO) will perform polarimetric measurements of the lunar surface from the lunar orbit for the first time. Since the degree of linear polarization is a function of phase angle (α), it is necessary to observe the same region for multiple times at various α. To prepare for any unfortunate case of incomplete PolCam or KPLO mission, here we study how to analyze the polarimetric measurements from sparse α observations. Using a ground–based polarimetry data, we study the use of reduced fitting formula to estimate the polarization maximum ($P_{\max}$). We also investigate the allowable range of α –coverage assuming several cases of sparse observations. When the polarimetric measurement at high–α is required, at least one measurement should be obtained at the $\alpha > 90^{\circ}$ to properly estimate $P_{\max}$.

10:30 [IV–2–5]
Basic research for the development of lunar far side highland soil simulant

Tae Yun Kang[1,2], Kyeong Ja Kim[2], Yi Yu[1]

[1]*Chung–nam national university department of Astronomy, Space Science and Geology*
[2]*Korea Institute of Geoscience and Mineral Resources*

Recently, various lunar soil simulants are made for purpose of lunar resource exploration & construction of the lunar basement in the world including USA, China, Japan, Korea etc. Developed lunar soil simulant helps to make the similar lunar surface environment so that scientists and engineers can test the ability of lunar mission equipment. In this research, the far side highland type soil simulant is supposed to develop for purpose of human/unhuman lunar exploration on the lunar surface. Apollo 16 sample is chosen as reference material and anorthosite collected from Hadong–Sancheong, peridotite, pyroxenite will be used for raw materials. Among lunar soil simulant properties for this study particle size distribution and composition of major elements are main parameters to simulate. In addition, how to simulate particle size distribution and elemental weight percent of oxides in the lunar simulant sample are explained.

10:45 [IV–2–6]
Physical properties of asteroid (298) Baptistina : light curve, shape and phase curve

Sang–Min Lee[1], Myung–Jin Kim[2], Yonggi Kim[1], Hong–Kyu Moon[2], Young–Jun Choi[2,3], Anna Marciniak[4], Murat Kaplan[5], Orhan Erece[5,6]

[1]*Chungbuk National University, Korea*
[2]*Korea Astronomy and Space Science Institute, Korea*

[3]*University of Science and Technology, Korea*
[4]*Adam Mickiewicz University, Poland*
[5]*Akdeniz University, Turkey*
[6]*TUBITAK National Observatory, Turkey*

Hirayama (1918) identified asteroids with similar orbital elements and first used the term "asteroid family". So far, 121 asteroid families have been found (Nesvorny et al. 2015) and are named after the largest asteroid among family members. An asteroid family is broken up leftovers from a same parent body and hence has similar physical and orbital properties. This is why study of asteroid families is crucial for the collisional and dynamical history of our Solar System. Baptistina asteroid family was once regarded as the K/T Impactor (Bottke et al. 2007) , however, the break-up age of this family is still not well-known. Therefore we conducted the time-series observation for the asteroid (298) Baptistina, which is considered a parent body of Baptistina family using several 1-2 m class telescopes from Dec 2017 to Jun 2018. The light curve, phase curve and 3D shape model of (298) Baptistina will be presented in this paper.

제3발표장 (아라홀)

■ IV-3 Space Technology & Application II
좌장: 이주희 (항우연)

09:30 [IV-3-1]
Development of Flight Dynamic Solutions to make Frozen Orbit after Separation from Launch Vehicle

Jae-Cheol Yoon

Korea Aerospace Research Institute

The interferometry is one of the significant missions for Synthetic Aperture Radar(SAR) Satellite. Two operation functions are essential to meet the mission requirement. First, the precise repeat ground track of satellite shall be designed and be maintained within narrow baseline limitation after launch. Second, the precision orbit ephemeris shall be expeditiously provided to interferometric processing entity. Expecially, the satellite should be operated in Frozen orbit to maintain the precise repeat ground track. Because launch vehicle will drop the satellite in circular orbit, it is required to maneuver satellite to make frozen orbit after separation from launch vehicle. The Flight Dynamic Solutions, which are able to generate maneuver plans for frozen orbit, were successfully developed. The solutions have functions to adjust Semi-major Axis, Inclination, Eccentricity, Argument of Perigee, and Right Ascension of Ascending Node. Using this solution, the maneuver plan was generated and its accuracy was verified for the KOMPSAT-6 satellite.

09:45 [IV-3-2]
A study on the process of combustion experiment using a reduced-gravity aircraft in microgravity environment

Jong-Won Lee[1], Won-Sik Nam[2], Youn-Kyu Kim[1], Joo-Hee Lee[1], Seul-Hyun Park[2]

[1]*Korea Aerospace Research Institute*
[2]*Chosun University*

Korea Aerospace Research Institute (KARI) has developed combustion experiment system for a cool flame research in microgravity environment. The combustion experiment system will be loaded on a reduced-gravity aircraft (so-called, parabolic flight campaign) and droplet combustion experiment will be conducted under microgravity environment. Most of the experiments using a reduced-gravity aircraft are currently executed in the United States, Japan, Europe, and Russia. And it is the only way to simulate a microgravity environment at least 20 seconds on Earth.
However, the success of the parabolic flight experiments cannot be guaranteed. To increase a success probability of parabolic flight experiment, we conducted performance test repeatedly for maintaining consistent performance of the device in a time-varying gravitational environment. Also, we seek the appropriate experiment location and role of experimenters for combustion experiment mission success.
In this paper, we will introduce an experiment overview and the operation process of the combustion experiment system using a reduced-gravity aircraft in microgravity environment.

10:00 [IV-3-3]
The deliberation and adjustment on the yearly budget of the Compact Advanced Satellite Development Project & The Deliberative Council of Presidential Advisory Council on Science and Technology.

Keun-Woong Shin, Ji-Mo Yang, Kyungjin Kwon, Eungsik Park

Korea Aerospace Research Institute

In accordance with the whole amendment of "The Act of The Presidential Advisory Council on Science and Technology" in April 2018, "The deliberative Council of The Presidential Advisory Council on Science and Technology(hereinafter referred to as "Deliberative Council") was in charge of deliberation on the matters the coordination of major science & technology policies and especially concerning allocating, adjusting and efficiently operating the budget for the national R&D projects implemented by the Government every year(on a yearly basis), which were in charge of the "National Science and Technology Council" before amendment. The minister of Science and ICT shall reflect matters related to the budget for a national R&D project among

matters deliberated by the "Deliberative Council" in the outcomes of allocating, adjusting, etc. The "Deliberative Council" also deliberates and adjusts the yearly budgets of the Compact Advanced Satellite Development Project(being drove as National R&D Project). We will look at the legal basis of establishment & organization of the "Deliberative council", the history of the Council and some deliberation agendas related to national R&D budget, etc. briefly.

10:15 [IV-3-4]
Analysis of Science Community Demand for Satellite Program in Korea

Jae-Min Lee

Korea Institute of Science and Technology Evaluation and Planning

Korea has been developing space satellites and sounding rockets since 1992 for diverse purposes such as earth observation, communication, security, space science, etc. . So far 12 satellites and 5 sounding rockets were successfully launched, on which 46 instruments in total were carried, and delivered remarkable achievements in many aspects. The scientific achievement from the instruments, however, has not been improved in quality and quantity for decades. This is because of a lack of goal- and mission-oriented programs that meet end-user's demand. Also, scientific views from the end-user community were not properly reflected in policy during instrument selection processes. Here I introduce the science community demand for satellite program, analysed using multiple methods. Then I suggest a strategy for demand-based space satellite program, addressing the environment surrounding space development in Korea.

10:30 [IV-3-5]
An investigation of photometric properties of KIC 8682849

Min-Ji Jeong[1], Chun-Hwey Kim[1,2]

[1]*Chungbuk National University in Korea*
[2]*Chungbuk National University Observatory in Jincheon, Korea*

The photometric properties of KIC 8682849, a short-period contact binary of about 0.36 days, are reported through the intensive analysis of the time-series and ultra-high-precision Kepler data. The system shows very dynamic variations in both light and eclipse timing. The light curve shows the quasi-periodic variation of about 77 days. The primary and secondary eclipse timings also vary in an anti-correlated pattern and a quasi-periodical way with the period similar to that of the light curve. After both of the light variations and the anti-correlated patterns are assumed to be due to the activity and the drift of a large spot on the primary star, a unique photometric solution is derived and then time-variations of the position of the spot based on the solution are searched. One of the results shows that the variations above may occur by an asynchronous rotation of the system. The light curve solution indicates that the system is an over-contact binary system with a very small mass ratio of about 0.14 and a fill-out factor of about 64.5%. The possible evolution of KIC8682849 is discussed together with those of the other systems to have the Roche geometries similar to it.

10:45 [IV-3-6]
A Study on the Escapement of Yi Min-cheol's Astronomical Clock

Seon Young Ham[1,2], Sang Hyuk Kim[2,3], Byeong-Hee Mihn[2,3], Yong-gi Kim[1], Yong Sam Lee[1]

[1]*Chungbuk National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Korea University of Science and Technology*

In a water hammering type astronomical clock made in Korea, the escapement generates torque with momentary strong force while minimizing the water flow rate. The water-hammering type astronomical clock is operated by torque, which affects the accuracy of the clock. We estimated that the escapement of Yi Min-cheol(李敏哲, 1631~1715)'s astronomical clock made in the middle of the Joseon Dynasty was Bucha(浮車). We designed Bucha by analyzing "*Jejeonggak-gi*" "*Gyujeonggak-gi*" and "*Seungjeongwon Ilgi*". Based on these, experimental apparatus was made and performance tests were performed.

포스터발표 논문 초록

1부 발표시간: 10월 24일(수) 16:40~17:40

[P-1] Radiometric Model and Performance of Lunar Terrain Imager(LUTI) for Korea Pathfinder Lunar Orbiter (KPLO)

Gmsil Kang, Jong-Euk Park, Hangpal Heo, Sang-Soon Yong,

KARI Satellite Payload Developmetn Division

The LUTI (Lunar Terrain Imager) which is a primary payload for KPLO (Korea Pathfinder Lunar Orbiter) is under development by KARI (Korea Aerospace Research Institute). The LUTI is the electro-optical camera system which consists of two independent panchromatic cameras. Its main mission is to provide high resolution image over the moon. each camera of LUTI consists of telescope of 90mm diameter aperture, CCD line detector of 2048 pixels, and electronics unit to detector control, video signal acquisition and transmission to spacecraft, LUTI system is designed to provide around 10km swath with 2.5m GSD at nominal orbit (100km). In this paper, radiometric model of the LUTI is introduced and radiometric performance are discussed. The linearity of LUTI camera response is mainly depend on the CCD characteristics. Because detector non-linearity is better than 0.5% in output range 10% to 90% of saturation level, radiometric model of the LUTI camera is considered as a linear response. In case of lower response part than 10% of saturation level, dedicated correction model will be needed and is not discussed in this paper. Linear radiometric gain consists of optic gain including optical aperture, transmissivity including optical filter, IFOV (Instantaneous Field Of View), and CCD SDE (Spectral Detection Efficiency). This linear gain is expected to be independent to the integration time. Therefore the radiance can be recovered from the digital output data with radiometric gain and integration time. Based on optical design parameters and measurements data of the CCD and the CEM, SNR performance is examined. Analysis results shows that SNR requirement (40) for minimum radiance can be satisfied under nominal orbit (100Km).

[P-2] In-Orbit Radiometric Gain Stability of Geostationary Ocean Color Imager (GOCI) Over Eight Years Operation

Gmsil Kang[1], Sang-Soon Yong[1], Sun-Hee Woo[2]

[1]*KARI Satellite Payload Development Division*
[2]*KARI Mission Operation and Infrastructure Service Division*

The Geostationary Ocean Color Imager (GOCI) has performed its mission to observe ocean color around Korean Peninsula from geostationary platform(COMS) after successful launch of CMOS on 27th of June 2010 over almost eight years. The GOCI observation provides multi-spectral radiance data over target area (2500km × 2500km) eight times per day. It is equipped with shutter wheel, 2-D pointing mirror, 2-D CMOS detector, and filter wheel. During mission operation, the radiometric gain of the GOCI has been periodically measured through solar calibration by on-board calibration devices, SD(solar diffuser) and DAMD (Diffuser Aging Monitoring Devices). In this paper, stability of the radiometric gain of eight spectral channels are discussed. Absolute radiometric gain can be estimated by using full aperture calibration with SD. Aging impact of the SD can be monitored by DAMD calibration. It is possible to monitor radiometric gain stability by using DAMD calibration w.r.t beginning of mission. In case of DAMD, the lower aging effect is expected because the DAMD calibration is performed once per month. In-orbit calibration results shows around 4% variation along spectral channels. There is periodical variation induced by model error of on-board calibration devices. If this periodical variation is considered, the actual gain variation will be around 2.0%. Monitoring results of the SD aging shows around 2.5% variation including periodical pattern which is not considered as a real aging characteristics.

[P-3] Preliminary Micro-vibration Analysis for precise optical payloads of KPLO

Beom-Suk Kang[1], Hyun-Jin Shin[1], Seung-Yong Min[1], Hyeon-Jung Park[2] and Seok-Weon Choi[1]

[1]*Korea Aerospace Research Institute*
[2]*Korea Aerospace Industries*

There are three optical payloads and three sources of disturbance in the Korea Pathfinder Lunar Orbiter(KPLO). The three optical payloads are LUTI(Lunar Terrain Imager), Shadow Cam, Polcam and the three sources of disturbance are RWA(Reaction Wheel), High Gain Antenna, SADM(Solar Array Drive Mechanism). In this paper, we will discuss preliminary micro-vibration analysis results of payloads and evaluate the influence of disturbance sources on micro-vibration.

[P-4] Imaging Planning Process for Lunar Terrain

Dong-Gyu Kim, Gmsil Kang, Seok-Weon Choi

Korea Aerospace Research Institute

Lunar Terrain Imager(LUTI) is the primary

payload of Korea Pathfinder Lunar Orbiter(KPLO) and its mission objective is to provide high resolution images of the future lunar landing site. Korea Aerospace Research Institute(KARI) has been developing the Mission Planning Subsystem(MPS) and one of the MPS' s major task is to generate a LUTI imaging plan to achieve its mission goals. Based on the pre-selected targer areas, MPS is going to follow the imaging planning procedures and generate a LUTI imaging plan. The first step is to select a target candidate from target areas on a daily predicted KPLO orbits with considering a targeting priority of target areas and a maximum imaging time of LUTI per orbit. if target candidates are selected out of target areas, MPS will calculate a phase angle between the KPLO and the Sun, estimate the radiance of the target candidate, and generate LUTI imaging condition, called Video Parameter (VP). In order to estimate the radiance from the target candidate, the MPS will refer to the lunar radiance maps of other lunar missions and apply photometric correction to update the radiance of common viewing angle to the calculated phase angle. IF the targets are in an off-nadir area, the MPS needs to generate the attitude maneuver angles. Finally the MPS will review the overall imaging plan to see and fix any violations against KPLO bus and LUTI operation constraints.

[P-5] Study of Photometric Correction for Imaging

Dong-Gyu Kim, Seok-Weon Choi

Korea Aerospace Research Institute

The primary payload of Korea Pathfinder Lunar Orbiter(KPLO) is Lunar Terrain Imager(LUTI). LUTI observation will be made in a different viewing condition in lunar orbit and we need to consider radiance condition of target area when we make a imaging planning for LUTI. The reference radiance lunar maps are generated in a common viewing angle and we should generate the estimated radiance in a specific viewing conditions using a photometric correction method. This photometric correction of reference radiance map will be only applied to the region which have a low and high radiance characteristic comparing to the dynamic range of LUTI. Comparison of observations from difference locations of a planetary surface cannot be properly made if the illumination conditions are not corrected(Besse et al). Precise photometric correction parameter set is crucial for many applications including mineral identification and reflectance map mosaics(Yakota et al).
This study will show the photometric correction functions for lunar surface radiance derived from recent researches of Bess and Yakota.
Besse, et. al, One Moon, Many Measurements 2: Photometric Corrections, Icarus 226, 127-139
Yakota Y. et. al, Lunar Photometric Properties at Wavelength 0.5-1.6 um acquired by SELENE Spectral Profiled and their Dependency on Local Albedo and Latitude Zones, Icarus 215, 639-660

[P-6] LUnar Terrain Imager (LUTI) Lens Radiation Analysis and Test of the Korea Pathfinder Lunar Orbiter (KPLO)

Seonghui Kim, Dai Ho Ko

Korea Aerospace Research Institute

The Korea Pathfinder Lunar Orbiter (KPLO) is under developing according to the Korean Lunar Exploration Project. It is the Korea' s first lunar orbiter and will be launched on the Korean launch vehicle which is also under developing. Among many other payloads on board the KPLO, LUnar Terrain Imager (LUTI) is high resolution camera with more or less than 2m ground sampling distance. Its' main mission is to observe and take image data of the candidate landing sites for the next lunar landing mission. LUTI mirror coating and lens material characteristics may change due to the radiation environment in the lunar orbit during an operation. Analysis for coating degradation and test for lens materials were conducted to see how much their characteristics change. Results show that coating has little impact during the mission operation period, whereas lens material may have some change even though their tests have more than 500% radiation dose margin(RDM). Optical design have been finished using only radiation-hardened material based on the test results. LUTI is expected not to have optical performance degradation due to the radiation damage during the mission period.

[P-7] Optical Alignment Process and Results for the CAS-500 Optical Module

Seonghui Kim[1], Deoggyu Lee[1], Hyunju Seo[2], Gimun Kim[3]

[1]*Korea Aerospace Research Institute*
[2]*Hanwha Systems*
[3]*Asia Pacific Satellite Inc.*

The Optical Module for CAS-500 Payload is designed for best performance using the 3-mirror Korsch Type optical system. For the precise optical alignment on this system, we developed 3-d measurement platform with high accuracy on the angles and positions. To measure optical performance we use both the interferometer and the wave-front sensor, to improve alignment accuracy and reliabilities. Using the its own merits, the accuracy, the resolution, the configuration, we performed lots of case studies for the alignment status on the each optical component, efficiently reduced the optical abberations of system. Also applying computer-aided alignment algorithm, the optical component has flexible positioning with respect to the desired nominal position. We will introduce overall alignment process and result in this presentation.

[P-8] Suggestion of lunar landing candidate sites for future Korean lunar exploration

Suyeon Kim[1,2], Yu Yi[1], Kyeong Ja Kim[2],

[1]*Chungnam National University*
[2]*Korea Institute of Geoscience and Mineral Resources*

Future Korean lunar exploration plans include sending a lander on the Moon. For this, two lunar landing site candidates be suggested. The first candidate is Crater Meton. It is located in the polar region of the Moon, which is relatively under-explored, and M^3 data shows that it has more hydroxyl than other regions. And there is a domed terrain at the center of the crater, which is due to volcanic activity. But the area is not a mare but a highland, therefore it is worth investigating. The second candidate is Crater Copernicus. Olivine, a major component of the Earth mantle, was found in this area, which is believed to be due to the impact of collision at the time that crater was born. Therefore, by studying this area, we can get information about the internal structure of the Moon. In addition, for both areas, SELENE altitude data analysis confirmed that there is a flat ground to land the spacecraft.

[P-9] Operation scenario and Data sequence of The Science Data Management Subsystem for The Korea Pathfinder Lunar Orbiter

Joo Hyeon Kim, Seok-Weon Choi

Korea Aerospace Research Institute

The Science Data Management Subsystem(SDMS) of the Korea Pathfinder Lunar Orbiter(KPLO) will archive and manage all science data from Korean domestic developed instruments in order to promote the achievement of their own science missions. The SDMS will also provide the web service for science data release to the publics.
The SDMS consists of two main modules that one is the Science Data Management Module (SDMM) in order to manage and archive the science data in a format of telemetry, and the other is the KARI Planetary Data System(KPDS) in order to manage and publicly release the data product in compliance with the NASA PDS4 standard to the public users.
The critical design review(CDR) of the KPLO program will be carried out in December 2018.
We will present the architecture and function of the component modules, data sequence, the subsystem operation scenario, and science data management plan in order to prepare the CDR.

[P-10] KPLO X band Data and RF Link Verification using X-band Downlink Test Set for Korea Pathfinder Lunar Orbiter

Sangman Moon, Changkyoon Kim, Inkyu-Kim

Korea Aerospace Research Institute

X-DLTS is X-band EGSE for KPLO. The purpose of X-DLTS is verifying with X-band mass data and RF link performance for KPLO communication. X-DLTS is peformed the BER test for RF link margin and the FEC performance test for data immunity. For the mass data transferring using X-band, PDHU manages the data, which is science data for the KPLO mission payload and SOH data for the KPLO spacecraft. X-DLTS is consist of the down converter and the demodulator with RF and IF path. This X-DLTS input is connected to X-band transmitter in KPLO and output is connected to PDHU EGSE. Also, the X-DLTS will be used for the data stream verification for KPLO.

[P-11] Integration Concept of the KPLO Payloads to the Bus Structure

Seung-Yong Min[1], Hyun-Jin Shin[1], Beom-Suk Kang[1], Hyeon-Jung Park[2] and Seok-Weon Choi[1]

[1]*Korea Aerospace Research Institute*
[2]*Korea Aerospace Industries*

Korea Pathfinder Lunar Orbiter (KPLO) has 6 payloads to investigate the lunar environment and demonstrate newly-developed technology. Each payload has its own mission and requirements. The KPLO bus structure has to accommodate the payloads complying with the requirements and preferences. In this paper, integration concept of KPLO payloads to the bus structure is described considering mechanical build-up process, harness routing, accessability and alignment tasks.

[P-12] Introduction of Lunar Science Project using Shadow Cam Data

Haingja Seo, Seung Hyub Baec, Dong Young Kim, Myungjin Choi

InSpace (Intelligence in Space)

Shadow Cam will be mounted on Korean Pathfinder Orbiter (KPLO), which is scheduled to be launch in 2020. The ShadowCam is being developed by investigators at Arizona State University and Malin Space Science System, and NASA has selected it for KPLO. It's objective is to detect water ice on the lunar permanent shadow region. The spectral data of M3/Chandraayn-1, VIMS/Cassini, and HRI-IR/Deep Impact revealed the evidence of water on the lunar surface. If there is water on lunar surface, owing to lunar environment, it will exist in the form of ice as there is a lack of sunlight all year due to tilted rotation axis and crater structure. In this project we will research on the airless body as like Moon using Mercury, Ceres, and lunar data. We will analyze the distribution of water ice on lunar surface, temporal and spatial variation by comparing spectral data. In addition, we will attempt to count of craters from images through applying deep-learning method.

Through this project we are pleased to have a chance to collaborate on the research with the ShadowCam team in the U.S. And we are honoured to be able to contribute to science of deep-space exploration as a private corporation.

[P-13] Design of Real-time Operation subsystem with standard link extension (SLE) service for KPLO's ground system

Seunghee Son, Seok-Weon Choi

Korea Aerospace Research Institute

Korea Pathfinder Lunar Orbiter (KPLO) and it's associated Korea Deep Space Ground System (KDGS) are currently under development. Within KDGS, real-time operation subsystem (ROS) is the front end of the KDGS and will be responsible for sending commands and receiving telemetries for KPLO operation. KPLO will be operated with Korea Deep Space Antenna (KDSA) and NASA's DSNs to maximize the communication window. Design of ROS has been considered with a connection with multi antenna systems which are expected with different environments and settings. SLE service was introduced to solve inter-operability between different ground system. In this study, we will introduce the merit of SLE and architecture of ROS.

[P-14] Operation Scenario with standard link extension service for real-time operation subsystem

Seunghee Son, Seok-Weon Choi

Korea Aerospace Research Institute

KARI is developing the Korea Deep Space Ground system and the real-time operation subsystem (ROS) has adapted standard link extension (SLE) service for inter-operability between several ground systems. SLE will replace the traditional cortex based connection rule to an antenna base system. Cortex based connection required the same and/or compatible equipments between ground system and antenna sites. The SLE service will add the flexibility to the ROS for utilizing several antenna sites. This is a desirable functionality for KPLO project which is planning to use NASA's DSN service during LEOP and normal operation of KPLO.
In this study, we will introduce the SLE operation concept and its setup. This will be compared with KARI-developed KOMPSAT series real-time operation.

[P-15] Product Generation Plan for Korea Pathfinder Lunar Orbiter's Flight Dynamics Subsystem

Young-Joo Song, Young-Rok Kim, Seok-Weon Choi

Korea Aerospace Research Institute

For the successful flight operation of the Korea Pathfinder Lunar Orbiter (KPLO), planned to be launched in late 2020, Flight Dynamics Subsystem (FDS) for KPLO mission is now under development by Korea Aerospace Research Institute (KARI). Unlike earth orbiting satellite mission, there are many different products that should be generated within FDS for the successful operation of KPLO. In this work, the list of products that are currently being planned to be generated within KPLO FDS is discussed. Rough design results of product generation plan for KPLO FDS is described: including products' generation purpose, type, format and generation frequency, product receiver etc. which are all strongly dependent to the different lunar mission phases. In addition, products that are to be used for Deep Space Network (DSN) as well as Near Earth Network (NEN) scheduling is also discussed. Based on a current product generation design result, further detailed product generation plan will be established and implemented to the KPLO FDS.

[P-16] Preliminaries of Korea Pathfinder Lunar Orbiter (KPLO) Electrical Test-Bed (ETB) Preparations

Jae-Hoon Song, Sang-Man Moon, Sang-Rok Lee, Yun-Goo Huh, Seok-Weon Choi

Korea Aerospace Research Institute

The Korea Pathfinder Lunar Orbiter (KPLO) system is being developed as a first space exploration program in Korea. In this article, a preparation status of the KPLO Electrical Test-Bed (ETB) to check electrical function and performance, to validate interfaces and performances, and to verify functional logic of subsystems is introduced.

[P-17] Development of Engineering Qualification Model for Korea Pathfinder Lunar Orbiter Magnetometer (KMAG)

Jehyuck Shin[1], Hyojeong Lee[1], Jung-Kyu Lee[1], Seongwhan Lee[2], Seungah Lee[1], Mangyu Lee[1], Hyunwoo Lee[1], Byungwook Jeong[1], Ho Jin[1], Khan-Hyuk Kim[1], Dukhang Lee[4,5] Derac Son[3] and Ian Garrick-Bethell[1,6]

[1]*School of Space Research, Kyung Hee University, Korea*
[2]*Intorule Inc., Korea*
[3]*Sensorpia Inc., Korea*
[4]*Korea Astronomy and Space Science Institute, Korea,*
[5]*Department of Earth and Space Science and Engineering*
York University, Canada
[6]*University of California, Santa Cruz, United States*

KMAG is a scientific experimental payload of the Korea Pathfinder Lunar Orbiter (KPLO) that is the first lunar exploration mission of the Korean space program. This payload will measures the

magnetic strength of the lunar environment to research the origin of lunar crustal magnetic anomalies. The magnetometer of the KMAG is the triaxial fluxgate designed to measure ±1000 nT range of DC magnetic fields with 0.2 nT resolution. KMAG consists of deployable boom structure as named Magnetometer (MAG) unit and Fluxgate magnetometer Control Electronics (FCE) unit. Total three fluxgates are installed in a 1.2 m boom tube and multi sensing method will be performed for data modification due to minimize magnetic disturbance from the KPLO. KMAG has 3.5 kg mass, 4.6 watt for power consumption and 295.31 Mbit/day as data generation. In this paper, we present the development of KMAG engineering qualification model with verification and environment test results.

[P-18] Harness routing concept design between Solar Array Panel and Solar Array Drive Mechanism in KPLO

Hyun-Jin Shin[1], Hyeon-Jung Park[2], Beom-Suk Kang[1], Seung-Yong Min[1], Seok-Weon Choi[1]

[1]*Korea Aerospace Research Institute*
[2]*Korea Aerospace Industries*

In the Korea Pathfinder Lunar Orbiter(KPLO), there are two Solar Array Panel(SA Panel). The SA can be rotated by the 1-axis gimbal mechanism of Solar Array Drive Mechanism (SADM). In KPLO, we have to study some aspects of harness routing before design the harness routing such as harness minimum bending radius, the dynamic envelope of solar panel and so on. In this paper, we will introduce the harness routing design concept between the solar array panel and SADM in KPLO.

[P-19] Critical Thermal Design of LUnar Terrain Imager(LUTI) on Korea Pathfinder Lunar Orbiter(KPLO)

Su-Young Chang, Haeng-Pal Heo, Sang-Soon Yong

Korea Aerospace Research Institute(KARI) Satellite Payload Development Division

In this paper, a critial thermal design and thermal hardware development status of LUTI mounted on KPLO is described. LUTI is a high-performance Electro-Optical Camera and a KPLO's Main Payload, whose target is to provide a high-resolution image for candidate areas on Moon for a future Korean Lunar Lander. LUTI consists of two identical optical modules, main supporting structure and a radiator. LUTI is thermally isolated from KPLO spacecraft and has its own thermal control system. LUTI has 4 operating heaters and 1 launch heater. LUTI has a cold-redundancy for operating heaters, controlled by thermostats. Several thermistors and AD590 are installed to control primary operating heaters and monitor interal temperatures on LUTI. And a dedicated radiator for two Camera Electronics Modules (CEM) is installed to extract heat generated from Camera Electronics during imaing. From a current thermal design of LUTI, all components are maintained within allowable limits and duties of all heaters are kept below a limit, but there is an issue about a temperature gradient in viewpoint of a best performance of Camera. As of today, a development status of LUTI thermal hardware including temerature sensors, thermostats, MLI, heaters and radiator is briefly described.

[P-20] Simple Calculation of the Geo-KOMPSAT-2B(GK2B) Pointing Angle from Latitude and Longitude and Vice Versa

Su-Young Chang, Dai Ho Ko

Korea Aerospace Research Institute

The GEMS is one of two instruments manifested aboard the GEO-KOMPSAT-2B (GK2B) satellite. GK2B is scheduled to launch in 2019 and is intended to be the successor mission to COMS (Communication, Ocean and Meteorological Satellite). The GEMS is a geostationary scanning ultraviolet-visible spectrometer designed to monitor trans-boundary pollution events for the Korean peninsula and Asia-Pacific region. The spectrometer provides high spatial and high temporal resolution measurements of ozone, its precursors, and aerosols. In order to manage the GEMS operation plan, latitude and longitude of the point of interest should be calculated as GEMS scan mirror pointing angle and GEMS scan mirror pointing angle should be converted to latitude and longitude of the point of interest.

[P-21] Activation Energy and Hydroxyl Distribution by Solar Wind Implantation on airless bodies

Eunjin Cho[1,2], Young-Jun Choi[1,2]

[1]*University of Science and Technology*
[2]*Korea Astronomy and Space Science Institute*

It is regards that hydroxyl is able to be formed by solar wind implantation on airless bodies. Moon Mineralogy Mapper (M3)/Chandrayaan-1 observed absorption features of hydroxyl, and other two spacecraft also detected the features during fly-by on the moon. Not only the moon but also other airless bodies showed possibilities of hydroxyl formation by solar wind protons. Near 2.8 um absorption feature of Eros and Ganymed was detected by NASA Infrared Telescope Facility (IRTF) as point sources, and hydroxyl of Phobos, Deimos, and Gaspra were observed in this wavelength during flyby as resolved data. Hydroxyl distribution on airless bodies might be determined by combination of solar wind flux and diffusion rate. Because the diffusion rate is a function of temperature and activation energy, the mechanism is associated with surface properties. We employ a statistical

mechanics method of Farrell et al., 2017 for other airless bodies mentioned above and briefly speculate the surface condition.

[P-22] Detection of subsurface lava tube feature with lunar gravity model filtering and stacking

Ik-Seon Hong[1], Young-Jun Choi[2], Hong-kyu Moon[2], Yu Yi[1]

[1]*Chungnam National University*
[2]*Korea Astronomy and Space Science Institute*

After the release of the high resolution lunar gravity model, several studies of lunar subsurface have been published. The gravity model has the form of spherical harmonics, and degree and order are related to depth of the body. In this study, we used the lunar gravity model (GL1500E) to find the lava tubes in the lunar subsurface. In order to reduce the regional trends of the deeper place and error of high degree and order, we specify the filtering range from analyzing power spectrum. And We create a three-dimensional image from a gravitational field with degree and order interval calculation in a form similar to a spectral image. Using this data, we attempted to detect the lava tube feature beneath the surface of the pit and around areas, and found that there was a decrease in gravity from a high degree and order.

[P-23] Application of Deep Learning to Solar and Geophysical Data: 6. Generation of COMS visible images from COMS IR images

Kimoon Kim, Yong-Jae Moon, Eunsu Park, Harim Lee

School of Space Research, Kyung Hee University

Communication, Ocean and Meteorological Satellite (COMS) has continuously monitored weather through InfraRed (IR) and visible channels. At night time, only IR images are avaliable. In this study, we apply a deep learning method for image-to-image translation, which is based on conditional Generative Adversarial Networks (cGAN), to COMS IR and visible images. We train our model using data sets from 2016 to 2017 except Feb and Aug. We evaluate our model using data sets in Feb and Aug. Our model successfully produce AI-generated visible images from IR ones, which gives a very good mean correlation (r=0.91) between actual visible images and AI-generated ones for 59 test samples. Using our model, we can monitor weather at night by IR images as well as AI-generated visible images.

[P-24] Comparison of Solar Flare classification models using AutoML and CNN

DoHyun Kim[1], TaeYoung Kim[1], Seung Bum Yang[1], MyungJin Choi[1], Eunsu Park[2], Suk-kyung Sung[2], Yong-jae Moon[2]

[1]*InSpace Co. Ltd.,.*
[2]*Kyung Hee University*

Recently, there have been many studies on applying deep learning using data observed in space environment. In order to apply the deep learning model to space environment, it is necessary to construct training data and hyperparameter configuration suitable for space environment. hyper parameters can affect accuracy, processing speed. The hyperparameter search methods include Manual Search, Grid Search, and Random Search. It takes time and effort to find and apply the optimum value, and it is the most difficult thing to make a deep learning model. AutoML is a technique that learns the model itself by finding optimal model layer and hyperparameter by applying the model without basic knowledge of deep learning by searching for the optimized parameter by modeling the network change through Bayesian optimization. The sunspot classification model was created using the CNN model and the AutoML model. SHO MDI Magnetogram After matching the data with XrayFlare in the full disk image between 1996 and 2008, 11,172 B, C, M, and X patch images were constructed through data argumentation. Compare the accuracy between two models and describe the architecture and hyper-parameter of model generated by AutoML.

이 논문은 2018년도 정부(과학기술정보통신부)의 재원으로 정보통신기술 진흥센터의 지원을 받아 수행된 연구임 (2018-0-01422,태양흑점폭발 분석 및 예측기술연구)

[P-25] Microwave brightness variation along a solar flare loop

Sujin Kim[1,3], Juongwoo Lee[2]

[1]*Korea Astronomy and Space Science Institute*
[2]*New Jersey Institute of Technology*
[3]*University of Science and Technology*

We have investigated a solar flare, SOL2013-10-28T02:01 (GOES class X1.0), in which a dominant microwave source appears to be dynamically switching its position within a flaring loop. The microwave imaging was made with the Nobeyama Radioheliograph (NoRH) at 17 GHz and 34 GHz. EUV images from SDO/AIA and Hard X-ray images from RHESSI satellite were also used. The time profiles of the flux at 17 GHz and 34 GHz consist of six flare peaks which occur quasi-periodically in about 20 sec time interval. Major microwave source was appeared in two areas of north and south within the flaring loop which is located near the limb. In the first three peaks, southern source is dominant and the fluxes in both sources are in phase. While the second three peaks have the northern source dominant and the fluxes in both sources are not in phase. On the other hand, the hard X-ray source appeared at the bottom of the northern microwave source for the first three peaks and at the bottom of the southern

microwave source for the last three peaks. The spatially-resolved flux time profiles imply that the northern source of microwave should be attributed to precipitating high energy electrons and the southern source, to the trapped electrons.

[P-26] Measuring Characteristics and Performance of a DICE(Diagnostic Coronal Experiment) CCD Camera(QSI 640i)

Jinhyun Kim, Seonghwan Choi, Jihun Kim, Young-Sam Yu, SuChan Bong, Jae-Ok Lee

Korea Astronomy and Space Science Institute

KASI have been developing a Diagnostic Coronal Experiment(DICE) system for total solar eclipse observation. We have tested the characteristics and performance of the DICE CCD camera 640i made by QSI company. For this we have used KASI' s photoelectron detector performance test system. (1) Using a lambertian light source flatted by integrating sphere, we were able to get the image signal value dependent on the exposure time. We have analyzed these images and measured readout noise, intensity and linearity. Using a Photon Transfer Curve(PTC) method, we have obtained CCD' s conversion gain for the 2 gain mode(High:0.7e^-/ADU, Low:1.5e^-/ADU) and full well capacity. (2) Using a monochromator that make light of a specify wavelength band, we have measured the quantum efficiency(200nm~1100nm). As a result, we found that the measured conversion gain value(High:0.71e^-/ADU, Low:1.51e^-/ADU) was almost similar to the specifications manual provided in QSI. In particular, It was confirmed that the peak value of the quantum efficiency is 55% and measured quantum efficiency was similar to the QSI manual. This test will be an important step in the performance of our next generation coronagraph CCD cameras.

[P-27] Large scale ducting of Pc1 pulsations observed by Swarm satellites and multiple ground networks

Hyangpyo Kim[1,2], Junga Hwang[1,2], Jaeheung Park[1,2], Yukinaga Miyashita[1,2], Kazuo Shiokawa[3], Ian R. Mann[4], Tero Raita[5] and Jaejin Lee[1,2]

[1]*Korea Astronomy and Space Science Institute*
[2]*Korea university of Science and Technology*
[3]*Center for International Collaborative Research (CICR), Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan*
[4]*Department of Physics, University of Alberta, Edmonton, Alberta T6G 2G7 Canada*
[5]*Sodankylä Geophysical Observatory University of Oulu, Finland*

Low earth orbit (LEO) satellites frequently encounter Pc1 pulsations, but most of them have been observed with limited latitudinal extent or short lifetime. In this study we analyze two large-scale Pc1 pulsations (latitudinally wide and long-lasting) generated by ionospheric ducting effect using Swarm constellation and multiple ground magnetometer networks (PWING, CARISMA and SGO) on 25 June and 3 September 2015. Swarm observed the 25 June pulsations on both dayside (10-14 MLT) and nightside (22-01 MLT) during the storm-time substorm (late recovery phase of a strong geomagnetic storm that occurred on 23 June). By combining with ground observations we found the Pc1 pulsations covered almost entire near-Earth region of all 24 MLT sectors for at least 2 hours via two different source regions. Coincident observations of Van Allen Probes reveal that not all the MLT sectors in the near-equatorial magnetosphere was filled with Pc1 pulsations. The dayside pulsation at Swarm altitudes shows that (1) the wave normal angle increases with decreasing latitude, (2) and the ellipticity is mixed at high latitude and becomes linear with decreasing latitude. For nightside waves, normal angle increases with decreasing latitude on Southern Hemisphere, but remains mixed in the Northern Hemisphere. The nighttime ellipticity exhibits mixed behavior at all latitudes. Another Pc1 pulsation on 3 September was observed by Swarm on the dawn sector (3-5 MLT) during a nonstorm-time substorm with largely oblique propagation and mixed polarization at all latitude. From our results we conclude that (1) ionospheric ducting can transmit Pc1 waves to a wide range of L shells at LEO and on the ground, (2) geomagnetic storm is not a prerequisite for such large scale ducting, and (3) wave intensity can abruptly decrease across sharp gradients or irregularities in the ionospheric plasma density.

[P-28] CME mean density from the corona to the Earth

Hyeonock Na and Yong-Jae Moon

School of Space Research, Kyung Hee University

Understanding three-dimensional structure and parameters (e.g., radial velocity, angular width, source location and density) of coronal mass ejections (CMEs) is essential for space weather forecast. In this study, we determine CME mean density in solar corona and near the Earth. We select 42 full halo CMEs, which have the corresponding interplanetary CME (ICME), by SOHO/LASCO from 2000 to 2014. To estimate a CME volume, we assume that a CME structure is a full ice-cream cone which is a symmetrical circular cone combined with a hemisphere. We derive CME mean density as a function of radial height in LASCO field of view, which are approximately fitted to power-law functions. The average of power-law indexes is about 2.0, implying that the CMEs are mainly expanding on the 2-D plane. We also obtain power-law functions for both CME mean densities and ICME mean density at 1AU, with the average power-law index of 2.58, implying that the CMEs

are expanding more spherically.

[P-29] Effect of energetic He+ on the electromagnetic ion cyclotron wave.

Sung-Jun Noh, Dae-Young Lee, Cheong-Rim Choi, Kyung Sun Park, Hee-Eun Wang, Ji-Hyeon Yoo

Chungbuk National University

Electromagnetic ion cyclotron (EMIC) wave has been generally considered to play an important role on the radiation belt dynamics via cyclotron resonance with relativistic electrons. Theoretically, EMIC wave is mainly excited by anisotropic distribution of protons. And also, Heavy ions (He+ and O+ in the Earth's magnetosphere) have an great effect on EMIC wave generation. Specifically, energetic He+ is known to affect both growth and damping of EMIC wave. However, previous studies have not revealed direct evidence of relationship between EMIC wave excitation and He+ ion distribution. Energetic He+ has not been significantly analyzed due to uncertainty of observational data. In this research, we analyze the relationship between energetic He+ and time evolution of EMIC waves in the inner magnetosphere using Van Allen Probes observations.

[P-30] Simulating mid-latitude ionospheric changes during a geomagnetic storm using TIEGCM

Suin Moon[1], Yong Ha Kim[1], YoungSook Lee[1], YoungSil Kwak[2]

[1]*Chungnam National University, Daejeon, South Korea*
[2]*Korea Astronomy and Space Science Institute, Korea*

Sudden changes in solar wind can affect the Earth's magnetosphere, leading to a geomagnetic storm during which the ionosphere may be globally disturbed. In this study, we conducted the analysis of mid-latitude ionosphere changes during a specific geomagnetic storm period of 22-23 June 2015, using the thermosphere-ionosphere-electrodynamics general circulation model (TIEGCM), developed by the national center for atmospheric research (NCAR) high-altitude observatory (HAO). For this particular storm period, ionospheric changes in the equatorial and low latitude regions have been analyzed using TIEGCM simulation (Astafyeva et al. 2018). Here we conducted similar study for the mid-latitude ionosphere by focusing on the region around Korean Peninsula. The TIEGCM simulates the global 3-D ionosphere by solving plasma transport equations. As the transport of ions and electrons is critically controlled by electric field, especially at high latitudes during a geomagnetic storm period, TIEGCM utilizes one of two empirical models for the electric potential at high magnetic latitudes: Heelis or Weimer model. As input parameters of space weather condition, Heelis model uses Kp index only, whereas Weimer model requires solar wind parameters (density, velocity, interplanetary magnetic field). With the two model inputs, we calculated 3-D ionospheric densities during the storm period and non-storm period (11-12 June). We note that global TIEGCM results with the two input models are essentially similar each other during non-storm period, but differ to some degree during the storm period. We will present specific comparison of F2 peak density (NmF2) between TIEGCM results and ionosonde measured values from Jeju (33.4N, 126.3E), Icheon (37.1N, 127.5E) and Yamagawa (31.2N, 130.6E) during the storm and non-storm periods.

[P-31] Effect of rotating Magnetic Field on Earth's Magnetosphere and Ionosphere: Results of Global MHD Simulation

Kyung Sun Park[1], Dae-Young Lee[1], Cheong-Rim Choi[1], Sung-Jun Noh[1], Hee-Eun Wang[1], Ji-Hyeon Yoo[1], Rok Soon Kim[2,3], Kyungsuk Cho[2,3] and Tatsuki Ogino[4]

[1]*Dept. Astronomy and Space Science, Chungbuk National University, Korea*
[2]*Korea Astronomy and Space Science Institute, Korea*
[3]*University of Science and Technology, Korea*
[4]*Nagoya University, Japan*

Orientation of magnetic flux ropes(MFR) in the solar wind are an important component that affects interactions with the Earth's magnetosphere and ionosphere. In this study, for understanding where the magnetic reconnection occur, how the reconnected field lines move to tail, and how many energy transported from the solar wind, we performed a three-dimensional global MHD simulation to examine effect of the rotating magnetic field of small/normal scale MFR. The magnetic field strength of small-scale MFR changes from 4 through 7 to 4nT during 3 hours (e.g. size ~ $678R_E$). Normal-scale MFR magnetic strength increase 5 to 10 and it decrease to 5nT during 15 hours (e.g. size ~ $3387R_E$). The solar wind condition with a density, n_{sw} = 5cm^{-3} and velocity, V_{sw} = 400km/s used in this simulation is maintained. From the simulation results, we find that the dayside magnetic reconnection tends to occur preferentially where the magnetosheath magnetic field line is antiparallel to the geomagnetic field. The location of dayside reconnection sites changes immediately by rotating magnetic field of SMFRs and MFR. The dayside reconnection site splits into two regions in both hemispheres cause by effect of the IMF By component. IMF By component creates a dawn-dusk asymmetry in magnetospheric configuration, as expected. One type of SMFR/MFR where Bz turns from south to north and By remains duskward leads to plasmoid formation in the tail, distinguishing it from the other types.The evolution of ionospheric convection pattern sensitively depends on the magnetic field variation within SMFRs than those of MFRs. The cross polar cap potential increase

above 20kV in each of scales. Also the potential obtained in our simulations increased by about 1.7 to 3.5 times for SMFR conditions and 2.2 to 3.8 times for MFR conditions the pre-impact value. This means that the peak potential is substantial enough to set a growth phase condition for the later release of energy via substorm triggering even though slowly rotating of magnetic field for MFRs (even small-scale).

[P-32] The new method of relativistic electron flux prediction at geostationary orbit based on neural network

Keunchan Park[1,2], Jaejin Lee[2], Kyungchan Kim[3], Yu Yi[1] BonJun Ku[4]

[1]*Department of Astronomy, Space Science and Geology, Chungnam National University*

[2]*Korea Astronomy & Space science Institute*

[3]*Division of Science education, College of Education, Daegu University*

[4]*Electronics and Telecommunications Research Institute*

The outer radiation belt is changed rapidly by solar wind condition and particles that are trapped in Earth' s magnetosphere have a bad effects on satellites. To protect the various risk, many researches have been progressed and prediction models have been developed. we have designed the electron flux prediction algorithm using artifical neural network (ANN) since 2016. We modified the ANN to solve the problem called overfitting, time shift and tried to improve the model performance. Input parameters are 1, 2, 3, 4 days ago data of solar wind (density, speed, IMF By and Bz), geomagnetic index (Dst, Kp) and electron flux data. The outputs of ANN are 24 hour ahead relativistic electron flux for each LT and we performed some correction for output. As a result of the model, to some extent, we confirmed that time shift disappeared for every prediction time. However, there is some difference between observed and predicted values. Also, correlation coefficient and prediction efficiency are getting low according to prediction time. Our goal is to develop an algorithm with high accuracy and achieve a accuracy similar to that of other models.

[P-33] Developing geomagnetic indices prediction algorithms 24 hours ahead using geosynchronous orbit magnetic field data

Wooyeon Park[1,2], Jaejin Lee[1], Kyung-Chan Kim[3], Yu Yi[2], Bon-Jun Ku[4], Hyesook Lee[5]

[1]*Korea Astronomy and Space Science Institute*

[2]*Chungnam national University*

[3]*Daegu University*

[4]*Electronics and Telecommunications Research Institute*

[5]*Korea Meteorological Administration*

Geomagnetic fields are disturbed by solar wind conditions, and geomagnetic indices such as Dst index and Kp index are commonly used to know how much these are disturbed. For space craft operations and power facilities geomagnetic indices prediction is important. Korea Meteorological Administration (KMA) develop KSEM (Korea Space wEather Monitor) payload on GEO-KOMPSAT 2A (GK-2A) satellite for the space weather operation. We use Solar wind parameters, proton density, bulk speed, interplanetary magnetic field Bz. Also we tried to use geosynchronous orbit magnetic field data of KSEM payload. We develop algorithms to estimate geomagnetic indices with a combination of two techniques, empirical fitting and artificial neural network. Algorithms predict 1 hour to 24 hours Dst and Kp indices in advance. We show results of performance.

[P-34] Review on the Anomaly of the MPPT Operation

Sung-Woo Park[1], Hee-Sung Park[1], Kyu-Dong Kim[1], Seong-Hee Yoo[2], Hee-Kwang Yoon[2]

[1]*Korea Aerospace Research Institute*

[2]*Korea Aerospace Industries*

The Solar Array Regulator (SAR) used for LEO satellites applications with adopting unregulated primary power bus scheme generally have three control modes; power limiting mode, maximum power point tracking (MPPT) mode and constant voltage (CV) mode. For power limiting, several control strategies such as direct energy transfer (DET), peak power limiting and constant current (CC) control can be used. And, there are also various kinds of MPPT control methods can be used for LEO satellite applications. Even though the same MPPT control scheme is used for the SAR in the PCU (Power Control Unit) of the compact LEO satellites, several anomalies was monitored in the MPPT mode during electrical testbed test using solar array simulator and real battery. In this paper, anomalies are described in details and several remedies for these kinds of malfunctions at MPPT mode are given.

[P-35] Review on the Battery Qualification for LEO Satellites (ABSL case)

Sung-Woo Park, Kyu-Dong Kim

Korea Aerospace Research Institute

Recently, many low earth orbit satellites are generally adopting battery-clamped unregulated power bus schemes. In these kind of electrical power systems, the major functions of the battery are to provide electrical energy to support launch and eclipse operations and to provide power for load peaks in excess of the solar array capability including fault clearance. One of the major battery supplier for LEO applications is ABSL. ABSL is the world' s 1st Li-Ion spacecraft battery launcher in 2001. The ABSL' s battery development philosophy is the commercial off-the-shelf(COTS) approach. And, for the next generation cells, currently ABSL has more 140 COTS cells under investigation. In this paper, general cell qualification process

performed by ABSL is summarized and rgeneral battery architectures are alsi given.

[P-36] Application of deep learning to solar and geophysical data: 7. Solar X-ray Flare Forecasting using Full-disk Magnetograms

Eunsu Park, Yong-Jae Moon, Seulki Shin, Kangwoo Yi, Daye Lim, and Harim Lee

School of Space Research, Kyung Hee University

In this study, we present the application of Convolutional Neural Network (CNN) to the forecast of solar flare occurrence. For this, we consider three CNN models (two pre-trained models, AlexNet and GoogLeNet, and one our proposed model). Our inputs are SOHO/MDI (from May 1996 to Dec 2010) and SDO/HMI (from Jan 2011 to Jun 2017) full-disk magnetograms at 00:00 UT. Outputs are the ``Yes or No'' of daily flare occurrence (C, M, and X classes). We train the models using the input and output data from 1996 to 2008, covering the entire solar cycle 23, and test them using the data sets from 2009 to 2017, covering solar cycle 24. Then we compare the results of the CNN models with those of three previous flare forecast models in view of statistical scores. Our major results from this study are as follows. First, our CNN models have ACC values larger than 0.78 and POD values greater than 0.72. Second, our CNN models have CSI values larger than 0.64, and FAR values smaller than 0.21. Third, our CNN models have HSS values greater than 0.57 and TSS values larger than 0.56. Fourth, our proposed CNN model has the best values of all statistical scores than other two pre-trained models except FAR. Fifth, our CNN models are much better than the previous models. Our results indicate a sufficient possibility that deep learning methods can improve the capability of solar flare forecast as well as similar types of forecast problems.

[P-37] A Flight Software Development of the Coronagraph for a Balloon-borne Experiment in 2019

Jongyeob Park, Seonghwan Choi, Ji-Hye Baek, Jihun Kim, Heesu Yang, Be-ho Jang, Su-Chan Bong, Yeon-Han Kim, Young-Deuk Park, and Kyung-Suk Cho

Korea Astronomy and Space Science Institute

We develop a flight software (FSW) for the scientific balloon mission BITSE (Balloon-borne Investigation of Temperature and Speed of Electrons in the corona) to measure the coronal electron density, temperature, and speed by observing the linearly polarized brightness of solar corona with 4 different wavelengths. The FSW interfaces with a communication system, a pointing system, and a science supporting system of a balloon platform and an aperture door, a power distribution unit, a filter wheel, and a polarization camera for the coronagraph. The FSW uses the core Flight System (cFS) a reusable open-source flight software framework developed by NASA. It runs on Linux for an Intel Core i7 single board computer based on PC/104. Test scripts are developed to support integration and test for hardware and software components using Pytest, the Python testing framework which provides full-featured testing functionality. The test scripts can be executed for parameterized test cases and shared with a lightweight command and telemetry server that can communicate with FSW by CCSDS packets via Ethernet or the RS-232 of the balloon communication system. We can reduce the cost and time to develop the FSW using the cFS. Also, we can use Pytest to build a software verification environment for developing the highly reliable FSW. The FSW will be integrated with the coronagraph and the balloon platform in 2019.

[P-38] Duration Analysis of SNIPE Nano-Satellite for Iridium Satellite Communication

Ho-Sub Song[1,2], Jaejin Lee[2] ,Yu Yi[1]

[1]*ChungNam National University*
[2]*Korea Astronomy and Space Science Institute*

SNIPE (Small scale magNetospheric and Ionospheric Plasma Experiments), which is begun by Korea Astronomy and Space Science Institute (KASI) in 2017, is 6U sized nano-satellite mission for space environment observation. Especially, SNIPE team decided to add an Iridium satellite communication payload. In this paper, for this reason, communication simulation for iridium satellites network is performed by using STK (System Tool Kit). Then, duration is calculated according to the date and the individual orbit pass, and the result is summarized statistically as table with total and average.

[P-39] Application of deep learning to solar and geophysical data: 5. Generation of solar magnetograms from Ca II images

Gyungin Shin[1], Yong-Jae Moon[1] Eunsu Park[1], Taeyoung Kim[1,2]

[1]*School of Space Research, Kyung Hee University*
[2]*Department of Research and Development, InSpace Co., Ltd.*

Deep learning has shown state-of-the-art performances on translating images from one to another kind as well as classifying various kinds of images. In the present work, we successfully translate Ca II spectroheliograms into HMI-like magnetograms after modifying a deep learning model called conditional generative adversarial networks (cGAN), one of the best performance methods for image translation. We train the model with 623 pairs of the National Solar Observatory Ca II 854.2 nm wing intensity

images and the corresponding Solar Dynamic Observatory HMI line-of-sight magnetograms from May 2012 to December 2015. To test the model, we use 217 pairs of Ca II images and HMI magnetograms in 2016. As a result, we successfully obtain AI-generated magnetograms whose bipolar structures are well consistent with those of real HMI magnetograms. Their total unsigned magnetic fluxes are well correlated with those of the real ones with a high correlation coefficient of 0.89 which is better than that of the original cGAN model (0.83). We have a plan to extend this application to historic Ca II images observed by the Mount Wilson Observatory since 1915 and the Kodaikanal Solar Observatory since 1907.

[P-40] Determination of Large Scale Plasma Properties of Solar Corona Using the X-Ray Telescope Onboard HINODE: I. Off-Axis Calibration of Vignetting Effect

Junho Shin[1,2], Takashi Sakurai[2], Ryouhei Kano[2], Yong-Jae Moon[1]

[1]*Kyung Hee University*
[2]*National Astronomical Observatory of Japan*

Long-term observation of coronal hole regions has an important meaning not only in the field of solar physics but also in relation to the space weather because the coronal hole is known as the source of solar winds. Detailed study on the physical conditions of solar plasma in the coronal hole and the off-limb area will give us a clue to understand the boundary conditions and constraints on the theoretical mechanism of heating the coronal plasma. The Sun is, however, a large astronomical object and thus targets near the limb of full-disk images are placed at the outskirt of the field of view. Therefore, the off-axis performance of the solar telescopes should be characterized very carefully in order for the data away from the center to be properly interpreted. We have evaluated the vignetting effect of Hinode/XRT by analyzing the 2D distribution of effective area in the field of view taken from MSFC/XRCF pre-launch experiment. It is revealed that, unlike the case of Yohkoh/SXT, the degree of offset of an optical center is not serious and thus shows little deviation from rotational symmetry. In particular, the energy dependence of vignetting pattern has been first found in our study, which is different from what has been used so far for the calibration of XRT data.

[P-41] Heat treatment of the core material Metglas 2714A for high precision fluxgate magnetometer

Ju-Hyeong Kim[1], Sung-Jun Noh[1], Seunguk Lee[1], Gi-Hong Rue[2], Dae-Young Lee[1], Cheong-Rim Choi[1]

[1]*Chungbuk National University*
[2]*Kyungpook National University*

The Earth's magnetic field fluctuation can cause space weather disturbances which can be problems to satellites and electronic equipments. Therefore, most satellites are equipped with a magnetometer to measure magnetic field changes in space and it is used for scientific research and forecasting based on measured data. In this study, we performed heat treatment experiments of the sensor material which is the key to high precision fluxgate magnetometer for space science research. We used Metglas 2714A amorphous alloy ribbon for the core material of magnetometer. We have done this experiment for several core designs having different specifications such as different thickness of ribbon and two different finishing methods of ribbon and by changing heat treatment temperature. After comparison of the hysteresis curves and testing linearity and noise level, we have determined the condition for the best performance sensor.

[P-42] Space Science payloads on board NEXTSat-1

Chang-Ho Woo[1], Kyoung-Wook Min[1], Eojin Kim[1], Jun-Chan Lee[1], Jong-Dae Sohn[2], Young-Soo Jo[2], Yongmyung Seo[3], Ju Woo[3], Go Woon Na[3], Jongho Seon[3], Sang-Yun Lee[3], Hee-Eun Kim[3], Ensang Lee[3], Kyoung-In Kang[4], Goo-Hwan Shin[4], Kwang-sun Ryu[4], Ji Hyeon Yoo[5], Dae Young Lee[5]

[1]*Department of Physics, KAIST*
[2]*Korea Astronomy and Space Science Institute*
[3]*School of Space Research, Kyung Hee University*
[4]*Satellite Technology Research Center, KAIST*
[5]*Department of Astronomy and Space Science,, Chungbuk National University*

Space science instruments, named Instruments for the study of Stable/Storm-time Space (ISSS), have been developed to be flown on board NEXTSat-1. ISSS, to be operated at an altitude of ~600 km in a sun-synchronous orbit, consists of Space Plasma Detectors (SPD) and Space Radiation Detectors (SRD), which will measure low latitude ionospheric plasmas and precipitating radiation belt particles in the sub-auroral region, respectively. Being composed of three conventional instruments (Langmuir Probe, Retarding Potential Analyzer, and Ion Drift Meter) with fast time resolution of 100 msec, SPD will provide valuable information that characterizes ionosphere irregularities such as plasma bubbles and blobs. SRD is composed of Medium Energy Particle Detector (MEPD) and High Energy Particle Detector (HEPD) that will measure the electrons of energy range of 25 keV - 400 keV and 300 keV - 2 MeV, respectively. With fast time resolution of 32 Hz and pitch angle information provided by multiple telescopes, SRD will help us better understand the physics of particle precipitation such as micro-bursts. As NEXTSat-1 is scheduled for launch in late 2018, a pipeline for preprocessing and data analysis is

currently under construction. This paper will discuss ISSS hardware systems, key sciences, and data analysis procedures.

[P-43] Universal scaling behavior of resonant absorption

Dae Jung Yu[1], Tom Van Doorsselaere[2]

[1]*School of Space Research, Kyung Hee University*
[2]*CmPA, Department of Mathematics, KU Leuven, Belgium*

We theoretically study the externally driven excitation and relevant resonant absorption of standing kink waves in coronal loops. We consider underdense loops such that the density inside the loop is lower than outside. This configuration may describe the excitation and propagation of a quasi-periodic wave train in funnels. We consider sinusoidal, linear, and parabolic density profiles for the nonuniform (inhomogeneous) transitional layer. We apply a newly developed invariant imbedding method to the ideal MHD wave equations and show how resonant absorption depends on the density profile, longitudinal wavelength, and wave frequency. We find a new scaling behavior of resonant absorption for these three density models in cylindrical geometry, which can be generalized to the density profiles with an arbitrary monotonic variation. This result implies that the scaling behavior is universal regardless of the geometry, for cylindrical configurations in the solar corona and planar configurations in the magnetosphere. The same analogy may apply to usual coronal loop density profiles and also to the well-known mode conversion of electromagnetic waves into electrostatic modes in unmagnetized cylindrical plasmas. We further speculate that a universal scaling behavior can exist regardless of the kind of mode conversion or resonant absorption.

[P-44] Economic Impacts of Space Weather on Industry

AMi Yuni[1], Se-Jin Park[1], Jae-Woo Park[1], Jae-Hung Lee[2]

[1]*Rader & Space*
[2]*Korean Space Weather Center, National Radio Research Agency*

It has already been revealed that changes in Space Weather has impact on electric power, satellite, telecommunications, and GNSS. However, researches on practical impact of Space Weather in society and economy are limited, One of a few researches taken place by NOAA National Weather Service in 2017, conducted socio-economic analysis on 4 industries(Social and Economic Impacts of Space Weather in the United States, 2017). The study, firstly, analyzed physical effect factors from NOAA's research which applied to different impact categories to estimate damage cost in US. Then, we have applied those effect factors to economic analysis on Korean society and found that more additional data and calculations are necessary.

[P-45] On limitations of the inverse relations between ion anisotropies and parallel plasma beta for ion cyclotron instabilities in the magnetosphere

Dae-Young Lee and Sung-Jun Noh

Chungbuk National University

It has long been known that threshold conditions for some instabilities can be expressed in terms of plasma beta. In particular, inverse relations between proton anisotropy and parallel plasma beta have long been recognized for ion cyclotron instabilities in the solar wind and magnetosphere (Anderson et al. 1994; Gary et al. 1994a; Gary et al. 1994b; Phan et al. 1994). Compared to the original expression for the instability criterion given by Kennel and Petschek (1966), such inverse relations have an advantage such that wave frequency does not appear explicitly because it is transformed into a form expressed in terms of plasma parameters. Therefore, they are convenient in the sense that one can apply the inverse relation forms not only to the specific wave times but also to non-wave times when a specific wave frequency is not defined. However, we demonstrate that the inverse relations are still an approximation to the original expression of threshold conditions for ion cyclotron instability. Here, we attempt to assess the usefulness and/or limitations of using the plasma beta as a key parameter in determining ion cyclotron instability.

[P-46] Real time satellite mission timeline optimization in orbit using GNSS navigation solutions

Seon-Ho Lee

Korea Aerospace Research Institute

Generally the satellite mission planning for image taking timeline allocation is performed on ground in response to the user request. As the timeline for image taking is longer the image coverage location performance becomes worse due to the limitation of the ground-based orbit propagator accuracy. This paper proposes a real time mission optimized methodology that is executed in orbit. The method does not incorporate any on-board accurate orbit propagator but it uses only GNSS (Global Navigation Satellite System) navigation solution data in orbit. The satellite position is gathered and processed every second from GNSS receiver. And then the unknown satellite position is predicted every sub-second by extrapolation computation. Finally a new imaging time is calculated by comparing the predicted position and the target position. The proposed method enables the satellite to take images with the improved coverage location

accuracy.

[P-47] Magnetospheric Particle Flux Prediction algorithm Spin up process for L*=1-7 Electron distribution during quite time of Radiation belt

Jongkil Lee[1,3], Kyungchan Kim[2], Jaejin Lee[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Daegu University*
[3]*University of Science and Technology*

This paper written for algorithm of MPF (Magnetospheric Particle Flux Prediction) and Level1 data verification of KSEM(Korean Space Environment Monitor) payload. The GOES-13 electron flux data, kp index, and VAP MagEIS electron data are used to estimate the electron distribution up to L * = 1-7. Spin up uses the 1 MeV electron distribution, the initial kp value, and the average state of electron density change at L * = 7 in a quiet magnetosphere without magnetic field storms. The 1-D Radial Diffusion equation was used to obtain the electron density and the condition and the source were calibrated.

[P-48] Simulation and Quasilinear Theory of Magnetospheric Bernstein Mode Instability

Junggi Lee[1,2], Peter H. Yoon[1,2,3], Jungjoon Seough[1], Juna Hwang[1,4], Jaejin Lee[1,4], Gwangson Choe[2],

[1]*Korea Astronomy and Space Science Institute*
[2]*School of Space Research, Kyung Hee University*
[3]*Institute for Physical Science and Technology, University of Maryland*
[4]*University of Science and Technology*

Multiple harmonic electron cyclotron emissions, often known in the literature as the $(n+0.5)f_{ce}$ emission, are a common occurrence in the magnetosphere. These emissions are often interpreted in terms of the Bernstein mode instability driven by the electron loss cone velocity distribution function. Alternatively, they can be interpreted as quasi thermal emission of electrostatic fluctuations in magnetized plasmas. The present paper carries out a one-dimensional relativistic electromagnetic particle-in-cell simulation and also employs a reduced quasilinear kinetic theoretical analysis in order to compare against the simulation. It is found that the Bernstein mode instability is indeed excited by the loss cone distribution of electrons, but the saturation level of the electrostatic mode is quite low and that the effects of instability on the electrons is rather minimal. This supports the interpretation of multiple harmonic emission in the context of the spontaneous emission and reabsorption in quasi thermal magnetized plasma in the the magnetosphere.

[P-49] Application of deep learning to solar and geophysical data 4. Generation of a magnetogram and EUV images from Carrington sunspot drawing

Harim Lee[1], Y.-J. Moon[1], Daye Lim[1], Eunsu Park[1], and Taeyoung Kim[1,2]

[1]*School of Space Research, Kyung Hee University, Yongin-si 17104, Korea*
[2]*Department of Research and Development, InSpace Co., Ltd., South Korea*

We apply an image-to-image translation model, which is a popular deep learning method based on conditional Generative Adversarial Networks (cGANs), to the generation from sunspot drawings to the corresponding magnetograms and EUV images. For this, we train a model using pairs of sunspot drawing from Mount Wilson Observatory (MWO) and their corresponding SDO/HMI magnetogram (or SDO/AIA images) from 2012 to 2013. We test the model by comparing pairs of actual magnetogram (EUV image) and the corresponding AI-generated one in 2014. Our results show that bipolar structures of the AI-generated magnetograms are consistent with those of the original ones and their unsigned magnetic fluxes (or intensities) are well consistent with those of the original ones. Using this model with the Carrington sunspot drawing, we successfully produce AI-generated magnetogram (EUV image) and estimate its unsigned magnetic flux. Using several empirical relationships (magnetic flux vs. CME speed, CME speed vs. ICME speed, and ICME speed vs. Dst) in 23 and 24th solar cycle, we conjecture the Dst value of the Carrington event, about -1,670nT, which is similar to that of Tsurutani et al. (2003).

[P-50] Magnetic and kinematic properties of very fast CMEs in the 24th solar cycle

Soojeong Jang[1,2], Yong-Jae Moon[1], Daye Lim[1], Jae-Ok Lee[2], Harim Lee[1], Eunsu Park[1], Gyungin Shin[1]

[1]*School of Space Research, Kyung Hee University*
[2]*Korea Astronomy and Space Science Institute*

It is important to understand very fast CMEs which are the main cause of geomagnetic storms and solar particle events (SPEs). During this solar cycle 24, there are 10 very fast CMEs whose speeds are over 2000 km/s. Among these, there were only two front-side events (2012 January 23 and 2012 March 7) and they are associated with two major flares (M8.7 and X5.4) and the most strong SPEs (6310 pfu and 6530 pfu). They have a similar characteristics: there were successive CMEs within 2 hours in the same active region. We analyze their magnetic properties using SDO HMI magnetograms and kinematic ones from STEREO EUVI/COR1/COR2 observations. We can measure their speeds and initial accelerations without projection effects because their source locations are almost the

limb. Additionally, we are investigating magnetic and kinematic characteristics of 6 backside events using AI-generated magnetograms constructed by deep learning methods.

[P-51] Assimilation of multiple type data into IDA4D model of the regional ionosphere around Korea during geomagnetic quiet and disturbed days

Se-Heon Jeong[1], Yong Ha Kim[1], YoungSook Lee[1], YoungSil Kwak[2], Suin Moon[1]

[1]*Chungnam National University*

[2]*Korea Astronomy and Space Science Institute, Korea*

Ionospheric Data Assimilation Four-Dimensional (IDA4D) is, developed by Bust et al. (2007), continuous-time, three-dimensional ionospheric algorithm that can optimally estimate the ionosphere from measured data. IDA4D is based on three-dimensional variational (3DVAR) data assimilation model that uses a Gauss-Markov Kalman filter to assimilate the next step. The assimilation model can ingest variety of data types. In this study, we use slant total electron contents (sTEC) obtained from a Global Positioning System (GPS) network, NmF2 (F2 layer peak electron density) from an ionosonde network, and electron density profiles from Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) satellite. The assimilation code assimilates these multiple type data into a background model, International Reference Ionosphere (IRI) 2016. We compare NmF2 map calculated by IDA4D, IRI with TIEGCM during geomagnetic quiet (June 10-16, 2015) and disturbed days (June 21-26, 2015). From this comparison, we found that assimilated NmF2 by IDA4D tends to be larger than IRI and TIEGCM in the region where measured data were assimilated. In order to validate the assimilation results, we compare foF2's (F2 layer critical frequency) of ID4D and IRI with measured foF2's by Jeju ionosonde. The comparison shows that IDA4D has higher correlation with measured values and smaller root mean square (RMSE) from measured values than IRI. Therefore, IDA4D model can provide reliable initial conditions (nowcast) of the ionosphere to a forecasting model in the region of Korea and vicinities.

[P-52] Study on seasonal change in diurnal variation of cosmic ray intensity at six neutron monitors

Jongil Jung[1], Suyeon Oh[2], Yu Yi[1]

[1]*Choungnam National University*

[2]*Chonnam National University*

Neutron monitors (NMs) are ground instruments to detect the neutrons as the secondary cosmic rays (CRs) coming from outside the Earth. The neutrons of secondaries are made by CR shower of primaries in atmosphere. NMs measure the CR particles in the energy of 500 MeV-~GeV, and CR intensity of this energy range can be easily modulated by solar activity. As a typical modulation of CR intensity, the diurnal variations have the sinusoidal pattern with an amplitude 1-2%. Diurnal variations have a minimum phase in the post-midnight and maximum phase in the early afternoon by the spiral-directed diffusion and the anti-sunward convection. Diurnal variations have a certain periodicity when viewed in terms of long term. Thus, in this study, to examine the long term change in diurnal variation, we analyze the seasonal change in diurnal variation of CR intensity at six stations. We present the results of the seasonal change in diurnal variation of CR intensity in this study.

[P-53] Estimation of Halo CME's radial speeds using coronal shock wave observations

Hyunjin Jeong and Yong-Jae Moon

School of Space Research, Kyung Hee University

We propose a method to estimate the radial speed of a Halo CME by combining a coronal shock front and an EUV-wave that occurs on the solar disk. According to recent studies, EUV-wave occurs as a footprint of the coronal shock wave on the lower solar atmosphere. In this study, the coronal shock on 2011 February 15 by SDO/AIA is assumed as a perfect sphere. This assumption makes it possible to determine the height of a coronal shock, by matching the position of an EUV-wave on the solar disk and a coronal shock front on the SOHO/LASCO coronagraph image. The radial velocity of the Halo-CME is calculated from the rate of coronal shock position shift. The calculated speed from this method is a little slower than the 3-D velocity estimated by multi-spacecraft, but much faster than the projected one by SOHO/LASCO. And these results and the efficiency of this approach are discussed.

[P-54] Structural analysis of engineering model of payloads for the Small scale magNetospheric Ionospheric Plasma Experiments

Gyeongbok Jo[1,2], Jongdae Sohn1, Jaejin Lee[1,3], Junga Hwang[1,3], Young-Sil Kwak[1,3], Jaeheung Park[1,3], Uk-Won Nam[1,3] and Won-Kee Park[1], Yu Yi[2]

[1]*Korea Astronomy and Space Science Institute*

[2]*Chungnam National University*

[3]*Korea University of Science and Technology*

In this time, we report the result of structural analysis for the Engineering Model (EM) of science payloads for the Small scale magNetospheric Ionospheric Plasma Experiments (SNIPE) mission. The SNIPE mission consisting of four (KASISAT-A, B, C, D)

6U-nanosatellites (approximately 10 kg) will be launched into a polar orbit at an altitude of 500-600 (TBD) km to resolve spatial and temporal variations of the microscale plasma structures on the topside ionosphere. The SNIPE mission aims to elucidate the fine-scale morphology of high-energy electron precipitation, cold plasma density/temperature, field-aligned currents, and electromagnetic ion cyclotron (EMIC) waves. To achieve scientific objectives, Solid State Telescope (SST), Langmuir Probe (LP), and 3-axis fluxgate MAGnetometer (MAG) will be installed on all of each spacecraft. We are developing these science payloads of the EM for the SNIPE mission and performing structural analysis of science payloads.

[P-55] The Simulation of Distributed Target for Polarimetric SAR

Jae-Min Shin

Korea Aerospace Research Institute

In the analysis field of Synthetic Aperture Radar (SAR), the analysis of point target (PT) is very important in order to assess the performance of SAR system and the processor. However in the assessment, PT is simulated under the ideal condition, which does not have a distributed target (DT) as the background characteristic. Because of that, the simulation and analysis is under a limit. Especially in the case of a polarimetric SAR simulation, background scattering, which is caused by DT, effects peculiar changes in the polarimetric response. Changes are mutual relations between PT and DT by SAR signals. Nevertheless in the assessment, DT simulation has been handled lightly due to a serious concern for PT focusing ability. Nowadays polarimetric SAR is more advantageous for other various applications than only detection and recognition applications based on resolution ability. Therefore effective method for DT simulation is studied on target analysis. Density of DT, which can change backscattering characteristic, also can be controlled by simulator. Analysts can change the distance of cells, which have a DT characteristic. and then mutual response between PT and DT can be simulated. With the result of PT and DT simulation for polarimetric SAR, the characteristics of polarimetric SAR can be analyzed profoundly. The analysis shall be able to improve quality of assessment finally.

[P-56] Application Results for the Remote Sensing of SAR Satellite

Jae-Min Shin

Korea Aerospace Research Institute

The most important objective of Satellite is for the Remote Sensing. This originated from observations for non-accessible area and/or objects. From those originations, Satellite has various objectives based on scientific applications. Satellite with SAR (Synthetic Aperture Radar) payload can take distinct applications from that with optical payload. In particular, the reason is SAR payload is an active system, which can radiate its energy by itself, for scientific applications. Nevertheless in the domestic field of SAR applications, access-limitation and/or non-confidence about SAR data is a kind of obstacle. However some results for scientific SAR applications has been produced and analyzed gradually. Those outcomes are introduced and summarized briefly in order to increase capability of SAR applications. In the summary, outcomes for GIS, Ocean, Land, Disaster, and Environment monitoring are shown for their application objectives. Using advantages of Satellite, which is able to analyze large scale area continuously and easily, time-series results for variation and deformation are detected. Vitality and confidence for the domestic field of SAR applications is expected.

[P-57]Development of Verification System Prototype for Space Environment Model

Kyu-Cheol Choi[1], Jeong-Deok Lee[1], Chang-Woo Kye[1], Sae-Rom Park[1], Hyun-Soo Kim[1], Jun-Cheol Mun[2], Jong-Yeon Yun[2]

[1]*SELab, Inc.*
[2]*Korean Space Weahter Center*

The Korean Space Weather Center (KSWC, RRA) operates various space environment analysis and forecast models. Though the accuracy and reliability of individual models are important for making decision using the model outputs, there is only little quantitative information on model accuracy and reliability. Moreover, to improve the accuracy of the forecasting model, quantitative measures of the accuracy of the prediction are required. Therefore, a prototype system was developed to verify the analysis and forecast model in real time. This space environment analysis model verification system consisted of 1) data collection system and standardization system for collected model outputs and observational data which will be used to verify model outputs, and 2) real-time quantitative verification system using standardized forecast outputs and verification data using various verification metrics. This prototype system was tested by applying it to the ASSA model. It will be applied to the other models

[P-58] Investigation of different types of oscillation patterns associated with solar coronal jet and filament eruption observed on 2017 August 21

Jae-Ok Lee[1], Kyung-Sun Lee[2], Sujin Kim[1], Jin-Yi Lee[3], Kyung-Suk Cho[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*National Astronomical Observatory of Japan*

[3]*Department of Astronomy & Space Science, Kyung Hee University*

By using high resolution and cadence observations such as SDO/AIA, HINODE/SOT, and CoMP, many researchers have found that transverse oscillations in solar spicules and coronal loops are one of the most common phenomena. We investigate different types of oscillation patterns above the solar limb, which are associated with solar coronal jet and filament eruption. For this, we use SDO/AIA and CoMP data observed on 2017 August 21 to determine plane of sky and line of sight oscillation patterns and their propagations. We will present origin and mechanism of each transverse oscillation patterns.

[P-59] Development a program for predicting the footprint of re-entering space debris

Siwoo Kim[1], Byeong-Un Jo[1], Eunjung Choi[2], Sungki Cho[2], Jaemyung Ahn[1]

[1]*Korea Advanced Institute of Science and Technology*
[2]*Korea Astronomy and Space Science Institute*

Along with the continual human space activity, the number of space-debris on Earth' s orbit is also steadily increasing. About 5,400 tons of debris have re-entered the Earth for the last 50 years and the debris footprint prediction techniques are needed to prevent damage from debris. In this research, a new program for predicting the footprint of re-entering space debris is developed. This program can quickly obtain footprints using prebuilt coefficient table while considering the fragmentation characteristics and uncertainties during the re-entry. And the validity of the methodology used in this program was verified through case studies using the orbit and impact information of space objects provided by the JSpOC.

[P-60] Design of Space Object Surveillance Sensor Simulator

Tae-Bong On[1], Jong-Bum Park[1], Dae-Won Jung[1], Hyun-Ki Min[2], Sang-Bok Song[2], Eun-Hee Kim[3], Su-Bum Kim[4]

[1]*Korea Aerospace Research Institute*
[2]*Technology & Development Division, OLZETEK*
[3]*Department of Defence Systems Engineering, Sejong University* [4]*RADSYS Co., Ltd.*

Currently, space object like satellite and debris has been increasing by space development activities around the world. Countries advanced in the field of space exploration have developed the space surveillance system and they are operating the system to detect and trace the object in space due to the risk of a collision with their space assets. Space object surveillance sensor is necessary to protect and monitor the our space asset, so we are carrying out precedent study. In this paper, design of space object surveillance sensor simulator and the current status in development are introduced.

[P-61] Adaptive Optics Deveopment in Geochang station

Sung-Yeol Yu, Hyung-Chul Lim, Ki Pyoung Sung, Mansoo Choi, Seonghwan Choi

Korea Astronomy and Space Science Institute

Korea Astronomy and Space Science Institute (KASI) has developed two SLR systems with separate (40 ㎝) and common Coude optical path (100 ㎝) respectively. The separate system has been operated in Sejong (SEJL, 7394) since 2015 and common Coude one was established in Geochang (GEOL, 7395) in 2017. The Geochang station consists of Satellite Laser Ranging (SLR), Adaptive Optics (AO) and Debris Laser Tracking (DLT) system. The SLR system and the AO system are under test operation, but the DLT system is now developing. The AO system was developed with the Australian National University in Canberra, Australia. The AO system has two modules, the beam reducer module and the adaptive optics module. The main purpose of the AO system is to analyze the shape of the satellites. The beam reducer module convert light incident through the telescope into a diameter suitable for the adaptive optics module. The adaptive optics module consists of a wavefront sensor, a deformable mirror and a camera. This module measures and compensates for image distortion due to atmospheric turbulence. Observations use the Lucky imaging algorithm to improve the quality of the observed image of space objects. In this study, the AO system using a 100 ㎝ telescope is addressed and its observations are also discussed.

[P-62] Design of the remote control of new RF total power detector for radio observation

Yong-Woo Kang, Min-Gyu Song

Korea Astronomy & Space Science Institute

We are developing new proto-type RF total power detector system using optical transmission for broadband RF observation. The system has fully remote control function to operate RF voltage to frequency conversion and data transmission. I will introduce the current status and the design.

[P-63] Unusual Features in the Emission Lines of Symbiotic Stars UV Aurigae and AG Draconis

Soo Hyun Kim, Tae Seog Yoon, Hyung-il Oh

Kyungpook National University

In the recent spectroscopic observations from November 2017 to June 2018, we have found

some unusual features in Hα emission lines of symbiotic star UV Aur and in Fe II emission lines of symbiotic star AG Dra, which we have not detected for last ten and more years observations with BOAO 1.8-m reflector and BOES (BOao Echelle Spectrograph). We suggest the possible reasons for these unexpected features based on revolution phase, brightness change, or other physical characteristics.

[P-64] Optical testing plan of linear astigmatism free three mirror system for demonstration model of space telescope

Yunjong Kim[1], Jihun Kim[1], Jeong-Yeol Han[1], Woojin Park[2], Soojong Pak[2], Seunghyuk Chang[3], Byeongjoon Jeong[4], Hwan-Jin Choi[4], Geon-Hee Kim[4,5]

[1]*Korea Astronomy and Space Science Institute*
[2]*School of Space Research, Kyung Hee University*
[3]*Center for Integrated Smart Sensors, KAIST*
[4]*Korea Basic Science Institute*
[5]*University of Science and Technology*

We are developing a demonstration model of a space telescope. This is an off-axis optical system with low f-number and wide field of view for sky monitoring programs such as supernova surveys. The optical design is based on a confocal off-axis three mirror system to remove linear astigmatism, which is one of the most dominant aberration degrading image qualities in common off-axis systems. We called this design linear astigmatism free three mirror system. The system comprises three pieces of aluminum-alloy freeform mirrors that are feasible to be fabricated with current single-point diamond turning machining technology. Those mirrors are under finishing processing by using magnetorheological finishing machine at KBSI. We are preparing a testing setup for alignment and performance evaluation of the system. In this paper, we will briefly present the current status of optical testing and future plan of the project.

[P-65] The photometric and spectroscopic studies of the near-contact binary XZ Canis Minoris

Hye-Young Kim[1], Chun-Hwey Kim[1], Kyeongsoo Hong[1,2], Jeong Min-Ji[1], Jae Woo Lee[2], Jang-Ho Park[1,2], Chung-Uk Lee[2], Mi-Hwa Song[1]

[1]*Chungbuk National University*
[2]*Korea Astronomy and Space Science Institute*

By now, there is a general agreement that XZ CMi is a near-contact binary with a hotter and more massive main-sequence primary star close to its Roche-lobe and a Roche-lobe filling giant/subgiant secondary star. However, the mass ratios and temperatures of XZ CMi had disagreements in previous studies ranging from 0.377 to 0.83, and from 7,000 K to 8,876 K. Also, a cyclical change of the period of XZ CMi was suggested. But it has not been confirmed yet. In order to resolve the problems above we conducted multiband photometric and spectroscopic observations at Sobaeksan Optical Astronomy Observatory (SOAO) and Bohyunsan Optical Astronomy Observatory (BOAO), respectively, and secured new light curves and radial velocity curves. In this presentation, we present physical parameters of XZ CMi through the simultaneous analyses of both the double-lined radial velocity curves and mutiband light curves. A period study was made with all published timings including ours. In addition, we shortly discuss the evolutionary status of XZ CMi.

[P-66] A Study on Optimization Technique for the Improved Performance of VLBI System

Min-Gyu Song, Yong-Woo Kang, Hyo-Ryung Kim, Do-Young Byun, Tae-Hyun Jung, Jong-Soo Kim, Seog-Oh Wi, Sung-Mo Lee

Korea Astronomy & Space Science Institute

In the field of VLBI data processing , the I/O performance is variable depending on the tuning of the network and server systems. There are many options to be considered for the good performance, but of which, CPU and Memory related elements represent the key elements. In this presentation, we introduce the importance of system tuning for the reliable VLBI operation, and discuss practical approach to implement high speed data systems.

[P-67] Physical properties of filaments and dense cores in different star-forming environments

Eun Jung Chung[1], Chang Won Lee[1,2], Shinyoung Kim[1,2]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*

How dense cores and filaments in molecular clouds form is one of key questions to address in star formation. To investigate this issue in detail we recently started a molecular line mapping survey namely 'Filaments, the Universal Nursery of Stars (FUNS; PI - Chang Won Lee, KASI)' toward nearby filamentary molecular clouds with various star-forming environments using TRAO 14m single dish telescope equipped with a 16 multi-beam array. In this presentation, we will give a brief introduction on the FUNS survey and report the first look results of kinematics of a low mass star forming region, L1478 of California molecular cloud, and a quiescent and non-star-forming region, MCLD123.5+24.9 in Polaris flare.

[P-68] An improved centering method for slit-obscured stellar images in long slit spectroscopic observations

Ueejeong Jeong, Moo-Young Chun, and Sungho Lee

Korea Astronomy and Space Science Institute

Centering algorithms for positioning of a star need PSF (Point Spread Function) input to be modeled. If the stellar PSF is partially obscured by a light-blocking feature such as a long slit or a fiber to a spectrograph, typical centering methods cannot make a correct model for the obscured PSF and the centering accuracy can be diminished. For example, the initial version of the Slit-View Camera Package of the IGRINS (Immersion GRating INfrared Spectrograph) had an issue with the on-slit star guiding function, which returned an incorrect centroid position of the obscured star. To solve the issue, we developed an improved centering method for a slit-obscured star based on the Moffat 2D fitting algorithm. We use a fixed slit mask for the obscured region and do not exclude the masked area from the input domain. We validated performance improvement of the newly developed routine by using simulated PSFs as inputs. The enhanced centering performance was also confirmed at an on-site test during the IGRINS engineering operation period in July 2015. In this poster, we present and discuss the results obtained from the validation tests and the site tests for the improved centering method.

[P-69] Global distribution of far-ultraviolet emission from the highly ionized gas in the Milky Way

Young-Soo Jo[1], Kwang-Il Seon[1,2], Kyoung-Wook Min[3], Jerry Edelstein[4], Wonyong Han[1]

[1]*Korea Astronomy and Space Science Institute (KASI)*
[2]*Astronomy and Space Science Major, Korea University of Science and Technology (UST)*
[3]*Korea Advanced Institute of Science and Technology (KAIST)*
[4]*University of California, Berkeley*

One of the keys to interpreting the characteristics and evolution of interstellar medium in the Milky Way is to understand the distribution of hot gas of which temperature is greater than 10^5 K. Gases in this phase are difficult to observe because they are in low density and lack of easily observable tracers. Hot gases are observed mainly in the emission of the FUV (912—1800 Å), EUV (80—912 Å), and X-rays (T>106 K) of which attenuation is very high. Of these, FUV emission lines originated from high-stage ions such as O VI and C IV can be the most effective tracers of hot gases. To determine the spatial distribution of O VI and C IV emissions, we have analyzed the spectral data which covers about 80 percent of the sky. The physical properties and global distributions of gases traced by O VI and C IV emissions are derived. The hot gas generation models are also verified from the results based on O VI and C IV observation.

[P-70] CHigh Speed Data Communication for Satellite Payload

Jong-Pil Kong, Sang-soon Yong

Korea Aerospace Research Institute,

The concern over EMI/EMC of a satellite system has been an always design issue, especially in the complicated payload system. With increased data speed caused by higher performance of optical payload such as smaller ground sampling distance, longer swath width and more pixels, it became more critical design issue in order to meet those requirements. In this paper, a new approach of image data communication in a payload system is proposed for Focal Plane Assembly (FPA), by which the FPA is electrically isolated from other electronic boxes and provides enhanced performance in terms of EMI/EMC design and payload system performance.

[P-71] System design & development of GPR (Ground Penetrating Radar) prototype for airborne application

Younkyu Kim, Gi-Hyuk Choi, Joohee Lee, Jongwon Lee

Korea Aerospace Research Institute

GPR(Ground Penetrating Radar) system developed as common wheel type mobility system on ground are widely used in defense and national territory management area. Recently, there are low frequency radar payloads for finding the water and the resource under ground on moon and mars exploration program in SHARD(20MHz) of NASA MRO, MARSIS(5MHz) of EAS Mars Express, and LRS(5MHz) of JAXA SELENE. This study is for the design and development of VHF/UHF GPR prototype system aimed at developing the payload of airborne system, which is meaningful in overcoming the limitations of the wheeled mobility GPR and verifying the validity of the use as the payload of lunar and mars exploration spacecraft. From this study, it is being performed for establishing the basic RF transmitter-receiver system and an RF signal and data processing platform considering the airborne system, and for promoting the development of an optimal system as the payload of airborne system and space exploration spacecraft based on these studies.

[P-72] On-board image data correction using black reference and pre-scan pixels

Youngsun Kim, Sang-Soon Yong

Korea Aerospace Research Institute

The focal-plane electronics which is to generate the digital image data from the CCD sensor performs the analog and the digital image data processing to make better image quality such as correlated double sampling, analog gain/offset

procession, and non-uniformity correction. Customized CCD sensors often provide black reference pixel and pre-scan pixel to use to remove unnecessary offset. This paper proposes an efficient and accurate dark correction method. Two steps of dark corrections are performed on the focal-plane electronics using black reference pixel and pre-scan pixel. The first offset correction using pre-scan pixel is used to eliminate the offset and the temperature dependancy with high speed synchronized with line speed. The second correction is to eliminate the remaining temperature dependancy with slow-rate such using pre-scan pixel and black-reference pixel. The paper also shows the concept design in order to apply to satellite electro-optical system.

[P-73] Digital controller design for satellite camera focus mechanism using heatable rings

Youngsun Kim, Sang-Soon Yong

Korea Aerospace Research Institute

A few focusing methods are used in satellite electro-optical camera. The method using hateable rings in these has advantages to perform accurate control with low risk. The paper shows the focus mechanism structure and its controller with a displacement of planar mirror on the beam path. The focus mechanism uses two heatable rings and three-legged system in combination with the mirror. The emulation technique is applied in order to design digital controller in the paper. At first the PID controller is designed in continuos domain, and then it is converted to the digital controller to be used in embedded software. The controller performance is investigated by changing sampling time. And also a few digitization methods are compared in the view of performance such as ZOH, Tustin method, and Matched Pole-zero method. Various simulations are carried out and the results are reviewed in the paper.

[P-74] The feasibility of space solar power satellite as a resource of base-load power

Guee Won Moon, Joon Min Choi

Korea Aerospace Research Institute

Space solar power satellite(SSPS) as space based solar power generation system is supposed to overcome the risk and limit of nuclear energy. This paper presents the SSPS model of several countries with emphasis on the latest approaches. In addition, we will briefly present the current status of key elements for future Korea indigenous SSPS model.

[P-75] Software design concepts of the high gain antenna for the lunar orbiter

Sangyoun Shin[1,2], Sung-Yong Cha[1], Hyungho Ko[2]

[1]*Korea Aerospace Research Insitutue*
[2]*Chungnam National University, Department of Electronics Engineering*

In this paper, the software design concepts of high gain antenna operation for the lunar exploration are studied. The data gathered by several payloads of the lunar orbiter will be sent to the ground station of the earth by the high gain antenna system. For the high gain antenna software design, operation concepts are studied first. The operational modes, command & telemetry, etc are defined and explained. The operation concepts are related to the satellite system and antenna hardware design as well. In this paper, the software architecture, functional block diagram, flow chart and parameters are studied.

[P-76] Environmental tests of telescope structure of Lunar Terrain Imager

Jeoung-Heum Yeon, Won-Beom Lee, Jongguk Choe, Haeng-Pal Heo, Sang-Soon Yong

Korea Aerospace Research Institute

Lunar Terrain Imager (LUTI) is the primary payload on the Korean Pathfinder Lunar Orbiter (KPLO). It is lighted weighted and high dynamic range electro-optical camera system. It is composed of telescope structure, optical module and electronics module. Each part are under development for the successful LUTI system development. In this paper, development of telescope structure is presented. Qualification model of telescope structure is developed. As environmental tests, thermal cycling test, vibration test and shock test are performed. Test requirements and results will be presented and the plan for the flight model will also be presented.

[P-77] Prototype model development of deployable telescope structure for geostationary huge electro-optical payload

Jeoung-Heum Yeon, Won-Beom Lee, Seunghoon Lee, Sang-Soon Yong

Korea Aerospace Research Institute

Geostationary orbit is in the altitude about 36,000km and orbit speed is coincide with earth rotation speed. The orbit is very useful for the earth observation and communication because satellites in this orbit look stationary from the earth. However, ground resolution is lower than that of low-earth orbit with the same optics because of the high altitude. The resolution of the optical payload is depends on the aperture size of the optics which is physically limited by the satellite size and launcher size. To overcome the size limitation, researches on the stowed and deployed telescope structure are required. In this research the prototype model development of deployable telescope structure is presented. As a first step reduced size partial model is developed.

The design and development will be presented.

[P-78] Development of Ground Verification Model for High Stability Telescope Structure based on New Material

Won-Beom Lee[1], Jeong-Heum Yeon[1], Chae-Hyeong Lim[2], Seung Hoon Leem[1]

[1]*Korea Aerospace Research Institute*
[2]*DACC Aerospace Co.,LTD*

As optical cameras grow in size, the weight of reflector becomes heavier, so the thermal expansion coefficient increases relative to the existing material. However, compared to other metals, mirrors are considered to be made using a new material that has a smaller thermal expansion coefficient, a smaller density and less rigid material. Therefore, the high stability telescope structure to support the mirrors is to be developed so that it is equally inflated and retracted using the same material. This paper describes the development of ground verification model for the high stability telescope structure using new materials.

[P-79] Mechanical Design of Telescope Structure of Lunar Terrain Imager

Won-Beom Lee, Jeong-Heum Yeon, Jong-Guk Choe, Haeng Pal Heo

Korea Aerospace Research Institute

Lunar Terrain Imager (LUTI) is the primary payload on the Korean Pathfinder Lunar Orbiter (KPLO). It is lighted weighted and high dynamic range electro-optical camera system. It is composed of telescope structure, optical module and electronics module. The mechanical design of the LUTI at the EOS level includes thermal hardwares mechanical interface, mounting the camera control unit, optical installation, and harnesses design. Therefore, the mechanical design of the camera has been carried out. This paper describes the mechanical design of the LUTI.

[P-80] Radiation hardened CMOS pixel design for Electro-Optical satellite

Ilseop Lee, Sang-soon Yong

Korea Aerospace Research Institute

Most optical detectors for EO satellite uses the CCD(Charge coupled device). Recently, the CMOS technology is mostly used in image-sensor application due to low-power consumption and high system integration. And advances in technology of CMOS Image-sensor has similar effects of radiation to the CCD. According to the ECSS document, ECSS-E-HB-10-12A, the radiation effects such as TID, TNID(DDD) and SEE for the optoelectronics and sensors should be considered. This paper presents the development trend of CMOS Image-sensor for satellite payload system and the design method for the radiation hardened CMOS pixel.

[P-81] Studies on Infra-red detector system for space application

Ilseop Lee, Eung-Shik Lee, Sang-soon Yong

Korea Aerospace Research Institute

The Infra-red focal plane detector array for space application consist of an infrared matrix detector and a specific read-out integrated circuit (ROIC), which are connected by a solder bump bonding technology. The infrared matrix detector is fabricated by processes such as MCT(HgCdTe), PtSi, or InSb depending on operating condition. The ROIC is mostly silicon based integrated circuit and the operational parameters of the ROIC are adapted to an operating temperature for the user required application to achieve best performance. This paper describes the overall infra-red detector system for space application.

[P-82] Microgravity environment simulating facilities and their utilization

Joo-Hee Lee[1], Jong-Won Lee[1], Youn-Kyu Kim[1], Gi-Hyuk Choi[1], Seul-Hyun Park[2]

[1]*Korea Aerospace Research Institute*
[2]*Chosun University*

Drop-towers, aircraft parabolic flights, and sounding rockets are used in many countries to conduct scientific experiments under microgravity environments and to prepare for space flight missions such as space experiments on the International Space Station (ISS).
Especially, an aircraft parabolic flight can provide researchers with a good platform for scientific experiments such as combustion experiment, fluid and fundamental physics, aerospace engineering, material science, biomedical and biotechnology research, and so on.
In this paper, the objectives and application of microgravity environment simulation facilities for the various researches will be introduced. The flight profile of the microgravity environments such as combustion experiment, and the aircraft currently used in the world to make these environments will also be presented.

[P-83] Development of multi channels silicon avalanche photodiode sensor for low light imaging detection.

H. Y. Lee[1], Jin-A Jeon[1], H.S. Lee[1], M.H. Lee[1], J.Jegal[2], Hongjoo Kim[2]

[1]Center for Underground Physics (CUP), Institute for Basic Science (IBS), Daejeon, Korea

[2]Department of Physics, Kyungpook National University, Daegu 41566, Korea

Silicon avalanche photodiode (APD) is a highly sensitive semiconductor photo sensor that uses the photoelectric effect converting light to electricity. APDs have high gain through avalanche multiplication in their pn junction. APD has various preferable characteristics such as operating with high quantum efficiency, large dynamic range, light-weighted shape, robust and insensitive to magnetic fields as well as enables low light measuring thanks to the gain of about 100. As a monolithic devices, however, they usually have the sizes of 5 x 5 mm2 ~ 16 x 16 mm2. The sensor is required to cover a large area. In this study, we have simulated the pn junction with high electric field on n type substrate for working at about 400 voltage for the APD sensor. We also have designed and fabricated the APD sensors with multi channels of 5 x 5 and 10 x 10 arrays in the wide area of about 5 x 5 cm2. We will present about the simulation, design and fabrication result for multichannel silicon APD sensor manufacturing in Korea

[P-84] Assessment of Ionospheric Correction Models for Single-Frequency GNSS Receivers

Youn-Jeong Heo, Byung-Seok Lee, Gi-Wook Nam

Korea Aerospace Research Institute

The ionosphere is one of the largest error sources in GNSS (Global Navigation Satellite System) based positioning. The users of single-frequency GNSS receivers should apply some kind of ionospheric correction models to remove the ionospheric delay. For real-time correction of the ionospheric delay, one can use Klobuchar model or NeQuick model provided by navigation messages of GPS and Galileo, respectively. Moreover, SBAS (Satellite Based Augmentation System) ionospheric method, which is providing navigation services suitable for safety critical applications, can be chosen to correct the GNSS measurements.
In this work, we evaluate the performance of those models by comparing their verification results at different seasons and latitudes. We employed the accurate data of the vertical total electron content, which is provided by the international GNSS service (IGS).
Consequently, the residual error of the SBAS ionospheric delay correction model is more accurate than Klobuchar model and NeQuick model, and it shows different results depending on seasons and latitudes.

2부 발표시간: 10월 25일(목) 13:30~14:30

[P-85] Station acquisition design for GEO-KOMPSAT-2A

Sang-Wook Kang, Bong-Kyu Park, Jae-Dong Choi

Korea Aerospace Research Institute,

The GEO-KOMPSAT-2A will be launched around December 2018 and will perform missions on the Korean peninsula and meteorological observations on longitude 128.25deg in Geostationary orbit(GEO). The size and mass of GK2A are 3.8×8.9×4.6(m) and 3500kg respectively. After Launch and Early Orbit Phase(LEOP) of GK2A, several maneuvers are required to bring it from longitude 119 deg to a target longitude 128.25 deg in GEO. In this study, we have simulated the station acquisition to transfer GK2A to a desired GEO. The constraints are set to be inclination 0.02 deg and longitude 128.25 deg. The simulation results show that GK2A is injected to a target orbit within tolerance.

[P-86] Launch and Early Orbit Phase design for the GEO-KOMPSAT-2A

Sang-Wook Kang, Bong-Kyu Park, Jae-Dong Choi

Korea Aerospace Research Institute,

The accurate design of Launch and Early Orbit Phase(LEOP) is very important to inject GK2A successfully into a target orbit. The objective of the LEOP is to control the GK2A to bring it to Geostationary orbit(GEO) after it is separated from a launch vehicle. Therefore, several maneuvers are required to adjust the orbit from Geostationary transfer orbit(GTO) to GEO. The GK2A will be injected into a first target orbit with drift rate 1.4deg/orb and longitude 119deg and then be put into the final GEO with longitude 128.25deg through station acquisition. In this study, we performed a simulation for LEOP design of GK2A. We used the STAN module of FOCUSLEOP developed by GMV. Through simulation, we confirmed that GK2A is injected into the LEOP target orbit with longitude 119 deg by a total of five maneuvers.

[P-87] Development of Flight Software for Korean Pathfinder Lunar Orbiter

Soo-Yeon Kang, Sun-Wook Kim, Jong-WookChoi, Jae-Yeop Jeong, Bum-Soo Yoo,Su-Hyun Park, Jae-Seung Lee, Hyun-KyuShin, Seung-Eun Yang

Korea Aerospace Research Institute

The Korea Aerospace Research Institute (KARI) is currently developing the flight software for Korea Pathfinder Lunar Orbiter(KPLO). The architecture and verification technology of KPLO flight software is based on the flight software on domestic low-earth orbit satellites and geostationary satellites, which have been successfully developed. KPLO has many other requirements than conventional low orbit and geostationary satellites, such as the limits of telecommunication and communication capacity, lunar orbit entry and the operation of six payload missions. We analyze and derive requirements that reflect the system requirements, the hardware design and operation, perform the preliminary design, and carries out the detailed design for KPLO flight software. In this paper, we describe the present KPLO software design contents, test bed development status for verification, and future plans.

[P-88] An analysis of the attitude control efficiency in the transfer orbit by change of the MOI

Woo-Yong Kang

Korea Aerospace Research Institute

GEO-KOMPSAT2(GK2) performs the liquid apogee engine firing(LAEF) in the transfer orbit and places the satellite in the geostationary orbit (mission orbit). During this period, large amounts of fuel are needed to increase the perigee altitude to the geostationary orbit. By using a lot of fuel, the satellite' s moment of inertia(MOI) changes. In order to maximize the LAEF efficiency, the attitude control performed by considering changes in the MOI. In this paper, we analyzed the attitude control efficiency in the transfer orbit by change of the MOI.

[P-89] Monitoring Typhoons and Hurricanes over the ocean using KOMPSAT-5 Wide Swath SAR

Chi-Ho Kang[1], Mi-Ri Kim[2], Ho-Il Cho[2]

[1]*Korea Aerospace Research Institute*
[2]*SI Imaging Service*

Atmospheric storms on the ocean surface can be observed and imaged by synthetic aperture radar (SAR). Although other existing sensors operated in both optical and infrared channels can easily detect large scale storms including typhoons and hurricanes and other meso scale storms, SAR can contribute to ocean surface information that cannot otherwise be obtained below the cloud dec with finer resolution. Typhoons and hurricanes formed during summer season in 2018 were observed by using KOMPSAT-5 SAR with wide swath mode. In this paper, we summerize the KOMPSAT-5 typhoon and hurricane observation campaign and present resultant imagery for typhoons and hurricanes, of which eye shape and patterns of sea surface wind are clearly shown.

[P-90] Ground System Hardware Implementation for Geo-KOMPSAT 2A

In-Hoi Koo

Korea Aerospace Research Institute

The Geo-KOMPSAT 2A which is scheduled to be launched by the end of 2018, has a functional and performance enhanced payload compared to the current COMS.
For GK2A successful mission, stable and optimized ground system hardware integration will be needed.
In order to integrate the ground system hardware, it is required to design optimal hardware to process high performance payload data, network design for reliable transmission and reception of data, system management environment for system failure and performance monitoring, and mass storage for save of data and image products produced in ground system.
In this paper, we describe the integration of the ground system hardware for testing and operating GK2A. After the completion of the integration, also, we describe the reliability test and the network performance test result of the system.

[P-91] Feasibility Analysis of Target Point Tracking Mission with Pitch Maneuvering

Jae-wook Kwon, Han-woong Ahn

Korea Aerospace Research Institute

The first lunar probe in Korea, the pathfinder Orbiter (KPLO) mission objectives are to place an orbiter via a cis-lunar transfer phase into polar lunar mission orbit, and to perform technology demonstration and science operations. The KPLO equips six payloads that consists of five payloads domestic and one payload which is a camera to take image of south pole of the moon to be developed by NASA in the United States. Some of mission with the camera are to perform the tracking the one point of the lunar surface with pitch maneuvering to obtain detail figures. The tracking mission has not been defined at the phase of mission definition. In addition, KPLO system that has already purchased reaction wheel has been designed. In order to check the feasibility for the mission, some of constraints, conditions and mission scenario are assumed. This paper shows the analysis result of the feasibility under those assumptions.

[P-92] Design for LCL Circuit on Satellite Power Distribution Unit considering Inrush Current of XTX Unit

Kyu-Dong Kim

Korea Aerospace Research Institute

To protect circuit and prevent from inrush current of each units on satellite payload system, latching current limiter circuit(LCL) is generally

used in power distribution unit on satellite bus system. LCL is designed by two factor; one is maximum load current and the other is trip-off duraion considering junction temperature of protection FET in line. Payload units especially XTX units have extremely unusual inrush current shape which has larger magnitude or long duration. In this paper, the design guide for LCL circuit in the manner ESA guideline when payload unit has unusually long inrush current.

[P-93] Proposal of function improvement model of visual analysis system for payload observation data of satellite

Dong-Oh Kim, Jun-Yeong Bok, In-Hoi Koo

Image Data System Development Division, Satellite Operation & Application Center, Korea Aerospace Research Institute

Ground station performs functions to build plans for imaging and downlink operation of payload, to receive payload observation data and to generate products using payload observation data(Product Management System, PMS, hereafter). In this paper, we proposed analysis system for payload observation data of satellite that could be quickly visual analysis. Proposed system can perform visual analysis without PMS. In order to improve the efficiency of visual analysis, we used subsampled data of payload observation data, synthesized images of MS channel and stored 24bit color image as output. The function of the proposed system were verified by using the payload observation data of the KOMPSAT.

[P-94] Lessons Learned from the Implementation of Semi-active Ranging System

Myungmuk Kim, Han Oh, Sangil Ahn

Korea Aerospace Research Institute

Korea Aerospace Research Institute (KARI) has been verifying the performance of Semi-Active Ranging (SAR) method for COMS. In this method, the ranging signal is transmitted from one active ground station and other ground stations which are called passive stations only receive the returned ranging signal from the satellite and determine the distances measuring times from pre-arranged ranging start time to the arrival time of the signal. Since the passive stations do not require the radio frequency transmission license, the SAR method is very useful to add ranging sites overseas. The hardware configuration for implementing the SAR system is composed of the modems which have the capability of SAR, GPS DOs (disciplined oscillators) for time synchronization between ranging sites, up/down converters, and antennas. This paper discusses the hardware issues and the ambiguity problem of the tone-ranging method, arising while implementing the system, and suggests their workaround.

[P-95] Study on Algorithm of Interference Analysis for Lunar Orbit Satellite

Youngwook Kim, Deawon Chung

Korea Aerospace Research Institute

KARI (Korea Aerospace Research Institute) is currently developing a lunar orbit satellite named KPLO (Korea Pathfinder Lunar Orbiter) which is targeted for launch in 2019.
Study on algorithm of interference analysis for lunar orbit satellite and its mutual impact is necessary to make quantitative analysis and estimation for interference between lunar orbit satellite network and other satellite networks to ensure reliable operation from frequency interference in operation phase later.
In this paper, interference analysis and estimation model which supplement the earth-centered interference analysis model recommended in the ITU international standard is presented for earth and lunar orbit satellites. Also, simulation for analyzing impact of interference according to diameter and radiation pattern for antenna of associated earth station which communicate with lunar orbit satellite is conducted and protection criteria for mutual operation between non geostationary orbit is presented

[P-96] A small thermal vacuum chamber for space parts test

Eui Keun Kim, Sang Hoon Lee, Dong Woo Lee

Korea Aerospace Research Institute

The space-parts(components) test center is under construction to develop the space industry in accordance with a national space program. Once the center which is equipped with test/inspection equipment and professional researcher is built, it will support various space-parts test and localization. The introduction equipments are divided into unit level test equipments and part level inspection equipments. Among the unit level test equipments, a small thermal vacuum chamber is manufacturing to determine whether the satellite operate normally during mission life in the space environment. In this paper, we will briefly investigate the thermal vacuum technology and related industry for space-parts development.

[P-97] Design of the transceiver for Multi-Channel Synthetic Aperture Radar

Jin-Gwang Kim[1], Sang-Burm Ryu[1], Jae-Min Kim[2]

[1]*Korea Aerospace Research Institute*
[2]*LIG Nex1*

As demands for satellites increase, needs of developing satellites for various purpose increase as well. Especially, the synthetic aperture

radar(SAR) satellite has greate advantage of taking an image under any circumstances comparing with optical or infrared satellite which can not take an image depending on weather. However, in order to supplement low accuracy of the image taken by SAR, multi-band radars are developed and finally more accurate result can be achieved. Because of the advantage, some leading nations of space technology like United States and India are developing multi-channel SAR satellite. In this paper, developing of the transceiver for multi-channel SAR will be introduced.

[P-98] Electric field analysis for Radiated Electromagnetic Compatibility

Tae Youn Kim, Jae Woong Jang, Kyoung Duk Jang, Chang Eun Lee

Korea Aerospace Research Institute

The electric field analysis due to the space-born antenna radiation should be performed in order to assess the EMC safety margin between the RF transmitting system and the radiated susceptibility level of spacecraft unit. This analysis is mainly focused on units which are installed the outside of spacecraft structure. The considering input parameters are the expected antenna gain in the direction of units, the expected emitted power at a single frequency, and the distance between units and radiating antennas. The analyzed electric field level is then compared to RS qualification level specified for external units in the interesting frequency.
In this paper, the electric field analysis method for the radiated electromagnetic compatibility demonstration is described. In addition to the measured electric field results during radiated EMC test campaign are presented.

[P-99] Geostationary Satellite System Radiated EMI/EMC Test

Tae Youn Kim[1], Jae Woong Jang[1], Kyoung Duk Jang[1], Chang Eun Lee[1], Byeung Hee Min[1], In Sang Yu[2]

[1]*Korea Aerospace Research Institute*
[2]*I-Spec Korea*

The satellite must be thoroughly tested and verified in order to prove its safety, reliability and compatibility with its orbit environment. The EMI/EMC testing is critically important in determining the safety of the system because of the effects of EMI/EMC can be highly unpredictable. The testing is used to verify that the system will operate properly when exposed to the interference generated by the satellite itself. The EMI/EMC testing can be categorized into two operational modes.
This paper presents the radiated EMI/EMC test of a geostationary satellite system. The test was carried out at large EMC test facility of KARI during July 2018.

[P-100] Lessons and learned from Solar Array Deploymnet Tests

Hyung-Wan Kim, Jung-Su Choi

Korea Aerospace Research Institute

GEO-KOMPSAT-2A Solar array wing integration and deployment tests have performed during assembly, integration and test sequence according to GK2A Flight Model integration & tests plan. One manual release and deployment test was performed on Satellite Sidewall Simulation before it was assembled and integrated to the Satellite. After integrating to the Satellite, one manual release and deployment test was performed and then one hot release test was performed with test NEAs. It had been decoupled for the Satellite thermal vacuum test, and then coupled with the Satellite again. As like these steps, the wing has been tested several times. I would like to describe some more details of those tests and lessons and learned from them in this paper.

[P-101] Case study on thermal design and control of lunar lander

Hui-Kyung Kim[1,2], Dong-Young Rew[1]

[1]*Korea Aerospace Research Institute*
[2]*University of Science and Technology*

A lunar lander is affected by different space thermal environments from a spacecraft or a lunar orbiter. In the latter case, the thermal environmental factors are direct solar flux, albedo and planet radiation; it has relatively short periodic thermal behavior which is resulted from a orbit motion with an hour more or less; a domestic thermal design technology for its thermal control has been developed sufficiently. On the other hand, the lunar lander landed on a lunar surface is influenced by the solar flux from the 27-day diurnal motion of the sun and the radiation of the lunar surface; it shows the thermal behavior of a steadily changing temperature profile in equilibrium. It means that the lunar lander has the completely different thermal condition from the spacecraft or the lunar orbiter in-orbit. Becase the lunar surface has optical properties of absorptivity and emissivity same as a black body, its temperature varies between about 100K and 400K; hence, the thermal condition of the lunar lader is dominated by the lunar surface temperature directly with solar flux and more severe than that of the lunar orbiter in-orbit. It is anticipated that the thermal design of the lunar lander can be conducted based on the well-known thermal control method of the spacecraft; however, in domestic, there is no experience of the thermal control, design, and analysis for the lunar lander. This research investigated the cases of the thermal control and design for the aboard lunar lander and suggests the thermal design baseline of the lunar lander under development.

[P-102] Mass Properties Measurment Test for Low Attitude Earth Observing Small Satellite

Nam-Jin Moon, Hee-Kwang Eun

Korea Aerospace Research Institute

Mass properties for satellite are required by launcher to insert target orbit. And mass properties which are measured or calculated by design model are used for controlling satellite accurately.
As a result, design values should be checked by mass properties measurement test.
In this paper, test process and result of center of gravity and moment of inertia for 3 axes are described.

[P-103] Study on Ranging Performance at Ground Station Depending on PLL Bandwidth

Durk-Jong Park

Korea Aerospace Research Institute

By changing PLL bandwidth, ranging performance was investigated in this paper. In the link analysis for ranging accuracy, PLL with wide bandwidth can be beneficial to acquisite ranging tone signal despite of a severe Doppler shift situation. However, due to the wide bandwidth, the nose density is increasing followed by link performance for ranging accuracy can be degraded. In this paper, the ranging performance vs. PLL bandwidth was investigated and compared with real-measured result. As a result, the standard deviation calculated from the given PLL bandwidth is aligned with real-measured value within the implementation loss of unit for ranging measurement.

[P-104] Station-keeping Propellant Budget Analysis of KPS(Korean Positioning System) Satellites

Bong-Kyu Park, Jae-Dong Choi

Korea Aerospace Research Institute

Concepts of KPS(Korea Positioning System) have been discussed through several papers in an effort to improve the navigation accuracy and stability around Korean peninsula. A concept of KPS using geostationary satellites and geosynchronous satellites in inclined orbits can be one of the possible solutions which is similar to QZSS of Japan. In this approach the eccentricity, inclination and argument of perigee of the inclined orbits are selected to make the satellites visible in service area to a maximum duration of time and to make the satellites spread as wide as possible to server good observability. In operation phase, the orbit shall be periodically adjusted to maintain the satellites in optimum constellation which is called station-keeping. Typically, for geostationary satellite, the station-keeping consists of two types of maneuvers; north/south maneuver and east/west maneuver. The north/south station-keeping is to keep the orbit plane as close as possible to the equatorial plane. The east/west station-keeping is to adjust the eccentricity and longitude. Similar concept of station-keeping shall be developed to the KPS satellites in inclined orbits. The propellant budget for station-keeping is one of the key parameters necessary to perform preliminary design. In this paper, the propellant mass for the station-keeping is roughly budgeted. To do that, a simple station-keeping concept for the satellite in the inclined orbit is developed and orbit simulations have been performed to estimate propellant budget under assumption of ten years of mission life.

[P-105] Lua coroutine recycling for on-board control procedure execution on spacecraft

Su-Hyun Park

Korea Aerospace Research Institute

On-Board Control Procedures(OBCP) are script-like computer programs running on the spacecraft embedded computer. OBCPs provide spacecraft higher level of autonomy as if ground operator is on-board. Korea Aerospace Research Institute(KARI) is working on development of OBCP execution engine with Lua. Because Lua is lightweight scripting language written in ANSI C, it can be easily integrated to the spacecraft flight software. It also provides interfaces to C functions, which allows Lua to communicate with the existing flight software. It supports Lua coroutines, which can be used to schedule multiple OBCPs concurrently. Lua, however, allocates memory dynamically when loading the scripts. For the spacecraft safety, dynamic memory allocation is not recommended in the flight software development. In this paper, we propose how to recycle a Lua coroutine once it is loaded into OBCP execution engine. A Lua coroutine is implemented by an infinite loop. In the infinite loop, the Lua coroutine waits until the value of flag turns true. The Lua flag shall be set by ground telecommands to start executing the Lua coroutine. This allows ground station to activate a Lua coroutine without loading the Lua coroutine repeatedly.

[P-106] FDIR(Fault Detection, Isolation and Recovery) Test for AOCS of GK2A

Young-Woong Park, Keunjoo Park

Korea Aerospace Research Institute

There are introduced the ETB test of the FDIR(Fault Detection, Isolation and Recovery) logic of GK2A satellite which is expected to launch in December, 2018, and the test results of some items are summarized in this presentation. The process of verifying whether or not the

corresponding FDIR logic of the AOCS(Attitude and Orbit Control Subsystem) is as follows. After classifying the error items, setting the range to detect the errors, generating the errors using the satellite dynamic simulator, and analyzing the corresponding process according to the detection result of the on-board computer. In the FDIR logic of AOCS, the main item is set as a state in which an error is not set for every hardware of AOCS but for main mission of AOCS, which is to control the satellite attitude.

[P-107] GK2A L1 Radiometric Calibration Algorithm Experiment Tool Development

Jong-Beom Park,Tea-Bong Oh

Korea Aerospace Research Institute

The GEO-KOMPSAT 2A is scheduled to launched by the end of 2018 and it has a design life of 10 years and operates for a long time compared to LEO satellites and produces various output products. In order to obtain good product, it is important to monitor and study for radiometric calibration quality changes that the basis for the subsequent output quality. In this paper, we introduce GK2A L1 Radiometric Calibration Algorithm Experiment Tool that provides various experiment and analysis result functions.

[P-108] Mass Property Estimation for a Geostationary Satellite

Jong Seok PARK, Jung-Su CHOI, Hyung Wan KIM, Jae Dong CHOI

Korea Aerospace Research Institute

Mass properties are one of the main characteristics of satellite representing its overall dynamic features. Those are required to be predicted for the launch vehicle interface verification and satellite attitude control design and the prediction has been done based on the mass properties of each component acquired during the spacecraft development process.
Specifically for geostationary satellites, the propellant accounts for a large portion of the satellite's launch mass due to a propulsive maneuver for orbit transfer, and when the LAE (Liquid Apogee Engine) is operated, it consumes a significant amount of propellant. In addition, changes in the gravitational field should be taken into account. These changes affect the mass properties of the satellite, and hence requires their accurate predictions for proper attitude control design. This paper describes how the mass properties are evolving to operational phase and how their prediction are carried out in the GK2 program and presents the results of mass property estimation according to operational phases.

[P-109] Electrical Test Plan of Compact Advanced Satellite-500 (CAS500) Flight Model (FM)

Jong-Oh Park[1] Hyeon-Jin Jeon[1], Bo-Sung Kim[2], Jin-Kon Bae[2]

[1]*Korea Aerospace Research Institute,*
[2]*Korea Aerospcae Industry*

The CAS500 is standard platform for 500kg-class satellite. This satellite' s standard platform is designed to support a variety of payloads with minimal design changes. The most of Flight Model (FM)units were delivered to KARI. The CAS500 FM Satellite is ready to integrate the units, harness and the various mechanical parts. In this paper, I will introduce the electrical preparation, integration process and the test plan including test items for CAS500 Flight Model Satellite.

[P-110] Electrical Integration Test of CAS 500 Electrical Test Bed

Jong-Oh Park[1], Jin-Kon Bae[2], Hyeon-Jin Jeon[1], Bo-Sung Kim[2]

[1]*Korea Aerospace Research Institute*
[2]*Korea Aerospcae Industry*

The CAS500 is standard platform for 500kg-class satellite. This satellite' s standard platform is designed to support a variety of payloads with minimal design changes. After DC integration test, Electrical Integration Test is performed for verifying Electrical Test Bed(ETB) signal interface between satellite internal unit and other units or Electrical Ground Support Equipments(EGSE).
Pulse, bi-level signals and serial bus communication is verified to designed voltage, frequency and its command /telemetry formed CCSDS format is verified in the test.

[P-111] Development of Level Product Color Composition System for GEO - KOMPSAT-2 AMI DPS

Jinhyung Park

Korea Aerospace Research Institute

Korea Aerospace Research Institute(KARI) will launch GEO-KOMPSAT-2A(GK-2A) in Dec 2018. GK-2A has Advanced Meteorological Imager payload for weather forecasting. KARI has developed Data Pre-processing Subsystem(DPS). The DPS parses and generates and reconstruct level 0 product from downlink packets from GK-2A satellite. And, DPS processes radiometric calibration and generates level 1A product. In this paper introduces development of color composer prototype system from level 0, 1a product and design of the products which are generated from the DPS. Level 0 and 1A product are consists of 'Header' file and 'Pixel' file. The 'Header' file contains general information and

image information including image size and timestamp. 'Pixel' file contains image pixel data. Color composer read header and pixel file and composes color image. This system will be used to data collection for AMI analysis during LEOP and IOT period.

[P-112] A study on interference mitigation techniques using joint detection for X-band LEO satellite system

Hong-Won Park[1,2], Whan-Woo Kim[2]

[1]*Korea Aerospace Research Institute*
[2]*Chungnam National University*

This paper addresses interference mitigation techniques using joint detection for X-band LEO satellite system where adjacent LEO satellite is positioned within the radiation pattern of the ground station antenna of the target satellite. When the adjacent satellite is getting closer to the target satellite and is transmitting its data, the receiver performance of ground station is largely degraded depending on the relative antenna gain corresponding to the offset angle of an interference signal for a ground station antenna.
The receiver generally may either ignore the interference or successively detect and then cancel the interference from the received signal, assuming that the desired signal from the target satellite and/or the interference signal from the adjacent satellite are Gaussian. Additionally, when the receiver can take into account the modulation formats of the desired signal and the interference signal, the performance enhancement can be achieved with the aid of joint detection.
As an optimal detector, the maximum-likelihood (ML) detector that minimizes the probability of detection error for a given modulation type, and the joint minimum-distance (MD) detector with a lower-complexity approximation of the ML detector are addressed and simulated in an AWGN channel and Rayleigh fading channel for downlink LEO satellite system.
The simulation results show that the joint MD detector as the interference-aware detector can significantly reduce the effect of adjacent satellite interference thereby improving the receiver performance.

[P-113] Redundant Design of Power Limit Mode for LEO Satellites

Heesung Park[1], Seunghee Yoo[2]

[1]*Korea Aerospace Research Institute*
[2]*Kore Aerospace Industries*

The unregulated solar array regulator used in low earth orbit satellites is designed with 2 of 3 redundancy concepts for weight and volume reduction. That is, three regulators operate in parallel under normal conditions and two regulators operate in the event of one regulator fault for providing stable power to the spacecraft. In order to implement the power limit mode in 2 of 3 redundant power conversion system, the signal circuit should be also designed with the redundancy concept. In this paper, the power limit circuit with 2 of 3 redundant scheme is proposed to perform the power limitation function even though one regulator or one output current signal circuit is malfunction. The proposed circuit is verified by simulation and experiment.

[P-114] Power Evaluation in Power Limit Mode of SAR

Heesung Park

Korea Aerospace Research Institute

When a satellite escapes an eclipse, a solar array produces much more power than an orbit average power due to the lowest solar array temperature. If a power regulator is developed for this condition, it is inefficient due to increased weight and volume. Therefore, a power regulator uses a technique to limit the power generation in the initial period of daylight. Although it is necessary to get the converted power for accurate power limitation, it is difficult to calculate the power using only analog circuits. In this paper, the approximated power calculation circuit is proposed and evaluated. The proposed circuit is developed for 900W solar array regulator with an unregulated bus of 26.4V ~ 32.8V and has only an error of less than 2% of the actual power.

[P-115] Concept of 'Power Control Test Set' for testing satellite

Su-Wan Bang, Yungoo Huh, Seungwon Cho

Korea Aerospace Research Institute

Power EGSE(Electrical Ground Support Equipment) is called by PCTS(Power Control Test Set) & SAS(Solar Array Simulator) in KARI. PCTS & SAS is used for support electric power and test for many control signals when AIT(Assembly, Integration & Test) before launch. The first purpose of 'Power EGSE' is supplying tot satellite power. This equipment name is PLTS(Power Load Test Set). PLTS is filled with power supplies it is capable of satellite power. And also satellite should be tested for using SAS(Solar Array Simulator). For each path, BDIFJ() is used and it can make another power path to using power electric test for example, using solar array power, battery power and etc.
Second purposed of 'Power EGSE' is simulator and control to test device. This equipment name is CMTS(Control Monitoring Test Set). It can emulate load of PCDU, payload and so on. And this device saves the data and give the data onto ITOS(Integrated Test and Operation System) when satellite is tested. ITOS has a main function of operating and testing satellite that user can make satellite DB and special user can design command structure and telemetry parsing process. In this paper, there are concept and

design of Power EGSE.

[P-116] Performance analysis of cross polarization cancellation for satellite downlink

Jun-Yeong Bok, Dong-Oh Kim, Hyun-Su Lim

Korea Aerospace Research Institute

In the satellite communication system, the polarization diversity technique is used as one way to increase the throughput between satellite and ground station. This technique can get double the link capacity using two polarization wave in the same frequency band. However, if orthogonality of this circular polarization wave is distorted by satellite down-link channel effects, these signals are affected as interference each other. In this paper, we discuss cross polarization cancellation technique by using the satellite high data rate receiver and analyze performance results.

[P-117] Software Developments of Schedule Generations for GK2B GEMS

Seok-Bae SEO, Seonghoon LEE, Sang-Soon YONG

Korea Aerospace Research Institute

GEMS(Geostationary Environment Monitoring Spectrometer) is on installing to complete mounting it on the GK2B (Geo-KOMPSAT 2B) Satellite. To observe earth for the GEMS, the schedules are uploaded to it by CBM (Command Block Memory) and CSM (Command Sequence Memory) format. This paper explains the format of CBM and CSM and the development results of them.

[P-118] Database Design of Commands and Telemetries for GK2B GEMS

Seok-Bae SEO, Seonghoon LEE, Sang-Soon YONG

Korea Aerospace Research Institute

GEMS(Geostationary Environment Monitoring Spectrometer) is on installing to complete mounting it on the GK2B (Geo-KOMPSAT 2B) Satellite. To operate GEMS, GK2B Database are designed for its commands and telemetries. This paper explains the results of database design for commands and telemetries of GK2B GEMS.

[P-119] Verification of the stored command processing function

Dong-Seok Chae

Korea Aerospace Research Institute

There are two types of stored comamnd: ATC(Absolute Time Command) and RTCS(Relative Time Command Sequences). ATCs are scheduled in CSA(Command Storage Ares) for execution at a specified time. Each ATC includes a time tag and a command to be executed at that time. RTCSs are maintained in the SCSA(Stored Command Sequence Area). Each RTCS consists of a sequence of commands and a time interval associated with each command. The stored commands are maintained in a linked-list data structure in each storage area. And the linked list should be rescheduled again whenever an ATC is activated or an RTCS is uploaded. It can take a lot of time depending on the number of stored commands. As a result, the stored commands are managed as a separate, dedicated, low-priority task to avoid interfering with other real-time tasks. In this paper, we describe the stored command processing function and the devepment process, test envirnments and the verification result for the next generation LEO satellite.

[P-120] 1553B communication error analysis reported during LEO satellite operation

Dong-Seok Chae

Korea Aerospace Research Institute

In spacecraft data handling subsystem, 1553B communicaiton is widely used for data interfaces between OBC(On-Board Computer) and external units such as STA(Star Tracker Assembly), GRA(Gyro Reference Assembly), GPS(Global Positioning System) receiver, payloads and so on. It has been used in most domestic low earth orbit satellites. Through various ground tests and actual operation, the 1553B communication function was verified sufficiently and operated normally for a certain period. However, as time elapsed and satellites getting old, errors began to occur, rarely occurred errors gradually increased, and other types of errors occurred depending on the operating method. In this paper, We describe the 1553b communication errors that occurred during the LEO satellite operation, and the mitigation methods we applied to resolve them.

[P-121] Verification of Thermal Control Software using Dynamic Thermal Simulator

Hyun-Kyu Shin

Korea Aerospace Research Institute

Satellites operate in the very severe environment, especially for thermal condition. In order to overcome this, lots of devices and control mechanism are needed. Among these solutions, thermal control software is able to provide a fine control in an active way. Temperature of each thermal control point is gathered and processed for turning on-and-off the corresponding heater. Thermal control software should be verified during the ground development phase, but it is very difficult due to the restriction of test from the difference between test environment and actual operating

one. Under the limited test facility, only partial behavior can be tested. In general, thermal engineers and software developers have a chance to examine the whole thermal operation and its performance during the system level thermal vacuum test. The TV test needs very high cost on human resources and test facilities. Also, the test is mostly conducted in the latter phase of development. This paper presents a novel way to verify thermal control software using a dynamic thermal simulator.

[P-122] Safety Analysis on Satellite Fault Management

Hyun-Kyu Shin

Korea Aerospace Research Institute

Satellite flight software (FSW) takes a very crucial role on accomplishment of its mission. FSW receives and processes ground commands and transmits health data of satellite as well as various mission-related information. Also it performs fault management including fault detection, isolation and its recovery. Once a fault is detected, FSW classifies it and proceeds corresponding procedures. Generally, those procedures consist of several timed commands as a form of RTCS (Relative Time Command Sequence). Sometimes a bunch of RTCSs are needed with conditional branches that construct RTCS chains. These planned actions of fault management on a specific failure case can be described as a series of pairs of time and command. The goal of fault management is to keep the satellite safe. Safety is very closely related with timing and sequence of actions. This paper introduces how to extract action information from RTCS chains and make a action-condition model for safety analysis.

[P-123] The study on the dependency of ranging measurement environment like sampling rate and measurement interval with the accuracy of orbit determination based on the real measurements with COMS

Sangil Ahn, Jaedong Seong, Sangcherl Lee, Han Oh, Myungmuk Kim

Korea Aerospace Research Institute

The ranging measurement operation needs to be optimized in duration and interval, especially for geostationary missions. Knowing the practical dependency between measurement environment and orbit determination accuracy is pre-requisite for ranging measurement scenario. In this paper, we will present the practical dependency between the environment and accuracy of OD based on the real measurements with COMS. Also, the key observations in study is summarized for the input of operation scenario development.

[P-124] The Efficient Semi-Active Ranging Operation Scenario for the multiple GEO satellites near 128.2 East longitude

Sangil Ahn, Jaedong Seong, Sangcherl Lee, Han Oh, Myungmuk Kim

Korea Aerospace Research Institute

By the end of 2019, minimum 3 geostationary satellites will be located near 128.2 deg in East longitude. The more satellites are collocated, the more accurate orbit determination and orbit maintenance is mandatory. Instead of individual flight dynamic software operation, systematic and synthetic orbit determination and orbit maintenance including ranging measurement activities for all satellites will be more critical for accurate and reliable orbit operation. In this paper, we will propose central flight dynamic system using Semi-Active Ranging and the ranging measurement operation scenario for at least 3 geostationary satellites: COMS, GK2A, GK2B.

[P-125] An Effective 1553B Transaction Scheduling Method for a Low Earth Orbit Satellite

Seung-Eun Yang

Korea Aerospace Research Institute

MIL-STD-1553B is a military standard published by the United States Department of Defense that describes serial data bus. It is widely used for on-board data handling in aerospace field because of the robust safety and performance. The serial bus is a time division multiplex data bus that transmit data at 1 MHz rate. The terminal is composed of BC (Bus Controller), BM (Bus Monitor) and RT (Remote Terminal). Normally, OBC (On-Board Computer) is executed as BC and other payload or external unit is operated as RT. BM is used to monitor the link status and data stream in the test facility. For 1 BC, up to 31 RTs can be connected through 1553B bus. Because of the limited data transfer speed compare to multiple RTs, the transaction should be effectively scheduled for OBC operation. In this paper, we describe an effective 1553B transaction scheduling method for low earth orbit satellite to enhance the operation capability.

[P-126] Tele-command and Telemetry Interface for Software Test Bed of a Low Earth Orbit Satellite

Seung-Eun Yang

Korea Aerospace Research Institute

Tele-command is a ground to satellite interface to control the OBC (On-Board Computer) and multiple subsystems in the satellite. Typically, a command consists of a synchronization code, spacecraft address bits, command message bits,

and error check bits. Telemetry is used to monitor the health and status of the satellite and receive payload data. Those data from all resources is converted to digital form and formatted into a serial stream of continuous data for down-link. Software test bed is a ground test facility to implement and test flight software. Therefore, hard line channel is applied for the tele-command and telemetry instead of the radio frequence. In this paper, the design and implementation of the tele-command and telemetry interface in software test bed is described. The functionality is verified through the implemented interface.

[P-127] Introduction to KARI's Dynamic Test Facility

Sung-Hyun Woo, Chang-Rae Cho

Korea Aerospace Research Institute

KARI's SITC(Satellite Integration Test and Center) has been widely utilized for the almost all Korean space programs since its foundation in 1996. Particularly to simulate the vibrational and acoustical environment induced for the launch process, the dynamic test facilities are equipped in the launch environmental test hall, a section of SITC. However, due to the recently rising needs for the larger facilities to test huge size satellites and launch vehicle developments with the interface size of larger than Φ3m, LVTF(Large Vibration Test Facility) has been established in 2016 and now fully operational for the ongoing space and launch vehicle development programs of KARI. This paper presents overall introduction to KARI's existing and newly built dynamic test facility.

[P-128] Dynamic Test of the Satellite with the Fuel Simulant

Sung-Hyun Woo, Chang-Rae Cho

Korea Aerospace Research Institute

For the dynamic test of the satellite flight model, it is of quite importance to implement its flight configuration for the test to exactly simulate its dynamic characteristic and accordingly to guarantee the reliable test results. In particular, it is even more important for the test case of the geo-stationary orbit satellite with huge amount of fuel which highly affects the static and dynamic features of the satellite. Recently, a flight model of the geo-stationary satellite being filled with isopropyl alcohol as fuel simulant has been successfully tested at KARI's Large Vibration Test Facility opened at the Mid. of 2016. For the safety of the test, special considerations in facility and operational respects has been made due to explosiveness of the fuel simulant just in case of the unexpected leak accident.

[P-129] Interface design of spaceborne AIS system for next generation SAR satellite

Young-Jin Won

Korea Aerospace Research Institute

AIS is an acronym for a universal shipborne Automatic Identification System recently introduced for traffic monitoring and safety at sea. The next generation LEO synthetic aperture radar (SAR) satellite will adopt AIS receiver system to gather the AIS signal, for example ship position, course, speed, and so on, as a secondary payload for SAR image fusion.
The spaceborne AIS system consists of the AIS receiver and the AIS antenna module. The overall electrical interfaces are categorized as the power interface, the RS-485 serial communication interface, the 1 pps interface, the redundancy control interface, the AIS antenna deployment interface, and the deployment status interface.
In this paper, the final interface design results of the AIS system are summarized and presented.

[P-130] Analysis of Spacecraft Agility Performance and Capacity of Reaction Wheels

Hyungjoo Yoon

Korea Aerospace Research Institute

In these days, the angular rotational maneuvering performance, or agility performance, of a spacecraft has become a key factor in the space industry and academy, because of its practical and academical significance. The present research proposes a new analysis method to estimate the optimal rotational agility performance of a spacecraft with a cluster of multiple reaction wheels. At first, a simple single axis rotation problem is briefly reviewed, and then we discuss on its application to the three-axis rotation of a rigid spacecraft. Then, a new analysis method is presented to calculate the maximum angular acceleration and angular velocity with given reaction wheels array. Combining these results with the optimal torque/momentum distribution methods, which use the minimum infinity-norm solution, one can obtain a control loop which can achieve the near-optimal agility performance of a spacecraft.

[P-131] Verification of Transportation Container for Large Satellite

Hee-Kwang Eun, Nam-Jin Moon

Korea Aerospace Research Institute

Large satellite should be shipped in lateral configuration owing to the height limitation of the cargo aircraft dimension. And the width of container is limited by the road traffic regulation. As a result, a new transportation container has a small clearance between satellite and container. But vibration isolation system has a very low frequency mode to isolate external vibration because satellite has a low frequency mode.

In this paper, the verification result of dynamic characteristics for the container are described.

[P-132] GK2A Satellite Propulsion Thruster Function Check Configuration and Method

Nayoung Lee, Jaedong Choi

Korea Aerospace Research Institute

The propulsion system interface of the GK2A satellite, which is developed with the goal of launch in December 2018, is largely composed of thermal control, Thruster control, and pressure measurement. At the stage of comprehensively verifying these interfaces, all of these interfaces should be constructed in the satellite flight model (FM) bus system. The thruster control algorithm fully verifies the control algorithm using the electric test bench (ETB). For the pressure measurement interface, the conversion algorithm between the simulated voltage and the pressure data was verified in the ETB, The conversion algorithm is verified with the actual data of the pressure system after mounted on the satellite FM bus system. In particular, the FM propulsion system interface is constructed on the satellite core module. Therefore, when the core module is mated with the FM wall structure on the open shape, which is named as a open wall shape, the propulsion FM system is subjected to a primary verification test with the power control unit and the propulsion control unit. The thermal control performance is verified at the stage of thermal vacuum test which is performed after the coupling of FM core module with the FM walls. In this paper, we describe the detailed verification of the performance verification of the GK2A satellite propulsion system using the Open Wall shape and the coupling shape.

[P-133] GK2A Satellite Database Management and telemetry data display Method

Nayoung Lee, Jaedong Choi

Korea Aerospace Research Institute

The database of the GK2A satellite which is being developed for the launch in December 2018 is generated and distributed for the rehearsal of the ground station and the satellite flight model (FM) test. In addition, it is necessary to systematically prepare the display screen for each satellite unit, satellite subsystem, and state data of various satellites generated from satellites and provide it to the user. On the other hand, it is necessary to transfer a satellite specific telemetry in a quick cycle depending on a specific test or a purpose. To do this, the satellite commands and usage methods are defined already, and also it is necessary to implement the usage methods by the automatical scripts to support users to utilize functions more conveniently. In this paper, details of these functions and database management are described.

[P-134] GK2A Satellite Payload Interface Management and Check Method

Nayoung Lee, Jaedong Choi

Korea Aerospace Research Institute

The payloads of the GK2A satellite which is being developed with the goal of launch in December 2018 are the advanced meteorology imager (AMI) and the korea space enviroment measure system (KSEM). The performance verifications of them are carried out after mounting them to the satellite flight model (FM) bus system. The verification progresses are defined according to the mounting sequence of the payload units on the FM bus system When the payload units are completely mounted, the stage of the thermal vacuum test begins, and long-term operation performance verification of 30 days or more including the thermal control performance of the payloads are carried out at this time. The mounting procedure and the performance verification item of each payload are different. After modifying the interface and the database related errors which are found after the performance verification, the interface and function check process are repeated and they are revalidated. In this paper, we describe details of construction and performance verification of each payload interface by the satellite assembly stage.

[P-135] Numerical study on Attitude Guidance Command Generation method

Donghun Lee, Seok-Won Choi

Korea Aerospace Research Institute

Attitude guidance command is required in order to perform various mission scenarios. In this paper, two methodologies to generate attitude guidance profile are compared. There are mainly two phases in the attitude guidance profile, which are the imaging phase and maneuvering phase. The attitude command for the imaging phase can be designed by using user defined target points and spacecraft position. The analytical attitude guidance profiles and numerical methods are studied for the agile spacecraft including optical payload system during attitude maneuvering phase. In the problems of the attitude guidance command generation, boundary conditions for the attitude and body rate are usually required to be considered. Attitude reconstruction module on the onboard computer is also studied from the computational load point of view. Through numerical examples, the performance of each method are compared and analyzed, further considerations in operation are recommended.

[P-136] Electrical Interface Design of Satellite Deployment Actuator

Sang-Rok Lee

Korea Aerospace Research Institute

Most satellites have deployment actuators that hold the various structures during launch. Purpose of holding is to prevent damage of structure due to vibration and to have small form factor during the launch process. Actuation sequence and signal delivering path should meet standards of double faults tolerance rule. This is to prevent the loss or injury of human life and the loss of launch vehicle due to deployment of fixed structure. In the case of NEA type, it uses a dedicated board designed to satisfy the double faults tolerance of signal delivery path and actuation sequence. However, in the case of frangibolt, the behavior of the actuation signal is similar to the of the power supply board output, but does not meet the double faults tolerance requirement when using the power supply board. In this paper, design method and actuation procedure to meet the double faults tolerance rule for the electrical interface of frangibolt will be proposed.

[P-137] Electrical Interface Design of Solar Array Drive Assembly

Sang-Rok Lee

Korea Aerospace Research Institute

Korea Pathfinder Lunar Orbiter(KPLO) is currently under development, and KPLO is equipped with Solar Array Drive Assembly(SADA) to simultaneously achieve the sun pointing for power generation and mission performing. SADA is composed of Solar Array Drive Mechanism(SADM) and Solar Array Drive Electronics(SADE). SADM delivers power and signal from solar array to satellite Electronics such as Power Control and Distribution Unit(PCDU) and On Board Computer(OBC). For choice of SADM in the aspect of power and signal transfer, maximum voltage and current from solar array and sufficient number of slip ring should be considered. Additionally sharing of power slip ring should be actively considered for efficient selection of SADM model. SADE is controlled by OBC and drives SADM. For OBC interface of SADE, harness design that minimize the EMC effect is necessary. For potentiometer interface, stimulus current limiting and relevant circuit should be reviewed to prevent damage. In this paper, considerations of electrical design of SADA will be discussed.

[P-138] Analog Circuit Design of High precision Three-axes Fluxgate for Space Science Research

Seunguk Lee[1], Sung-Jun Noh[1], Juhyung Kim[1], Cheong-Rim Choi[1], Kyung-In Kang[2], Gi-Hong Rue[3], Joonsung Kim[1], Hyunhwa Lee[1], Dooyoung Choi[1], Daeyoung Lee[1]

[1]*Chungbuk National University*
[2]*Satellite Technology Research Center, KAIST*
[3]*YeungJin University*

The Fluxgate magnetic field developed by Chungbuk National University is being developed for near-earth space exploration and space science research. In the previous study, an analogue circuit including Analog to Digital Converter (ADC) was developed for three-axis sensor core development and sensor signal processing using Metglas 2714A, an unformatted material. This study addressed the instability of the signal due to parasitic capacity components of the sensor Pick-up coil To resolve this, the circuit was calculated for instability, the resistance was connected in parallel with the Pick-up coil, and the appropriate resistance value was determined. In addition, the feed-back circuit was designed using V-I Converter and Digital to Analog Converter (DAC) to overcome nonlinearity of sensors. It is planning to test operation using the developed Fluxgate within this year.

[P-139] Comparison of Satellite ETB Test Result with/without Satellite Dynamics Simulator

Seung-Hun Lee, Hyungjoo Yoon

Korea Aerospace Research Institute

The satellite dynamics simulator (SDS) has been developed for testing on satellite electrical test bench (ETB) and simulates the electrical signal inputs and outputs of all the sensors and actuators used in the attitude control subsystem of satellite. When the SDS is run independently, it does the function of performance analysis simulator which includes not only all sensors and actuators models of the satellite but also control algorithm code together. By independently operating the SDS, the desired operation mode is simulated and the satellite control result is generated through calculation of current attitude, determination of errors between target point and current attitude, and actuator driving. It also includes a software model that simulates space environment, such as ephemeris and disturbance, in order to implement a more rigorous verification environment. Verification of the SDS was carried out through the additional SDS which also served as a backup function in case of emergency. We confirmed that there is no problem in connecting the SDS to ETB through the interface check test. In this presentation, we show that the SDS operates without error by comparing the result of satellite operation mode using only the SDS and the result of satellite operation mode using the SDS an ETB.

[P-140] Interface Check Test Result Between Satellite Dynamics Simulator and Electrical Test Bench

Seung-Hun Lee, Hyungjoo Yoon

Korea Aerospace Research Institute

The satellite dynamics simulator (SDS) has been developed for testing on satellite electrical test bench (ETB) and simulates the electrical signal inputs and outputs of all the sensors and actuators used in the attitude control subsystem of satellite. To verify the development of the SDS, additional SDS was developed and a close-loop test between two SDS was performed to confirm that the desired signal was transmitted and received. After that, SDS was installed on the ETB and the interface test was performed to see whether the electrical signal input/output is transmitted or received within the normal range of data. In this presentation, we compare the data exchanged between the SDS and the ETB to explain that the expected signal was transmitted and received without any problems.

[P-141] Study on the EDAC Error Processing for Memory with PCI Bus in LEO-Satellites

Jae-Seung Lee, Jong-Wook Choi

Korea Aerospace Research Institute

In LEO-Satellites, SGM(Safe-Guard Memory) is used for fault management. SGM contains 3 kinds of information for satellite operation and fault detection and isolation. The first data is commands uplinked from the ground. The second data is CODA(Contingency Operation Data Area) that includes fault triggering information, error information, the last status of satellite, and information for recovery procedure. The last data is code blocks to be applied for Code Patch.
Various kinds of errors can be occurred in satellite memory due to space environment. Thus, EDAC(Error Detection and Correction) function is applied to satellite memory to cope with these errors.
In this paper, the method to detect and process the Single-bit/Double-bit EDAC errors occurred in SGM will be described. This method can be used to resolve abnormal operation or fault. And it can also provide detailed information about the problem and for the proper recovery process.
In particular, PCI Bus interface is used to communicate between processor module and SGM, the error condition and position can be reported by reading AHB Status register and AHB Failing Address register.

[P-142] Approach Method for Review of Space Material (Example: Urethane Conformal Coating)

Juhun Rhee

Korea Aerospace Research Institute

Materials for space are reviewed with the consideration of the space environment, therefore, satisfies the requirements described herein. Due to limited life, safety concerns or known instability, the restricted materials (see the presentation materials) are not recommended. And, the corrosion resistant, stress corrosion cracking, susceptibility of hydrogen embrittlement, avoidance of magnetism, fluid compatibility, vacuum stability(TML/CVCM requirements), nonflammability or self-extinguishing in air, resistant to atomic oxygen erosion, radiation sensitivity, and electrostatic discharge protection are reviewed to choose the proper materials for space. This paper describes the requirements for the space materials, as an example, illustrates the suitibility of the urethane conformal coating/Arathane 5750-A/B(L/V) for the space materials.

[P-143] Technical Considerations on Design/Manufacture of Composite Grid Stiffened Structure

Juhun Rhee

Korea Aerospace Research Institute

Grid stiffened composite structures generally consists of the thin outer skin that employs a repetitive triangular or rectangular pattern of stiffening ribs, providing lightweight characteristics and excellent bending stiffness. It has been applied to the launch vehicle payload fairing and spacecraft structures. The dimension of the substrate panel consists of 860×890×21.14mm3. The skin and ribs are designed to be co-cured with the PAN-based CFRP prepreg M55J/epoxy. This paper shows the technical determinations for the Pan-based carbon fibers instead of the Pitch-based carbon fibers that have the excellent tensile modulus and high thermal conductivity, the stacking sequence of the skin and ribs to minimize the thermal deformation, the material selection of the tooling blocks(teflon, aluminum or steel) to manufacture the ribs of the 3.0mm thickness, and the fillet dimension of the tooling block edges due to the superposition of the prepreg at the intersection nodes of the ribs.

[P-144] STM Jitter Test and Verification for Electro Optical Satellite

Jeong-Heum Im[1], Jae-Hyuk Lim[2]

[1]*Korea Aerospace Research Institute*
[2]*Chonbuk National University*

Developing a satellite system requires considerable time and cost. It is obvious that it will require quite a time and expenses to recover them in case of system level failure. To reduce these kinds of risks, it is general to develop several types of system verification model together with the flight model. Objectives of the CAS500 satellite program are to provide submeter level of high resolution electro optical earth ground images and to transfer satellite system developing technologies to domestic enterprises. As for the CAS500 program, to mitigate the above mentioned programmatic and technical risks, one ETB (Electrical testbed), one

STBM (Software testbed) and one STM (Structural thermal model) are developed together with one FM (Flight model). For the CAS500 satellite which is equipped with a high resolution electro optical camera payload, jitter is one of the main factors which affects final product, image performance. CAS500 satellite has two main jitter sources, one is the RWA (Reaction wheel assemblies) and the other is XAA (X-band antenna assemblies). This paper described jitter analysis and STM jitter test for the CAS500 satellite system. Base on the test evaluation, it was concluded to re-manufacture the XAA. After re-manufacturing and retest of the XAA, it is shown that the requirement was met finally.

[P-145] Design of Signal Processing Unit in Dynamic Force Measurement System

Jong-Min Im, Nam Jin Moon, Chang Rae Cho

Korea Aerospace Research Institute

KARI has developed force measurement device to reduce the over-testing problem during the spacecraft vibration testing. This system allows the measurement of forces and moments applied to satellite interface during the vibration test. By using the forces and moments information, double controlled method using acceleration and force can be applied during the vibration test. Generally it is called as the force limited control method. In the force limited vibration test, the forces and moments measurement and control technology are critical. Therefore design on the mechanical interface on force sensors, the collection and processing of force signals should be implemented with high requirements.
In order to use the forces and moments information in the vibration control, the measured force signals from the many locations of satellite interface should be collected and processed to give resultant forces and moments. So the signal processing unit should be developed for this function.
In this paper, design and development process on signal processing unit are presented.

[P-146] Operational Assessment & Design Improvement of High Frequency Acoustic Source

Jong-Min Im, Chang Rae Cho, Nam Jin Moon

Korea Aerospace Research Institute

During the launch process of a satellite, the satellite is affected by acoustic loading induced by vibration and jet noise of launch vehicle. The acoustic loading cause the random vibration and fatigue effects in the satellite structure. To qualify acoustic environment during its flight, acoustic test is performed at ground facility. For the acoustic test, the high intensity acoustic chamber is used which can generate the acoustic energy of 150dB in the volume of 1200m3. The acoustic source is the core element part to generate high intensity sound. KARI has developed the high frequency acoustic source for the koreanization of test facility element.
In this paper, operational assessment for the acoustic source is presented to verify the performance of acoustic source. Firstly, by applying a standards test spectrum in progressive wave tube, performance of acoustic power is verified. Based on the test results, the modifications for acoustic source are investigated.

[P-147] Analysis of Conducted System EMC Safety Margin of Compact Satellite

Kyung-Duk Jang, Tae-Youn Kim, Jae-Woong Jang, Chang-Eun Lee

Korea Aerospace Research Institute

Analysis of conducted system EMC margin of compact satellite was performed. Every units of the satellite system make conducted current noise, and the current noise is combined at the power distribution units and make voltage noise. That voltage noise will affect other units in the same satellite system, and may make some problem, such as malfunction or degradation of performance. Therefore, all unit should be performed EMC test to verify their EMC performance. At the satellite system level, the combined voltage noise should be lower than the voltage level of the conducted susceptibility test at least 6 dB so that the satellite system has conducted EMC safety margin. In this analysis, the total voltage noise at the power distribution unit output are calculated by combining all the current noise from all units and multiplying the power line impedance. Then, compared the voltage noise to the CS test voltage level, and verified the compact satellite system has conducted EMC safety margin.

[P-148] Analysis of Radiated System EMC Safety Margin of Compact Satellite

Kyung-Duk Jang, Tae-Youn Kim, Jae-Woong Jang, Chang-Eun Lee

Korea Aerospace Research Institute

Analysis of radiated system EMC margin of compact satellite was performed. Every units of compact satellite radiate the electric emission noise over the air, and the radiated noise will affect the other units and make some problem. Therefore, all the units have to be verified their EMC performance. At the satellite system level, the electrical field noise from all units will be added each other, and getting higher. For the system EMC margin, it should be lower than the electric field level of the radiated susceptibility test. In this analysis, the total electrical field noise has been calculated, and compared to the electrical noise level of RS test. Assume the distance between E-field source and vitctim unit are 10 cm for the worst case, nevertheless the

analysis shows the compact satellite has enough radiated system EMC safety margin.

[P-149] Trade-Off Study for Next GEO Satellite with full Electric Propulsion System

Sung-Soo Jang

Korea Aerospace Research Institute

New geostationary satellites in Korea are expected to continue to be developed in order to carry out various missions such as weather monitoring, ocean and environmental observation, and high-speed broadcasting communication, etc. And satellite gradually will be required to be developed with high performance in order to perform various missions more precisely and efficiently. In order to perform the mission with high performance, it is expected that the weight of satellite is expected to increase due to many components. As a result, it will be cause much maintenance cost of satellites in operation. Especially propellant, which make up a significant portion of the weight of satellites, typically require a large amount of chemical propellant to transfer to GEO and for station keeping in orbit. If the capacity of conventional chemical propellant can be reduced, the overall development cost of the satellites can be reduced and/or the capacity of the satellite to adopt payload is expected to increase further. In recent, electric thrusters have been considered in many satellites as a way to reduce the weight of satellites. This paper summarizes the trend of satellites with full electric thruster, and also shows the preliminary satellite configuration and results of trade-off for system budgets.

[P-150] Countermeasure Against Thruster Firing Failure Caused by Malfunction of Valve Drive Electronics in Satellite

Hyeon-Jin Jeon and Jong-Oh Park

Korea Aerospace Research Institute

In satellites, thrusters are an essential actuator for controlling attitude of satellite in safe-hold mode. If a valve drive electronics (VDE), which control thrusters, has any malfunction to cause thruster controlling problem, all elements like VDE, thruster, and even input signals to VDE shall be switched to its redundant side. The reason why all elements shall be switched is no one know which element causes the thruster firing problem. Regarding input signals to VDE, time mark can be one of its examples. This is because time mark signal can be used to count thruster firing time or initiate thruster firing.
This paper studies countermeasures against thruster firing failure caused by malfunction of valve drive electronics in satellite. This paper can be a guideline for any similar applications.

[P-151] Detecting Anomalous Patterns in Attitude Control Telemetry of Low Earth Orbit Satellites

Dawoon Jung

Korea Aerospace Research Institute

Satellite attitude control typically produces large volumes of telemetry containing data such as attitude sensor and actuator readouts, and current satellite attitude and angular rate. While alarms are routinely used to signal anomalies in individual telemetry mnemonics, gradual deterioration of parameters is not easily detected in practice. This work outlines some preliminary work in both simple and sophisticated, automated techniques to detect anomalous trends in attitude control telemetry. The techniques outlined here can be used during pre-launch attitude control software testing, and during post-launch operations.

[P-152] Calibration of KMAG's on board Magneto-resistive Sensor

Byungwook Jeong[1], Hyojeong Lee[1], Jehyuck Shin[1], Seungah Lee[1], Ho Jin[1,2]

[1]*School of Space Research, Kyung Hee University*
[2]*Department of Astronomy & Space Science, Kyung Hee University*

KMAG (KPLO MAGnetometer) is one of scientific payloads in KPLO (Korea Pathfinder Lunar Orbiter). The scientific objective of KMAG is the measurement of the magnetic field on the moon using three fluxgate magnetometers in a 1.2 meter boom structure. The KMAG payload consists of MAG (MAGnetometer) unit and FCE (Fluxgate magnetometer Control Electronics) unit. In addition to these scientific fluxgate sensors, On-Board Computer (OBC) has a magneto-resistive sensor to measure the magnetic interference which is generated by inner instrument of the spacecraft. For the calibration of this sensor, we performed by placing electronics including magneto-resistive sensor at the center of Helmholtz coil that generates constant magnetic field. In this study, we described the calibration test procedure and the result about the magneto-resistive sensor. For the future, we expect that this research is able to use as a reference data to reduce magnetic interference from spacecraft.

[P-153] Reentry prediction based on estimated ballistic coefficient using two line elements

Okchul Jung, Jaedong Seong, Daewon Chung

Korea Aerospace Research institute

Some space objects with low altitude pose risks to human on the Earth during the atmospheric reentry phase, which is one of hazards from space. In order to mitigate and/or identify these risks, precise reentry prediction is an essential research area. However, the major source of error in reentry prediction is the perturbation

force due to atmospheric drag which mainly depends on the drag coefficient, area-to-mass ratio, and the atmospheric density. Although the atmospheric density can be assessed by using many well-known models, the drag coefficient and area-to-mass ratio, which can be combined into ballistic coefficient is too difficult to compute them because of their uncertainty as well as lack of available information. In this paper, the reentry prediction with estimated ballistic coefficient is investigated by using historical TLE(Two Line Element) data of reentered objects. The ballistic coefficient is estimated by using two different approach. One is to find the ballistic coefficient by comparing the change on semi-major axis which is numerically propagated from the TLE data set. The other method is to directly estimate ballistic coefficient during the orbit determination process by using generated pseudo measurement data from the TLE. In order to validate the methodology, case study results are compared with previous reference papers.

[P-154] Design and Fabrication of Power Station for Power EGSE

Seung Won Cho, Dong Chul Chae, Yun Goo Huh

Korea Aerospace Research Institute

Power Electrical Ground Supporting Equipment (EGSE) is utilized to provide electrical power to low earth orbit or geostationary orbit satellite for various electrical integration test during Assembly Integration & Test (AI&T). The power station provides the electrical protected bus and battery power through the protection module to spacecraft. power station was designed to monitor bus and battery discharge regulator power bar voltage and current. It also provides buzzer and lamp alarm function. The test interface for checking insulation between power bar and ground is provided. For safety, the fuse was applied against over current or over voltage signals and diode was installed to prevent reverse current. In this paper, the detailed design of the power station for the power EGSE is described and it is also shown that the power station is fabricated as designed.

[P-155] Introduction on Solar array Deployment Test on System Level of GK2

Chang-Kwon Cho, Young ho Cho, Hyung Wan Kim

Korea Aerospace Research Institute

The Geostationary Earth Orbit-Korea Multi-Purpose SATellite-2 (GK2)) completed the Overall Integration of satellite according to the planned schedule and conducted a Pre-Shipment Review(PSR) meeting in early September as the final test with the ground station was completed. Currently, only shipments are left in satellite containers.
Generally, Solar Arrays provide power to satellite. Satellite use battery power from wating on the ground before the launch and until it is separated after the launch. So we need to deploy solar array to get power as soon as possible. For this reason, the deployment of solar Array is very important for satellite operation. In order to reduce the risk of vibration until the satellite reaches its desired target orbit and deploys the solar array, it uses a hold-down point mechanism to secure the solar panels firmly to the satellite body. In space at extremely low temperatures, a piezoelectric plate will be burst to release the fixed pin and a complete deployment will be carried out using the Motor Gear Unit(MGU) with the micro switch.
This paper will introduce the test performed at the system level with regard to the deployment of solar array.

[P-156] Accelerometer Calibration for Satellite Dynamic Test

Chang-Rae Cho, Sung-Hyun Woo

Korea Aerospace Research Institute

Dynamic test of the satellite is an essential work to qualify its design and structural performance under the launch environment which is mainly represented by high level vibration and acoustic excitation induced by the launch process. For conventional vibration tests, accelerometers are used as primary sensors to pick up the acceleration responses on the interested locations so that the reliability of the accelerometers is of quite an importance for the accuracy of the entire test results. This paper presents overall explanation on KARI's process for the calibration and maintenance of the accelerometers to be used for the space program applications and equipment involved for the work.

[P-157] Pyroshock Test of Satellite Components

Chang-Rae Cho, Sung-Hyun Woo

Korea Aerospace Research Institute

Shock excitation represented by high level acceleration, high frequency contents and short time duration is induced by activation of pyrodevice on satellite and its appendage separation system and can cause a catastrophic result being transferred to critical and sensitive components of satellite. For this reason, the shock test to check the design and functionality of the space hardware under the shock excitation on the ground is quite an essential work to be done in the frame of the space hardware development. This paper provides the theoretical explanation, the introduction to the test equipment operated by KAR and the procedure usually adopted for the shock test

[P-158] GEO-KOMPSAT-2A Final Alignment Measurement and Adjustment.

JungSu Choi[1], JongSeok Park[1], InGul Kim[2]

[1]*Korea Aerospace Research Institute*
[2]*Chungnam National University*

The GK2A (GEO-KOMPSAT-2A) is a follow-up geostationary meteorological satellite to continue the Cheollian satellite, and it will be launched into space by the end of 2018. The GK2A satellite is equipped with AMI(Advanced Meteorological Imager) and KSEM(Korean Space Environment Monitor) sensor unit. The AMI sensor unit is much improved performance compared to the Chollian satellite and KSEM is a space environmental monitoring sensor developed in Korea. Geostationary satellites such as the GK2A can be serviced continuously 24 hours a day, but are much more distant from Earth' s surface than low-earth orbit satellites. Therefore, not only attitude control equipment, antennas, sensors but also the engine nozzle of the satellite for reaching the geostationary orbit must be more precisely aligned. In this study, the final alignment measurement and adjustment after GK2A thermal vaccume test and vibration test are described.

[P-159] Focal Plane Registration Algorithm for AMI on GEO-KOMPSAT-2A

Sungsik Huh, Ki-Ryeok Yong, Jae-Dong Choi

Korea Aerospace Research Institute

Image Navigation and Registration (INR) of Advanced Meteorological Imager (AMI) on GEO-KOMPSAT-2A navigates 16-channel images and resamples the images on the same coordinate for registration. All channel images are acquired by VIS and IR detectors on each focal planes.
Before launch, the every detector positions of both VIS and IR focal planes are measured. However, on the orbit, diurnal thermo-elastic deformation in the payload and temperature difference may cause geometric variation between VIS and IR focal planes.
In this paper, we address the focal plane registration algorithm to estimate the geometrical model between the focal planes to improve registration quality between VIS-IR channels.
A least-square method is applied to estimate the linear model parameters by using the predicted detector positions at the estimated INR states and the measured LOS including IR star residuals.

[P-160] Impact Analysis of INR by Detector Position Error of AMI on GEO-KOMPSAT-2A

Sungsik Huh, Ki-Ryeok Yong, Jae-Dong Choi

Korea Aerospace Research Institute

Image Navigation and Registration (INR) of Advanced Meteorological Imager (AMI) on GEO-KOMPSAT-2A estimates state vectors of the imager by star and landmark images. The state vectors are used to navigate the earth images and resample them to generate output product. During the process, noise and error affect the geometric quality of the output product, so it needs to find out the root cause by some characteristics in the output data.
In this paper, we address a case that causes erroneous resampled image which shows seriously mismatched pixels on overlapped area between two swath images.
For this case study, two resampled images computed by original detector position and error-added detector position are generated. The trending of star and landmark image processing results for both cases are compared, and we characterize the error source by the image analysis. The direct comparison method using two points without trending analysis is also presented.

[P-161] The electrical test plan for the spacecraft integration and test on the ground.

Yungoo Huh, Suwan Bang, Seungwon Cho

Korea Aerospace Research Institute

KARI (Korea Aerospace Research Institute) has been developing so many satellites. The test plan is essential for the spacecraft integration and test. First of all, the test plan must include test matrix which describes test item, test methods, criteria of success and so on to verify satellite interfaces and functionalities. All electrical tests to be performed at satellite level are split over several test groups. Each test group has its own objective and they are performed during the spacecraft integration and test on the ground. Secondly, Test team organization and Role & Responsibility are also described in the test plan. The test team should be composed of test operator, test engineer, responsible leading engineer and so on. All members have the assigned roles and responsibilities during the electrical test. Lastly, the test plan have to include test schedule, test room layout, test process from selecting test Items to analyzing test result, and test documents which are prepared, reviewed and approved.

[P-162] A Study on configuration baseline management for satellite configuration control

Kang Chul

Korea Aerospace Research Institute

After the approval of the configuration baseline and the identification, rejection of approval or approval is requested according to the necessity of change of configuration, and the implementation of the approved change is called from configuration control. In order to change

configuration during configuration control, definition of configuration baseline is required, and configuration baseline is defined by functional baseline, development baseline, and product baseline according to each development level. In this paper, we propose a new configuration baseline for configuration change control based on the definition of multi-purpose practical satellite and geostationary complex satellite.

[P-163] Assignment and management of satellite frequency resources for geostationary orbit satellite programs

Seorim Lee

Korea Aerospace Research Institute

The assignment and management of satellite frequencies forms an essential basis for the development and operation of satellites. This is particularly true for geostationary orbit satellites where orbital locations and frequencies are a limited resource. The related activities such as the notification and coordination of satellite networks have thus become a standard procedure for implementing satellite development programs. Compared to previous papers which have documented these activities with an emphasis on the assignment aspect of acquiring the necessary satellite frequencies, this paper looks at the management aspect of protecting and maintaining such assigned satellite frequencies. This will provide a more comprehensive insight necessary for the future planning of satellite frequency activities.

[P-164] Portable optical alignment system for high resolution electro-optical camera development

Youngchun Youk, Deoggyu Lee, Sang-Soon Yong

Korea Aerospace Research Institute

We developed a two-dimensional and two-angular measurement system for the optical alignment of high resolution electro-optical camera.
The existing accurate alignment system installed in KARI has been restricted that it cannot be used elsewhere after being fixed and installed.
This system was designed to be able to be installed on any optical table and was devised specially to minimize the influence from the rigidity of the optical table as a surface
Despite the convenient portable equipment, the system's accuracy and repeatability can be compared with fixed it.
In this paper, we will explain the specification and configuration, and discuss the installation and measurement results of the portable optical alignment system.

[P-165] Electro-optical camera alignment for Lunar Terrain Imager (LUTI)

Youngchun Youk, Seonghui Kim, Daejun Jung, Eung Shik Lee, Haeng-Pal Heo, Sang-Soon Yong

Korea Aerospace Research Institute

LUTI is the primary payload of Korea Pathfinder Lunar Orbital (KPLO). It is electro-optical camera system provides the high-resolution optical images of the Lunar surface.
LUTI have two optical modules and two CCD in order to meet the payload requirement. It is composed of two telescope structures.
In order to use two optical cameras with one system, not only design and manufacture, but also a different approach is required for assembly and alignment.
In this paper, we will discuss the electro-optical camera alignment with alignment configuration and conceptual design.

[P-166] Enhanced electromagnetic compatibility of electronic circuits for satellites using SMPS

Chang-Eun Lee, Jae-Woong Jang, Kyung-Duk Jang, Tae-Youn Kim

Korea Aerospace Research Institute

Radiative or conductive noise are often induced by electromechanical equipment and systems. Emissions that exceed a certain level have a significant adverse effect on equipment such as receivers in the satellite. Therefore, electromagnetic compatibility of electronic circuits should be executed to ensure that there is no excessive radiated and conducted emissions before installed on the satellite. Especially, the power source has a huge influence on the release of electromagnetic noise from electronic circuits in satellites. In this paper, radiated electromagnetic field of the satellite with SMPS(Switched-Mode Power Supply) were improved through Electromagnetic Compatibility test. This paper proposes ways to reduce electromagnetic emissions generated by systems using SMPS. We discuss how to reduce noise by placing the CM filter at the back of the SMPS with experimental data.

[P-167] Introducing the Simulation Modeling Template used in KPLO DSS (Dynamic System Simulator)

Hoonhee Lee

Korea Aerospace Research Institute

KARI is developing Korea' s first lunar probe, KPLO(Korea Lunar Pathfinder Orbiter). KPLO DSS (Dynamic System Simulator) as a ground support simulator is composed of simulation models to simulate various areas such as KPLO itself and ground systems. This simulation model is designed from various perspectives such as each developer for a model and integrated developers. In order to efficiently carry out the design review and actual code implementation of this model, a template of the model is required

and this template should be reusable in the next project or next simulator development. This paper describes how the simulator' s model template is defined for simulator development.

[P-168] Upgrade of Cooling System for Multiple Electro-dynamic Shaker system

Jong-Hyub Jun, Eui-Keun Kim

Korea Aerospace Research Institute

The vibration environment test is essential to develope artificial satellite or launch vehicle. The test goal is to verify the structural strength for each specimen. KARI performs the environment test with specific test facilities. Especially, new large vibration test system is the sole big facility for large structure like big satellite and launch vehicle stage in Korea. The vertical large vibration system consists of 4 shakers which are working simultaneously. So a bigger cooling capacity system is necessary to use the new system compared with the existing system with only 1 shaker. Therefore, through some research, upgrade of cooling system was done successfully. The upgrade makes the large vibration system working stably and the cooling system easy to handle.

Vol.27 No.2

The Proceedings of The Korean Space Science Society 2018 Fall Meeting

October 24-26, 2018

차 례

CANYVAL-C 임무를 위한 큐브위성 자세 시스템 설계 및 분석

강호철, 강대은, 김극남, 박상영†
연세대학교 천문우주학과

Design and analysis of attitude system of Cubesat for CANYVAL-C Mission

Ho-Chul Kang, [1]Dae-Eun Kang, Geuk-Nam Kim, Sang-Young Park†
Department of Astronomy, Yonsei University, Seoul, 03722, Korea

요 약

CANYVAL-C 임무는 분리형 우주망원경의 핵심기술인 관성정렬(Inertial Alignment)기술을 활용하여 태양의 코로나를 촬영하는 과학검증을 목표로 한다. 본 연구는 CANYVAL-C 임무를 수행하는 두 대의 큐브위성에 탑재될 자세 시스템의 설계와 그 분석을 다룬다. 각 위성의 자세를 결정하기 위해 태양센서와 지구자기장센서를 사용하여 자세 결정 알고리즘을 적용한다. 초기 자세 결정 알고리즘은 TRIAD 방법을 사용하고, 실시간 자세 결정에는 확장칼만필터를 사용한다. 자세를 제어하기 위해 자기장토커와 반작용 휠을 사용하여 자세 제어 알고리즘을 적용한다. 감쇠제어에는 자기장토커를 사용한 B-dot 제어를 사용한다. 1U의 지향제어에는 자기장토커를 사용한 Sliding mode 제어를 사용하고, 2U에는 반작용 휠을 사용한 PD 제어를 사용한다. 지구자기장 벡터는 IGRF-12 모델을 사용하였고, 태양 벡터는 Astronomical Almanac의 계산 방법을 사용하였다. 시뮬레이션의 결과와 주어진 요구조건의 비교를 통해 큐브위성이 태양과학 임무를 성공적으로 수행할 수 있는지를 확인하였다.

Abstract

CANYVAL-C mission is aimed at scientific verification of the Sun's corona using inertial alignment technology. This study deals with the design and analysis of attitude systems for two cube satellites performing CANYVAL-C mission. Attitude determination algorithms are applied by using the Sun sensor and the Earth magnetic field sensor. The TRIAD method is used for the initial attitude determination algorithm and the extended Kalman filter is used for real time attitude determination. Attitude control algorithms are applied by using the magnetic torquer and the reaction wheel. Detumbling control uses B-dot control with magnetic torquer. Sliding mode control using magnetic torquer is used for 1U Sun/nadir-pointing control, and PD control using reaction wheel is used for 2U. The IGRF-12 model is used for the geomagnetic field vector and the Astronomical Almanac method is used for the sun vector. By comparing the results of the simulations with the given requirements, it is confirmed that the Cube satellites could successfully accomplish the mission.

Keywords: Virtual Telescope, Cube satellite, CANYVAL-C mission, Attitude Determination and Control

1. 서 론

분리형 우주망원경은 인공위성 편대비행 기술을 이용하여 광학부와 검출부가 나뉜 형태의 우주망원경이다. 이러한 형태의 우주망원경은 두 위성의 상대위치에 따라 초점거리가 결정되므로, 임무 목적에 따라 초점거리를 조절하거나 긴 초점거리를 만들 수 있다. 이러한 분리형 우주망원경의 특징은 높은 분해능이 필요한 X선 관측 임무나 고에너지 천체 관측에 활용될 수 있다.

분리형 우주망원경의 핵심기술은 두 위성이 천체에 대해 정렬하는 기술로, 관성정렬(Inertial Alignment)이라 한다. CANYVAL-C 임무는 관성정렬 기술의 과학임무 적용 가능성을 검증하기 위해 태양의 코로나를 촬영한다. 본 임무는 태양광을 가리는 엄폐위성(2U)과 코로나 촬영을 수행하는 코로나 촬영위성(1U)으로 구성된다. 2U는 가상의 식을 구현하고 1U는 코로나를 촬영한다. 관성

정렬이 성공적으로 이루어진 경우에는 Fig.1 (a)와 같이, 성공적으로 코로나를 촬영할 수 있다.

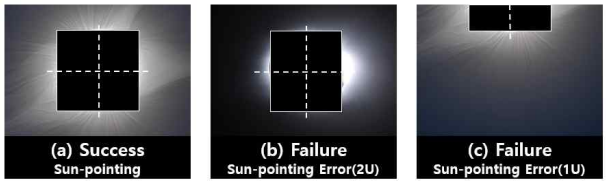

Fig. 1. Results according to the Attitude

그러나 태양 빛을 가리는 2U의 태양지향 오차가 커지면 유효 태양 차폐면적이 감소하여 Fig.1 (b)와 같이, 코로나가 관측되지 않게 된다. 또한 코로나를 촬영하는 1U의 태양지향 오차가 커지면 Fig.1 (c)와 같이, 코로나의 상이 카메라 화각을 벗어날 수 있다.

본 연구는 CANYVAL-C 임무에 사용되는 두 큐브위성의 자세에 따른 임무 성공 요구조건의 도출 과정과 시뮬레이션 분석에 기반한 검증을 다룬다.

2. CANYVAL-C 자세 시스템 알고리즘

2.1 자세 결정 요구조건

CANYVAL-C 임무에 필요한 자세 결정 요구조건은 Table 1 과 같다.

Table 1. Attitude Determination Requirement

Attitude Determination Error(3σ)	
Angle	Angular velocity
$< 1.5^\circ$	$< 0.15^\circ/s$

2.2 임무 시나리오에 따른 자세 제어 요구조건

CANYVAL-C 임무에서는 시나리오에 맞게 자세 제어를 수행한다. 각속도를 줄이는 감쇠(Detumbling) 제어는 궤도 진입 직후와 외란에 의해 Fig.2 (a)와 같이 큐브위성의 각속도가 증가하는 경우 수행한다.

코로나를 촬영할 때는 태양 지향(Sun-pointing) 제어를 한다. 태양 지향은 Fig.2 (b)와 같이 1U의 카메라와 2U의 태양광 차폐막이 태양을 향하고 자세를 유지하는 제어이다. 그리고 Fig.2 (c)와 같이 지상국과의 원활한 교신을 위해 지구 지향(Nadir-pointing) 제어를 수행한다.

자세 제어 요구조건은 Table 2 와 같다.

Table 2. Attitude Control Requirement

	Control	Pointing Error	Angular velocity
1U	Detumbling	–	$< 2^\circ/s$
	Sun-pointing	$< 5.0^\circ$	$< 0.5^\circ/s$
	Nadir-pointing	$< 45.0^\circ$	–
2U	Detumbling	–	$< 2^\circ/s$
	Sun-pointing	$< 3.0^\circ$	$< 0.5^\circ/s$
	Nadir-pointing	$< 45.0^\circ$	–

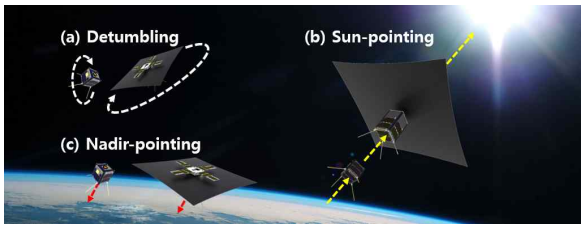

Fig. 2. Attitude Control

2.3 자세 시스템 알고리즘

큐브위성의 자세 결정을 위해 태양 센서, 자기장 센서, 그리고 자이로 센서를 사용한다. 초기 자세 결정은 TRIAD 방법을 사용하여 결정하며, 초기 자세 결정 이후의 자세 결정은 확장칼만필터를 사용한다. 식 구간에서는 태양 벡터 대신 지구자기장 방향벡터의 변화량을 사용한 보조벡터를 사용하여 자세를 결정한다. 자세 제어를 위해 1U는 자기장 토커를 사용하고, 2U는 자기장토커와 반작용 휠을 모두 사용한다. 각각의 자세 제어에 대해 사용하는 구동기와 제어기는 Table 3 과 같다.

Table 3. Controller

	Control	Actuator	Controller
1U	Detumbling	MTQ	B-dot
	Sun-pointing		Sliding mode
	Nadir-pointing		
2U	Detumbling	MTQ	B-dot
	Sun-pointing	RWA	PD
	Nadir-pointing		

3. 소프트웨어 시뮬레이션 결과

감쇠 제어 시뮬레이션은 큐브위성의 자세가 가장 불안정해질 수 있는 상황인 사출 직후 상황을 가정하여 수행하였다. Fig.3은 초기 각속도로 사출시 발생할 수 있는 최대 각속도 값인 $10^\circ/s$를 설정하여 감쇠 제어를 적용하였다. 감쇠 제어 제어기의 제어 이득 값을 조절하면 각속도의 수렴 속도를 조절할 수 있다. 이를 조절하여 감쇠 제어 시뮬레이션 결과를 궤도 6~7주기 이내에 각속도가 $2^\circ/s$ 아래로 감소할 수 있도록 설정하였다. 시뮬레이션 결과 주어진 요구조건을 궤도 6주기 이내에서 만족하는 것을 확인하였다.

Fig.4에서는 태양의 코로나를 촬영하는 상황을 가정하여

시뮬레이션을 수행하였다. 촬영 준비단계와 촬영 단계 모두 포함하여 10주기 동안 지속적으로 태양을 바라보도록 설정하고 각속도와 지향오차(Pointing error)를 확인한다. 태양 지향 제어의 경우 촬영 단계에서만 각속도와 지향제어의 요구조건을 만족하면 된다. 태양 지향 제어 시작 후 35,000초 후 10분간의 각속도와 지향오차를 확인해보면 Table 4와 같다. 이는 주어진 태양 지향 제어 요구조건을 만족한다.

Table 4. Sun-pointing result (3σ)

	Pointing Error	Angular velocity
1U	3.98°	$[0.23\ \ 0.27\ \ 0.37]^\circ/s$
2U	2.51°	$[0.19\ \ 0.20\ \ 0.20]^\circ/s$

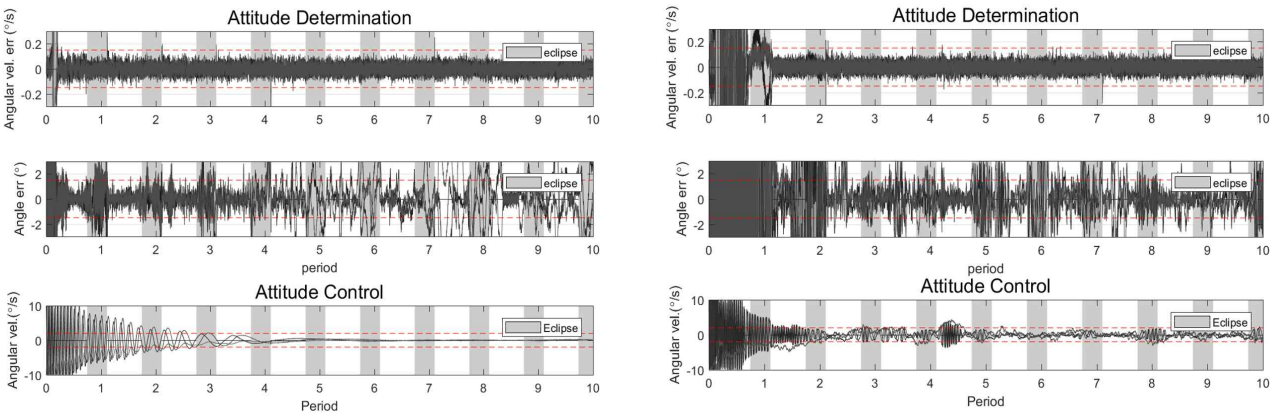

Fig. 3. Control simulation result (a) Detumbling (left : 1U, right : 2U)

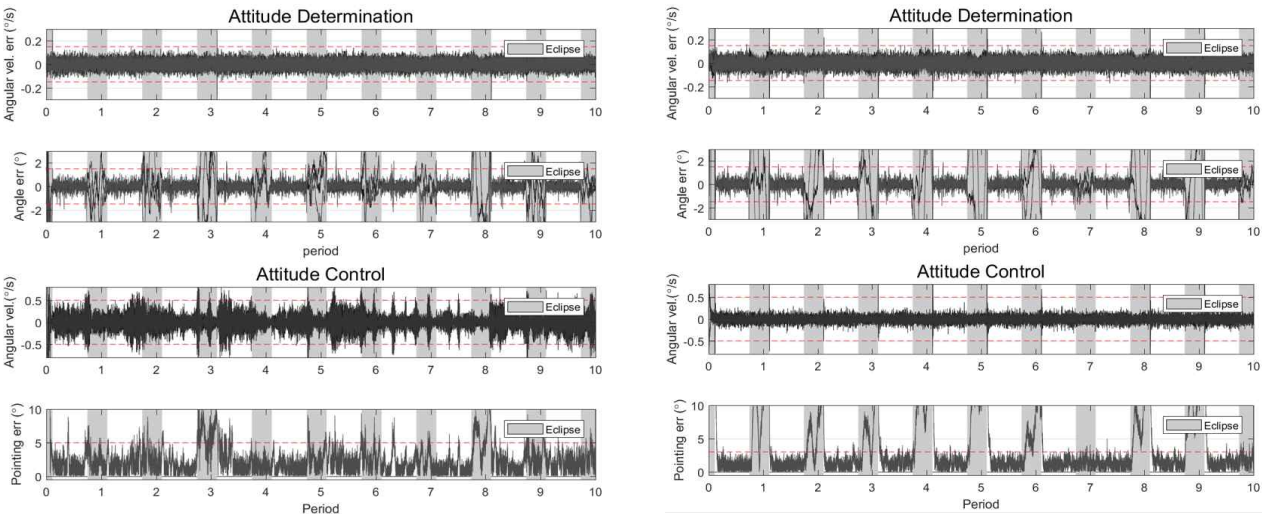

Fig. 4. Control simulation result (b) Sun-pointing (left : 1U, right : 2U)

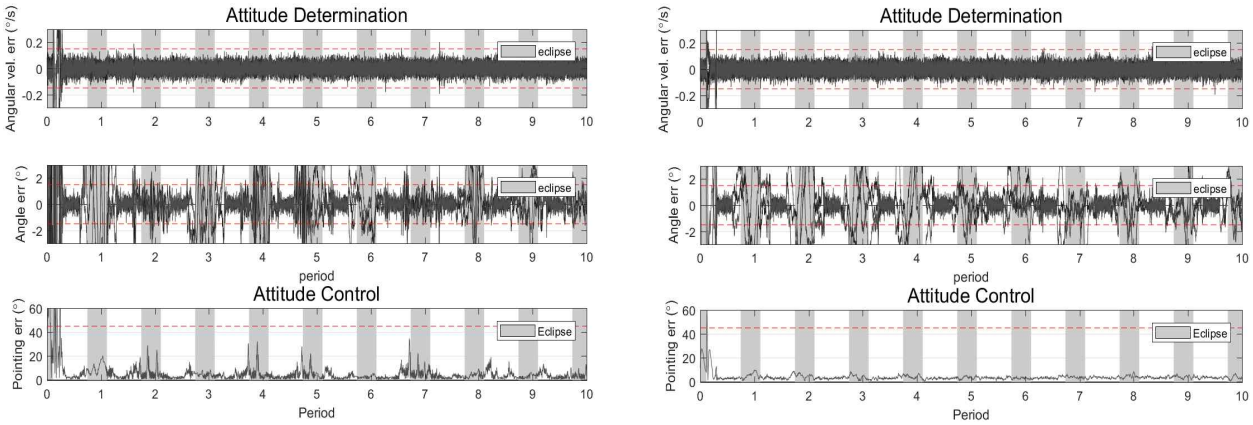

Fig. 5. Control simulation result (c) Nadir-pointing (left : 1U, right : 2U)

Fig.5에서는 큐브위성이 지상국과 통신하는 상황을 가정하여 시뮬레이션을 수행하였다. 두 큐브위성이 궤도 10주기 동안 지속적으로 지구의 중심을 바라보도록 설정하고 지향오차를 확인한다. 통신은 식 상황에서도 해야 하므로, 지구 지향 제어의 경우는 식 상황에서도 지구와 안테나가 이루는 지향오차가 이내로 유지되어야 한다. 지구 지향 제어를 하는 궤도 10주기 동안의 지향오차를 확인해보면 Table 5와 같다. 이는 주어진 지구 지향 제어 요구조건을 만족한다.

Table 5. Nadir-pointing result (3σ)

	Pointing Error
1U	30.56°
2U	10.28°

4. 결 론

본 연구는 CANYVAL-C 임무를 위한 큐브위성의 자세 시스템 설계에 초점을 두고 진행하였다. 연구 결과 현재까지 설계한 자세 시스템 알고리즘은 소프트웨어 시뮬레이션을 통해 감쇠 제어, 태양 지향 제어, 지구 지향 제어에 대해 CANYVAL-C 임무 요구조건을 모두 만족하는 것을 확인하였다. (Fig. 3~5. 점선으로 표시)

태양의 코로나를 촬영한다는 임무를 완전하게 수행하기 위해서는 아직 고려해야 하는 사안들이 남아있다. 특히 2U에는 편대비행을 위해 추력기가 사용되므로, 추력기를 사용하기 위해 수행되어야 하는 새로운 제어 알고리즘을 디자인해야 한다. 또한 시뮬레이션도 더 구체적인 상황과 하드웨어적 특성들을 반영하여 더욱 실제와 가깝게 만들고 그것을 통해 임무가 진행되는 동안 발생할 수 있는 사건들에 대해 분석해 보아야 할 것이다. 특히 이는 실험과 병행하여 실제로 하드웨어들이 주변 환경에 어떠한 영향을 주는지 확인해보고 필요한 경우 그 현상을 모델링하여 시뮬레이션에 적용해야 한다.

감사의 글

이 논문은 2018년도 정부(과학기술정보통신부)의 재원으로 한국연구재단의 지원을 받아 수행되었습니다.
(NO.NRF-2018M1A3A3A02065610, 우주핵심기술개발사업)

참고문헌

B. R. dennis, G. K. Skinner, M. J. Li, A. Y. Shih, “Very High-resolution Solar X-Ray Imaging Using Diffractive Optics,” Solar Physics, Vol. 279, Issue 2, pp. 573~588.

Jae-Pil Park, Sang-Young Park, Young Bum Song, Guk Nam Kim, Kwangwon Lee, Hyungjik Oh, Jin-Chul Yim, EunJi Lee, Soon-Hong Hwang, SungWoo Kim, Seok Ju Kang, Min-Sik Kim, Sungmin Jin, Jiyoon Hwang, Soo Hwi Lee, Sang Hoon Kwon, Dong Shin Lee, Won-Hyuk Cho, Jung-Hyun Park, Seung-Won Yeo, Joong-Won Seo, Kang Been Lee, Seung-hee Lee, Jin-Ho Yang, Jungpyo Lee, Yong Woo Kim, Tae-Hyun Kim, *“System Development for CANYVAL-X(CubeSat Astronomy NASA and Yonsei by using Virtual telescope ALignment-eXperiment) Mission,” KSAS 2016 Spring Conference,* 2016.4, pp. 334~339

시험용 달 궤도선 (KPLO)의 운동학적 궤도력 생성기 개발 : 알고리즘과 성능 검증

송민섭, 김영광, 박상영†
연세대학교 천문우주학과, 우주비행제어 연구실

Development of Kinematic Ephemeris Generator for KPLO : Algorithms and Performance verification

Min-Sup Song, Young-Kwang Kim, Sang-Young Park†
Astrodynamics and Control Laboratory, Department of Astronomy, Yonsei University, Seoul, 03722, Republic of Korea

초 록

시험용 달 궤도선의 궤도력 생성 알고리즘은 크게 두 가지 방법으로 개발 중이다. 이 중 하나는 온보드에서 궤도 전파를 하여 궤도력을 계산하는 동역학적 방법이며, 다른 하나는 지상국에서 궤도전파 결과를 압축하여 온보드에 전송하고 이를 통해 온보드에서 궤도력을 계산하는 운동학적 방법이다. 본 연구에서는 이 중 운동학적 궤도력 생성기의 궤도력 생성 알고리즘 제시 및 궤도력 생성기 개발과, 개발된 알고리즘을 통한 궤도력 계산이 요구조건을 만족하는지 검증 한다. 궤도력 생성 알고리즘의 핵심은 Chebyshev 보간법을 이용한 궤도력 압축이며, 이는 적은 데이터를 전송하여 궤도력 계산을 수행하고 최대오차가 작다는 장점이 있다. 실제 임무 궤도인 달 저궤도에서 시뮬레이션을 수행한 결과, 특정 보간 차수와 보간 간격에 대해 궤도력 계산 오차가 요구조건을 만족함을 확인 하였다. 따라서 이 연구에서 개발한 알고리즘을 시험용 달 궤도선 미션에 활용할 수 있다.

Abstract

Two methods of ephemeris generation algorithms for the Korea Pathfinder Lunar Orbiter (KPLO) are under development. One of these is dynamical method that calculates ephemeris in onboard propagation and the other is kinematical method that compress ephemeris in ground station and transmits it to onboard. In this study, kinematic ephemeris generation algorithm is presented and performance of it is verified. The core method of this algorithm is ephemeris compression using Chebyshev interpolation and it has advantages of calculating ephemeris with small amount of data and having small maximum error. As a result of simulations on Lunar low orbit, which is the actual mission orbit, it is confirmed that the error of the ephemeris calculation satisfies the requirements for the specific interpolation degree and interpolation interval. Hence, the algorithm developed in this study can be utilized for the KPLO mission.

Keywords: Ephemeris Compression, Chebyshev interpolation, Korea Pathfinder Lunar Orbiter(KPLO)

1. 서 론

시험용 달 궤도선 (Korea Pathfinder Lunar Orbiter, KPLO)은 현재 개발 중인 대한민국의 첫 번째 달 탐사선으로 2020년에 발사될 예정이며, 달 표면 100 km 상공에서 임무를 수행한다. 달 탐사 임무를 수행하기 위해서는 탐사선 온보드에서 궤도력 계산을 수행해야 하는데, 이를 위해 한국 항공우주연구원과 카이스트, 연세대학교에서는 현재 동역학적 방법과 운동학적 방법으로 궤도력 생성기를 개발 중이다. 이 중 동역학적 방법은 탐사선에서 궤도 전파를 하는 방법으로 현재 카이스트에서 개발 중에 있으며. 운동학적 방법은 지상국에서 전송한 궤도력 압축 데이터를 이용하여 궤도력을 계산하는 방법으로 현재 연세대학교에서 개발 중에 있다.

운동학적 궤도력 생성기를 개발하는데 있어서 고려하여야 할 점은 전송할 수 있는 궤도력 압축 데이터의 크기가 제한된다는 점이다. 이는 달 탐사 임무가 심우주 환경에서 수행되므로 통신제약이 있기 때문이다. 반면 적은 데이터로도 정확성을 보여야 하는데, 현재 제시된 요구조건은 탐사선의 궤도력의 경우 하루 궤도전파 결과를 압축한 데이터의 크기가 10,000 byte 이내, 압축한 데이터를 이용해 궤도력을 계산한 결과가 최대 거리 오차 50

m 이내를 가져야 하며, 태양과 달의 궤도력의 경우 최대 각오차가 각각 0.00012°, 0.001° 이내여야 한다.

현재 개발 중인 운동학적 궤도력 생성기는 JPL planetary Ephemeris의 천체궤도력 압축 방법을 참조하여 만들었다. 이 방법은 천체궤도력 전파결과를 정밀하게 근사하는 함수를 찾아 함수의 계수를 저장하는 방법이다. 보간법이 주어진 노드의 개수보다 하나 큰 차수로 함수를 근사한다면, 이 방법은 라그랑주 승수법을 이용하여 더 높은 차수의 함수로 궤도력을 근사한다. 이 때 근사하는 함수를 Chebyshev 다항식의 형태로 나타내며 천체궤도력을 Chebyshev 다항식으로 계수로 저장한다(X X Newhall 1989). JPL planetary ephemeris의 궤도력 압축 방법은 궤도를 정밀하게 근사하는 함수를 찾는데는 효율적이나 주어진 노드보다 더 높은 차수로 함수를 근사하게 되므로, 적은 데이터의 크기로 궤도력은 압축하는 것에 있어서는 비효율적인 면이 있다. 반면 보간법을 이용할 경우 주어진 노드만큼의 차수로 함수를 근사하므로 궤도력을 적은데이터로 압축하는데 있어서 비효율적인 면이 없다. 이러한 보간법을 이용한 사례로는 위성의 경우 정지궤도 위성의 사례가 있으며 , 천체 궤도력의 경우 JPL planetary ephemeris의 DE 96 버전의 사례가 있다 (Yim et al. 2014; Deprit 1979). 현재 개발 중인 운동학적 궤도력 생성기는 보간법을 기반으로 한 궤도력 압축하는 알고리즘을 가지고 있으며, 이를 다항식의 계수로 저장하는 방법을 이용하였다.

운동학적 궤도력 생성방법을 이용하기 위해서는 정밀한 궤도 전파가 필요하다. 탐사선 궤도력의 경우 정밀 궤도 전파를 수행한 결과가 필요하지만, 천체의 궤도력의 경우, 이미 JPL planetary ephemeris에서 정밀한 동역학 모델을 통한 결과를 제공하므로 이를 이용 했다. (William M. Folkner et al. 2009)

본 논문의 구성은 다음과 같다. 먼저 운동학적 궤도력 생성기의 알고리즘을 제시한 뒤, 탐사선 궤도력과 천체 궤도력을 압축하는 방법에 대해 기술한다. 이후 실제 달 탐사 궤도에서의 시뮬레이션을 통해 요구조건을 만족하는 보간차수와 보간 간격이 있음을 보인다.

2. 운동학적 궤도력 생성기 알고리즘

2.1 Chebyshev 보간법

궤도력 압축은 보간을 이용하여 수행되며, 보간 오차 식은 다음과 같다.

$$f(x)-P_n(x)=\frac{f^{(n+1)}(\xi)}{(n+1)!}\prod_{k=0}^{n}(x-x_k),(x_0\le\xi\le x_n) \quad (1)$$

위 식에서 $f(x)$는 궤도력을, P_n은 궤도력을 근사하는 n차 다항함수를 나타내며 x_k는 노드를 나타낸다. $f^{(n+1)}(\xi)$는 궤도력에 따라 달라지는 부분이며, 노드 x_k를 어떻게 선정하는가에 따라 보간 오차가 달라진다. 따라서 노드를 선정할 때에는 요구조건에 맞추어 가장 작은 최대오차를 가지도록 한다. 이 때 Chebyshev 노드 $\bar{x}_k$에 대해 다음과 같은 식이 성립한다.

$$\max\prod_{k=0}^{n}|x-\bar{x}_k|\le\max\prod_{k=0}^{n}|x-x_k| \quad (2)$$

따라서 Chebyshev 노드는 다른 어떤 노드보다 보간의 최대 오차가 작으며, Chebyshev 보간법을 이용한 궤도력 압축이 요구조건에 만족할 수 있는 가장 효율적인 방법이라고 할 수 있다.

2.2 궤도력 압축 알고리즘

궤도력을 압축하는 순서는 크게 4단계로 구성된다. 첫 번째 단계에서는 근사하고자 하는 함수의 시간 간격을 설정하고, Chebyshev 노드에 해당하는 시간을 계산한다. 이 때 Chebyshev 노드를 계산하는 식은 다음과 같다.

$$\bar{x}_k=\frac{a+b}{2}+\frac{b-a}{2}cos(\frac{2k+1}{2(n+1)}\pi),\quad k=0,\dots,n \quad (3)$$

위 식에서 a는 시간간격의 시작점, b는 시간간격의 끝지점이다.

두 번째 단계에서는 Chebyshev 노드에 해당하는 시간에서의 궤도력을 계산한다. 탐사선 궤도력의 경우 궤도 전파결과를 이용하는데 궤도전파결과는 이산적인 값이기 때문에 Chebyshev 노드에 해당하는 시간의 궤도력이 없는 경우가 있다. 이러한 경우 노드에 해당하는 궤도력은 이산적인 값을 보간을 하여 찾을 수 있다. 천체 궤도력의 경우 JPL planetary ephemeris에서 근사함수의 계수를 제공하므로 이를 이용하면 Chebyshev 노드에 해당하는 시간에서의 궤도력을 계산할 수 있다.

세 번째 단계는 Chebyshev 노드에 해당하는 시간을 표준화 하는 것이다. 이 때 표준화는 적당히 작은 어떤 간격으로 해도 무관하나, 일반적으로 Chebyshev 노드는 [-1, 1]에서 정의 되므로 이 간격으로 표준화를 수행하였다. 노드를 표준화하는 식은 다음과 같다.

$$\hat{x}_k=\frac{2}{b-a}(\bar{x}_k-(\frac{a+b}{2})) \quad (4)$$

마지막으로 이전 단계에서 계산된 Chebyshev 노드에서의 궤도력, 표준화 된 시간을 이용해 보간 함수의 계수를 계산한다. 이 때 Vandermonde 행렬을 이용하면 쉽게 보간함수의 계수를 계산할 수 있다. Vandermonde 행렬을 이용한 행렬식은 다음과 같다.

$$\begin{bmatrix} C_0 \\ C_1 \\ \vdots \\ C_n \end{bmatrix} = \begin{bmatrix} \hat{x}_0^n & \hat{x}_0^{n-1} & \cdots & 1 \\ \hat{x}_1^n & \hat{x}_1^{n-1} & \cdots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ \hat{x}_n^n & \hat{x}_n^{n-1} & \cdots & 1 \end{bmatrix}^{-1} \begin{bmatrix} y_0 \\ y_1 \\ \vdots \\ y_n \end{bmatrix} \quad (5)$$

위 식에서 $\hat{x}$는 표준화 된 노드에서의 시간을 의미하며 아래첨자는 노드를 의미한다. 또한 y는 계산된 궤도력, C는 보간함수의 계수이다.

만들어진 보간계수는 그림1과 같은 형식으로 저장이 된다. 파일의 첫 번째 열은 시간정보가 적힌 열로, 각 행의 보간계수가 포함 하는 시간 중 시작시간이 적혀있으며, 온보드에서 계산의 편의성을 위해 MJD 형식으로 저장이 된다. 시간이 적힌 열은 계수가 적힌 열보다 크기가 하나 크며 마지막 행의 시간은 마지막 계수행이 끝나는 시간이다. 보간계수는 x축, y축, z축 순으로 정리되어 있으며 오름차순으로 정리되어 있다.

Time row	Coefficient sets		
MJD time (1)	X-axis coefficients (1)	Y-axis coefficients (1)	Z-axis coefficients (1)
MJD time (2)	X-axis coefficients (2)	Y-axis coefficients (2)	Z-axis coefficients (2)
⋮	⋮	⋮	⋮
MJD time (M)	X-axis coefficients (M)	Y-axis coefficients (M)	Z-axis coefficients (M)
MJD time (M+1)			

그림1. 궤도력 압축 파일의 구조

2.3 온보드 알고리즘

압축된 궤도력이 파일형식으로 온보드에 전송이 되면 온보드에서는 3가지 단계를 거쳐 궤도력 계산을 수행한다. 첫 번째 단계는 입력된 온보드 시간에 해당하는 보간 계수를 찾는 과정이며, 해당 시간의 보간 계수는 시간열을 통해 찾을 수 있다. 두 번째 단계에서는 온보드의 시간을 표준화 한다. 표준화 식은 (4)와 같으며, 시작시간 a는 해당 시간열의 시간이며, 끝 시간 b는 다음 시간열의 시간이다. 마지막으로 표준화된 시간과 보간 계수를 통해 궤도력을 계산 한다.

3. 시뮬레이션 결과

3.1 탐사선 궤도력

제시된 알고리즘의 성능을 검증하기 위하여 실제 임무 궤도와 유사한 궤도전파 결과를 만들었다. 궤도전파는 표1과 같은 조건을 주어 수행을 하였다. 전파 기간을 24일로 두었는데 이는 탐사선의 지상궤적이 달의 표면을 모두 커버하는데 소요되는 시간으로, 모든 달 중력의 섭동에 대해 궤도력 생성기의 성능검증을 할 수 있는 기간이다.

표1. 궤도전파 조건

Propagator	Type	RK89
	Accuracy	1e-13
	Step size	10 sec
	Propagation time	2 days
	Lunar model	LP-165 : 165×165
	Coordinate System	Lunar inertial Coordinate
Initial condition	Semi major axis	1850 km
	Eccentricity	0.01
	Inclination	90°
	RAAN	0°
	Argument of perigee	120°
	True anomaly	0°

탐사선 궤도력 생성기의 요구조건은 최대 위치 오차가 50 m 이내, 데이터량은 하루에 10000 byte 이내이다. 시뮬레이션은 보간 차수와 보간 간격을 독립변수로 두어 수행하였으며, 임무 운용을 고려해 보간 간격은 30분 간격으로 두었다. 위치 오차는 매 1초 간격으로 참값과 계산값을 비교하여 계산 하였고, 전체 궤도 전파 중 최대 위치오차를 구해 요구사항을 만족하는지 확인하였다. 데이터량은 다음과 같은 식을 이용하여 계산하였다.

$$\frac{86400(\mathrm{s/days})}{b-a(\mathrm{s})} \times (3n+1) \times 8(\mathrm{byte/double}) \quad (6)$$

표2는 테스트 결과 중 요구조건을 만족하는 경우이다. 테스트 결과, 달 저궤도에서 가장 최대 위치 오차를 적게 보인 경우는 보간 차수 6차 보간 간격 30분이다.

표2. 탐사선 궤도에 대한 궤도력 생성기 성능

보간 차수	보간 간격	최대 위치 오차 (m)	데이터량 (byte/day)
5	30 min	32.1195	8448
6	30 min	22.0167	9600
8	60 min	37.6575	5952
9	60 min	33.8224	6528

3.2 태양, 달 궤도력

천체 궤도력의 경우 JPL planetary ephemeris의 DE421 버전을 이용하여 궤도력의 압축을 수행하였다. 시뮬레이션은 탐사선 궤도력 시뮬레이션과 같은 방법으로 수행하였다. 시뮬레이션 기간은 실제 임무 기간을 고려하여 2020년 7월 1일부터 2022년 7월 22일로 2년으로 설정하였고, 매 1분마다 오차를 구하였다. 또한 보간 간격은 태양의 경우 8일과 16일로 달의 경우 2일과 4일로 설정하였다. 천체궤도력의 경우 주어진 요구조건은 지구에서 보았을 때 태양과 달의 각 오차가 각각 0.00012°, 0.001°이다. 이 때 각 오차는 다음과 같은 식으로 계산하였다.

$$\theta \cong \tan\theta = \frac{d_{Err}}{d_{Earth-Sun/Moon}} \quad (7)$$

d_{Err}은 계산한 궤도력의 거리오차이며, $d_{Earth-Sun/Moon}$은 지구에서 태양/달 까지의 거리이다. 데이터량 계산은 식(8)을 통해 계산하였다

.

$$\frac{30(\text{days/month})}{b-a(\text{days})} \times (3n+1) \times 8(\text{byte/double}) \quad (8)$$

표3. 태양 궤도력에 대한 궤도력 생성기 성능

보간 차수	보간 간격	최대 각 오차 (deg)	데이터량 (byte/month)
2	8 days	8.8304e-5	390
3	8 days	5.9025e-6	480
4	8 days	9.9630e-7	570
	16 days	3.8330e-5	285
5	8 days	1.5683e-7	660
	16 days	1.0760e-5	330

표4. 달 궤도력에 대한 궤도력 생성기 성능

보간 차수	보간 간격	최대 각 오차 (deg)	데이터량 (byte/month)
3	2 days	2.4898e-4	1920
4	2 days	1.2709e-5	2280
	4 days	6.9797e-4	1140
5	2 days	5.1100e-7	2640
	4 days	5.3149e-5	1320

표3과 표4는 태양과 달에 대한 궤도력 생성 시뮬레이션 결과 중 최대각 오차의 요구조건을 만족하는 경우이다. 데이터량이 가장 적으면서 각 오차의 요구조건을 만족하는 보간차수와 보간 간격은 태양 궤도력의 경우 4차, 16일, 달의 경우 4차, 4일이다.

4. 결 론

본 논문에서는 시험용 달 궤도선(KPLO)을 위한 궤도력 생성 알고리즘을 제시하였다. 운동학적 궤도력 생성기는 지상국에서 궤도력을 압축하고 이를 온보드로 전송을 하여, 온보드에서 궤도력을 계산하는 구조를 갖고 있다. 적은 데이터량으로 효율적으로 궤도력을 압축하기 위해 보간법을 이용하였으며, 보간법 중 최대 오차가 가장 작은 Chebyshev 보간법을 이용하였다. 시뮬레이션을 수행한 결과 탐사선 궤도력의 경우, 달의 임무궤도에서 보간 차수 6차 보간 간격 30분이 요구조건을 만족하며 가장 적은 최대오차를 보이는 경우이다. 마찬가지로 태양 궤도력의 경우 보간차수 4차, 보간 간격 16일이, 달 궤도력의 경우 보간차수 4차, 보간간격 4일이 가장 적은 데이터량으로 요구조건을 만족하는 경우이다.

추후 달 탐사의 임무 단계별 시나리오에 대해 궤도력 생성기 테스트를 수행할 예정이며 각 단계 별로 어떠한 차수와 어떠한 보간 간격이 효율적인지 분석을 할 예정이며 이 외에도 다양한 궤도에 대해 시뮬레이션을 수행할 예정이다.

감사의 글

본 연구는 달탐사 사업의 지원으로 수행 되었습니다 (NRF-2017M1A3A 9014638).

참고문헌

X X Newhall, Numerical Representation of planetary ephemeris (1989).

Yim JR, Park BK, Park WY, Choi, HT, Development of Onboard Orbit Generation Algorithm for GEO satellite (Aerospace Engineering and Technology 13(2) 2014.11, 7-11).

Andre Deprit, Compression of Ephemerides by Discrete Chebysehv Approximations (1979).

William M. Folkner, James G. Willams, Dale H. Boggs, Ryan S.Park, Petr Kuchynka, The Planetary and Lunar Ephemerides DE 421 (2009).

Experimental Validation of Adaptive Saturated Controller for Spacecraft Formation

[1,2]Kewei Xia, [2]Youngho Eun, [1,2]Sang-Young Park
[1]Yonsei University Observatory Yonsei University, Seoul, 03722, Republic of Korea
[2]Astrodynamics and Control Laboratory, Yonsei University, Seoul, 03722, Republic of Korea

Abstract

The experimental validation of an adaptive saturated controller for spacecraft formation flying is investigated. By introducing a smooth switching auxiliary system, a novel adaptive controller is proposed for each spacecraft in the presence of unknown inertial parameters, bounded external disturbances, and actuator saturation. The proposed controller is experimentally validated on the ground test facility, where a 3 degree-of-freedom (3DOF) floating simulator tracks a planar trajectory while synchronizing its rotation angle with the desired angle. Experimental results illustrate the effectiveness of the proposed controller.

Keywords: Spacecraft formation, Saturated control, Hardware-in-the-loop experiments

1. Introduction

With the advances in orbit activity of multiple spacecraft, formation flying control technique has become extensively interested throughout the past decades. To achieve the formation flying control objectives with high accuracy, various controllers have been developed (Kristiansen et al. 2008; Xia and Huo 2016). However, most existing results are lack of perhaps the most critical experimental validations (Ciarcia et al. 2017).

In this work, we are aiming to design an adaptive saturated controller for spacecraft formation flying and its hardware-in-the-loop validation. An adaptive robust controller is proposed for each spacecraft by introducing the signals generated from an auxiliary dynamical system. Experimental results validated on the ASTERIX facility (Eun et al. 2018) illustrate that the proposed controller guarantees the simulator subject to thruster saturation tracking a desired trajectory and robustness to the unknown parameters and disturbances and that the results meet theoretical predictions within a margin of error.

2. Controller Design

Consider the following integrated 3-DOF error dynamics of the simulator subject to thruster saturation

$$\begin{aligned} \dot{x}_1 &= x_2 \\ M\dot{x}_2 &= Bsat(p) + d \end{aligned} \tag{1}$$

where $x_1 = [\psi - \psi_d, r_x - r_{xd}, r_y - r_{yd}]^T$, $M = diag(j,m,m)$, $B = DA$, $D = diag(1, R_s^T)$, $R_s^T = [\cos\psi, -\sin\psi; \sin\psi, \cos\psi]$, p, consists of 4 pairs of thrusters, d is the disturbance generated by the testbed, and the distribution matrix A is given by $A = [l, l, -l, -l; 1,0,0,1; 0,1,1,0]$, and l is the arm of force generated by each thruster. We design the following adaptive controller

$$p = B^{+}\left(-x_1 - K_2 s - \Phi\hat{\theta} - \frac{\hat{\gamma}s}{\| s \| + \epsilon} + \kappa_1 B\chi\right) \tag{2}$$

with adaptation laws

$$\dot{\theta} = \vartheta_1\left(\Phi^T s - \vartheta_2\hat{\theta}\right),\ \dot{\gamma} = \vartheta_3\left(\frac{\| s \|^2}{\| s \| + \epsilon} - \vartheta_4\hat{\gamma}\right) \tag{3}$$

Where $s = x_2 + K_1 x_1$, $B^{+} = B^T(BB^T)^{-1}$, $K_2 = K_2^T > 0$, $\kappa_1, \vartheta_i, i = 1,2,3,4$ are positive constants, ϵ is a small constant, χ is generated by the following dynamical system

$$\dot{\chi}=-\kappa_2\chi-\frac{h(\chi)s^TB\triangle p}{\|\chi\|^2}\chi+(1-h(\chi))\triangle p \quad (4)$$

where $\triangle p=sat(p)-p$, and $h(\chi)$ is a switching function (Xia and Huo 2016) If the control parameters are chosen based on $\lambda_{\min}(K_2)\geq\kappa_1\alpha_1+\alpha_2$ and $\kappa_2\geq\frac{\beta\kappa_1}{4\alpha_1}+\alpha_3$ with α_i, $i=1,2,3$ being arbitrary positive constant and $\beta=sup(\|B\|^2)$, then the ultimate boundedness of the closed-loop system is achieved.

3. Experimental Results

We consider the experiment scenario of the spaceflight simulator tracking an elliptical trajectory on the surface of the testbed while synchronizing its rotation angle with the desired angle. The desired planar trajectory and desired rotation angle are governed by

$$\psi_d=\psi(0)-\frac{\psi(0)}{150}t,\ r_{xd}=\cos\left(\frac{\pi}{75}t\right),\ r_{yd}=0.15\sin\left(\frac{\pi}{75}t\right)$$

The experiment time is 150 s. The control parameters are chosen as follows: $K_1=K_2=diag(2.4,6,6)$, $\kappa_1=0.1$, $\kappa_2=1$, $\vartheta_1=0.02$, $\vartheta_2=0.001$, $\vartheta_3=0.04$, $\vartheta_4=0.005$, and $\epsilon=0.005$. The experimental results are presented in Figs.1-4.

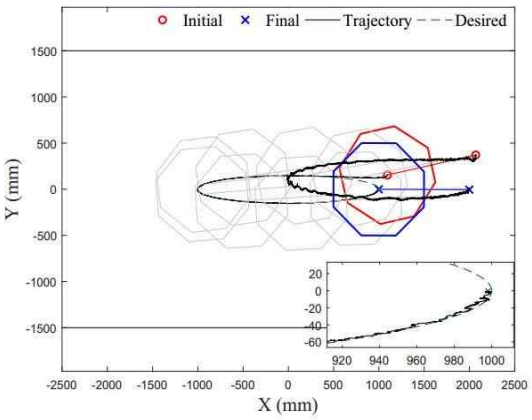

Figure1. Experimental result: trajectories of simulator

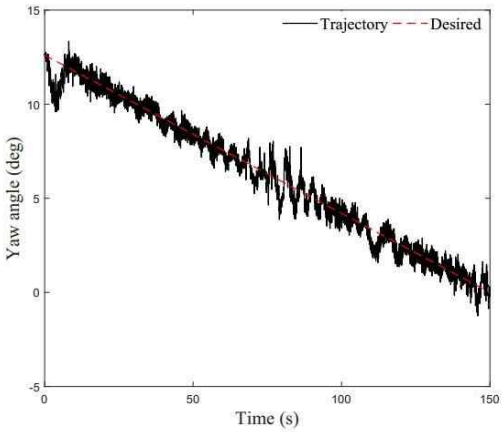

Figure2. Experimental result: rotation angle of simulator

Fig.1 illustrates the top view of the experiment, where the red octagon and solid line each denotes the initial orientation and the x-axis in body-fixed frame representing initial angle of the simulator and the blue octagon is the final orientation of the simulator. It can be observed that the simulator tracks the desired elliptical trajectory while keeps its angle synchronizing with the desired angle throughout the experiment with a good performance. Fig.2 shows the time histories of the simulator's angle compared with the desired angle. Besides, the command control of each thruster is collected in Fig.4. It can be seen that all the control signals are within their magnitude constraints, respectively.

4. Conclusions

In this paper, we present the hardware-in-the-loop experimental validation of an adaptive saturated controller for spacecraft formation flying subject to unknown inertial parameters and disturbances. To satisfy the magnitude constraint of each thruster, a new continuous auxiliary dynamical system is developed to compensate for the nonlinear term arising from the input saturation by employing a smooth switching function. The performance of the proposed controller is experimentally evaluated on the ASTERIX facility for a 3 DOF floating simulator tracking an elliptical trajectory while synchronizing its rotation angle with the desired angle, where the angle error is within one degree and the tracking errors of position are within one centimet

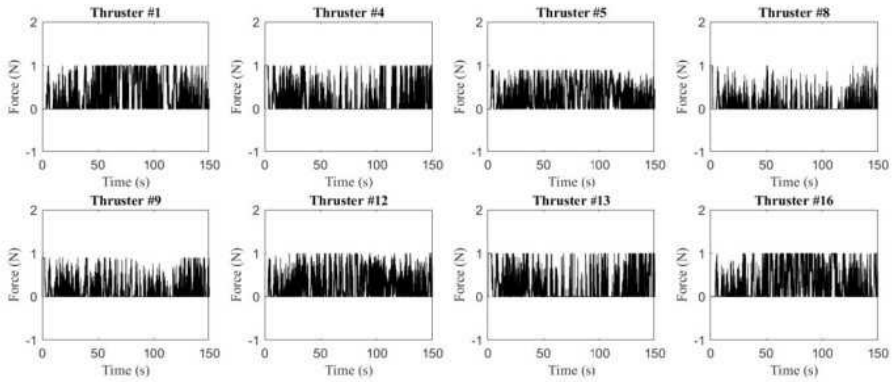

Figure3. Experimental result: command control force of each thruster

Acknowledgment

This work was supported by KASI (Korea Astronomy and Space Science Institute) and Yonsei research collaboration program for the frontiers of astronomy and space science

References

Kristiansen, R, Nicklasson, PJ, Gravdahl, JT., Spacecraft coordination control in 6DOF: Integrator backstepping vs passivity based control, Automatica, 44(11), 2896~2901, (2008).

Xia, K, Huo, W, Robust adaptive backstepping neural networks control for spacecraft rendezvous and docking with input saturation, ISA Transactions, 62, 249-257, (2016).

Ciarcia, M, Cristi, R, Romano, M, Emulating scaled Clohessy-Wiltshire dynamics on an air-bearing spacecraft simulation testbed, Journal of Guidance, Control, and Dynamics, 40(10), 2496-2510, (2017).

Eun, Y, Park, S-Y, Kim, G-N, Development of a hardware-in-the-loop testbed to demonstrate multiple spacecraft operations in proximity, Acta Astronautica, 147, 48-58, (2018).

정관 및 규정

■ 사단법인 한국우주과학회 정관 ■

1995년 5월 3일 제정
1996년 5월 4일 개정
2014년 10월 30일 개정

제1장 총칙

제1조 (목적) 이 법인은 사회일반의 이익에 공여하기 위하여 공익법인의 설립운영에 관한 법률의 규정에 따라 우주과학의 발전과 그 응용 및 보급에 기여하고 나아가 과학의 발전에 이바지함을 목적으로 한다.

제2조 (명칭) 이 법인은 사단법인 한국우주과학회(이하 학회)라 칭하고, 영어명칭은 The Korean Space Science Society 로 한다.

제3조 (사무소의 소재지) 학회의 사무소는 대전광역시 유성구 대덕대로 776 한국천문연구원 내에 둔다.

제4조 (사업) 학회는 제1조의 목적을 달성하기 위하여 다음 각 호의 목적사업을 행한다.
1. 학술적 회합의 개최
2. 학술간행물의 발행 및 배포
3. 학술자료의 조사, 수집, 교환
4. 학술의 국제교류
5. 과학기술진흥에 관한 지원 및 건의
6. 기타 본 학회 목적에 적합한 사업

제5조 (법인 공여이익의 수혜자)
1. 학회가 목적사업을 수행함에 있어서 그 수혜자에게 제공하는 이익은 이를 무상으로 한다. 다만, 부득이한 경우에는 미리 감독청의 승인을 받아 그 대가의 일부를 수혜자에게 부담시킬 수 있다.
2. 학회의 목적 사업의 수행으로 인하여 제공되는 이익은 수혜자의 출생지, 출신학교, 근무처, 직업 또는 기타 사회적 지위 등에 의하여 차별을 두지 않는다.

제2장 회원

제6조 (회원의 종류 및 자격) 학회 회원의 종류와 자격은 다음과 같다.
1. 정회원: 정회원은 우주과학에 관심을 갖는 개인으로서 대학에서 우주과학 또는 그에 관련된 과정을 수학한 자 또는 이사회에서 동등한 자격을 가진 자라고 인정된 자
2. 학생회원: 학생회원은 대학 학부 과정에서 우주과학 또는 그에 관련된 과정을 수학하고 있는 자 또는 이사회에서 동등한 자격을 가진 자라고 인정한 자
3. 준회원: 준회원은 정회원 중 과거 3년간 회원의 의무를 이행하지 아니한 자
4. 명예회원: 명예회원은 우주과학 발전에 공적이 현저하거나 학회의 목적달성에 큰 공적이 있는 자
5. 특별회원: 특별회원은 학회에 찬조 및 기부행위 또는 동등한 기여를 한 개인 또는 단체
6. 기관회원: 기관회원은 학회의 목적에 뜻을 같이하고 사업에 기여하는 학술 및 연구단체

제7조 (입회) 학회의 회원은 다음 각 호에 따라 그 자격을 얻을 수 있다.
1. 본 학회의 정회원 혹은 학생회원이 되고자 하는 자는 정회원 2인의 추천을 얻어 입회를 신청하고 이사회의 승인 후 입회금과 회비를 납부함으로서 회원이 된다.
2. 명예회원은 회장의 제청에 의하여 이사회에서 의결하여 총회에서 추대한다.
3. 특별회원 및 기관회원은 이사 2인의 추천에 의하여 이사회의 승인을 받아야 한다.

제8조 (의무와 권리) 학회 회원은 다음 각 호의 의무와 권리를 갖는다.
1. 정관 및 의결사항의 준수와 회비납부의 의무
2. 회원은 연구발표, 논문 기고 및 학술 활동에 참여할 수 있다.
3. 회원은 학회 운영에 참여 할 수 있으며, 별도 규정이 정한 바에 따라 선거권과 피선거권을 갖는다.

제9조 (회원의 탈퇴 및 권리의 정지)
1. 회원은 임의로 탈퇴할 수 있다.
2. 회원으로서 의무를 다하지 아니한 경우나 학회의 목적에 배치되는 행위 또는 명예나 위신에 손상을 가져오는 행위를 하였을 때에는 이사회의 의결로서 권리를 정지하거나 제명할 수 있다.

제3장 임원

제10조 (임원) 학회에 다음 임원을 둔다.
1. 회 장 1인
2. 부회장 1인 이상 3인 이내
3. 감사 2인
4. 이사 15인 이상 25인 이내 (회장, 부회장 포함)

제11조 (임원의 임기)
1. 임원의 임기는 2년으로 하며 연임할 수 있다. 다만, 회장은 연임할 수 없다.
2. 임원의 임기 중 결원이 생긴 때에는 2개월 이내에 이사회에서 보선하고, 보선에 의해 취임한 임원의 임기는 전임자의 잔여기간으로 한다.
3. 임원은 임기가 끝난 후일지라도 후임자가 선출 확정될 때까지는 그 직무를 담당한다.

제12조 (임원의 선임방법)
1. 회장과 감사는 총회에서 직접선거로 선출하며, 부회장은 회장이 지명하고 이사의 절반은 투표로 선출하고 나머지 절반은 회장이 지명한다.
2. 상기 임원 선출을 위하여 임원선출방법을 별도로 정하여

야 하며, 선출된 임원은 감독관청의 취임 승인을 받아야 한다.
3. 임기전의 임원의 해임은 총회의 의결을 거쳐 감독관청의 승인을 받아야 한다.

제13조 (회장 및 부회장의 직무)
1. 회장은 학회를 대표하고 학회 업무를 총괄하며, 총회 및 이사회의 의장이 된다.
2. 부회장은 회장의 직무를 보좌하며 회장 유고시 부회장 중 연장자가 회장의 직무를 대행한다.

제14조 (이사의 직무)
1. 이사는 이사회에 출석하여 학회의 업무에 관한 사항을 의결하며 회장으로부터 위임받은 사항을 처리한다.
2. 필요에 따라 이사 중에서 총무, 재무, 학술 이사 등을 둘 수 있다.

제15조 (감사의 직무) 감사는 다음 각 호의 직무를 행한다.
1. 학회의 재산상황을 감사하는 일
2. 이사회의 운영과 그 업무에 관한 사항을 감사하는 일
3. 제1호 및 제2호의 감사결과 부정 또는 불법한 점이 있음을 발견할 때에는 이를 이사회, 총회에 그 시정을 요구하고 그래도 시정치 않을 때에는 감독관청에 보고하는 일
4. 제3호의 보고를 하기 위하여 필요한 때에는 총회 또는 이사회의 소집을 요구하는 일
5. 학회의 재산상황, 또는 총회, 이사회의 운영과 업무에 관한 사항에 대하여 회장 또는 총회, 이사회에서 의견을 진술하는 일
6. 총회 및 이사회의 회의록에 기명 날인하는 일

제4장 총회

제16조 (총회의 구성 및 기능) 총회는 정회원으로 구성하고 다음 각 호의 사항을 의결한다.
1. 임원 선출에 관한 사항
2. 정관 변경에 관한 사항
3. 예산 및 결산의 승인
4. 사업계획의 승인
5. 기타 중요한 사항

제17조 (총회 소집)
1. 총회는 정기총회와 임시총회로 나누며 회장이 소집한다. 정기총회는 년 1회, 임시총회는 필요에 따라 소집할 수 있다.
2. 회장은 회의안건을 명기하여 회의 7일전에 각 회원에게 통보하여야 한다.
3. 총회는 제2항의 통지사항에 한하여서만 의결할 수 있다.

제18조 (총회의결과 정족수)
1. 총회는 국내에 있는 정회원 10분의 1 이상의 출석으로 개회한다.
2. 총회의 의사는 출석한 정회원의 과반수의 찬성으로 의결한다. 다만, 가부동수인 경우에는 의장이 결정한다.

제19조 (총회소집의 특례)
1. 회장은 다음 각 호의 하나에 해당하는 소집요구가 있을 때에는 그 소집 요구일로부터 20일 이내에 총회를 소집하여야 한다.
① 재적이사 과반수가 회의의 목적을 제시하고 소집을 요구한때
② 제15조 제4호 규정에 따라 감사가 소집을 요구한때
③ 국내에 있는 정회원의 10분의 1이상이 회의의 목적을 제시하여 소집을 요구한때
2. 총회 소집권자가 궐위되거나 또는 이를 기피함으로서 총회소집이 불가능할 때에는 재적이사 과반수 또는 국내에 있는 정회원 10분의 1 이상의 찬성으로 감독관청의 승인을 받아 총회를 소집할 수 있다.
3. 제2항에 의한 총회는 출석 이사 중 연장자의 사회아래 그 의장을 지명한다.

제20조 (총회의결 제적사유) 의장 또는 정회원이 다음 각 호의 하나에 해당하는 때에는 그 의결에 참여하지 못한다.
1. 임원 취임 및 해임에 있어 자신에 관한 사항
2. 금리 또는 재산의 접수를 수반하는 사항으로서 의장 또는 정회원 자신과 학회의 이해가 상반되는 사항

제5장 평의원회 (삭제)

제21조 (평의원의 자격 취득과 상실)

삭제

제22조 (평의원회의 직무)

삭제

제6장 이사회

제23조 이사회의 구성 및 기능) 이사회는 회장, 부회장 및 이사들로 구성되며 다음 각 호의 사항을 심의 의결한다.
1. 업무집행에 관한 사항
2. 사업계획 운영에 관한 사항
3. 예산 결산서 작성에 관한 사항
4. 총회에서 위임받은 사항
5. 정관에 의하여 그 권한에 속하는 사항
6. 기타 중요한 사항

제24조 (의결 정족수)
1. 이사회는 이사 정원수의 과반수가 출석하지 아니하면 개회하지 못한다.
2. 이사회의 의사는 출석이사 과반수의 찬성으로 의결한다. 다만 가부동수인 경우에는 의장이 결정한다.
3. 감사는 이사회에 출석하여 의견을 진술할 수 있다.

제25조 (이사회 소집)
1. 이사회는 회장이 소집한다.
2. 이사회를 소집하고자 할 때에는 적어도 회의 7일전에 목적을 제시하여 각 이사에게 통지하여야 한다.
3. 이사회는 제2항의 통지사항에 한하여서만 의결할 수 있다. 다만 재적이사 전원이 출석하고 출석이사 전원의 찬성이 있을 때에는 통지하지 아니한 사항이라도 이를 안건으로 채택하여 의결할 수 있다.

제26조 (이사회 소집의 특례)
1. 회장은 다음 각 호의 하나에 해당하는 소집요구가 있을 때에는 그 소집요구일로부터 20일 이내에 이사회를 소집하여야 한다.
① 재적이사 과반수로부터 회의의 목적을 제시하여 소집을 요구한때
② 제15조 제4호에 의하여 소집을 요구한때
2. 이사회의 소집권자가 궐위되거나 또는 이를 기피함으로서 7일 이상 이사회의 소집이 불가능할 때에는 재적이사 과반수의 찬성으로 감독관청의 승인을 받아 소집할 수 있다.
3. 제2항에 의한 이사회는 출석이사 중 연장자의 사회 아래 그 의장을 지명한다.

제27조 (서면의결 금지) 이사회의 의사는 서면의결에 의할 수 없다.

제7장 재산 및 회계

제28조 (재정) 학회의 재정은 다음의 수입금으로 충당한다.
1. 회원의 회비
2. 재산의 과실
3. 사업 수익금
4. 기부금 및 기타 수익금

제29조 (회계연도) 학회의 회계연도는 정부 회계연도에 따른다.

제30조 (세입, 세출, 예산) 학회의 세입, 세출, 예산은 매 회계년도 개시 1개월 전까지 사업계획서와 함께 이사회의 의결과 총회의 승인을 얻어 감독관청에 제출한다

제31조 (예산외의 채무부담 등) 학회의 예산외의 채무의 부담이나 채권의 포기는 총회의 의결을 거쳐 감독관청의 승인을 받아야 한다.

제8장 보칙

제32조 (해산) 학회를 해산하고자 할 때에는 총회에서 국내에 있는 재적 정회원 3분의 2 이상의 찬동으로 의결하여 감독관청의 허가를 받아야 한다.

제33조 (해산법인의 재산 귀속) 학회가 해산할 때의 잔여 재산은 감독관청의 허가를 받아 국가 또는 지방자치단체에 귀속된다.

제34조 (정관 개정) 학회의 정관을 개정하고자 할 때에는 재적이사 3분의 2 이상의 찬성과 총회의 승인을 얻어야 한다.

제35조 (시행 세칙) 정관의 시행에 필요한 세부적인 사항은 이사회에서 정하여 총회의 승인을 얻어야 한다.

제36조 (공고사항 및 방법) 법령의 규정에 의한 사항과 다음 각 호의 사항은 이를 일간신문에 공고함을 원칙으로 한다.
1. 법인의 명칭
2. 학회의 해산
3. 학회 운영과 관련하여 이사회에서 공고하기로 의결한 사항

제37조 (설립당초의 임원 및 임기) 학회의 설립당초의 임원 및 임기는 다음과 같다.

성 명	현 직	전화번호	임 기
회장 오규동	전남대학교 교수	062-520-6965	94.5-96.5
부회장 정장해	충북대학교 교수	0431-61-2313	94.5-96.5
이사 강영운	세종대학교 교수	02-460-0234	94.5-96.5
이사 김천휘	충북대학교 교수	0431-61-3139	94.5-96.5
이사 김철희	전북대학교 교수	0652-70-2807	94.5-96.5
이사 김호일	천문대 연구원	042-865-3217	94.5-96.5
이사 민경욱	한국과학기술원 교수	042-869-2525	94.5-96.5
이사 박경윤	시스템공학센터연구원	042-869-1571	94.5-96.5
이사 서경원	충북대학교 교수	0431-61-2315	94.5-96.5
이사 이영욱	연세대학교 교수	02-361-2689	94.5-96.5
이사 이용복	서울교육대학교교수	02-580-5456	94.5-96.5
이사 이우백	표준연구원천문대장	042-865-3215	94.5-96.5
이사 조경철	한국우주환경연구소장	02-761-0031	94.5-96.5
이사 천문석	연세대학교 교수	02-361-2685	94.5-96.5
이사 최규홍	연세대학교 교수	02-361-2686	94.5-96.5
이사 한원용	천문대연구원	042-865-3217	94.5-96.5
감사 나일성	연세대학교 교수	02-361-2681	94.5-96.5
감사 이용삼	충북대학교 교수	0431-61-2314	94.5-96.5

부 칙

제1조 (시행일) 이 정관은 감독관청의 허가를 받은 날부터 시행한다.
1. 1995년 12월 26일 과학기술처장관 허가
2. 1996년 7월 24일 과학기술처장관 허가
3. 2014년 12월 03일 미래창조과학부장관 허가

■ 학회운영에 대한 규정 ■

2014년 10월 30일 제정
2016년 2월 18일 개정

제1조(목적) 한국우주과학회(이하 “학회”) 정관 제35조에 근거하여 학회 운영에 필요한 사항을 규정함을 목적으로 한다.

제1장 회비

제2조(회비) 학회 정관 제7조, 제8조 및 제28조의 각 1호에 근거하여 회원이 납부해야 할 연회비는 다음과 같다.

① 임원: 10만원
② 정회원: 5만원
③ 학생회원: 1만원
④ 명예회원: 면제
⑤ 특별회원: 면제
⑥ 기관회원 : 이사회에서 결정

제3조(회비의 면제) 2년 이상 해외 체류하는 자에 한하여 연회비를 면제할 수 있다.

제2장 위원회 및 분과 활동

제4조(구분)

① 학회 정관 제4조의 학회 활동에 관련하여 아래 각호와 같이 위원회, 분과회, 그리고 연구회를 둘 수 있다.
1. (위원회) 위원회는 학회원의 학술활동에 대한 지원을 목적으로 한다.
2. (분과회) 분과회는 학회원의 전문분야별 자율적 학술활동을 목적으로 한다.
3. (연구회) 연구회는 학회원의 특정 목적 학술 활동을 목적으로 한다.

② 상설위원회로는 편집위원회, 포상위원회, 학술대회준비위원회를 둔다.
③ 특별 위원회는 학회의 필요에 따라 수시로 구성 및 해산할 수 있다.
④ 분과회의 전문 분야는 학회원들의 자율적 논의와 참여를 통하여 정하고 회칙을 정하여 이사회의 승인을 얻어야 한다.
⑤ 연구회의 특정 학술 활동 분야는 대내외적 요구에 따라 수시로 정할 수 있다.

제5조(편집위원회)

① 편집위원회는 학회에서 발간하는 정기 학술지에 게재되는 논문의 심사, 편집 및 출판을 관장한다.
② 학술이사가 위원장을 맡고, 국내위원은 15인 내외로 하며 정회원 중에서 이사회의 동의를 얻어 회장이 임명한다. 국외위원은 20인 내외로 하며 이사회의 동의를 얻어 회장이 임명한다. 임기는 모두 2년으로 한다.
③ 학술지 논문 투고규정 및 세부사항은 편집위원회에서 논의한 후 이사회의 의결을 거쳐 시행한다.

제6조(포상위원회)

① 포상위원회는 학회를 통한 대내외 수상 관련 수상자 추천 및 선발을 관장한다.
② 포상위원회의 구성은 위원장을 포함하여 5인 이내로 하되 위원은 정회원 중에서 이사회의 동의를 얻어 회장이 임명하며, 임기는 2년으로 한다.
③ 포상자의 추천 및 수상 관련 세부 규정을 둘 수 있으며, 이사회의 의결을 거쳐 시행한다.

제7조(학술대회준비위원회)

① 학술대회준비위원회는 학회가 개최하는 정기 및 비정기 학술대회와 관련된 모든 것을 관장한다.
② 위원회는 위원장을 포함한 8인 이내로 하며 위원은 정회원 중에서 이사회의 동의를 얻어 회장이 임명하며, 임기는 2년으로 한다.

제8조 (활동)

① 세부 사업계획은 자체적으로 결정하여 수립한다.
② 세부 규정 및 세부 사업계획은 이사회에 보고하여야 한다.
③ 필요시 학회에서 예산 및 행정 지원을 할 수 있다.

제3장 간행물

제9조(간행물) 학회의 간행물에 대해서는 다음과 같이 정한다.

① 정기 학술대회의 발표순서가 담긴 회보는 총무이사가 담당한다.
② 논문집 우주과학회지는 편집위원회에서 담당한다,
③ 기타 우주과학전반에 걸친 간행물에 관한 토의 및 규정은 필요에 따라 위원회를 두어 담당한다.

제4장 이사회 운영

제10조(이사회 운영)

① 이사회 직무를 수행하기 어려운 이사는 휴직할 수 있다.
② 휴직한 이사는 본 학회의 정관 24조 1항의 정원수에서 제외 한다.

제5장 규정의 개폐 및 시행세칙

제11조 (세칙) 이 규정의 시행을 위해 필요한 세부사항은 이사회의 승인을 받아 별도로 정할 수 있다.

제12조 (규정 개폐) 이 규정을 개정하거나 폐지할 때는 이사회 재적이사 과반수의 찬성과 총회의 승인을 받아야 한다.

부칙

제1조(시행일) 이 규정은 총회의 승인을 받은 2014년 10월 30일부터 시행한다.

이 규정은 이사회의 승인을 받은 2016년 2월 18일부터 시행한다.

제2조(경과조치) 이 규정이 제정되기 이전에 시행된 모든 사항은 이 규정을 따른 것으로 본다.

■ 사단법인 한국우주과학회 사무국 규정 ■

2008년 4월 24일 제정
2014년 2월 6일 개정
2014년 9월 30일 개정

제1조 (사무국) 학회 업무를 원활하게 수행하기 위하여 사무국을 설치, 운영하며, 약간 명의 직원을 고용할 수 있다.

① 사무국에는 국장, 과장 및 일반 직원의 직제를 둘 수 있으며, 이는 회장이 정한다.

② 사무국은 문서접수 및 발송, 회원관리, 회비징수와, 총회, 이사회에 대한 회의 준비, 진행 및 기록, 직인관리, 법인 관련업무, 자산관리, 회계, 서무 일반과 아울러 학회 홈페이지와 서버 관리업무를 담당한다.

제2조 (결재)

① 사무국의 모든 업무는 회장과 총무이사의 결재를 통하여 집행된다. 단 업무처리 효율을 위하여 회장이 지정한 일상 업무에 대해서는 총무이사 전결로 사후 결재할 수 있다.

② 사무국의 모든 재정 지출은 재무이사가 승인하며 회장이 정한 일정 금액 이상의 지출에 대해서는 회장의 승인을 받는다. 단 업무처리의 효율을 위하여 재무이사와 회장이 정한 일정 금액 이하의 일상적 경비는 재무이사 전결로 사후 결재할 수 있다.

제3조 (보수 및 용어의 정의)

① 국장, 과장, 일반직원은 능력과 경력을 감안하여 적절한 보수를 지급한다.

② 연봉이라 함은 매년 1월 1일부터 12월 31일까지 직원에게 지급되는 급여를 말한다. 연봉 책정은 회계연도 개시 1개월 전까지 이루어져야 한다. 단, 이사회 의결에 따라 체결 시점을 변경할 수 있다.

③ 연봉은 담당 업무를 기초로 하여 책정하며 직원과 연봉계약을 통하여 확정한다. 연봉계약은 매년 체결하며, 학회대표와 해당 직원이 연봉계약서에 서명날인 함으로써 효력이 발생한다.

④ 월급은 연봉의 1/13로 매월 말일 지급하며, 지급일이 휴일인 경우 그 전 날 지급한다. 발령 월에는 근무일을 기준으로 일할 계산하여 지급하고, 1년 이상 근속한 직원에 대해서는 해당 월의 14일 이후 퇴직하는 경우 봉급 전액을 지급하며 14일 이내인 경우에는 일할 계산하여 지급한다.

⑤ 퇴직금은 1년 이상 근속한 직원에게 지급하고, 근무 연수에 월급을 곱한 금액으로 한다. 근무연수가 1년 미만인 경우에는 퇴직금을 지급하지 않는다.

제4조 (직원의 채용) 직원의 신규임용은 공개채용을 원칙으로 하며 채용에 결격이 있는 자는 채용하지 않는다.

제5조 (수습기간 및 처우) 신규직원은 3개월의 수습기간을 두며, 정규 급여의 70%를 지급한다. 다만, 수습기간도 근무연수에 포함된다.

제6조 (건강검진) 사무국 직원은 기본검진에 준하는 범위에서 매년 정기 건강검진을 받을 수 있다.

제7조 (휴가 및 용어의 정의) 유급휴가는 일반휴가, 특별휴가, 출산휴가를 지칭하며, 사무국 직원은 근로기준법에 따라 이를 사용할 수 있다.

제8조 (직원의 정년) 직원의 정년은 57세로 정한다

제9조 (규정개폐) 이 규정을 개정하거나 폐지할 때는 이사회의 승인을 받아야 한다.

제10조 (기타) 이 규정에 명시되지 않은 사항은 한국과학기술단체총연합회의 관례에 따른다.

■사단법인 한국우주과학회 편집국 규정 ■

2014년 9월 30일 제정

제1조 (편집국) 학회는 학회간행물 및 학회편집위원회 관련업무의 원활한 수행을 위하여 편집국을 설치 · 운영하며, 이를 위하여 편집전담 직원을 고용할 수 있다.

제2조 (담당업무) 편집전담 직원은 아래의 각 호에 해당하는 업무를 담당한다.

① 학회지; Journal of Astronomy and Space Sciences (이하 JASS)의 발행을 위한 저자교신 및 게재 논문의 편집

② 학회보 발행 시 게재논문의 편집

③ 학회논문집(Monograph)의 편집, 발행

④ 학회지 JASS 게재 논문과 관련된 자료관리 및 대외 온라인 논문등록 업무(ADS, KCI, KISTI, KOFST; eNEST 등)

⑤ 학회지 온라인 투고시스템(http://janss.kr)의 운영지원 및 관리

⑥ (기타업무) 편집국의 책임자인 편집위원장의 협의 하에 업무를 지원할 수 있다.

제3조 (경비결재)

① 편집국의 모든 재정지출은 재무이사가 승인하며 회장이 정한 일정 금액 이상의 지출에 대해서는 회장의 승인을 받는다.

② 업무처리의 효율을 위하여 재무이사와 회장이 정한 일정 금액 이하의 일상적 경비는 재무이사 전결로 사후 결재할 수 있다. 단, 편집국의 재정 지출과 관련된 모든 행정· 회

계 업무는 학회사무국에서 지원한다.

제4조 (직원의 채용) 직원의 신규임용은 공개 채용을 원칙으로 하며 채용에 결격이 있는 자는 채용하지 않는다.

제5조 (수습기간 및 처우) 신규직원은 3개월의 수습기간을 두며, 정규 급여의 70%를 지급한다. 다만, 수습기간도 근무연수에 포함된다.

제6조 (보수 및 용어의 정의)

① 편집전담 직원에게는 업무능력과 경력을 감안하여 적절한 보수를 지급한다.

② 연봉이라 함은 매년 1월 1일부터 12월 31일까지 직원에게 지급되는 급여를 말한다. 연봉 책정은 회계연도 개시 1개월 전까지 이루어져야 한다. 단, 이사회 의결에 따라 체결시점을 변경할 수 있다.

③ 연봉은 담당 업무를 기초로 하여 책정하며 직원과 연봉계약을 통하여 확정한다. 연봉계약은 매년 체결하며, 학회대표와 해당 직원이 연봉계약서에 서명날인 함으로써 효력이 발생한다.

④ 월급은 연봉의 1/13로 매월 말일 지급하며, 지급일이 휴일인 경우 그 전 날 지급한다. 발령 월에는 근무일을 기준으로 일할 계산하여 지급하고, 1년 이상 근속한 직원에 대해서는 해당 월의 14일 이후 퇴직하는 경우 봉급 전액을 지급하며 14일 이내인 경우에는 일할 계산하여 지급한다.

⑤ 퇴직금은 1년 이상 근속한 직원에게 지급하고, 근무 연수에 월급을 곱한 금액으로 한다. 근무연수가 1년 미만인 경우에는 퇴직금을 지급하지 않는다.

제7조 (건강검진) 편집국 직원은 기본검진에 준하는 범위에서 매년 정기 건강검진을 받을 수 있다.

제8조 (휴가 및 용어의 정의) 유급휴가는 일반휴가, 특별휴가, 출산휴가를 지칭하며 편집국 직원은 근로기준법에 따라 이를 사용할 수 있다.

제9조 (직원의 정년) 직원의 정년은 57세로 정한다.

제10조 (규정개폐) 이 규정을 개정하거나 폐지할 때는 이사회의 승인을 받아야 한다.

제11조 (기타) 이 규정에 명시되지 않은 사항은 한국과학기술단체총연합회의 관례에 따른다.

■ 연구윤리위원회의 설치 · 운영에 관한 규정 ■

제정 2008년 1월 2일

제1장 총칙

제1조 (목적)

이 규정은 사단법인 한국우주과학회(이하 “학회”라 한다) 회원으로서 연구를 수행하는 자의 연구윤리를 확립하고 연구부정행위를 사전에 예방하며, 연구부정행위 발생시 공정하고 체계적인 진실성 검증과 처리를 위한 비상설 연구윤리위원회(이하 “위원회”라 한다)의 설치 및 운영 등에 관한 사항을 규정함을 목적으로 한다.

제2조 (정의)

①연구부정행위(이하 ”부정행위“라 한다)라 함은 다음 각 호가 정의하는 바와 같이 연구의 제안, 연구의 수행, 연구결과의 보고 및 발표 등에서 행하여진 위조·변조·표절·부당한 논문저자 표시·자료의 중복사용 등을 말한다. 다만, 경미한 과실에 의한 것이거나 데이터 또는 연구결과에 대한 해석 또는 판단에 대한 차이의 경우는 제외한다.

1. “위조”는 존재하지 않는 데이터 또는 연구결과 등을 허위로 만들어 내는 행위를 말한다.
2. “변조”는 연구 재료·장비·과정 등을 인위적으로 조작하거나 데이터를 임의로 변형·삭제함으로써 연구 내용 또는 결과를 왜곡하는 행위를 말한다.
3. “표절”이라 함은 타인의 아이디어, 연구내용·결과 등을 정당한 승인 또는 인용 없이 도용하는 행위를 말한다.
4. “부당한 논문저자 표시”는 연구내용 또는 결과에 대하여 과학적·기술적 공헌 또는 기여를 한 사람에게 정당한 이유없이 논문저자 자격을 부여하지 않거나, 과학적·기술적 공헌 또는 기여를 하지 않은 자에게 감사의 표시 또는 예우 등을 이유로 논문저자 자격을 부여하는 행위를 말한다.
5. “자료의 중복사용”은 본인이 이미 출판한 자료를 정당한 승인 또는 인용없이 다시 출판하거나 게재하는 행위를 말한다.
6. 타인에게 위 제1호 내지 제4호의 행위를 제안·강요하거나 협박하는 행위
7. 기타 학계 또는 과학기술계에서 통상적으로 용인되는 범위를 현저하게 벗어난 행위

②“제보자”라 함은 부정행위를 인지한 사실 또는 관련 증거를 해당 연구기관 또는 연구지원기관에 알린 자를 말한다.

③“피조사자”라 함은 제보 또는 연구기관의 인지에 의하여 부정행위의 조사 대상이 된 자 또는 조사 수행 과정에서 부정행위에 가담한 것으로 추정되어 조사의 대상이 된 자를 말하며, 조사과정에서의 참고인이나 증인은 이에 포함되지 아니한다.

④“예비조사”라 함은 부정행위의 혐의에 대하여 공식적으로 조사할 필요가 있는지 여부를 결정하기 위하여 필요한 절차를 말한다.

⑤“본조사”라 함은 부정행위의 혐의에 대한 사실 여부를 검증하기 위한 절차를 말한다.

⑥“판정”이라 함은 조사결과를 확정하고 이를 제보자와 피조사

자에게 문서로써 통보하는 절차를 말한다.

제3조 (적용범위) 이 규정은 학회 회원의 연구활동과 직·간접적으로 관련 있는 자에 대하여 적용한다.

제4조 (다른 규정과의 관계) 연구윤리 확립 및 연구진실성 검증과 관련하여 다른 특별한 규정이 있는 경우를 제외하고는 이 규정에 의한다.

제2장 연구윤리위원회의 설치 및 운영

제5조 (소속등) 위원회는 학회내에 비상설위원회로 둔다.

제6조 (구성)
①위원회는 위원장 1인을 포함한 3인의 당연직위원과 3인의 추천직위원으로 구성한다.
②당연직위원은 학회 부회장 2인과 학술이사로 하며, 추천직위원은 학회장이 임명한다.
③위원장은 학술이사로 한다.
④위원회는 특정한 안건의 심사를 위하여, 특별위원회를 둘 수 있다.

제7조 (위원장)
①위원장은 위원회를 대표하고, 회의를 주재한다.
②위원장이 부득이한 사유로 직무를 수행할 수 없는 때에는 위원장이 미리 지명한 위원이 그 직무를 대행한다.

제8조 (위원의 임기) 위원의 임기는 위원회의 활동기한으로 제한한다.

제9조 (간사등)
①위원회의 원활한 업무수행을 위하여 간사 1인을 둘 수 있다.
②위원회의 각종 업무를 지원하기 위하여 전문위원을 둘 수 있다.

제10조 (업무) 위원회는 다음 각 호의 사항을 심의·의결한다.
① 연구윤리 관련 제도의 수립 및 운영에 관한 사항
② 부정행위 제보 접수 및 처리에 관한 사항
③ 예비조사와 본조사의 착수 및 조사결과의 승인에 관한 사항
④ 제보자 보호 및 피조사자 명예회복 조치에 관한 사항
⑤ 연구윤리 검증결과의 처리 및 후속조치에 관한 사항
⑥ 기타 위원장이 부의하는 사항

제11조 (회의)
①위원장은 위원회의 회의를 소집하고 그 의장이 된다.
②회의는 재적위원 과반수이상의 출석과 출석위원 3분의 2 이상의 찬성으로 의결한다.
③위원장은 심의안건이 경미하다고 인정할 때에는 서면심의로 대체할 수 있다.
④위원회에서 필요하다고 인정될 때에는 위원이 아닌 자를 출석케 하여 의견을 청취할 수 있다.

제12조 (경비) 위원회의 운영에 필요한 경비를 학회예산의 범위내에서 지급할 수 있다.

제3장 연구진실성 검증

제13조 (부정행위 제보 및 접수)
①제보자는 학회에 구술·서면·전화·전자우편 등 가능한 모든 방법으로 제보할 수 있으며 실명으로 제보함을 원칙으로 한다. 다만, 익명으로 제보하고자 할 경우 서면 또는 전자우편으로 연구과제명 또는 논문명 및 구체적인 부정행위의 내용과 증거를 제출하여야 한다.
②제보 내용이 허위인 줄 알았거나 알 수 있었음에도 불구하고 이를 신고한 제보자는 보호 대상에 포함되지 않는다.

제14조 (예비조사의 기간 및 방법)
①예비조사는 신고접수일로부터 15일 이내에 착수하고, 조사시작일로부터 30일 이내에 완료하여 학회장의 승인을 받도록 한다.
②예비조사에서는 다음 각 호의 사항에 대한 검토를 실시한다.
1. 제보내용이 제2조제1항의 부정행위에 해당하는지 여부
2. 제보내용이 구체성과 명확성을 갖추어 본조사를 실시할 필요성과 실익이 있는지 여부
3. 제보일이 시효기산일로부터 5년을 경과하였는지 여부

제15조 (예비조사 결과의 보고)
①예비조사 결과는 위원회의 의결을 거친 후 10일 이내에 학회장과 제보자에게 문서로써 통보하도록 한다. 다만 제보자가 익명인 경우에는 그렇지 아니하다.
②예비조사 결과보고서에는 다음 각 호의 내용이 포함되어야 한다.
1. 제보의 구체적인 내용 및 제보자 신원정보
2. 조사의 대상이 된 부정행위 혐의 및 관련 연구과제
3. 본조사 실시 여부 및 판단의 근거
4. 기타 관련 증거 자료

제16조 (본조사 착수 및 기간)
①본조사는 위원회의 예비조사결과에 대한 학회장의 승인 후 30일 이내에 착수되어야 한다.
②본조사는 판정을 포함하여 조사시작일로부터 90일 이내에 완료하도록 한다.
③위원회가 제2항의 기간 내에 조사를 완료할 수 없다고 판단될 경우 학회장에게 그 사유를 설명하고 조사기간의 연장을 요청할 수 있다.
④본조사 착수 이전에 제보자에게 위원회 명단을 알려야 하며, 제보자가 위원 기피에 관한 정당한 이의를 제기할 경우 이를 수용하여야 한다.

제17조 (출석 및 자료제출 요구)
①위원회는 제보자피조사자증인 및 참고인에 대하여 진술을 위한 출석을 요구할 수 있다.
②위원회는 피조사자에게 자료의 제출을 요구할 수 있으며, 증거자료의 보전을 위하여 소속 기관장의 승인을 얻어 부정행위

관련자에 대한 실험실 출입제한, 해당 연구자료의 압수·보관 등의 조치를 취할 수 있다.
③제1항 및 제2항의 출석요구와 자료제출요구를 받은 피조사자는 반드시 이에 응하여야 한다.

제18조 (제보자와 피조사자의 권리 보호 및 비밀엄수)
①어떠한 경우에도 제보자의 신원을 직·간접적으로 노출시켜서는 아니되며, 제보자의 성명은 반드시 필요한 경우가 아니면 제보자 보호 차원에서 조사결과 보고서에 포함하지 아니 한다.
②제보자가 부정행위 제보를 이유로 징계 등 신분상 불이익, 근무조건상의 차별, 부당한 압력 또는 위해 등을 받은 경우 피해를 원상회복하거나 제보자가 필요로 하는 조치 등을 취하여야 한다.
③부정행위 여부에 대한 검증이 완료될 때까지 피조사자의 명예나 권리가 침해되지 않도록 주의하여야 하며, 무혐의로 판명된 피조사자의 명예회복을 위해 노력하여야 한다.
④제보·조사·심의·의결 및 건의조치 등 조사와 관련된 일체의 사항은 비밀로 하며, 조사에 직·간접적으로 참여한 자는 조사 및 직무수행 과정에서 취득한 모든 정보에 대하여 누설하여서는 아니 된다. 다만, 정당한 사유에 따른 공개의 필요성이 있는 경우에는 위원회의 의결을 거쳐 공개할 수 있다.

제19조 (제척·기피 및 회피)
①위원이 해당 안건과 직접적인 이해관계가 있는 경우에는 그 직무집행에서 제척된다.
②위원회는 직권 또는 당사자의 신청에 의하여 제척의 결정을 한다.
③위원에게 직무수행의 공정을 기대하기 어려운 사정이 있는 경우에는 제보자와 피조사자는 기피신청을 할 수 있다.
④위원은 제1항 또는 제3항의 사유가 있는 때에는 위원장의 허가를 얻어 회피할 수 있다.

제20조 (이의제기 및 변론의 권리 보장) 위원회는 제보자와 피조사자에게 의견진술, 이의제기 및 변론의 권리와 기회를 동등하게 보장하여야 한다.

제21조 (본조사결과보고서의 제출)
①위원회는 의견진술, 이의제기 및 변론내용 등을 토대로 본조사결과보고서(이하 “최종보고서”라 한다)를 작성하여 학회장에게 제출한다.
②최종 보고서에는 다음 각 호의 사항이 포함되어야 한다.
1. 제보 내용
2. 조사의 대상이 된 부정행위 혐의 및 관련 연구과제
3. 해당 연구과제에서의 피조사자의 역할과 혐의의 사실 여부
4. 관련 증거 및 증인
5. 조사결과에 대한 제보자와 피조사자의 이의제기 또는 변론내용과 그에 대한 처리결과
6. 위원 명단

제22조 (판정) 위원회는 학회장의 승인을 받은 후 최종 보고서의 조사내용 및 결과를 확정하고 이를 제보자와 피조사자에게 통보한다.

제4장 검증 이후의 조치

제23조 (결과에 대한 조치)
①위원회는 학회장에게 다음 각 호에 해당하는 행위를 한 자에 대하여 징계조치를 권고할 수 있다.
1. 부정행위
2. 본인 또는 타인의 부정행위 혐의에 대한 조사를 고의로 방해하거나 제보자에게 위해를 가하는 행위
②징계조치에 관한 사항은 별도로 정할 수 있다.

제24조 (기록의 보관 및 공개)
①예비조사 및 본조사와 관련된 기록은 학회에서 보관하며, 조사 종료 이후 5년간 보관하여야 한다.
②최종보고서는 판정이 끝난 이후에 공개할 수 있으나, 제보자·위원·증인·참고인·자문에 참여한 자의 명단 등 신원과 관련된 정보에 대해서는 당사자에게 불이익을 줄 가능성이 있을 경우 공개대상에서 제외할 수 있다.

제5장 기 타

제25조 (시행세칙) 위원회는 이 규정의 시행을 위하여 필요한 세부사항을 별도로 정할 수 있다.

부 칙 1. (시행일) 이 규정은 2008년 1월 2일부터 시행한다.

■ 포상위원회 운영에 관한 규정 ■

2011년 10월 27일 제정
2011년 12월 7일 개정
2015년 1월 16일 개정
2017년 4월 27일 개정

제1조 (목적) 본 학회 운영규정 제2장 위원회 및 분과활동, 제6조 포상위원회 규정에 따라 포상에 관련된 추천 및 수상관련 세부규정을 정함을 목적으로 한다.

제2조 (포상위원장의 역할) 포상위원장은 위원들을 회장에게 추천하고 위원회 소집, 회의 주재, 수상자 추천 등 제반 업무를 총괄하며 정기총회에서 위원회 활동 사항을 보고 한다. (신설, 2015.1.16)

제3조 (포상의 종류) 본 학회와 관련된 학술활동 및 대외활동에 있어서 뚜렷한 업적이 있는 경우 이에 대한 포상을 하며 그 종류는 다음과 같다. 세부적인 기준은 별도 포상위원회 내부기준으로 정한다.
가. 학술상: 학문적 업적이 뚜렷한 회원에게 매년 정기총회에 수여한다.
나. 두진 우주과학자상: 학문적인 업적이 뛰어난 박사학위 후 10년 이내의 회원에게 매년 정기총회에서 수여한다. (신설 2015.1.16.)

다. 신진 우주과학자상: 우주과학회 회원으로 학문적 업적이 뛰어나며 국내에서 박사학위를 취득 후 5년 이내의 회원에게 매년 정기총회에서 수여한다. (신설 2017.4.27.)
라. 공로상: 학회의 발전에 커다란 공헌을 한 회원에게 수여한다.
마. 특별상: 학회가 주관하는 활동에 대하여 그 업적이 뛰어난 자 또는 단체에게 수여한다.

제4조 (대외 추천요령) 대외에서 요청받는 포상에 대한 후보자 선정의 경우는, 적절한 기간을 설정하여 전체 회원에게 이 내용을 공지하며, 적절한 형태의 추천형식에 따라 추천을 받는다. 포상위원회에서 별도의 추천을 할 수 있다. 포상위원회에서는 이들 후보자 중에서 해당자를 선정하며, 회장이 결정한다.

제5조 (기타 사항) 선정 기준이 정해지지 않은 포상의 경우는 그 특성에 따라 수상자 혹은 후보자 선정기준을 별도로 적용할 수 있으며, 회장이 포상위원회와 협의하여 선정한다.

제6조 (내부기준) 포상위원회 세부규정 시행을 위해 필요한 세부사항을 내부기준 또는 지침으로 정할 수 있다 (신설, 2015.1.16)

제7조 (운영규정 개폐) 이 규정을 개정하거나 폐지할 때는 이사회의 승인을 받아야 하며 총회에 보고하여야 한다 (신설, 2015.1.16)

부 칙 (시행일)

1. 이 규정은 2011년 10월 27일부터 시행한다.
2. 이 규정은 2012년 1월 1일부터 시행한다.
3. 이 규정은 2015년 1월 16일부터 시행한다.
4. 이 규정은 2017년 4월 27일부터 시행한다.

■ 편집위원회 운영에 관한 규정 ■

2014년 4월 24일 제정

제1장 총 칙

제1조 (목적) 본 한국우주과학회 (이하 본 학회) 정관 제4조 (사업) 2항 학술간행물의 발행 및 배포와 학회 운영에 대한 규정 제5조 (편집위원회) 임무와 위원 구성 조항과 관련된 제반 사항을 규정함을 목적으로 한다.

제 2조 (임무)
1. 본 위원회의 주임무는 학술간행물의 발간과 배포 관련하여 논문의 기획, 접수, 심사, 편집, 관리 등을 주관한다.
2. 기획 논문집, 자료의 발굴 및 수집 등 본 학회에서 발간하는 모든 도서의 기획 및 편집 등을 주관한다.
3. 학회지 발간과 관련된 제반 규정을 정한다.

제 2장 편집위원회의 구성

제3조 (위원회의 구성) 위원회의 위원은 학회 운영에 대한 규정 제5조에 의거하여 내국인 15인 내외 외국인 20인 내외로 한다.

제4조 (위원의 선임)
1. 위원은 학회 운영에 대한 규정 제5조에 따라 지역과 전공 등을 고려하여 편집위원장이 추천하고 본 학회 이사회의 동의를 받아 회장이 임명한다.
2. 위원이 개인사정으로 인하여 사임하는 경우, 그 후임자를 즉시 새로 위촉한다.

제5조 (위원의 임기)
1. 위원의 임기는 학회 운영에 대한 규정 제5조에 의거하여 2년으로 한다.
2. 위원의 사임으로 인하여 새로 보임된 자의 임기는 전임자의 잔여임기로 한다.
3. 위원은 필요한 경우 연임할 수 있다.

제6조 (위원의 자격) 편집위원의 자격은 다음과 같다.
1. 학회 활동에 적극적이고 학술 활동을 활발히 하는 자.
2. 연구 업적이 국내외의 학계에서 현저한 자.

제7조 (위원의 의무)편집위원은 다음의 의무를 가진다.
1. 위원은 위원회 개최시에 특별한 사유가 없는 한 출석하여야 한다.
2. 위원은 공정해야 하고, 항상 학회와 학문 발전을 위하여 부단히 노력하여야 한다.

제8조 (위원장 및 부위원장의 선임)
1. 위원회의 위원장은 학회 운영에 대한 규정 제5조에 의거하여 학술이사가 당연직으로 맡는다.
2. 위원장은 위원회를 소집하고, 그 의장이 된다.
3. 위원장의 업무를 보조하기 위해 부위원장을 둘 수 있으며 부위원장은 위원장이 임명한다.
4. 위원장과 부위원장의 임기는 2년으로 하고 연임할 수 있다.

제9조 (회의 소집)
1. 회의 소집은 개최일 1주일 이전에 연락하여 위원장이 행한다.
2. 위원장이 임무를 수행하기 곤란할 때는 부위원장이 소집한다.

제10조 (의결)
1. 위원회는 재적위원 과반수 출석으로 성립하고, 출석위원 과반수의 찬성으로 결정한다.
2. 출석하지 못한 위원이 위임장을 제출한 경우, 출석인원에는 포함하되, 의결시에는 포함하지 않는다.

3. 시간이 촉박한 중대한 사항에 대하여는 위원장이 직접 전화나 전자우편 등으로 위원의 의견을 들어 결정할 수 있다.
4. 특정 사안에 대하여 위원장이 위원회의 위임을 받은 경우 위원장이 처리할 수 있다.

제11조 (문서 관리)
1. 위원회의 회의록은 반드시 작성하고, 작성일로부터 3년간 보관한다.
2. 위원회의 원고 접수, 관리, 심사위원 위촉, 심사결과 보고서 취합, 심사결과통보 등은 모두 문서로 하며, 그 문서는 3년간 보관한다.

제3장 학회지 Journal of Astronomy and Space Sciences (이하 JASS)의 발간

제12조 (분야) JASS는 천문학 및 우주과학 전반에 관한 주제의 영문논문을 출판한다.

제13조 (발행 횟수) JASS는 년 4회 발행하는 것을 원칙으로 한다.

제14조 (발행일) 발행일은 매년 3, 6, 9, 12월의 15일로 한다.

제15조 (발행 부수) 현재 회원수와 보관용 등을 감안하여 위원회에서 정한다.

제16조 (편집 체제) 한국우주과학회 학술지 투고 규정에 따른다.

제17조 (학회지 배포)
1. 회비를 납부한 회원에게 발행일로부터 15일 이내에 학회지를 우송하는 것을 원칙으로한다.
2. 발행일 이후에 회비를 납부한 회원에게는 당해연도 발행부를 일괄 우송한다.
3. 학술대회 등 다수 회원이 참석하는 회의 일정이 30일 이내에 계획되어 있는 경우, 우송을 연기할 수 있다.
4. 외국에 거주하는 회원의 우송료는 별도로 징수할 수도 있다.

제18조 (논문 접수 및 투고 논문의 관리) 논문은 연중 수시로 접수하며 투고논문은 반드시 접수 대장을 작성하여 관리한다.

제19조 (심사 의무)
1. 학회지에 게재할 논문은 반드시 심사를 거쳐야 한다.
2. 기획 논문 및 특별히 청탁한 원고나 외국인의 원고와 학술대회 발표논문 등은 위원장의 결정으로 심사를 면제할 수 있다.

제20조 (심사위원 위촉)
1. 심사위원의 위촉은 위원회의 결의로 편집위원장이 행한다.
2. 심사위원은 논문 1편 당 2인을 위촉한다. 단 위원회는 만일의 경우를 대비하여 후보위원 1인을 추가로 선정하여 둔다.
3. 심사위원의 위촉은 가급적 전공, 연령, 지역 등이 편중되지 않도록 위촉한다.
4. 논문 투고자와 근무지가 같거나 학연 등 특별한 관계가 있는 자를 심사위원으로 선정하지 않는 것을 원칙으로 한다.
5. 심사위원에게는 소정의 심사료를 지불한다.
6. 심사위원의 위촉에 관한 사항은 공개하지 않는다.

제21조 (심사위원 수칙)
1. 공평한 기준을 정하여 공정하게 평가하여야 한다.
2. 논문 심사결과 등을 타인에게 발설하여서는 안 된다.

제22조 (심사기준)
1. 심사위원은 심사대상 논문이 JASS가 추구하는 주제를 다루고 있고 기존에 발표되지 않은 새로운 결과임을 확인하여야 한다.
2. 심사위원은 심사대상 논문이 국제적 수준의 결과를 포함하고 있는지 판단하여야 한다.
3. 심사위원은 심사대상 논문이 JASS의 편집체제에 맞추어 작성되었는지 확인하여야 한다.
4. 심사위원은 심사대상 논문의 영문 교열을 확인하여야 한다.

제23조 (심사결과 보고) 심사위원은 심사 대상 논문을 접수한 날로부터 10일 이내에 소정의 심사결과 보고서를 위원회에 제출하여야 한다.

제24조 (심사결과 통보) 심사위원이 심사결과 보고서를 제출하면, 위원장은 심사위원의 성명이나 소속 등을 삭제하고, 즉시 그 결과를 투고자에게 전자우편으로 통보한다.

제25조 (수정보완)
1. 심사결과 통보를 받은 투고자는 심사위원의 수정의견을 최대한 반영하여 논문의 질적 향상을 도모하여야 한다.
2. 심사의 종합결과 '게재 가' 혹은 '수정 후 게재' 등급을 받은 투고자는 학회에서 정한 기일내에 수정논문을 학회에 제출해야 한다.
3. 심사의 종합결과 '수정 후 재심' 등급을 받은 논문 투고자는 충분히 연구보완 수정 후에 다음 호에 게재 될 수 있도록 완벽하게 수정한 논문을 학회에 제출해야 한다.

제26조 (논문 투고자의 자격) 논문의 교신저자는 한국우주과학회 회원으로 한정한다.

제27조 (논문 게재료 납부)
1. 심사완료 게재된 논문의 투고자는 학회에서 지정한 기일까지 소정의 게재료를 납부하여야 한다.
2. 국제 학술회의, Symposium, Workshop 등의 Proceeding 논문을 JASS에서 출판하는 경우, 편집위원장의 청원으로 이사회의 동의를 받아 논문 게재료를 면제할 수 있다.
3. 위원회에서 요청한 논문이나 기타 본 학회의 국제성을 위

한 특별한 원고에 대해서는 게재료를 징수하지 않는다.

제28조 (원고료) 위원회에서 요청한 논문이나 기타 본 학회의 국제성을 위한 특별한 원고에 대해서는 원고료를 지급할 수 있다.

제 4장 규정의 개정

제29조 (개정절차) 이 규정의 개정은 이사회의 승인을 요한다.

제30조 (개정발표) 개정된 편집규정은 다음 호의 학회지에 게재하여 발표한다.

1. (효력발생) 이 규정은 2014년 1월 1일부터 시행한다.
2. (시행규칙) 이 규정의 시행에 필요한 세부사항은 편집위원회에서 별도로 정하여 이사회의 승인을 받는다.

■ 임원 선출에 관한 규정 ■

2011년 8월 26일 제정
2011년 12월 7일 개정
2014년 10월 30일 개정

제1조 (목적) 한국우주과학회 정관 제12조 1항에 따라 임원선출에 관한 사항을 규정함을 목적으로 한다.

제2조 (선거권) 정회원 자격을 취득한지 만 1년이 경과된 회원은 선거권을 갖는다.

제3조 (임원 자격)

① 회장은 최근 10년간 학회의 정회원으로 활동하고 있으며, 이사로 봉사한 경험이 있는 회원이어야 한다.
② 이사는 최근 5년간 본 학회의 정회원으로 활동하고 있는 회원이어야 한다.
③ 감사는 10년간 본 학회의 정회원으로 활동한 회원이어야 한다.

제4조 (회장후보 선출)

① 회장 후보는 선거권자 온라인 추천 투표에서 최소 10명 이상의 추천을 받은 자로 한다.
② 제①항을 충족하는 후보자가 없을 경우, 이사회에서 2명의 후보를 지명할 수 있다.
③ 회장은 회장 후보를 총회 개최 최소 1주일 전에 회원에게 알려야 한다.
④ 회장 후보 선출 온라인 추천 투표에서 선거권자 1인은 1명의 후보를 추천할 수 있다.
⑤ 회장 후보 선출 온라인 추천 투표는 임원선출 정기 총회 개최 30일 전에 실시하고 그 기간은 2주로 한다.

제5조 (회장 선출)

① 회장은 총회에서 회장 후보를 대상으로 하여 선거권자의 무기명 비밀선거로 선출한다.
② 무기명 투표에서 과반수의 득표를 한 후보자가 없을 경우 상위 득표자 2인을 대상으로 재투표하여 다수 득표자를 차기회장으로 한다.

제6조 (부회장 선출) 부회장은 회장이 지명한다.

제7조 (이사선출)

① 전체 이사 수의 1/2을 선거권자 온라인 투표로 선출하며, 나머지 1/2은 차기 회장이 지명한다.
② 이사 선출 온라인 투표는 선거권자 1인이 3명을 추천한다.
③ 투표 결과 상위 다득점자로 수락 여부를 거쳐 이사의 1/2을 확정한다.
④ 선출된 이사 중에서 총회 당일 회장 또는 감사로 선출되어 결원이 생긴 경우 차득점 순으로 수락 여부를 거쳐 이사로 확정한다.
⑤ 부회장, 총무, 재무, 학술이사는 회장이 지명하며, 당연직 이사가 된다.

제8조 (감사선출) 감사는 총회에서 직접선거로 선출한다.

제9조 (세칙) 이 규정의 시행을 위해 필요한 세부사항은 이사회의 승인을 받아 별도의 세칙으로 정할 수 있다.

제10조 (규정 개폐) 이 규정을 개정하거나 폐지할 때는 이사회 재적이사 과반수의 찬성과 총회의 승인을 받아야 한다.

부칙 1. 이 규정은 2014년 10월 30일부터 시행한다.

■ 사단법인 한국우주과학회 용역사업 규정 ■

2011년 12월 7일 제정

제1조 (목적) 이 규정은 용역사업의 시행에 대하여 필요한 사항을 규정함을 그 목적으로 한다.

제2조 (적용범위) 이 규정은 외부로부터 수탁하거나 학회 예산으로 직접 수행하는 용역사업에 적용한다.

제3조 (사업구분) 학회에서 수행하는 용역사업은 정관 제4조의 사업 중 다음 각 호의 사업에 한한다.

① 우주과학 및 그와 관련된 분야의 기초 및 응용 연구, 연구지원, 기술교육
② 우주과학 및 그와 관련된 분야의 자료의 발행과 보급
③ 국내외 관련 학회와의 기술 교류
④ 우주과학 및 그와 관련된 분야의 기준 및 규정의 제안
⑤ 정부, 공공단체, 기타 기관에 대한 자문 및 건의
⑥ 기타 학회의 목적을 달성하기 위한 사업

제4조 (연구진의 구성과 자격)
① 연구진은 연구책임자, 연구원, 보조연구원으로 구성하며, 사업의 규모, 기간 및 사업비 등을 고려하여 필요한 경우에는 총괄 연구책임자를 둘 수 있다.
② 연구진은 학회 회원으로 구성함을 원칙으로 한다. 다만, 학회에 해당분야 전공자가 없거나 보조연구원인 경우에는 예외로 할 수 있다.

제5조 (연구책임자의 자격과 선임)
① 총괄 연구책임자 또는 연구책임자(이하 "연구책임자"라고 칭함)는 학계의 지식과 경험이 풍부한 전문가로서, 특히 연구분야별로 연구진을 통솔하고 연구기획, 조정능력을 갖춘 자이어야 한다.
② 연구책임자는 학회 분과위원회, 전문성, 지역성을 최대한으로 고려하여 회장이 선임한다. 단, 의뢰자가 연구책임자를 지명할 경우 의뢰자의 뜻에 따라 선임함을 원칙으로 하되, 지명된 회원이 연구책임자로 부적합하다고 판단되는 경우에 회장은 의뢰자와 협의하여 연구책임자를 변경할 수 있다.

제6조 (연구책임자의 역할과 책임)
① 연구책임자는 연구진의 구성과 변경에 관하여 책임을 져야 한다.
② 연구책임자는 연구사업의 진행, 성과의 신뢰성, 연구기간의 엄수 등 계약서의 모든 사항을 책임져야 한다.
③ 연구책임자는 수탁용역사업 종료 후 1년 이내에 사업수행성과에 대한 개요를 학회지 혹은 학회논문집에 게재하여야 한다.

제7조 (비용징수와 비용의 산정) 개인 또는 단체가 3조의 용역사업을 학회로 위탁하는 경우에는 필요한 비용을 징수한다. 용역비용 산정은 다음 각 호에 따른다.
① 용역비용은 교육과학부 장관이 고시하는 연구개발사업처리규정의 제20조의 연구개발비 사용(이하 정부기준)의 범위 내에서 학회와 의뢰자가 협의하여 정한다.
② 전항에 규정되지 아니한 용역사업은 당해 사업 수행에 필요한 직접경비의 범위 내에서 학회와 의뢰자가 협의하여 정한다.

제8조 (정부기준 적용원칙) 정부기준의 적용은 다음에 따른다.
① 직접인건비: 당해 사업에 참여하는 회원 및 외부전문가의 인건비로서 정부기준을 적용한다.
② 직접경비: 당해 사업 수행에 직접 필요한 여비, 재료비, 인쇄비, 복사비, 시험비, 외부전문가 자문비 등을 포함한 실비를 계산 산출한다.
③ 간접경비: 간접경비의 계상은 의뢰자가 학회에 직접 의뢰한 경우는 전체 용역 금액의 20%로 하고, 의뢰자가 학회의 회원에게 직접 의뢰하였으나 그 회원이 학회를 통하여 수주하는 경우는 전체 용역 금액의 5%로 한다.

제9조 (용역비용의 수령 및 지출) 용역의뢰자가 용역기간 중에 용역비용의 일부만을 학회에 지급하고, 용역계약 만료시 그 나머지 비용을 지급하는 경우, 학회는 원활한 연구진행을 위해 필요한 비용을 연구책임자에게 선 지급할 수 있다.

제10조 (용역비용의 관리) 학회는 용역사업의 용역비용의 지출을 연구책임자와 협의 하에 관리할 수 있다.

제11조 자세한 운영내용은 운영세칙에 정한다.

부 칙 1. (시행일) 본 규정은 2012년 1월 1일부터 시행한다.

■ 한국우주과학회 학술지 투고 규정 ■

1. PUBLICATION TYPES, QUALIFICATION FOR AUTHORSHIP

Five types of manuscripts are published in this journal: Editorials, Review Papers, Research Papers, Technical Papers, and Letters to the Editor.

Editorials:
Editorials are submitted by invitation only and will be on topics considered to be essential by the Editorial Board of the journal.

Review Papers:
Review papers will be published by direct sub mission as well as from invited experts. In both cases, the work will be subject to editorial review. Review papers should critically review topics not only to inform the reader of the background, but also to communicate the state of the art and outstanding research problems.

Research Papers:
Following a peer review, original findings within the scope of the journal will be published. Critical and new results of experiments or theories should be described in full-length research papers.

Technical Papers:
Articles in this category introduce scientific work on novel skills dealing with new methods and techniques.

Letters to the Editor:
Any issues of interests to the journal readership may be contained in letters to the editor. Letters concerning articles published earlier will generally be sent to the author of the previous research for possible response before publication.

2. RESEARCH AND PUBLICATION ETHICS

Research published in JASS must follow institutional, national, and international guidelines. For the policies on the research and publication ethics that are not stated in this instructions, International standards for editors and authors (http://publicationethics.org/node/11184) can be applied.

Authorship

An author is defined as one who has made a significant contribution to the overall design and execution of the experiment; the Korean Space Science Society thus deems all authors responsible for the entire paper.

Originality and Duplicate Publication

All submitted manuscripts should be original and should not be submitted to other scientific journals for consideration while under JASS review. No part of an accepted manuscript should be duplicated in other scientific journals without the permission of the Editorial Board. If duplicate publication related to papers in this journal is detected, the names of the authors will be announced in this journal, the authors' institutes will be informed, and the authors will be subject to restrictions on future publications in JASS.

CrossCheck is a multi-publisher initiative to screen published and submitted content for originality. JASS uses iThenticate software to detect instances of overlapping and reproduced text in submitted manuscripts. Detailed information about CrossCheck can be found at https://www.crossref.org.

Conflict of Interest Statement

Authors should disclose any conflicts of interest in their manuscripts.

3. PEER REVIEW PROCESS

Once manuscripts are submitted, they will be reviewed by two or more experts in the corresponding field. The Editorial Board may request that authors revise the manuscripts in light of the reviewers' suggestions. The authors should upload the revised files with a reply to each item in the reviewers' comments after revision of the manuscript. The authors should complete the revisions within 60 days of request. If the authors want to extend the revision period to more than 60 days, they should contact the Editorial Board. The manuscript review process should be completed after the second review. If the authors wish to engage in further revision, the Editorial Board may consider it. The Editorial Board will make a final decision on the approval for publication of submitted manuscripts and can request further corrections of the article text if necessary. Review and publication processes that are not described in the Instructions for Authors will be incorporated from the Editorial Policy Statements, approved by the Council of Science Editors Board of Directors (https://www.councilscienceeditors.org/resource-library/editorial-policies/white-paper-on-publication-ethics/2-3-reviewer-roles-and-responsibilities/).

4. COPYRIGHTS

The Korean Space Science Society requires a corresponding author to sign a copyright transfer agreement on behalf of all the authors in order to maintain and protect the ownership and the rights of the Society, as well as to protect the original authors from misappropriation of their work. If this agreement is not assented to, the Korean Space Science Society will not publish the manuscript. This agreement is sent with the proofs to the corresponding author.

5. PAGE CHARGES

Manuscripts accepted for publication in JASS will be charged a base fee of ₩400,000 (US $400). An additional charge of ₩20,000 (US $20) per page will be added to this. Authors must pay additional page charges for each color illustration. Charges may be changed without notice by the board.

6. SUBMISSION OF MANUSCRIPT

Authors must submit manuscript files to the Editorial Office of the Korean Space Science Society using the online submission system of the Journal at http://janss.kr. We do not accept direct email submission to the Editor-in-Chief or Editors. Incomplete manuscripts will be returned to the author without review. Manuscripts submitted to the journal must represent reports of original research and must be written in English. Manuscripts are accepted for review under the condition that important parts of the study have not been published and are not being considered for publication. Also, no submission can be published without approval of the institution and all the authors. The usual prerequisites for publication will be originality, clarity, and significance as relevant to a better understanding of space science and technology.

7. MANUSCRIPT PREPARATION

Word Processors and Format of Manuscript:

Manuscripts should be submitted in the file format of Microsoft Word 2007 or a later version. Manuscripts should be doublespaced, using a font size of 11. Pages should be numbered consecutively, beginning with the title page. Page numbers should be placed at the middle of the bottom of each page. There is no fixed maximum length for full-length papers, but they rarely exceed 30 double-spaced, typewritten pages on 210×297 mm (A4 size) paper, including figures and tables.

Research and Technical Papers

The manuscript for a research or technical paper should be

organized in the following sequence: title page, abstract and keywords, introduction, methods, results, conclusion, acknowledgments, references, tables, and figure captions.

Title page:

The title page should include the full title of the article, authors' names, affiliations, footnotes, and a short title. The title should emphasize the principal objectives covered by the paper. Authors' names should be consistent and preferably be written in a standard form for all publications to facilitate indexing and to avoid ambiguity. If some of the authors have different affiliations, use superscript numbers (1, 2, 3…) after the surnames of authors and before the names of their affiliations. Use a dagger (†) after the name of one designated corresponding author. The contact information for correspondence should include the mailing address, e-mail address, telephone number, and the ORCID iD.

Abstract & Keywords:

The abstract should state the objectives and present salient conclusions in no more than 200 words. This should be a clear, concise summary describing the scope and purpose, methods or procedures, significant new results, and conclusions. The abstract should be written as one paragraph. At the end of the abstract, the keywords should be given in 3 to 6 words or phrases.

Introduction:

The paper should begin with an introduction that is written for the general reader of the journal as well as for the specialist. This section should include the background and objectives, together with significant prior works.

Methods:

The methods section should include sufficient information to allow the results to be repeated. Refer to published procedures by citing both the original description and pertinent published modifications. Do not include extensive details unless they present a substantial modification. For commonly used methods, a simple reference is sufficient. If several alternative methodologies are employed, it is useful to identify the methods briefly as well as to cite the references.

Results:

The results should be described in logical order using text, tables, and illustrations, to make clear the protocol of the study. Where appropriate, tests should be described and supported by a reference to the original citation of the test.

Conclusions:

The conclusions section should highlight key findings and compare the results of the work to appropriate findings of other studies. The conclusions should be based on the evidence presented in the paper.

Acknowledgments:

The acknowledgments section is placed at the end of body. It can cite financial and any other support.

References:

References must be obviously related to the manuscript. In the text, references should be cited with the author's surname and year of publication. When reference is made to a work by two authors, both names should be given using "&" (e.g., Kim & Lee 1996); for three or more author names, give the first author followed by "et al.'' and the year (e.g., Park et al. 2010). Multiple references must be arranged in chronological order (e.g., Sohn 1982; Choi & Kang 1991; Ahn et al. 2003). If more than two papers with the same authors and publication years are cited, list a, b, c… after the year to clarify (e.g., Jung & Han 2011a, b). Only cite articles or books already published or in press, not unpublished work "in preparation.'' In the references section, the references should be listed in alphabetical order by letter of the first author's surname. List the first five authors followed by "et al." if there are more than five authors. If more than two papers with the same authors and publication years are cited, list a, b, c… after the year in publication order. Abstracts of conferences should not be included in the references. Lines after the first line of a reference are indented by one tab space ("hanging indent" in MS Word). The style for citing papers in periodicals is surname and initials of authors, title, journal name, volume, first and last page numbers, year, and digital object identifier (DOI) if available. The styles to be used for references are as follows:

Journal articles:

1. Takahashi K, McPherron RL, Hughes WJ, Multispacecraft observations of the harmonic structure of Pc3-4 magnetic pulsations, J. Geophys. Res. 89, 6758-6774 (1984). https://doi.org/10.1029/JA089iA08p06758
2. Hwang KJ, Kuznetsova MM, Sahraoui F, Goldstein ML, Lee E, et al., Kelvin-Helmholtz waves under southward interplanetary magnetic field, J. Geophys. Res. 116, A08210 (2011). https://doi.org/10.1029/2011JA016596

Book, Book in series:

3. Kelley MC, The Earth's Ionosphere (Academic Press, San Diego, 1989).

Articles from book, conference or symposium proceedings:

4. Holmberg E, Magnitudes, colors, surface brightness, intensity distributions, absolute luminosities, and diameters of galaxies, in stars and stellar systems, vol. 9, Galaxies and the Universe, eds. Sandage A, Sandage M, Kristian J (Univ. Chicago Press, Chicago, 1975), 123-157.
5. Capitaine N, Gambis D, McCarthy DD, Petit G, Pay J, et al., Proceedings of the IERS Workshop on the Implementation of the New IAU Resolutions, Observatoire de Paris, Paris, France, 18-19 April 2002.
6. Kim K, Hwang J, Sung S, Geosynchronous magnetic field variations associated with the passage of interplanetary shocks or solar wind discontinuities, in 2007 AGU Fall Meeting, San Francisco, CA, 10-14 Dec 2007.

Technical report:

7. Mazanek DD, Roithmayr CM, Antol J, Park SY, Koons RH, et al., Comet/asteroid protection system (CAPS): preliminary space-based system concept and study results, NASA Langley Research Center Technical Report, NASA/TM-2005-213758 (2005).

Dissertation:

8. Park SY, Optimization and guidance of ascent trajectories with inequality constraints, PhD Dissertation, Texas A&M University (1996).

Website:

9. National Radio Astronomy Observatory, Very long baseline array [Internet], cited 2011 Feb 20, available from: https://www.vlba.nrao.edu

Tables:

Each table should be prepared on a separate page and numbered with an Arabic numeral in the order of its appearance in the text. When it is difficult to present data that cannot be synthesized conveniently in the text, tables should be used. Authors should avoid extensively repeating in the text data that appear in tables. Abbreviated names should be defined when they are used for the first time in each table. Tables should have a concise and informative title with the table content between horizontal lines. Vertical lines should not be used. The structure should be clear, with simple column headings giving all units. A table should not exceed one page when printed. Use lower case letters in superscripts (a, b, c...) for special remarks. Unaltered computer output and notation are generally unacceptable.

Figures:

Each figure or figure plate must have a caption written in one paragraph. For figure plates, a summary statement should precede the specific explanation of each figure. Abbreviated names are not allowed when they are used for the first time in each figure. The explanatory caption of each illustration should be understandable without reference to the text. Number figures in order of citation. Authors should place the figure number in the lower-left corner of each figure, and the numbering order must be from left to right, and from top to bottom. Citations of figures in the text or parentheses are abbreviated, e.g., Fig. 1, Figs. 1 and 2, Figs. 1-3, (Fig. 1), (Figs. 1 and 2), (Figs. 1-3). When the text refers to both figures and tables, they may be mentioned in parentheses, e.g., (Table 1; Fig. 2) and (Tables 1-3; Figs. 4-6). Line drawings should be prepared in high quality using India ink on tracing paper. Computer-generated graphics must be produced with high tones JOURNAL OF ASTRONOMY AND SPACE SCIENCES and resolution. Photographs must be of sufficient contrast to withstand the inevitable loss of contrast and detail during the printing process. Authors should double check whether the text withstands reduction and remains legible if a figure or a figure plate is reduced. Electron and light microscopic figures must be original or scanned copies from the original.

Review papers

Review papers may be solicited or submitted. A comprehensive presentation of a topic should discuss previously published material. Topics of scientific consensus as well as topics that remain controversial may be dealt with in reviews. A review is organized as follows: title page including abstract and keywords, introduction, body text, conclusions or summary, acknowledgments, and references. Text that exceeds 5,000 words, excluding references, will not be accepted.

Letters to the editor

Brief constructive comments about previously published articles and interesting new ideas should be submitted as Letters to the Editor. The body text should not exceed 1,000 words and should include references. The Editorial Board may edit the Letters. In the case of comments on previously published articles, Letters to the Editor should be submitted no more than three months after the original paper has been published. The Editorial Board may contact the authors for a response to the Letters.

General points on text style

Verb tense:

Generally, authors should use the past tense or present perfect tense to delineate specific events in the past, including the procedures, observations, and data of the

study that authors are reporting. Use the present tense for the authors' own general conclusions, firm conclusions of previous researchers, and generally accepted facts and phenomena. The Abstract, Methods, and Results should generally be in the past tense or present perfect tense, whereas most of the Introduction and some of the Conclusions can be in the present tense. However, the tense may be different in a single sentence.

Units:

If authors describe length, height, weight, and volume, they should use standard metric units. Temperature should be given in degrees Celsius. All other units should follow the International System of Units (SI). All units must be preceded by a space.

Numbers:

Except when beginning a sentence in the text, numbers should be Arabic numerals. Authors should use commas if numbers are greater than 999, e.g., 1,984,826. The 24-hour system is used to indicate time, e.g., 20:00 hr.

Abbreviations:

Abbreviations must be used as an aid to the reader, rather than as a convenience of the author, and therefore their use should be limited. Generally, avoid abbreviations that are used less than three times in the text, including tables and figure legends. Standard SI abbreviations and units in astronomy are recommended. Other common abbreviations are as follows (the same abbreviations are used for plural forms): hr (hour), sec (second), min (minute), day (not abbreviated), year (yr), and g (gravity).

한국우주과학회 제36차 정기총회

일 시 : 2018년 10월 24일 17:40
장 소 : 라마다 프라자 제주호텔

1. 정족수 확인 ····· 총무이사 곽영실
2. 개회선언 ····· 회장 김용하
3. 전회의록 낭독 ····· 총무이사 곽영실
4. 사업보고 ····· 총무이사 곽영실
5. 학술대회준비위원회 보고 ····· 위원장 이대영
6. 학술보고 ····· 학술이사 이 유
7. 포상위원회 보고 ····· 위원장 손영종
8. 감사보고 ····· 감사 한원용
9. 안건1. 2018년 결산(안) 심의 ····· 재무이사 김관혁
10. 안건2. 2019년도 예산(안) 심의 ····· 재무이사 김관혁
11. 기타토의 ····· 회장 김용하
12. 폐회 ····· 다같이

■ 한국우주과학회 제35차 정기총회 회의록 ■

■ 소집연월일 : 2017년 10월 25일 17:30
■ 개 최 장 소 : 부산 코모도 호텔
■ 개 최 일 시 : 2017년 10월 25일(수) 17:30 - 19:00
■ 참 석 회 원 : 국내 거주 정회원 701명 중 132명 참석

국내 거주 정회원 701명 중 정회원 132명 참석으로 정관 제18조 1항에 의거 총 정회원의 1/10이상(성원 71명) 출석하였으므로 한원용 의장이 제35차 정기총회 개회를 선언함.

■ 전회의록 낭독
이의 없이 유인물대로 채택되었음.

1. 사업보고(최영준 총무이사)
최영준 총무이사가 2017년도 정기 학술대회, 학술지 및 학회보 발행, 이사회 회의에 대하여 보고하였으며 이의 없이 통과 됨.

2. 학술대회준비위원회 보고(이대영 학술대회준비위원장)
이대영 학술대회준비위원장이 학술대회준비위원회 구성과 학술대회 개최실적에 대하여 보고하였으며 이의 없이 통과 됨.

3. 학술보고(이유 학술이사)
이유 학술이사가 편집위원회 구성, 학술지 발간현황, ESCI 등재(2017.8) 대하여 보고하였으며 이의 없이 통과 됨.

4. 포상위원회 보고(최영준代 총무이사)
김용기 포상위원장 대신 최영준 총무이사가 포상위원회 구성, 2017년 한국우주과학회 학술상, 두진 우주과학자상, 신진 우주과학자상 및 에스이랩상 수상자, 제27회 과학기술우수논문상 수상자, 포상 위원회 운영에 관한 규정 변경에 대하여 보고하였으며 이의 없이 통과 됨.

5. 감사 보고(이용삼代)
강영운, 양종만 감사가 2017년 1월 1일부터 9월 30일까지의 업무 및 회계감사를 실시(2017년 10월 13일), 이용삼 회원이 대신하여 그 결과를 보고하였으며 이의 없이 통과 됨.

■ 의결 안건
안건 1. 2017년도 결산(안) 승인 건
이병선 재무이사가 2017년 결산(안)을 보고하였으며 동의와 재청으로 원안대로 통과 됨.

안건 2. 2018년도 예산(안) 승인 건
이병선 재무이사가 2018년도 예산(안)에 대하여 보고하였으며 동의와 재청으로 원안대로 통과 됨.

안건 3. 제 18대 회장 선출 건
학회 정관 제12조에 의하여 당 법인의 대표권이 있는 이사 한원용의 2017년 12월 31일 임기만료로 인하여 차기회장을 선출하여 줄 것을 제안하고 임원 선출 규정에 따라 차기회장을 선출함.
차기 회장 선출을 위하여 정회원 자격을 취득한지 만 1년이 경과된 회원들로부터 온라인으로 후보를 추천 받은 결과 10명 이상의 추천을 받은 김용하 회원과 최기혁 회원이 후보로 결정되어 총회에서 무기명 비밀선거를 실시함. 투표에 정회원 130명이 참여했으며, 김용하 회원이 과반수의 득표를 얻어 차기 회장으로 선출, 한원용 의장이 이를 공표하고 김용하 회원은 즉석에서 취임을 승낙함.
- 임기 : 2018. 1. 1. ~ 2019. 12. 31.

안건4. 감사 선출 건
의장은 법인 감사 양종만, 강영운 회원이 2017년 12월 31일 임기만료로 인하여 후임 감사를 선출하여 줄 것을 제안하고 후보자로 김갑성 회원, 한원용 회원이 추천 됨. 추천된 2인의 후보자를 감사로 선임하는 것에 동의와 재청이 있어 2인의 후보를 감사에 선임하기로 한원용 의장이 공표하고 김갑성 회원, 한원용 회원은 즉석에서 취임을 승낙함.
- 임기 : 2018. 1. 1. ~ 2019. 12. 31.

안건5. 부회장, 이사 선출 건
의장은 법인 부회장 김용기, 최기혁, 박재우 회원이 2017년 12월 31일 임기만료로 인하여 후임 부회장 선임을 임원선출규정 제6조에 의하여 차기회장에게 위임하기로 동의와 재청으로 가결함.
- 임기 : 2018. 1. 1. ~ 2019. 12. 31.

의장은 제17대 이사가 2017년 12월 31일 임기만료로 인하여 임원선출규정 제7조에 따라 전체 이사의 1/2을 온라인투표로 선출하고 나머지1/2은 차기 회장이 지명하도록 함에 따라 2017년 9월 25일(월) ~ 10월 8일(일)까지 학회 홈페이지(http://ksss.or.kr)를 통하여 온라인투표로 선출된 이사를 공표하고 나머지 이사는 차기 회장이 지명하는데 동의와 재청으로 가결함. 온라인투표로 선출된 이사는 즉석에서 취임을 승낙함.
- 온라인 선출이사(12명) : 곽영실, 이유, 박장현, 박종욱, 유광선, 이대영, 이병선, 이주희, 조중현, 지건화, 진호, 최영준
- 임기 : 2018. 1. 1. ~ 2019. 12. 31.

안건6. 명예회원 추대 건
정관 제2장 제7조에 의거 2017년 제1차 이사회(2017.4.27.)에서 의결된 양종만, 오규동, 이용삼 회원을 명예회원으로 추대하여 줄 것을 제안하여 동의와 재청으로 원안대로 3인의 회원을 명예회원으로 추대하기로 결의함.

이상으로, 금일의 회의 목적인 안건이 전부 심의 종료되었으므로 의장이 폐회를 선언함.

위 결의를 명확히 하기 위하여 본 의사록을 작성하고 의장과 출석한 이사와 감사가 다음에 기명날인함.

오후 7시 00분 폐회

2017년 10월 25일
사단법인 한국우주과학회 제35차 정기총회

의 장	한 원 용 인	부 의 장	박 재 우 인
부 의 장	최 기 혁 인	총무이사	최 영 준 인
재무이사	이 병 선 인	학술이사	이 유 인
이 사	곽 영 실 인	이 사	김 영 수 인
이 사	김 용 하 인	이 사	김 호 일 인
이 사	박 장 현 인	이 사	유 광 선 인
이 사	윤 태 석 인	이 사	이 대 영 인
이 사	이 동 훈 인	이 사	이 재 우 인
이 사	조 경 석 인	이 사	조 중 현 인
이 사	지 건 화 인		

■ 사업보고 ■

1. 정기 학술대회 개최

(1) 봄 학술발표회
- 장소 : 홍천 대명비발디파크
- 일시 : 2018년 5월 9일(수) ~ 11일(금)
- 논문발표 : 155편

(2) 제1회 KGU 연합학술대회 보고
- 장소 : 홍천 대명비발디파크
- 일시 : 2018. 5. 9.(수) - 11.(금)
- 논문발표 : 101편

(2) 가을 학술발표회
- 장 소 : 라마다 프라자 제주 호텔
- 일 시 : 2018년 10월 24일(수) ~ 26일(금)
- 논문발표 : 243편

2. 학술지 및 학회보 발행

(1) 영문학술지발간 : JASS Vol 35, NO. 1, 2, 3호 발간
(2) 한국우주과학회보 Vol 27 N0 1, 2호 발간

3. 이사회

(1)회의 개최 및 주요안건

가. 2017년도 2차 회의(2017.10.25.) 부산 코모도 호텔
- · 2018년 예산(안) 승인
- · 신입회원 인준: 정회원 35명
- · 2017년(2017.1.1~09.30) 결산(안) 승인
- · 2018년 사업계획(안) 승인

나. 2018년 1차 회의(2018.01.23.) 대전 롯데시티호텔 씨카페
- · 우주관측기기 분과회 설립 승인
- · 우주감시 분과회 설립 승인
- · JASS 발전위원회 설치 승인: 위원장 김관혁, 위원 9명
- · 포상위원회 구성 승인: 위원장 손영종, 포상위원 4명
- · 학술대회준비위원회 구성 승인: 위원장 이대영,준비위원5명
- · 편집위원회 구성 승인: 위원장 이유, 부위원장 이은상, 편집위원 32명
- · 대외협력위원회 설치 승인: 위원장 문홍규
- · 2018년 가을 학술대회 개최: 회장단에 위임

다. 2018년도 2차 회의(2018.04.13.) 대전 경복궁
- · 신입회원 인준: 정회원 17명
- · 우주관측기기 분과회 회칙 승인
- · 우주감시 분과회 회칙 승인
- · 강원도(강원컨벤션뷰로)와 KGU MOU 체결 승인

■ 학술대회준비위원회 보고 ■

1. 학술대회준비위원회 구성

- 임기 : 2018년 1월 ~ 2019년 12월
- 학술대회준비위원장 : 이대영
- 학술대회준비위원 : 김연한, 이주희, 정종균, 진호, 황정아

2. 학술대회 개최 실적 보고

(1) 2017년 가을학술대회 및 제35차 정기총회
- 장소: 부산 코모도호텔
- 일시 : 2018. 10. 25.(수) ~ 27.(금)
- 발표논문 : 총 232편
  (초청강연 5편, 구두발표 74편, 포스터발표 153편)
- 참가인원 : 등록 272명
- 총사업비 : 48,879,380원

(2) 2018년 봄 학술대회
- 장소 : 홍천 대명비발디파크
- 일시 : 2018년 5월 9일(수) ~ 11일(금)
- 발표논문: 총 155편
  (초청강연 1편, 구두발표 67편, 포스터발표 87편)
- 참가인원: 등록 220명
- 총사업비: 11,437,990원

(3) 2018년 가을학술대회 (10월 13일 현재)
- 장소 : 라마다 프라자 제주 호텔
- 일시 : 2018년 10월 24일(수) ~ 26일(금)
- 논문발표 : 총 243편
  (초청강연 5편, 구두발표 70편, 포스터발표 168편)
- 등록인원 : 260명
- 총사업비 예상: 60,000,000원

■ 학술보고 ■

1. 편집위원회 구성

- 임기 : 2018년 1월 ~ 2019년 12월
- 편집위원장: 이 유
- 부편집위원장: 이은상
- 편집실장: 김숙경
- 편집위원: 김방엽, 나자경, 박찬덕, 이기원, 이대희, 이병선, 이수창, 이재진, 이주희, 지건화, 최영준, Chung Yue Hui, Xinlin Li, Tapas Kumar Das, Edward F. Guinan, Boonrucksar Soonthornthum, Paul A. Evenson, David Ruffolo, eongwoo Lee, Eunhwa Kim, Ivan L. Andronov. Lee-Anne Mckinnell, Lin-Ni Hau, Vitaly P. Kim, Jiuhou Lei, Charles Lin, Huixin Liu, Valery Nakariakov, Yuichi Otsuka, Ilya Usoskin, Chao Xiong, Sungpil Yoon

2. Journal of Astronomy and Space Sciences 발간

(가) 출판현황
- 2017년 12월호 (Vol. 34, No.4) 영문 11편 출판
- 2018년 3월호 (Vol. 35, No.1) 영문 6편 출판
- 2018년 6월호 (Vol. 35, No.2) 영문 7편 출판
- 2018년 9월호 (Vol. 35, No.3) 영문 9편 출판

(나) 인쇄본 출판 : 학회 정회원과 기관회원 배부, 학회 보관 20부

(다) On-line 출판 :
- JASS 홈페이지(http://janss.kr)
- KISTI에서 제공하는 과학기술학회마을
- 한국연구재단(KCI)
- ADS 등에서 무료로 원문 검색 가능

■ 포상위원회 보고 ■

1. 포상위원회 구성

- 임기 : 2018년 1월 ~ 2019년 12월
- 위원장 : 손영종
- 위원 : 곽영실, 이유, 진호, 채종철

2. 2018년 수상자

(가) 2018년 한국우주과학회 학술상 - 이동훈(경희대)

(나) 2018년 한국우주과학회 두진 우주과학자상 수상자
- 수상자 없음

(다) 2018년 한국우주과학회 신진 우주과학자상 수상자
- 손종대(천문연)

(라) 에스이랩상 수상자 -(주)에스이랩 지원
- 봄 학술대회 : 최규철(에스이랩)
- 가을 학술대회 : 이성숙(충남대)

(마) 제28회 과학기술우수논문상 수상
(시행처: 한국과학기술단체총연합회)
- 수상자 : 최은정(천문연)
- 수여일 : 2018년 6월 27일
- 논문제목 : Performance Analysis of Sensor Systems for Space Situational Awareness
- 게재지명 : JASS 34권 4호, 303-313

■ 감사 보고 ■

(사)한국우주과학회 2018년 감사보고서

회계년도 : 2018. 1. 1.~ 2018. 9. 30.

사단법인 한국우주과학회장 귀하

본 감사는 2018년 10월 12일, 2018년 1월 1일부터 2018년 9월 30일까지 한국우주과학회에 대한 회계감사 및 업무감사를 실시하였다.

회계부문에서는 회계기간에 해당하는 결산서, 손익계산서, 대차대조표를 검토한 결과 재무제표의 모든 항목이 제반 규정대로 정확하게 표시되었으며, 차년도 사업예산도 규정에 따라 적법하게 계획되었다. 재무제표를 뒷받침하는 회계장부와 지출결의서, 통장 등 증빙서류도 제대로 정리되었으며, 통장잔액과 장부잔액이 일치한다는 사실을 확인하였다.

학술행사 사업으로 2018년 봄 학술대회가 5월 9일~11일 홍천 대명비발디파크에서 제1회 KGU 연합학술대회와 공동으로 개최되었으며, 우리 학회는 총 220명 등록하여 155편의 논문이 발표되었고, 봄 학술대회 사업비로 11,437,990원 사용되었다. 한편 KGU 연합학술대회는 총 909명 등록하여 98편의 논문이 발표 되었으며 여러 학회가 융합할 수 있는 좋은 계기가 되는 뜻깊은 자리였다.

2018년 9월 30일 현재 학회 유동자산은 374,642,270원이며 보통예금으로 158,642,270원, 정기예금으로 200,000,000원, 두진 우주과학자상 예금으로 7,000,000원, 신진 우주과학자상으로 9,000,000원을 운영하고 있다. 2018년 9월 30일 현재 2017년 말 대비 총자산이 61,821,653원만큼 증가하였다. 12월 결산시에는 가을학술대회 행사비 지출을 하고 나면 손익이 현재보다 다소 줄어들 것으로 예상되나, 학회 자금 운용이 예산대비 합리적으로 이루어지고 있음을 확인하였다.

사업부문에서는 2018년 발행된 JASS Vol.35, No.1 ~ No.3에 대한 학술지 발행사업비로 총 13,036,948원 사용되었다. 발행된 논문은 JASS 3월호 6편, JASS 6월호 7편, JASS 9월호 9편 총 22편의 논문이 발간되었다. 2018년 사업 계획 부문에서는 각 위원회별로 사업내용과 예산이 합리적으로 계획되었음을 확인하였다.

다만 2018년에 법인등록을 추진하고 있는 KGU (Korea Geoscience Union)와 지학연(한국지구과학학회 연합회)의 관계 설정이 명확하지 않은 만큼, 관련된 학회 분담금 지출을 포함한 모든 대외 학회활동에 두 단체의 입장과 상황을 고려하여, 유의할 필요가 있다.

이상과 같이 2018년 9월 30일 기준으로 한국우주과학회 사업부문과 결산 회계처리 내역을 감사한 결과 결산서와 다르지 않다는 사실을 확인하고 이에 서명 날인한다.

2018년 10월 12일

사단법인 한 국 우 주 과 학 회

감사 김 갑 성 (인)

감사 한 원 용 (인)

■ 안건1. 2018년도 결산(안) 승인건 ■

1. 2018년도 결산서

기간: 2018.1.1~2018.09.30. (단위:원)

수입			지출		
과목	금액		과목	금액	
1.회비수입	24,460,000		1. 발행사업비	13,036,948	
1-1 연회비		24,460,000	1-1 인쇄비		5,250,300
1-2 특별회비		-	1-2 Manuscript Editing		2,640,000
2.기부금	5,000,000		1-3 영문교열		2,094,288
2-1 지정기부금		5,000,000	1-4 심사비 외		2,802,360
3.학술발표회	61,819,000		1-5 과편협등록비		100,000
3-1 봄학술대회		20,200,000	1-6 논문인용지원금		150,000
3-2 가을학술대회		41,619,000	2. 학술행사비	11,437,990	
4.게재료	16,802,775		2-1 봄학술대회		11,437,990
4-1 JASS		16,802,775	2-2 가을학술대회		-
5.광고수입	21,700,000		2-3 비정기학술대회		-
5-1 연구홍보		6,800,000	3. 비정기활동사업비	-	
5-2 기업광고		14,900,000	3-1 대중화 사업		-
6.지원금	6,850,000		4. 위원회 사업비	343,000	343,000
6-1 과총		6,850,000	5. 회의비	3,045,000	
6-2 연구재단		-	5-1 이사회/임원회		2,327,000
6-3 기타지원금		-	5-2위원회		718,000
7.용역비	-		6. 용역비	-	
7-1 용역비		-	6-1 용역직접비		-
8.사업수익	-		6-2 용역간접비		-
8-1 용역간접비		-	7. 급료와 임금	42,264,735	
9.사업외수익	15,610,883		7-1 내부인건비		42,264,735
9-1 예금이자		50,160	7-2 퇴직금정산		-
9-2 인지세		-	8. 4대보험료	2,899,570	2,899,570
9-3 사무지원비		15,066,523	9. 우편료/통신비	49,580	49,580
9-4 국세환급금		494,200	10. 세금과공과/연회비	8,751,452	
			10-1 연회비		4,660,000
			10-2 카드수수료		2,675,832
			10-3 법인등기비용		742,240
			10-4 기타공과금		672,880
			10-5 송금수수료		500
			11. 광고비	-	-
			12. 경조사비	440,000	440,000
			13. 인쇄복사비	-	-
			14. 사무용품비	1,273,630	1,273,630
			15. 출장비	3,899,100	3,899,100
			16. 제행사비	1,000,000	1,000,000
			17. 제잡비	-	-
			18. 정보화사업비	1,980,000	1,980,000
수 입 계 ①	**152,242,658**		**지 출 계 ④**	**90,421,005**	
전년도 이월금 ②	**312,820,617**	**(2017.12.31)**	**차기 이월금 (⑤=③-④)**	**374,642,270**	***회계장부 잔액**
합 계 (③=①+②)	**465,063,275**		**합계**	**465,063,275**	

전년도이월금	312,820,617
당기손익(+)	61,821,653
차기이월금	374,642,270

2. 전년도(2017 회계년도) 결산서

기간: 2017.1.1~2017.12.31. (사)한국우주과학회 (단위:원)

수입			지출		
과목	금액		과목	금액	
1.회비수입	28,920,000		**1. 발행사업비**	29,469,254	
1-1 연회비		28,920,000	1-1 인쇄비		14,313,200
1-2 특별회비		-	1-2 Manuscript Editing		4,040,000
2.기부금	-		1-3 영문교열		5,660,434
2-1 지정기부금		-	1-4 심사비 외		5,355,620
3.학술발표회	97,435,000		1-5 과편협등록비		100,000
3-1 봄학술대회		35,685,000	1-6 논문인용지원금		-
3-2 가을학술대회		61,750,000	**2. 학술행사비**	84,223,440	
4.게재료	28,061,760		2-1 봄학술대회		27,344,060
4-1 JASS		28,061,760	2-2 가을학술대회		48,879,380
5.광고수입	16,000,000		2-3 비정기학술대회		8,000,000
5-1 연구홍보		10,000,000	**3. 비정기활동사업비**	-	
5-2 기업광고		6,000,000	3-1 대중화 사업 등		-
6.지원금	45,570,000		**4. 위원회 사업비**	74,000	74,000
6-1 과총		45,570,000	**5. 회의비**	1,199,100	
6-2 연구재단		-	5-1 이사회/임원회		846,000
6-3 기타지원금		-	5-2위원회		353,100
7.용역비	-		**6. 용역비**	-	
7-1 용역비		-	6-1 용역직접비		-
8.사업수익	-		6-2 용역간접비		-
8-1 용역간접비		-	**7. 급료와 임금**	55,917,040	
9.사업외수익	3,993,940		7-1 내부인건비		51,930,290
9-1 예금이자		3,093,997	7-2 퇴직금정산		3,986,750
9-2 인지세		-	**8. 4대보험료**	4,006,650	4,006,650
9-3 사무지원비		397,003	**9. 우편료/통신비**	645,609	645,609
9-4 국세환급금		502,940	**10. 세금과공과/연회비**	9,088,130	
			10-1 연회비		4,660,000
			10-2 카드수수료		3,639,100
			10-3 법인등기비용		-
			10-4 기타공과금		785,530
			10-5 송금수수료		3,500
			11. 광고비	-	-
			12. 경조사비	-	-
			13. 인쇄복사비	-	-
			14. 사무용품비	668,870	668,870
			15. 출장비	2,751,610	2,751,610
			16. 제행사비	1,300,000	1,300,000
			17. 제잡비	-	-
			18. 정보화사업비	3,960,000	3,960,000
수 입 계 ③	**219,980,700**		**지 출 계 ④**	**193,303,703**	
전년도 이월금 ②	286,143,620	(2016.12.31)	**차기 이월금 (⑤=③-④)**	**312,820,617**	*회계장부 잔액
합 계 (③=①+②)	**506,124,320**		**합계**	**506,124,320**	

전년도이월금	286,143,620
당기손익(+)	26,676,997
차기이월금	312,820,617

■ 안건2. 2019년도 예산(안) 승인 건 ■

1. 일반회계
- 2019년 수입(안)

단위 : 원 기간 2019. 1. 1 ~ 2019. 12. 31.

2019년도 예산 수입(안)

과목	2019년 예산(A)		2018년 가결산(B)		증감(A-B)
	대분류	소분류	대분류	소분류	
1. 회비수입	**28,700,000**		**28,460,000**		**240,000**
1-1 연회비		28,700,000		28,460,000	240,000
1-2 특별회비		0		0	0
2. 기부금	**0**		**5,000,000**		**-5,000,000**
2-1 지정기부금		0		5,000,000	-5,000,000
3. 학술발표회	**91,000,000**		**76,819,000**		**14,181,000**
3-1 봄학술대회		43,000,000		20,200,000	22,800,000
3-2 가을학술대회		48,000,000		56,619,000	-8,619,000
4. 게재료	**36,000,000**		**33,802,775**		**2,197,225**
4-1 JASS		36,000,000		33,802,775	2,197,225
5. 광고수입	**16,000,000**		**26,700,000**		**-10,700,000**
5-1 연구홍보		8,000,000		8,800,000	-800,000
5-2 기업광고		8,000,000		17,900,000	-9,900,000
6. 지원금	**10,000,000**		**6,850,000**		**3,150,000**
6-1 과총		10,000,000		6,850,000	3,150,000
6-2 연구재단		0		0	0
6-3 기타지원금		0		0	0
7. 용역비	**0**		**0**		**0**
7-1 용역비		0		0	0
8. 사업수익	**0**		**0**		**0**
8-1 용역간접비		0		0	0
9. 사업외수익	**5,100,000**		**19,610,883**		**-14,510,883**
9-1 예금이자		4,200,000		4,050,160	149,840
9-2 인지세		0		0	0
9-3 사무지원비		400,000		15,066,523	-14,666,523
9-4 국세환급금		500,000		494,200	5,800
합 계	**186,800,000**		**197,242,658**		**-10,442,658**

– 2019년 지출(안)

단위 : 원 기간 2019. 1. 1 ~ 2019. 12. 31.

2019년도 예산 지출(안)

과목	2019년 예산(A)		2018년 가결산(B)		증감(A-B)	
	대분류	소분류	대분류	소분류		
1. 발행사업비	**31,000,000**		**25,236,948**		**5,763,052**	
1-1 인쇄비		10,000,000		10,550,300		-550,300
1-2 Manuscript Editing		10,800,000		4,440,000		6,360,000
1-3 영문교열		5,000,000		5,094,288		-94,288
1-4 심사비 외		4,700,000		4,802,360		-102,360
1-5 과편협등록비		200,000		100,000		100,000
1-6 논문게재장려금		300,000		250,000		50,000
2. 학술행사비	**85,000,000**		**71,437,990**		**13,562,010**	
2-1 봄학술대회		40,000,000		11,437,990		28,562,010
2-2 가을학술대회		45,000,000		60,000,000		-15,000,000
2-3 비정기학술대회		0				0
3. 비정기활동사업비	**0**		**0**	0	**0**	
3-1 대중화사업 등		0				0
4. 위원회사업비	**2,000,000**		**843,000**		**1,157,000**	
5. 회의비	**3,000,000**		**3,745,000**		**-745,000**	
5-1 이사회/임원회		2,000,000		2,727,000		-727,000
5-2 위원회		1,000,000		1,018,000		-18,000
6. 용역비	**0**		**0**		**0**	
6-1 용역직접비		0		0		0
6-2 용역간접비		0		0		0
7. 급료와 임금	**36,700,000**		**59,264,735**		**-22,564,735**	
7-1 내부인건비		34,200,000		55,264,735		-21,064,735
7-2 퇴직금정산		2,500,000		4,000,000		-1,500,000
8. 보험료	**4,200,000**		**3,899,570**		**300,430**	
9. 우편료/통신비	**150,000**		**99,580**		**50,420**	
10. 세금과공과/연회비	**8,060,000**		**9,573,952**		**-1,513,952**	
10-1 연회비		3,650,000		4,660,000		-1,010,000
10-2 카드수수료		3,500,000		3,275,832		224,168
10-3 법인등기비용		0		742,240		-742,240
10-4 기타공과금		900,000		892,880		7,120
10-5 송금수수료		10,000		3,000		7,000
11. 광고비	**330,000**		**330,000**		**0**	
12. 경조사비	**400,000**		**540,000**		**-140,000**	
13. 인쇄복사비	**0**		**0**		**0**	
14. 사무용품비	**980,000**		**1,573,630**		**-593,630**	
15. 출장비	**2,000,000**		**4,399,100**		**-2,399,100**	
16. 제행사비	**1,000,000**		**1,000,000**		**0**	
17. 제잡비	**0**		**0**		**0**	
18. 정보화사업비	**11,980,000**		**1,980,000**		**10,000,000**	
지 출 계	**186,800,000**		**183,923,505**			**2,876,495**
차기이월(당기손익)	**0**		**13,319,153**			**-13,319,153**
수 입 계	**186,800,000**		**197,242,658**			**-10,442,658**

2. 특별회계(정기예금)

항목	2019년(A)	2018년(B)	증감(A-B)
특별회계	200,000,000	200,000,000	0
두진상	6,000,000	7,000,000	-1,000,000
신진상	13,000,000	9,000,000	4,000,000
합계	**219,000,000**	**216,000,000**	**3,000,000**

한국우주과학회보
제27권 2호 2018년 10월
전화 042-865-3391 (FAX: 042-865-3392)
학회 홈페이지 http://ksss.or.kr

발행인 김용하
편집인 곽영실 · 고미희
발 행 사단법인 한국우주과학회
인 쇄 ㈜연이프린텍(02-322-2700)

학회 소재지 대전시 유성구 대덕대로 776 한국천문연구원 내
전화: 042-865-3391 / 팩스: 042-865-3392
학회대표메일: ksss@ksss.or.kr