ISSN 1598-5601

한국우주과학회보

Bulletin of The Korean Space Science Society

2022년 4월 제31권 1호

사단법인 한국우주과학회
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 바립니다.

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

▣ 은행계좌:
국민은행 012-01-0603-888
예 금 주 한국우주과학회

▣ 회비납부안내

회원구분	입회비	연회비
학생회원(학부생)	10,000원	10,000원
정회원	10,000원	70,000원
회장, 부회장	-	150,000원
이사, 감사	-	150,000원

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

※ 뒷면의 입회원서를 복사하여 사용해 주십시오.

[표지사진 설명]

한국천문연구원이 수행 중인 한미 민간달착륙선 탑재체 공동연구 사업으로 NASA Commercial Lunar Payload Services에 탑재 예정인 한국측 과학관측기기 개념도: LUSEM(달 우주환경 모니터), LVRAD(달 표면 우주방사선 측정기), LSMAG(달 표면 자기장 측정기), GrainCams(달 표토 3차원 영상카메라)

입 회 원 서

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영문</td><td>성 별</td><td>남/여</td><td>생 년 월 일</td><td colspan="2">년 월 일</td></tr>
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선택</td><td colspan="7">- 중복선택 가능
☐ 태양우주환경분과 ☐ 우주탐사분과 ☐ 우주관측기기분과
☐ 우주감시분과 ☐ 초소형위성분과 ☐ 활동 안함</td></tr>
<tr><td>경 력</td><td colspan="7"></td></tr>
<tr><td>연구 업적</td><td colspan="7"></td></tr>
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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
2022년 봄 학술대회

일　　시 : 2022. 4. 27.(수) 14:00 ~ 29.(금) 13:00

장　　소 : 쏠비치 삼척

발표논문 : 초청강연 2편, 구두발표 105편, 포스터발표 86편, 총 193편

발표시간 : 초청강연(30분~40분), 연구발표(10분~15분) 3세션 동시 진행

포스터 발표 : 2022. 4. 29.(목)　16:00~18:00

후　　원 : 한국과학창의재단 Korea Foundation for the Advancement of Science & Creativity

THE SATELLITE BREWING CO.

사단법인 한국우주과학회

등록 및 교통 안내

1. 등록

회원의 등록비는 200,000원이며, 학생회원과 정회원 중 석·박사과정(전일제) 학생은 120,000원입니다. 사전등록을 하신 회원은 등록자 명부에 서명 후 학회보, 명찰을 수령하시기 바랍니다. 등록비 영수증은 홈페이지에서 발행 가능합니다.

2. 발표자료 준비

구두발표: 발표자료는 파워포인트 파일로 준비하시기 바랍니다. 위촉된 심사위원이 우수 구두발표를 선정하여 폐회식 때 시상을 합니다(세션별 좌장이 심사하지 않음).

포스터발표: 포스터 발표는 4월 27일(수) 15시까지 지정된 장소에 게시하고, 30일(금) 10시에 수거하여 주시기 바랍니다. 집중발표 시간에 발표자는 자신의 포스터 앞에서 회원들의 질문에 답할 수 있도록 준비해 주시기 바랍니다. 위촉된 심사위원이 우수 포스터발표를 선정하여 폐회식 때 시상을 합니다. 포스터를 부착하지 않거나 학회 종료 후 수거하지 않은 회원은 추후 학회발표가 제한될 수 있습니다(2006년 3차 이사회 결정).

3. 발표장

그랜드볼룸 I	그랜드볼룸 II	에메랄드	Lobby
- Invited Talk (I), (II) - 우주기술/응용우주/우주천문 - 달탐사와 우주탐사 - SS:달 착륙선 과학기술임무 - SS: Rendezvous Mission to Apophis - 특별포럼	- 태양 및 우주환경 (I), (II), (III), (IV) - SS: 심우주탐사	- SS: Energy Coupling in the Heliosphere (I), (II) - 우주감시 - 초소형 위성 - SS: 과학문화	포스터 발표

4. 교통 안내

가. 주소: 강원도 삼척시 수로부인길 453 쏠비치 호텔 & 리조트 삼척 (Tel: 033-803-7511)

나. KTX 이용시

▶ 대전역 → 서울역 → 동해역

- 동해역에서 리조트 오시는 방법
  1. 동해역 21-1(시내버스), 91(좌석버스) → 향교 하차 → 11번 버스 환승 → 삼척 해수욕장 하차
  2. 택시: 동해역 → 리조트(약 7,500원)

다. 고속/시외버스이용시

	소요시간	요금
강남터미널	3시간 30분	우등 25,700원
동서울터미널	3시간 30분	17,400원
대전복합터미널	4시간 20분	우등 33,600원

- 고속버스 터미널에서 리조트 오시는 방법
  고속/시외버스 터미널에서 11번 버스 → 삼척 해수욕장 하차(11번 버스시간 07:30, 10:30, 13:30, 15:00, 18:00)
- 택시: 고속/시외버스 터미널 → 리조트(약 5,500원)

5. 구두발표 색인표

I - 1 - 1

세션번호 발표장 발표순서

2022 KSSS SPRING CONFERENCE PROGRAM

Apr. 27. (Wed)

Time	Functions					
12:00~	Registration Open					
14:00~14:10	Opening Ceremony : Grand Ballroom I					
14:10~14:20	Coffee Break					
Room	Grand Ballroom I (그랜드볼룸 I)		Grand Ballroom II (그랜드볼룸 II)		Emerald (에메랄드)	
Session I	우주기술/응용우주/우주천문 Chair : 임조령 (항우연)		태양 및 우주환경 I Chair : 이준찬 (과기원)		SS: Energy Coupling in the Heliosphere I Chair : 곽영실 (천문연)	
14:20~14:35	I-1-1	문건웅	I-2-1	김연한	I-3-1	조경석
14:35~14:50	I-1-2	이상원	I-2-2	양희수	I-3-2	김록순
14:50~15:05	I-1-3	조우현	I-2-3	이준찬	I-3-3	최경은
15:05~15:20	I-1-4	안상일	I-2-4	유광선	I-3-4	안준모
15:20~15:35	I-1-5	이정현	I-2-5	곽한나	I-3-5	이재옥
15:35~15:50	I-1-6	최두영	I-2-6	채종철	I-3-6	Yukinaga Miyashita
15:50~16:05	I-1-7	손동호	I-2-7	임은경	I-3-7	박경선
16:05~16:20	I-1-8	한지민	I-2-8	Bendict Lawrance		
16:20~16:30	Break Time					
Session II	달탐사와 우주탐사 Chair : 김주현 (항우연)		SS: 심우주탐사(BtM공동주관) Chair : 김방엽 (항우연) 유광선 (과기원)		SS: Energy Coupling in the Heliosphere II Chair : 양태용 (천문연)	
16:30~16:45	II-1-1	홍익선	II-2-1	김방엽	II-3-1	곽영실
16:45~17:00	II-1-2	이종훈	II-2-2	최성환	II-3-2	김정헌
17:00~17:15	II-1-3	송영주	II-2-3	한정열	II-3-3	이영숙
17:15~17:30	II-1-4	최기혁	II-2-4	조경석	II-3-4	지건화
17:30~17:45	II-1-5	유지현	II-2-5	황정아	II-3-5	감호식
17:45~18:00	II-1-6	조은진	II-2-6	유광선	II-3-6	송인선
18:00~18:15	II-1-7	이진아	II-2-7	박재흥	II-3-7	이우경
18:15~18:30			II-2-8	이진근		
	Board Meeting					

Apr. 28. (Thu)

Time	Functions					
09:00~09:30	**Invited Talk I** Room : Grand Ballroom I Chair : 이 유 (충남대) 황진영 (항우연) Outer Space and International Order					
09:30~09:40	Break Time					
Room	Grand Ballroom I (그랜드볼룸 I)		Grand Ballroom II (그랜드볼룸 II)		Emerald (에메랄드)	
Session III	SS: 달 착륙선 과학기술임무 Chair : 문봉곤 (천문연)		태양 및 우주환경 II Chair : 이진이 (경희대)		우주감시 Chair : 노동구 (천문연)	
09:40~09:52	III-1-1	천이진	III-2-1	박진혜	III-3-1	김윤학
09:52~10:04	III-1-2	문봉곤	III-2-2	이진이	III-3-2	최승환
10:04~10:16	III-1-3	윤형주	III-2-3	정현진	III-3-3	유지웅
10:16~10:28	III-1-4	심채경	III-2-4	손지현	III-3-4	성재동
10:28~10:40	III-1-5	류동영	III-2-5	나현옥	III-3-5	최 진
10:40~10:52	III-1-6	한정열	III-2-6	Sumaiay Rahman	III-3-6	최은정
10:52~11:04	Break Time				III-3-7	조중현
11:04~11:16	III-1-7	예성준	III-2-7	송석민	우주감시분과워크숍	
11:16~11:28	III-1-8	김성환	III-2-8	이영숙		
11:28~11:40	III-1-9	김홍주	III-2-9	Ram Singh		
11:40~11:52	III-1-10	정광수	III-2-10	이재욱		
11:52~12:04	III-1-11	백슬민	III-2-11	홍준석		
12:04~12:16	III-1-12	설우형	III-2-12	이원석		
12:30~13:30	Lunch Time					
13:30~15:00	**특별 포럼** Room : Grand Ballroom I Chair : 임종빈 (과학기술정책연구원) - 주제 : 제4차 우주개발진흥 기본계획 우주탐사 분야 방향성 모색 - 발제발표 : 권윤영 (과학기술정책연구원 국가우주정책연구센터)					
15:00~15:20	Photo Time / Coffee Break					
15:20~16:00	**Invited Talk II** Room : Grand Ballroom I Chair : 김록순 (천문연) Stefaan Poedts : KU Leuven (Belgium) & UMCS (Poland) Modelling CME Evolution from the Corona to the Earth and Beyond					
16:00~18:00	Poster Session					
18:00~20:00	Banquet (Grand Ballroom)					

Apr. 29. (Fri)

Time	Functions					
Room	Grand Ballroom I (그랜드볼룸 I)		Grand Ballroom II (그랜드볼룸 II)		Emerald (에메랄드)	
Session Ⅳ	SS: Rendezvous Mission to Apophis Chair : 이덕행 (천문연)		태양 및 우주환경 III Chair : 김정헌 (천문연)		초소형 위성 Chair : 김해동 (항우연)	
09:00~09:15	Ⅳ-1-1	최영준	Ⅳ-2-1	김은솔	Ⅳ-3-1	최원섭
09:15~09:30	Ⅳ-1-2	김명진	Ⅳ-2-2	정세헌	Ⅳ-3-2	손종대
09:30~09:45	Ⅳ-1-3	정민섭	Ⅳ-2-3	윤종연	Ⅳ-3-3	김민기
09:45~10:00	Ⅳ-1-4	김푸름	Ⅳ-2-4	오대현	Ⅳ-3-4	박재흥
10:00~10:15	Ⅳ-1-5	정안영민	Ⅳ-2-5	이재희	초소형위성분과 총회	
10:15~10:30	Ⅳ-1-6	이희재	Ⅳ-2-6	김희은		
10:30~10:45	Ⅳ-1-7	최진행				
10:45~11:00	Break Time					
Session Ⅴ			태양 및 우주환경 IV Chair : 김관혁 (경희대)		SS: 과학문화 Chair : 황정아 (천문연)	
11:00~11:15			Ⅴ-2-1	곽재영	Ⅴ-3-1	10:40~11:00 조중현
11:15~11:30			Ⅴ-2-2	권종우	Ⅴ-3-2	11:00~11:20 임소정
11:30~11:45			Ⅴ-2-3	이준현	Ⅴ-3-3	11:20~11:40 전은지
11:45~12:00			Ⅴ-2-4	김관혁	Ⅴ-3-4	11:40~12:00 이정원
12:00~12:15			Ⅴ-2-5	민경국	12:00~12:30 패널 토의	
12:30~13:00	Closing Ceremony : Grand Ballroom I 우수 구두발표상, 우수포스터상 시상식					

Poster Session

4. 28. (Thu) 16:00~18:00

Area	No	Author	Area	No	Author
우주기술	P-1	강우용	우주기술	P-25	신근웅
	P-2	강 철		P-26	신현규
	P-3	권기호		P-27	안상일
	P-4	김동규		P-28	양승은
	P-5	김동오		P-29	양정환
	P-6	김명묵		P-30	양지모
	P-7	김영윤		P-31	연정흠
	P-8	김유광		P-32	윤석택
	P-9	김중표		P-33	윤영수
	P-10	김진혁		P-34	이상록
	P-11	김창호		P-35	이서림
	P-12	김혜원		P-36	이선익
	P-13	김희경		P-37	임원규
	P-14	명환춘		P-38	임은숙
	P-15	박성우		P-39	임조령
	P-16	박은빈		P-40	임현수
	P-17	박종범		P-41	장경덕
	P-18	박종석		P-42	장성수
	P-19	박종오		P-43	전종협
	P-20	박주호		P-44	전현진
	P-21	박진형		P-45	정옥철
	P-22	방수완		P-46	채동석
	P-23	복준영		P-47	한조영
	P-24	송새한			

Poster Session

4. 28. (Thu) 16:00~18:00

Area	No	Author	Area	No	Author
우주응용	P-48	박종억	달 착륙선 과학기술임무	P-68	이춘우
	P-49	이원범		P-69	정다운
	P-50	이종태	태양 및 우주환경	P-70	박은수
우주천문	P-51	김영수		P-71	송호섭
	P-52	민병희		P-72	양태용
우주감시	P-53	정유연		P-73	우창호
	P-54	김한익		P-74	이강우
달탐사와 우주탐사	P-55	김민배		P-75	이경선
	P-56	김연규		P-76	이승욱
	P-57	김주현		P-77	이창은
	P-58	문상만		P-78	이하림
	P-59	박경선		P-79	이호진
	P-60	박현후		P-80	임다예
	P-61	배종희		P-81	임진구
	P-62	백길호		P-82	장은진
	P-63	송재훈		P-83	최윤승
	P-64	안한웅		P-84	홍지민
	P-65	이주희		P-85	황재민
	P-66	조우인		P-86	황준영
초소형 위성	P-67	김지석			

특별포럼 개최

진행: 임종빈(과학기술정책연구원)

과학기술정책연구원 국가우주정책연구센테에서는 제4차 우주개발진흥기본계획 수립을 위한 기획연구를 진행하고 있습니다. 우리나라의 우주개발은 추격자의 입장에서 발사체와 인공위성 등의 기술 검증과 기술 확보 중심으로 이루어져 왔습니다. 이제 우리 우주기술은 성숙단계로 접어들고 있으며, 따라서 우리나라 우주개발 비전과 계획을 기술 중심에서 임무 중심으로, 검증을 넘어 성과 중심으로 전환해야 한다는 시대적인 요구가 높아지고 있습니다. '우주탐사'는 이런 변화를 이끌 수 있는 중요한 주제인 동시에, 또한 국제협력을 통해 선진국의 기술을 흡수할 수 있는 좋은 수단이기도 합니다. 이에 대한민국 우주탐사의 최고 전문가이신 한국우주과학회 회원님들을 모시고 대한민국 우주탐사의 미래 비전, 방향성, 추구할 임무·과학, 이들을 실현할 수 있는 전략 등에 대해 소중한 의견을 듣고자 합니다.

(1) **주제:** 제4차 우주개발진흥 기본계획 우주탐사 분야 방향성 모색

(2) **일시:** 2022년 4월 28일(목) 13:30~15:00

(3) **장소:** 쏠비치 삼척 Grand Ballroom I

(4) **13:30~13:50** 발제발표 : 권윤영 (과학기술정책연구원)
제4차 우주개발진흥 기본계획 우주탐사 분야 방향성 모색

13:50~14:10 토론 1 국가적 가치/기술수준, 미래 국제 경쟁력을 고려한 향후 50년(100년) 국가 전략적 우주탐사 과학 임무

14:10~14:30 토론 2 국내 기술 수준을 초과한 우주탐사 과학 임무- 큰 보폭을 위한 국제 협력

14:30~14:50 토론 3 국가 우주탐사 계획의 철학과 비전, 실현 방안- 제5차 우주개발진흥 기본계획 준비

14:50~15:00 자유 토론

(5) **패널:**
○ 김은혁 박사 (항우연)
○ 김주현 박사 (항우연)
○ 김해동 박사 (항우연)
○ 문봉곤 박사 (천문연)
○ 박경선 박사 (충북대)
○ 이주희 박사 (항우연)
○ 정영진 박사 (항우연)
○ 지건화 박사 (극지연)

제4회 우주감시분과 워크숍

- **제목:** 우주감시분야의 민간 기업 활동 현황 공유 및 협력 워크숍
- **일시:** 2022년 4월 28일(목) 11:10~12:40
- **장소:** 쏠비치 삼척, 에메랄드
- **모시는 글**

우주를 향한 민간기업의 도전과 사업영역의 확장은 우주개발을 통한 경제적 이익을 창출하는 '뉴 스페이스 시대'를 이끌고 있습니다. 우주산업을 선점하기 위해 전 세계 민간 기업들의 우주개발이 더욱 활발해지면서 더불어 안전한 우주활동을 위한 우주감시 활동의 필요성도 높아지고 있습니다. 따라서 인공위성, 우주쓰레기와 같은 인공우주물체를 탐지하고 식별하는 광학, 레이더, 레이저 관측 시스템의 개발도 확대되고 있고, 이러한 우주감시 체계를 개발하는 민간 기업의 확보도 매우 중요해지고 있습니다. 우주감시분야에서도 연구역량뿐만 아니라 산업적인 토대가 마련될 수 있도록 많은 기업의 참여가 필요합니다. 이번 워크숍에서는 현재 국내 우주감시분야의 민간기업의 활동 현황과 개발 방향을 공유함으로써 국가적인 우주감시 대응을 위한 역량을 강화하고 우주감시분야의 산업도 발전하는데 기여하고자 합니다. 관심있는 분들의 많은 참석을 기대합니다.

- **프로그램**

시간	주제	발표
우주감시분야의 민간 기업 활동 현황 공유 및 협력 워크숍		
11:10~11:20	우주감시분과 워크숍 개회	진행: 최은정 (천문연)
11:20~12:20	우주감시레이다 관련 LIG 넥스원의 연구 현황 및 향후 개발 방향	문현욱 (LIGNex1)
	레인보우로보틱스사의 우주감시용 마운트 개발 현황	정병준 ((주)레인보우로보틱스)
	우주감시기술 국내・외 개발 동향 및 한화 시스템 개발 현황	김남문 (한화시스템)
12:20~12:40	민간 우주감시기술 확대 및 발전을 위한 논의	우주감시분과

* 우주감시분과: 위원장 최은정(천문연), 간사 김명진(천문연), 고문 김천휘(충북대)
운영위원: 강병국((주)솔탑), 박상영(연세대), 성재동(항우연), 안재명(KAIST), 최만수(천문연)

워크숍 주제 발표 초록

[발표 1] 우주감시레이다 관련 LIG 넥스원의 연구 현황 및 향후 개발 방향

문현욱(LIG넥스원 수석연구원)

장차 국내 우주 자산 및 국민 안전 보호를 목적으로 하는 우주감시레이다 개발을 위해, 현재까지 LIG넥스원에서 수행하고 있는 연구 실적을 공유함으로써, 우주감시레이다 개발을 위한 요구사항, 설계 제원, 환경 영향 등에 대해 알아보고 이를 통해 향후 우주감시레이다 개발 방향에 대해 제시하고자 합니다.

[발표 2] 레인보우로보틱스사의 우주감시용 마운트 개발 현황

정병준(레인보우로보틱스 부장)

레인보우로보틱스사는 휴보, 협동 로봇으로 대표되는 로봇과 천체관측용 마운트 제조사이다. 로봇 기술을 응용한 천체관측 장비를 개발, 판매하고 있으며, 우주감시용 마운트와 주변 장치를 개발하여 한국천문연구원의 우주물체전자광학감시체계와 공군의 전자광학위성감시체계에서 사용되고 있다. 본 발표에서는 지금까지 개발된 장비와 그것에 사용된 기술을 소개한다.

[발표 3] 우주감시기술 국내・외 개발 동향 및 한화 시스템 개발 현황

김남문(한화시스템 전문연구원)

지속적인 우주개발 및 대규모 인공위성 배치와 최근 정부 주도의 우주개발이 민간 주도로 변화되면서 우주 자산이 급격하게 증가하고 있으며, 현재 수명을 다한 인공위성 혹은 요격 시험에 의한 우주 파편 등과 같은 우주 잔해물이 우주물체의 70% 이상을 차지하는 것으로 알려져 있다. 이와 같이 급증하는 우주 자산과 우주 잔해물 간의 충돌은 정상적인 인공위성 임무 수행에 차질을 줄 뿐만 아니라 우주 잔해물의 지구추락 위험성이 증가하고 있다. 이러한 위협에 대한 판단 및 대응을 위한 우주감시 및 우주상황인식에 대한 필요성이 증대되고 있다.
주요 선진국들은 지상에서 우주를 감시하기 위하여 광학시스템, 파라볼릭 안테나 기반 레이다 그리고 위상배열 안테나 기반 레이다 등을 활용하여 우주감시체계를 구축하여 운용하고 있다. 국내에서는 광학기반의 감시체계를 운용하고 있으며, 위상배열레이다를 활용한 감시체계는 시작단계에 있다.
한화시스템에서는 다 수의 능동위상배열 레이다 개발경험을 보유하고 있으며, 현재 개발 중인 L-SAM 다기능레이다에서 위성 탐지/추적 기능이 개발되었다. 현재 모의시험을 통한 탐지/추적 성능을 확인하였으며, 실표적 대상으로의 시험이 계획되어 있다.
한화시스템은 축적된 레이다 개발, 시험 및 검증 능력을 바탕으로 우주감시 레이다 개발을 준비하고 있다.

구두발표 논문 제목 및 시간표

4월 27일(수)

제1발표장 (그랜드볼룸 I)

14:20 [I-1-1]

PIC-DSMC Simulation of Hall Thruster Plume Flow under VLEO Operation Condition

Geonwoong Moon, Eunji Jun†

Korea Advanced Institute of Science and Technology

14:35 [I-1-2]

Design of Autonomous Attitude Control Algorithm of Multi-Static SAR Micro-Satellites for HRSI (High Resolution Strip-Map Imaging)

Sangwon Lee[1], Jeongbae Kim[2], Sang-Young Park[1], Jihae Son[3], Sung-Chan Song[3]

[1]*Astrodynamics and Control Lab, Yonsei University*
[2]*RADAR System Lab, Yonsei University*
[3]*Hanwha System Corporation*

14:50 [I-1-3]

Preliminary Study of Wide Frequency Range Fluxgate Magnetometer

Woohyun Jo, Ho Jin, Khan-Hyuk Kim, Hyeonhu Park, Wooin Jo, Yun-Ho Jang, Jehyuck Shin

School of Space Research, Kyung Hee University

15:05 [I-1-4]

The S-Band RF Test in PVSAT FM AIT

Sangil Ahn[1], In Hoi Koo[1], Sang Hyun Han[2], Jung Mo Yang[2], Seung Hoon Han[2]

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

15:20 [I-1-5]

Geo-Kompsat 2A Telemetry Data Long-Term Analysis Software (G-TLAS) Prototype Development

Junghyun Lee[1], Sungchul Park[2], Seokrae Jang[2], Sangcherl Lee[1]

[1]*Korea Aerospace Research Institute (KARI)*
[2]*Just In Time (JIT) Solution*

15:35 [I-1-6]

Calibration Plan and Early Results of Noise Test for AIMAG onboard CAS500-3

Dooyoung Choi[1], Kwangsun Ryu[2], Seunguk Lee[1,2], Junchan Lee[2], Chang Ho Woo[2], Eunjin Jang[2], Jaemin Hwang[2], Wonho Cha[2], Cheong Rim Choi[1]

[1]*Chungbuk National University*
[2]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*

15:50 [I-1-7]

Retrieval of Precipitable Water Vapor from Ship-Borne Multi-GNSS Measurements in the Ocean

Dong-Hyo Sohn[1], Byung-Kyu Choi[1], Yosup Park[2], Byung-Il Lee[3]

[1]*Korea Astronomy and Space Science Institute*
[2]*Korea Institute of Ocean Science and Technology*
[3]*National Meteorological Satellite Center, KMA*

16:05 [I-1-8]

Coordinate Modeling for Optical Alignment of Off-Axis Reflective Telescope

Jimin Han[1], Hojae Ahn[1], Joong Kyu Ham[2], Daewook Kim[3], Geon Hee Kim[2], Jong Gyun Kang[2], Young Tae Kwak[2], Dae-Hee Lee[4], Youngsik Park[4], Bongkon Moon[4], Seunghyuk Chang[5], Soojong Pak[1†]

[1]*School of Space Research and Institute of Natural Science, Kyung Hee University*
[2]*AeroSpace Optics Center, Hanbat University*
[3]*James C. Wyant College of Optical Sciences, University of Arizona*
[4]*Korea Astronomy and Space Science Institute*
[5]*Center for Integrated Smart Sensors, Korea Advanced Institute of Science and Technology (KAIST)*

16:30 [II-1-1]

MGM Analysis of Shield Volcano with Olivine-Rich in Birt E

Ik-Seon Hong, Yu Yi

Department of Astronomy, Space Science, and Geology, Chungnam National University

16:45 [II-1-2]

Test Particle Simulations of the Dynamics of Plasmas around Lunar Magnetic Anomalies

Jong Hoon Lee, Ensang Lee, Jongho Seon

School of Space Research, Kyung Hee University

17:00 [II-1-3]

Simulation of KPLO Flight Dynamics Subsystem Using Blind Test Data for Operational Readiness Preparation

Young-Joo Song, Jonghee Bae, SeungBum Hong, Jun Bang, Jae-ik Park, Young-Rok Kim

Korea Aerospace Research Institute

17:15 [II-1-4]

Development of Lunar Underground Detection Mission Using Low Frequency Radar for Korea Lunar Lander (KLL)

Gi-Hyuk Choi, Dae-Yeong Kim

Korea Aerospace Research Institute

17:30 [II-1-5]

Predicting Fast Temporal Changes of Energetic Neutral Atom Flux in the Outer Heliosheath

Ji-Hyeon Yoo, Dae Young Lee

Department of Astronomy and Space Science, Chungbuk National University

17:45 [II-1-6]

The Early Activity of Jupiter Trojans after Their Migration through Exploring a Thermal and Mechanical Evolution

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

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

18:00 [II-1-7]

Gravitational Potential Estimations for the Near-Earth Asteroid Ganymed (1036)

Jinah Lee, Chandeok Park

Department of Astronomy, Yonsei University

제2발표장 (그랜드볼룸 II)

14:20 [I-2-1]

Development of a Diagnostic Coronagraph on the ISS: CODEX Progress Report

Yeon-Han Kim[1], Seonghwan Choi[1], Su-Chan Bong[1], Kyungsuk Cho[1,2], Jeffrey Newmark[3], Nat Gopalswamy[3], KASI-NASA Coronagraph Team

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

14:35 [I-2-2]

CORIFS2.0: CORonal Integral Field Spectropolarimeter for the Total Solar Eclipse

Heesu Yang[1], Kyuhyoun Cho[2], Su-Chan Bong[1], Seoung-Hwan Choi[1], Jihun Kim[1], Juhyung Kang[1], Donguk Song[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Lockheed Martin Solar Astrophysics Laboratory*

14:50 [I-2-3]

Design and Preliminary Experiment of Integrated Plasma Measurement Payload, AIPIM for CAS500-3

Junchan Lee[1], Kwangsun Ryu[1], Chang-Ho Woo[1], Seunguk Lee[2], Eunjin Jang[1], Jaemin Hwang[1]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

15:05 [I-2-4]

EQM Design Progress Report of the IAMMAP Scientific Instrument for the CAS500-3 Satellite

Kwangsun Ryu[1], Junchan Lee[1], Seunguk Lee[1,2], Chang-Ho Woo[1], Eunjin Jang[1], Jaemin Hwang[1], Jinkyu Kim[1], Wonho Cha[1], Dongkook Kim[1], Bon-ju Koo[1], Seong-Og Park[1], Du-young Choi[2], Jeongrim Choi[2]

[1]*SaTReC, KAIST*
[2]*Chungbuk National University*

15:20 [I-2-5]

Spectroscopic Detection of Alfvénic Waves in the Chromospheric Fibrils of a Solar Quiet Region

Hannah Kwak, Jongchul Chae
Seoul National University

15:35 [I-2-6]

Propagating Alfvenic Waves Observed in the Chromosphere of a Sunspot Region: Tales of Three-Minute Waves and Ten-Minute Waves

Jongchul Chae
Seoul National University

15:50 [I-2-7]

Dynamical and Thermal Properties of RBEs and RREs Derived from Fast Imaging Solar Spectrograph

Eun-Kyung Lim[1,2], Jongchul Chae[3], Vasyl Yurchyshyn[4], Heesu Yang[1], Kyung-Suk Cho[1,2], Kyuhyoun Cho[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Seoul National University*
[4]*Big Bear Solar Observatory, NJIT, USA*

16:05 [I-2-8]

Generation of Coronal White Light Images from Extreme Ultraviolet Solar Images Using Deep Learning

Bendict Lawrance[1], Harim Lee[1], Eunsu Park[1], Il-Hyun Cho[1], Yong-Jae Moon[1,2], Jin-Yi Lee[1], Shanmugaraju[3], Sumiaya Rahman[2]

[1]*Department of Astronomy and Space Science, Kyung Hee University*
[2]*School of Space Research, Kyung Hee University*
[3]*Department of Physics, Arul Anandar College, Karumathur, India*

16:30 [II-2-1]

A Study on the Characteristics of Space Exploration Mission Orbits Using Domestically Developed Launch Vehicles

Bangyeop Kim[1], Jaemyung Ahn[2]

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

16:45 [II-2-2]

Free Space Optical Communication for Space Communications

Seonghwan Cho[1], Jeong-Yeoll Han[1,2], Sang Yeong Park[3], Joon Huh[4], Kihun Lee[4]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Hanwha System Co., Ltd.*
[4]*Defense Industry Technology Center*

17:00 [II-2-3]

Proposal of Development Perspective for Korean Space Telescope

Jeong-Yeol Han[1,2], Woojin Park[1], Youra Jun[1], Jihun Kim[1], Yunjong Kim[1], Seonghwan Choi[1], Young-Soo Kim[1], Ji-Hye Baek[1], Bongkon Moon[1], Biho Jang[1], Jae-Woo Kim[1], Sungwook E. Hong[1,2], Youn Kil Jung[1], Soojong Pak[3]

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

17:15 [II-2-4]

Heliosphere Observations at Lagrange Points

Kyung-Suk Cho, Junga Hwang, Jeong-Yeol Han, Seonghwan Choi, Eun Kyung Lim, Jungjoon Seough, Young-Soo Kim, Rok-soon Kim, Jongdae Sohn, Jihun Kim, Jaejin Lee, Soyoung Hong

Korea Astronomy and Space Science Institute

17:30 [II-2-5]

A Multi-Purpose Heliophysics L4 Mission

Junga Hwang[1,2], Kyung-suk Cho[1,2], Jeongreol Han[1,2], Seong-Hwan Choi[1], En-Kyung Im[1,2], Jeoungjun Seo[1], Young-Su Kim[1], Roksoon Kim[1], Jongdae Son[1], Jiheon Kim[1], Jaejin Lee[1,2], Soyoung Hong[2]

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

17:45 [II-2-6]

Proposal of Highly Elliptical Magnetosphere and Tail Region Survey Mission as a Step-Stone for Deep Space Exploration

Kwangsun Ryu, BtM Members, SSG Members

SaTReC, KAIST

18:00 [II-2-7]

Electron Drift Instrument (EDI) for Future Korean

Missions

Jaeheung Park[1,2], The Space Science Group (SSG)

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

18:15 [II-2-8]

Space Exploration Using Mass Spectrometer

Jingeun Rhee, Ju Woo

Youngin ACE Co., Ltd.

제3발표장 (에메랄드)

14:20 [I-3-1]

How Can We Decide a Coronal Mass Ejection will be Geoeffective or Not?

Kyung-Suk Cho

Korea Astronomy and Space Science Institute

14:35 [I-3-2]

Evidence of CME-CME Interaction in the Interplanetary Space

Rok-Soon Kim[1], Stefaan Poedts[2,3], Brigitte Schmieder[2,4], Jasmina Magdalenic[3]

[1]*Korea Astronomy and Space Science Institute*
[2]*Katholieke Universiteit Leuven*
[3]*Royal Observatory of Belgium*
[4]*Observatoire de Paris, Section Meudon*

14:50 [I-3-3]

Multi-Point Observations of Flux Ropes Using PSP, STEREO, and Wind

Kyung-Eun Choi[1], Dae-Young Lee[1], Katsuhide Marubashi[2]

[1]*Department of Astronomy and Space Science, Chungbuk National University*
[2]*National Institute of Information and Communications Technology, Tokyo, Japan*

15:05 [I-3-4]

Solar Wind and CME Propagations from Sun to 1 AU with MHD Simulation

Junmo An

Department of Astronomy and Space Sicence, Kyung Hee University

15:20 [I-3-5]

Effects of Geometries and Substructures of ICMEs on Geomagnetic Storms

Jae-Ok Lee[1], Kyung-Suk Cho[2], Rok-Soon Kim[2], Soojeong Jang[3], Katsuhide Marubashi[4]

[1]*Chungnam National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Kyung Hee University*
[4]*Asia Space Environment Research Consortium*

15:35 [I-3-6]

Coupling of the Magnetosphere and the Polar Ionosphere during Storms and Substorms from an Observational Point of View

Yukinaga Miyashita[1,2]

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

15:50 [I-3-7]

Global MHD Simulations of the Solar Wind-Magnetosphere-Ionosphere Coupling

Kyung Sun Park

Department of Astronomy and Space Science, Chungbuk National University

16:30 [II-3-1]

Responses and Changes in the High-Latitude Upper Atmosphere during Solar Activity and Geomagnetic Storms, and Their Global Propagation

Young-Sil Kwak

Korea Astronomy and Space Science Institute (KASI)

16:45 [II-3-2]

Ionospheric Responses over North-East Asia and Europe during the G3 Extreme Geomagnetic Storm (Nov 4, 2021) Induced by Solar CME Event

Jeongheon Kim[1], Young-Sil Kwak[1,2], Hosik Kam[1], Jae-Wook Lee[1,2], Tae-Yong Yang[1], Woo Kyoung Lee[1], Junseok Hong[1], ChangSup Lee[3], GeonHwa Jee[3], YongHa Kim[4], JongYeon Yun[5]

[1]*Korea Astronomy and Space Science Institute, KASI*

[2]*University of Science and Technology, UST*
[3]*Korea Polar Research Institute, KOPRI*
[4]*Chungnam National University, CNU*
[5]*Korea Space Weather Center, KSWC*

17:00 [II-3-3]

Modulation of High-Latitude Ionosphere and Mesosphere in Responding to Energetic Electron Precipitation (〉 30 keV) during Geomagnetic Disturbances

Young-Sook Lee[1], Yong Ha Kim[1], Young-Sil Kwak[2]

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

17:15 [II-3-4]

Polar Middle Atmospheric Responses to High-Speed Solar Wind Streams and Geomagnetic Stroms

Geonhwa Jee[1,2], Ji-Hee Lee[1], In-Sun Song[3]

[1]*Korea Polar Research Institute*
[2]*University of Science and Technology*
[3]*Yonsei University*

17:30 [II-3-5]

Geomagnetic Activity Impacts on Meteor Plasma Trails in the Mesosphere and Lower Thermosphere

Hosik Kam[1], Young-Sil Kwak[1,2], Jeong-Heon Kim[1], Junseok Hong[1], Yong Ha Kim[3], Changsup Lee[4], Jeong-Han Kim[4], Tae-Yong Yang[1], Jaewook Lee[1,2], Seonghwan Choi[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Department of Astronomy and Space Science, Korea University of Science and Technology*
[3]*Department of Astronomy, Space, and Geology, Chungnam National University*
[4]*Division of Polar Atmospheric Sciences, Korea Polar Research Institute*

17:45 [II-3-6]

Investigation on Ionospheric and Thermospheric Variability Using Specified Dynamics WACCM-X 2.0

In-Sun Song, Ja Soon Shim, Wonseok Lee

Department of Atmospheric Sciences, Yonsei University

18:00 [II-3-7]

Development of Space-Borne Wide-Field Auroral/Airglow Imager

Woo Kyoung Lee[1,2], Seonghwan Choi[1], Kyoung-Min Roh[1,2], Young-Sil Kwak[1,2], Jihun Kim[1], Yunjong Kim[1], Jongyeop Park[1], Jihye Baek[1], Jong-Kyun Chung[1], Jaeheung Park[1,2], Tae-yong Yang[1], Dukhaeng Lee[1], Hyosub Kil[3], Larry J. Paxton[3], Geonhwa Jee[4], Yongha Kim[5]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Johns Hopkins University Applied Physics Laboratory*
[4]*Korea Polar Research Institute*
[5]*Chungnam National University*

4월 28일(목)

제1발표장 (그랜드볼룸 I)

09:00 [IS-I]

Outer Space and International Order

Chin-Young Hwang

Korea Aerospace Research Institute

09:40 [III-1-1]

Overview of Planning Research on the Korean Lunar Lander Project

Yee-Jin Cheon

Korea Aerospace Research Institute

09:52 [III-1-2]

Introduction to Science & Technology Mission Formulation (STMF) Working Group Activity for Korean Lunar Lander in 2030s

Bongkon Moon

Korea Astronomy and Space Science Institute

10:04 [III-1-3]

Korean Lunar Lander for Exploration: Preliminary Design of System and Architecture

Hyungjoo Yoon

Korea Aerospace Research Institute

10:16 [III-1-4]

Potential Science Topics for Future Lunar Explorations

Chae Kyung Sim

Korea Astronomy and Space Science Institute

10:28 [III-1-5]

Technology Demonstration Trends in Recent Robotic Lunar Surface Missions

Dong Young Rew

Korea Aerospace Research Institute

10:40 [III-1-6]

Proposal of Multi-Band Imager for Lunar Lander

Jeong-Yeol Han[1,2], Youra Jun[1], Chae Kyung Sim[1], Young-Soo Kim[1], Bongkon Moon[1], Hyoungkwon Lee[3]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*LeO SPACE Inc.*

11:04 [III-1-7]

Active Neutron Spectroscopy to Measure Abundance of H/OH-Bearing Materials and Rare-Earth Elements on the Lunar Subsurface

Sung-Joon Ye[1], Sukwon Youn[1], Uk-won Nam[2], Won-Kee Park[2], Jongdae Sohn[2], Hongjoo Kim[3], Sunghwan Kim[4], Jintae Hong[5], Insoo Jun[6]

[1]*Department of Applied Bioengineering and Research Institute of Convergence Science, Graduate School of Convergence Science and Technology, Seoul National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Department of Physics, Kyungpook National University*
[4]*Department of Radiological Science, Cheongju University*
[5]*Korea Atomic Energy Research Institute*
[6]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA*

11:16 [III-1-8]

Dosimetry of Human Exploration on the Lunar Surface Using Si-Sensors

Sunghwan Kim[1], Uk-won Nam[2], Won-Kee Park[2], Jongdae Sohn[2], Hongjoo Kim[3], Sincheol Kang[3], Sung-Joon Ye[4], Sukwon Youn[4], Insoo Jun[5]

[1]*Department of Radiological Science, Cheongju University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Department of Physics, Kyungpook National University*
[4]*Department of Applied Bioengineering, Graduate School of Convergence Science and Technology, Seoul National University*
[5]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA*

11:28 [III-1-9]

Good Energy Resolution and High Gamma Detection Efficiency Crystal Scintillators for Space Mission

Hong Joo Kim[1], Phan Quoc Vuong[1], Arshad Khan[1], Nguyen Thanh Luan[1], Sinchul Kang[1], Uk-Won Nam[2], Sunghwan Kim[3]

[1]*Kyungpook National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Cheongju University*

11:40 [III-1-10]

Lunar Architecture ISRU System & Role of Private Sector in the Field of ISRU in Korea

Kwang-Soo Jung[1], Won-Suk Lee[1], Koo-Young Kwon[1], Sun-Kyu Lee[2]

[1]*Hanwha Aerospace*
[2]*Hanwha Systems*

11:52 [III-1-11]

Lunar Science Expected from Magnetometers on the Surface of the Moon

Seul-Min Baek[1], Ho Jin[2], Khan-Hyuk Kim[2], Young-Jun Choi[1,3]

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

12:04 [III-1-12]

Particles-and-Fields Instrument for the Korean Lunar Lander Mission

Woo-Hyeong Seol, Jongho Seon, Ho Jin, Khan-Hyuk Kim

School of Space Research, Kyung Hee University

13:30 [특별포럼]

15:20 [IS-II]

Modelling CME Evolution from the Corona to the Earth and Beyond

Stefaan Poedts

KU Leuven (Belgium) & UMCS (Poland)

제2발표장 (그랜드볼룸 II)

09:40 [III-2-1]

Revisiting the Source Regions of Solar Energetic Particles by Synchronic Potential Field Source Surface Model

Jinhye Park[1], Hyun-Jin Jeong[2], Yong-Jae Moon[1,2]

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

09:52 [III-2-2]

Study on Plasma Heating along a Current Sheet in Nonequilibrium

Jin-Yi Lee[1], John C. Raymond[2], Katharine K. Reeves[2], Chengcai Shen[2], Stephen Kahler[3], Yong-Jae Moon[1], Yeon-Han Kim[4,5]

[1]*Kyung Hee University*
[2]*The Center for Astrophysics | Harvard & Smithsonian*
[3]*Air Force Research Laboratory*
[4]*Korea Astronomy & Space Science Institute*
[5]*University of Science and Technology*

10:04 [III-2-3]

Toward Accurate Ai-Generated Solar Farside Magnetograms and Their Applications

Hyun-Jin Jeong[1], Yong-Jae Moon[1,2], Eunsu Park[2], Harim Lee[2]

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

10:16 [III-2-4]

3-Day Time Series Forecasting of Solar Wind Speed by Deep Learning

Jihyeon Son[1], Suk-Kyung Sung[2], Yong-Jae Moon[1,2], Harim Lee[2]

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

10:28 [III-2-5]

Determination of Three-Dimensional Parameters of Coronal Mass Ejections Using a Deep Learning Method

Hyeoncok Na[1], Yong-Jae Moon[1,2]

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

10:40 [III-2-6]

Fast Reconstruction of 3-D Solar Parameters Based on MAS by Deep Learning

Sumiaya Rahman, Seungheon Jeon, Hyun-Jin Jeong, Yong-Jae Moon

School of Space Research, Kyung Hee University

11:04 [III-2-7]

Observation of Auroral Electrojet Echoes Expanding to Middle Latitude by Fort Hays SuperDARN during Sudden Enhancement of Solar Wind Dynamic Pressure

Seok-Min Song, Young-Sook Lee, Ram Singh, Y. H. Kim

Department of Astronomy and Space Science, Chungnam National University

11:16 [III-2-8]

First Observation of D-Region Eastward Plasma Flow Channel Participating in Ionospheric Plasma Convection in the Post-Midnight of the Dawn-Cell

Young-Sook Lee[1], Yong Ha Kim[1], Ram Singh[1], Young-Sil Kwak[2], Seok-min Song[1]

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

11:28 [III-2-9]

Ionospheric Density Responses to the Prompt Penetration Electric Field during the Space Weather Event over the East-Asian Sector

Ram Singh[1], Young-Sook Lee[1], Seok-Min Song[1], Y. H. Kim[1], Jong-Yeon Yun[2], S. Sripathi[3],

B. Rajesh[3]

[1]*Department of Astronomy and Space Science, Chungnam National University*
[2]*Observation Division, Korea Space Weather Center (KSWC)*
[3]*Indian Institute of Geomagnetism (IIG), Mumbai, India*

11:40 [III-2-10]

A Comparison of MLT Winds Observed from the Ground- and Satellite-Based Observations over South Korea

Jaewook Lee[1,2], Young-Sil Kwak[1,2†], Hosik Kam[1], Hyosub Kil[3], Jaeheung Park[1], Jeongheon Kim[1], Junseok Hong[1], Tae-Yong Yang[1], Woo Kyoung Lee[1], Changsup Lee[4]

[1]*Division of Space Science, Korea Astronomy and Space Science Institute*
[2]*Department of Astronomy and Space Science, Korea University of Science and Technology*
[3]*Johns Hopkins University Applied Physics Laboratory*
[4]*Division of Atmospheric Sciences, Korea Polar Research Institute*

11:52 [III-2-11]

Ionospheric Disturbances near the Korean Peninsula Related to 2022 Tonga Volcanic Eruption

Junseok Hong[1], Hyosub Kil[2], Wookyoung Lee[1], Young-Sil Kwak[1,3], Byung-Kyu Choi[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Johns Hopkins University Applied Physics Laboratory*
[3]*University of Science and Technology*

12:04 [III-2-12]

Seasonal Variation of Quasi-10-Day Wave Activity during 2012-2016 in the Southern High-Latitude MLT Region

Wonseok Lee[1], In-Sun Song[1], Yong Ha Kim[2]

[1]*Department of Atmospheric Sciences, Yonsei University*
[2]*Department of Astronomy and Space Science, Chungnam National University*

제3발표장 (에메랄드)

09:40 [III-3-1]

All-Sky Space Object Monitoring System: Data Reduction Process and Some Preliminary Results

Yun Hak Kim[1], Dong-Goo Roh[1], Jang-Hyun Park[1], Sungki Cho[1], Jung Hyun Jo[1], Jeong Yoo Hong[1], Hong-Suh Yim[1], Mansoo Choi[1], Myung-Jin Kim[1], Eun-Jung Choi[1], Jin Choi[1], Jiwoong Yu[1], SeongHo Son[2]

[1]*Korea Astronomy and Space Science Institute*
[2]*Open Sky Partners Inc.*

09:52 [III-3-2]

Real-Time Conjunction Assessment and Maneuver Optimization in SPACEMAP

Seunghwan Choi[1,2], Mohamed Elsadig Osman Abdelkarim[1,2], Joonghyun Ryu[1,2,3], Deok-Soo Kim[1,2,3]

[1]*(주)SPACEMAP*
[2]*Department of Mechanical Engineering, Han Yang University*
[3]*Voronoi Diagram Research Center, Han Yang University*

10:04 [III-3-3]

Conjunction Assessment Based on GPU CUDA

Jiwoong Yu, Sungki Cho, Jung Hyun Jo, Eun-Jung Choi, Jin Choi

Korea Astronomy and Space Science Institute

10:16 [III-3-4]

Space Object Conjunction Assessment Activities for KARI Satellite Constellation in 2021

Jaedong Seong, Okchul Jung, Youeyun Jung, Sae-Han Song

Korea Aerospace Research Institute

10:28 [III-3-5]

Case Study of Tracking Space Object Using the OWL-Net: Abnormal Public Space Data

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

Korea Astronomy and Space Science Institute

10:40 [III-3-6]

Orbit Determination Strategy Using Optical and Radar Data for Space Situational Awareness

Eun-Jung Choi, Jin Choi, Jiwoong You, Sungki Cho

Korea Astronomy and Space Science Institute

10:52 [III-3-7]

Operational Status of Space Situational Awareness Observation System in Korea National SSA Organization (NSSAO)

Jung Hyun Jo

Korea Astronomy and Space Science Institute

4월 29일(금)

제1발표장 (그랜드볼룸 I)

09:00 [IV-1-1]

Rendezvous Mission to Apophis: I. Mission Overview

Young-Jun Choi[1,2] on behalf of the RMA Team

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

09:15 [IV-1-2]

Rendezvous Mission to Apophis: II. Science Goals

Myung-Jin Kim[1], Hong-Kyu Moon[1], Young-Jun Choi[1,2], Minsup Jeong[1], Masateru Ishiguro[3], Youngmin JeongAhn[1], Hee-Jae Lee[1], Hongu Yang[1], Seul-Min Baek[1], Jin Choi[1], Chae Kyung Sim[1], Dukhang Lee[1], Dong-Heun Kim[1,4], Eunjin Cho[1,2], Mingyeong Lee[1,2], Yoonsoo Bach[3], Sunho Jin[3], Jooyeon Geem[3], Hangbin Jo[3], Sangho Choi[5], Yaeji Kim[6], Yoonyoung Kim[7], Yuna Kwon[7]

[1]*Korea Astronomy and Space Science Institute*
[2]*Univ of Science and Technology*
[3]*Seoul National University*
[4]*Chungbuk National University*
[5]*Yonsei University*
[6]*Auburn University, USA*
[7]*Technical University of Braunschweig, Germany*

09:30 [IV-1-3]

Rendezvous Mission to Apophis: III. PolACam and Operation Scenario

Minsup Jeong[1], Young-Jun Choi[1,2], Hong-Kyu Moon[1], Myung-Jin Kim[1], Jin Choi[1], Bongkon Moon[1], Dukhang Lee[1]

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

09:45 [IV-1-4]

Rendezvous Mission to Apophis: IV. Trajectory Design

Pureum Kim, Sang-Young Park

Astrodynamics and Control Lab., Yonsei University

10:00 [IV-1-5]

Rendezvous Mission to Apophis: V. Changes of the Spin State of Apophis during the 2029 Earth Encounter

Youngmin JeongAhn[1], Hee-Jae Lee[1], Myung-Jin Kim[1], Hong-Kyu Moon[1], Young-Jun Choi[1,2]

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

10:15 [IV-1-6]

Rendezvous Mission to Apophis: VI. Physical Properties of Apophis Revealed from the Observations in 2021

Hee-Jae Lee[1], Myung-Jin Kim[1], Dong-Heun Kim[1,2], Hong-Kyu Moon[1], Young-Jun Choi[1,3] on Behalf of the Apophis Observation Team

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

10:30 [IV-1-7]

Asteroid Exploration Mission and Trajectory Design: Formulations, Charateristics, Solution Approaches and Analysis

Jin Haeng Choi, Chandeok Park

Yonsei University

제2발표장 (그랜드볼룸 II)

09:00 [IV-2-1]

Assessment of Polar Ionospheric Observations by VIPIR/Dynasonde at Jang Bogo Station, Antarctica: Ionospheric Densities

Eunsol Kim[1], Geonhwa Jee[1,2], Young-Bae Ham[1,2],

Changsup Lee[1,2], Hyuck-Jin Kwon[1], Junseok Hong[3], Nickolay Zabotin[4], Terrence Bullett[5]

[1]*Korea Polar Research Institute*
[2]*Korea Uiversity of Science and Technology*
[3]*Korea Astronomy and Space Science Institute*
[4]*Department of Electrical and Computer Engineering, University of Colorado*
[5]*Cooperative Institute for Research in Environmental Sciences, University of Colorado*

09:15 [Ⅳ-2-2]

Reconstruction of the Regional Total Electron Content Maps over Korean Peninsula Using Deep Convolutional Generative Adversarial Network (DCGAN) and Poisson Blending

Se-Heon Jeong[1,2], Hyosub Kil[3], Woo Kyoung Lee[2], Soojeong Jang[4], Yong Ha Kim[1], Junseok Hong[2], Byung-Kyu Choi[2]

[1]*Chungnam National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Applied Physics Laboratory, Johns Hopkins University*
[4]*Kyung Hee University*

09:30 [Ⅳ-2-3]

The Plan of Ionospheric Alerts & Forecast Services by the KSWC

Jong-Yeon Yun

National Radio Research Agency, Korean Space Weather Center

09:45 [Ⅳ-2-4]

In-Situ Energetic Particles Flux Measurements in 2021 Using KSEM on the GK2A Geostationary Satellite

Daehyeon Oh, Jiyoung Kim

National Meteorological Satellite Center, Korea Meteorological Administration

10:00 [Ⅳ-2-5]

Statistical Study of Low Energy Ions Originated from the Dayside of the Moon in the Geomagnetic Tail

Jaehee Lee[1], Khan-hyuk Kim[1], Seul-Min Baek[2], Ho Jin[1]

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

10:15 [Ⅳ-2-6]

Observations of Ion Flattop Distributions at the Quasi-Perpendicular Bow Shock

Hee-Eun Kim[1], Ensang Lee[1], George K. Parks[2]

[1]*School of Space Research, Kyung Hee University*
[2]*Space Sciences Laboratory, University of California, Berkeley, CA, USA*

11:00 [Ⅴ-2-1]

Statistical Analysis of Pc1 Wave at Mid-Latitude Detected by BOH Magnetometer during Solar Cycle 24

Jaeyoung Kwak[1,2], Junga Hwang[1,2], Jaeheung Park[1,2], Jiwoo Kim[3]

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

11:15 [Ⅴ-2-2]

Hybrid Simulations of Cold Protons and Helium Ions Energized by EMIC Waves in the Inner Magnetosphere

Jong-Woo Kwon[1], Khan-Hyuk Kim[1], Kyungguk Min[2]

[1]*School of Space Research, Kyung Hee University*
[2]*Chungnam National University*

11:30 [Ⅴ-2-3]

Low-Energy Ion Flux Enhancement and a Positive Spacecraft Charging inside the Plasmasphere

Junhyun Lee, Khan-hyuk Kim, Hee-Eun Kim, Ensang Lee

School of Space Research, Kyung Hee University

11:45 [Ⅴ-2-4]

Spacecraft Potential Changes Associated with EMIC Waves in the Inner Magnetosphere

Khan-Hyuk Kim, Junhyun Lee

Kyung Hee University

12:00 [Ⅴ-2-5]

Origin of Banded Chorus: The Role of Parallel Electron Plateau on the Nonlinear Growth of

Chorus

Kyungguk Min

Chungnam National University

제3발표장 (에메랄드)

09:00 [Ⅳ-3-1]

Dynamic Simulation for Verifying Control Algorithms of the SNIPE Cubesat

Won-Sub Choi, Ki-Duck Kim, Hae-Dong Kim

Korea Aerospace Research Institute, KARI

09:15 [Ⅳ-3-2]

Development of the Solid State Telescope Instrument for Measuring Spatial Scale and Energy Dispersion of Electron Microbursts

Jongdae Sohn, Jaejin Lee, Junga Hwang, Young-Sil Kwak, Jaeheung Park, Tae-Yong Yang, Uk-Won Nam, Won-Kee Park, SNIPE Payload Team

Korea Astronomy and Space Science Institute

09:30 [Ⅳ-3-3]

Implementation of 6U Nanosatellite Separation Switch

Min Ki Kim[1], Won Sup Choi[1], Jin Hyung Kim[1], Jong Dae Sohn[2], Jae Jin Lee[2]

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

09:45 [Ⅳ-3-4]

Very-Low-Earth-Orbit (VLEO) Cubesats for Monitoring Atomic Oxygen Fluence

Jaeheung Park[1,2], Ji-Hye Baek[1], Seonghwan Choi[1], Yougwang Kim[3], YunKyong Hyon[4], Keunyoung Park[3], Sunju Lee[4], Sukhoon Lee[5]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Korea Aerospace Research Institute*
[4]*National Institute for Mathematical Sciences*
[5]*Chungnam National University*

10:40 [Ⅴ-3-1]

Boundary of Public Activities on the Promotion of the Korea SSA Amid Making Cocktail of Civil and Government Policy: Difficulties on Public Science Communication

Jung Hyun Jo

Korea Astronomy and Space Science Institute

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Science, Taking It to Public: Sow Your Own Kind of Seeds

Sojeong Yim

Pohang University of Science and Technology

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A Scientist Who Writes the Narrative 'The Life of a Scientist'

Eun-ji Jun

Korea Advanced Institute of Science and Technology

11:40 [Ⅴ-3-4]

Current Status of Space Education for the Students in the Republic of Korea and Consideration of Researcher Participation

Jeongwon Lee

Korea Aerospace Research Institute

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4월 28일(목) 16:00~18:00

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Chul Kang
Korea Aerospace Research Institute

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Kiho Kwon
Korea Aerospace Research Institute

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[2]*HANCOM inSPACE*

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Dong-Oh Kim, Jun-Yeong Bok, Jong-Bum Park
National Satellite Operation & Application Center, Korea Aerospace Research Institute

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Myungmuk Kim, Okchul Jung, Jaedong-Seong
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Young-Yun Kim, Sung-Woo Park
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You Gwang Kim[1], Guen Young Park[1], Jong Hwi Choi[1], Seo Hyun Lee[2]
[1]*Korea Aerospace Research Institute*
[2]*Insight Mining*

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

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[1]*Korea Aerospace Research Institute, KARI*
[2]*Setrec Initiative, SI*

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

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Geostationary Satellite Program Office, KARI

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

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

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[1]*Korea Aerospace Research institute*
[2]*SI-Imaging Service, SIIS*

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Satellite Research Directorate, Korea Aerospace Research Institute

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Byeong-Hee Mihn[1,2], Sang Hyuk Kim[1], Jae-Young Kim[3]

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

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Aerospace Engineering Department, Korea Advanced Institute of Science and Technology

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

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Department of Astronomy and Space Science, Chungbuk National University

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[1]*School of Space Reseach, Kyung Hee University*
[2]*University of California, Santa Cruz*

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Korea Aerospace Research Institute

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

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Ji-Seok Kim[1], Hae-Dong Kim[1,2]

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Korea Aerospace Research Institute

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Eunsu Park[1,2], Yong-Jae Moon[1,2], Harim Lee[1]

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

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Hosub Song[1,2], Jaeheung Park[1,3], Jaejin Lee[1],Yu Yi[2]

[1]*Space Science Division, Korea Astronomy and Space Science Institute*
[2]*Department of Astronomy, Space Science and Geology, ChungNam National University*
[3]*Department of Astronomy and Space Science, University of Science and Technology (UST)*

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[1]*Korea Astronomy and Space Science Institute*

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Changho Woo[1], Kwangsun Ryu[1], Junchan Lee[1], Seunguk Lee[1,2], Eunjin Jang[1], Jaemin Hwang[1]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

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Kangwoo Yi[1], Yong-Jae Moon[1,2]

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

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Kyoung-Sun Lee, Jongchul Chae

Seoul National University

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Seunguk Lee[1,2], Kwangsun Ryu[1], Dooyoung Choi[2], Junchan Lee[1], Chang Ho Woo[1], Eunjin Jang[1], Jaemin Hwang[1], Wonho Cha[1], Cheong Rim Choi[2], Dae-Young Lee[2]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

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Harim Lee[1], Hyun-Jin Jeong[2], Eunsu Park[1], Yong-Jae Moon[1,2]

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

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Hojin Lee[1,2], Junga Hwang[1,2], Jaeyoung Kwak[1,2], Jongdae Son[2]

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

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Daye Lim[1], Yong-Jae Moon[1,2], Hyun-Jin Jeong[2]

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

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Jinkoo Yim[1], Yong-Jae Moon[1,2], Hyun-Jin Jeong[1]

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

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Eunjin Jang[1], Kwangsun Ryu[1], Junchan Lee[1], Seunguk Lee[1,2], Changho Woo[1], Jaemin Hwang[1]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

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Yoonseung Choi[1], Geonhwa Jee[1,2], Hyuckjin Kwon[1]

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

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Jimin Hong[1], Jungjoon Seough[2], Kyungguk Min[1]

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

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

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Jaemin Hwang[1], Wonho Cha[1], Kwangsun Ryu[1], Junchan Lee[1], Changho Woo[1], Eunjin Jang[1], Seunguk Lee[1,2], Dooyoung Choi[2], Jeongrim Choi[2]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

[P-86] A Comparison of the Propagating Characteristics of Mesospheric Gravity Waves over King Sejong Station, Antarctica (62.2°S, 58.8°W) and Mt. Bohyeon Observatory (36.2°N, 128.9°E)

Jun-Yeong Hwang[1], Young-Sook Lee[1], Yong Ha Kim[1], Hosik Kam[2], Young-Sil Kwak[2,3], Tae-Yong Yang[2]

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

구두발표 논문 초록

4월 27일(수) 제1발표장 그랜드볼룸 I

I-1 우주기술/응용우주/우주천문

Chair: 임조령 (항우연)

14:20 [I-1-1]

PIC-DSMC Simulation of Hall Thruster Plume Flow under VLEO Operation Condition

Geonwoong Moon, Eunji Jun†

Korea Advanced Institute of Science and Technology

Application of an electric propulsion (EP) system for orbit maintenance of a satellite is expanding based on an advantage of high specific impulse. Due to the plasma plume of the electric propulsion system, some exhausted ions may cause a backflow phenomenon. The backflow of ions is known to cause damage to satellite payloads and optical equipment. A precise analysis of the ion backflow phenomenon is necessary. The backflowing ion current might be increased by the plume-background gas interaction around satellites on the very-low-earth-orbit (VLEO). To investigate the interaction of the background gas and the plume of the electric propulsion, a 2D axi-symmetric particle simulation is performed based on the hybrid method of Particle-In-Cell(PIC) and Direct Simulation Monte Carlo (DSMC) method. In this study, configuration and flow properties are adopted from SPT100 and D55 Hall thrusters. The plume is composed of neutral atoms, electrons, single and doubly charged ions. PIC method is employed for plasma dynamics and DSMC method is used for collisional dynamics of particles. For a numerical model, collisions between ions and atoms are considered in 2 types; momentum exchange collision (MEX) and charge exchange collision (CEX). Electrons are treated as fluid with the Boltzmann relation and polytropic model. The simulation scheme is verified with reference ground/flight test data of SPT-100 and D55 hall thrusters. Behavior of exhausted ions and far-field distributions of plasma properties are investigated in the VLEO. NRLMSISE-00 atmosphere model is considered to take into account the chemical composition and flow properties of Earth's ionosphere/thermosphere.

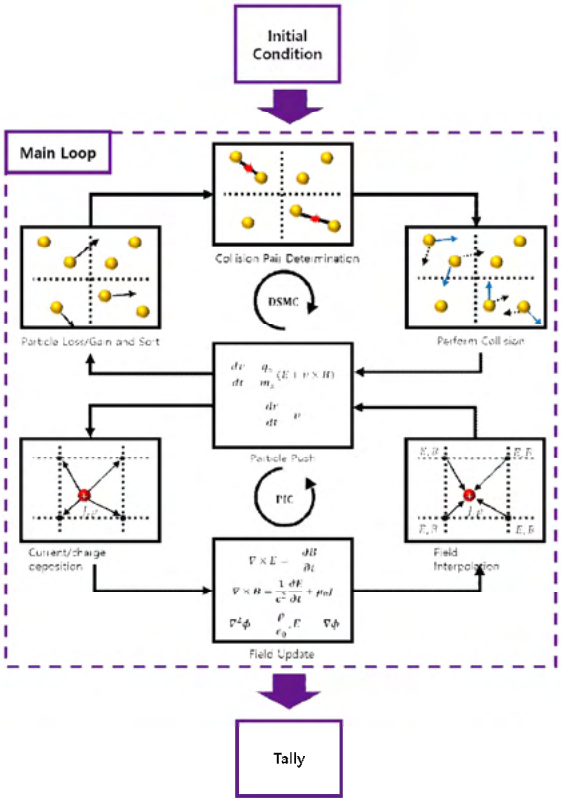

Fig. 1. Flow chart of PIC-DSMC simulation

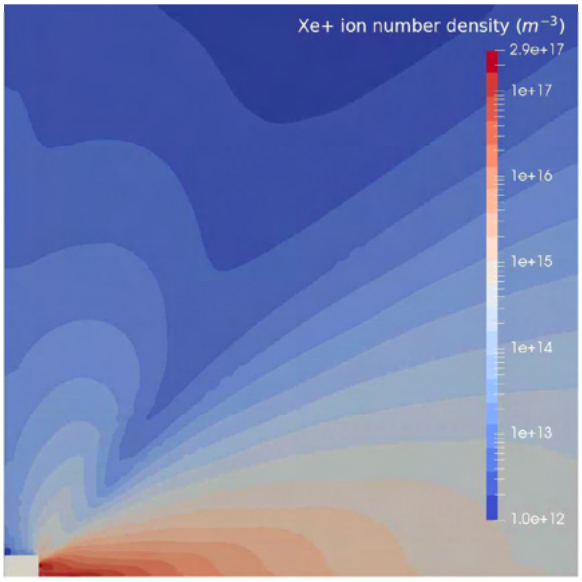

Fig. 2. An example of Xe^+ ion number density profile obtained from the hall thruster plume simulation

14:35 [I-1-2]

Design of Autonomous Attitude Control Algorithm of Multi-Static SAR Micro-Satellites for HRSI (High Resolution Strip-Map Imaging)

Sangwon Lee[1], Jeongbae Kim[2], Sang-Young Park[1], Jihae Son[3], Sung-Chan Song[3]

[1]*Astrodynamics and Control Lab, Yonsei University*

[2]*RADAR System Lab, Yonsei University*

[3]*Hanwha System Corporation*

HRSI means to high-resolution (≦1 m) SAR imaging performed

in strip-map mode by applying the multi-static SAR concept. For HRSI, the satellites that make up the formation must point for the same target while performing SAR imaging.
The purpose of this study is to establish an autonomous attitude control strategy and develop algorithms for HRSI. To this end, a multi-static SAR formation consisting of three satellites for HRSI is presented. Then, the concept of RADN sectors for determining the possibility of SAR imaging is presented. The autonomous attitude control strategy applying the presented concept of RADN sectors is established. Finally, the attitude control algorithm is verified through simulation.

14:50 [I-1-3]

Preliminary Study of Wide Frequency Range Fluxgate Magnetometer

Woohyun Jo, Ho Jin, Khan-Hyuk Kim, Hyeonhu Park, Wooin Jo, Yun-Ho Jang, Jehyuck Shin

School of Space Research, Kyung Hee University

The fluxgate magnetometer is measuring dc magnetic field between 0 to dozens of Hz frequency range. Therefore general fluxgate magnetometers are not able to measure High frequency waves such as ION cyclotron, Plasmaspheric Hiss, chorus, etc. So, this study started from our question which is “How much can we increase the measurement frequency of fluxgate magnetometer?”.
For this experiment, we made the test bed to investigate the available measurement frequency range of the fluxgate magnetometer.
The test bed has been made capable of measuring signals up to 1 kHz with Field-Programmable Gate Array (FPGA). The test bed consists of an ADC capable of sampling up to 250 ksps, system controlled by FPGA, and other electronic circuits for signal control. Test parameters are controlled by PC software connected by UART serial protocol.
In this study, results of the initial study on frequency response test performed by lab-level test bed and configuration of test bed system are to be introduced.

15:05 [I-1-4]

The S-Band RF Test in PVSAT FM AIT

Sangil Ahn[1], In Hoi Koo[1], Sang Hyun Han[2], Jung Mo Yang[2], Seung Hoon Han[2]

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

Reliable space communication is pre-requisite for all phase of mission operation following the launch. Therefore RF test during AIT phase is mandatory in most space program.
Like other space program, S-Band RF test has been done for uplink, downlink channel for both on-board S-Band transceiver considering different communication mode in PVSAT AIT phase,
Test categories include S-Band uplink, S-Band downlink, Power Consumption, Duplexer Isolatipn. Data rate, frequency, BER, EIRP were tested. This paper shows all test performed and its test results.

15:20 [I-1-5]

Geo-Kompsat 2A Telemetry Data Long-Term Analysis Software (G-TLAS) Prototype Development

Junghyun Lee[1], Sungchul Park[2], Seokrae Jang[2], Sangcherl Lee[1]

[1]*Korea Aerospace Research Institute (KARI)*
[2]*Just In Time (JIT) Solution*

GK-2A is a geostationary orbit satellite developed by domestic technology, launched on December 5, 2018, and is carrying out their missions (Earth and Space meteorology) from July 1, 2019. Real-time operation of GK-2A carried out through the Integrated Test Operation System (ITOS), which monitors the status of the satellite via telemetry and sends tele-commands. Furthermore, they examine the states throughout trends analysis function.
Long-term analysis is essential for satellite operation. However, existing S/W cannot be applied real operation environments following reasons. First, there was no physical space for processing long-term data at once due to the unconstructed large-capacity telemetry data. Second, numerous telemetry generates network traffic for parsing process.
Therefore, we developed and applied GK2A long-term analysis S/W (G-TLAS) for GK2A state analysis; maintenance and advanced plan are intended from 2022.

15:35 [I-1-6]

Calibration Plan and Early Results of Noise Test for AIMAG onboard CAS500-3

Dooyoung Choi[1], Kwangsun Ryu[2], Seunguk Lee[1,2], Junchan Lee[2], Chang Ho Woo[2], Eunjin Jang[2], Jaemin Hwang[2], Wonho Cha[2], Cheong Rim Choi[1]

[1]*Chungbuk National University*
[2]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*

AIMAG (Adaptive Inphase MAGnetometers) is a fluxgate magnetometer with a ring core structure under development for CAS500-3 (Compact Advanced Satellite 500-3) and two will be mounted on edges of solar panel wings and the other two on

the satellite body. For securing accurate measurement of the EEJ (Equatorial Electro-Jet) in the LEO, AIMAG needs state-of-the-art calibration process. In this talk, the calibration plan for validating the magnetometer manufacturing process is presented. Also, the noise test results are described. Calibration is planned to use the MAGSAT calibration method which was performed at MAVEN, JUNO, and MAGSAT, that accurately rotates the sensor within a known magnetic field generated by 3-axis Helmholtz coils. For the noise test of the circuit board, a magnetic shielding can is utilized, and the goal of resolution is less than 1nT. As a future work, thermal calibration is also planned.

15:50 [I-1-7]

Retrieval of Precipitable Water Vapor from Ship-Borne Multi-GNSS Measurements in the Ocean

Dong-Hyo Sohn[1], Byung-Kyu Choi[1], Yosup Park[2], Byung-Il Lee[3]

[1]*Korea Astronomy and Space Science Institute*
[2]*Korea Institute of Ocean Science and Technology*
[3]*National Meteorological Satellite Center, KMA*

The Global Navigation Satellite System (GNSS) is an effective tool to estimate the signal delay caused by water vapor in the troposphere. GNSS consists of satellite constellations such as the United States' GPS, Russia's GLONASS, China's Beidou, and the European Union's Galileo. Multi-GNSS can improve the estimation accuracy for precipitable water vapor (PWV). Unfortunately, however, most of the equipment that receives GNSS signals is installed on land. In contrast, GNSS observations made in the ocean are relatively insufficient. In this study, we estimate GNSS PWV using multi-GNSS measurements obtained from the research vessel in the Pacific ocean. For the multi-GNSS PWV, we use the kinematic precise point positioning (PPP) solution developed by Korea Astronomy and Space Science Institute (KASI). The experiment was conducted for about one month using a weighing 5,894 tons research vessel 'ISABU' operated by the Korea Institute of Ocean Science and Technology (KIOST) in the northwest Pacific region. The GNSS-derived PWV is compared with ship-borne radiosonde and space-borne observations onboard Geostationary Korea Multi-Purpose Satellite 2A.

16:05 [I-1-8]

Coordinate Modeling for Optical Alignment of Off-Axis Reflective Telescope

Jimin Han[1], Hojae Ahn[1], Joong Kyu Ham[2], Daewook Kim[3], Geon Hee Kim[2], Jong Gyun Kang[2], Young Tae Kwak[2], Dae-Hee Lee[4], Youngsik Park[4], Bongkon Moon[4], Seunghyuk Chang[5], Soojong Pak[1†]

[1]*School of Space Research and Institute of Natural Science, Kyung Hee University*
[2]*AeroSpace Optics Center, Hanbat University*
[3]*James C. Wyant College of Optical Sciences, University of Arizona*
[4]*Korea Astronomy and Space Science Institute*
[5]*Center for Integrated Smart Sensors, Korea Advanced Institute of Science and Technology (KAIST)*

In this presentation, we introduce a novel method of optical alignment for an infrared imaging spectrometer. We have adopted a LAF-TMS system on a UAVs mission instrument with a wide field-of-view (8.25° × 6.21°) and a 40 mm entrance pupil diameter, in the wavelength of MWIR (3–5 μm) and LWIR (8–12 μm) bands. The telescope has been designed based on the off-axis aberration control theory that completely removes linear astigmatism aberration. Since the image quality of this confocal off-axis optical system is sensitive to the optical alignment, we are developing a coordinate modeling method using a coordinate-Measuring Machine (CMM). Three freeform mirrors have reference planes on the side of the reflective surface. During the assembly process, we measured the absolute positions of the reference plane and the center of the reflective surface. Based on the relative positions, we constructed the 3-dimensional coordinate model of each mirror. In the processes of assembling and alignment, we monitored the absolute positions of the reference planes via the CMM and derived the alignment error. We repeated the alignment process until the residual error became less than the tolerance limit. Finally, we got a spot diagram that 80% EED is smaller than 30 μm (Nyquist sampling).

제2발표장 그랜드볼룸 II

I-2 태양 및 우주환경 I

Chair: 이준찬 (과기원)

14:20 [I-2-1]

Development of a Diagnostic Coronagraph on the ISS: CODEX Progress Report

Yeon-Han Kim[1], Seonghwan Choi[1], Su-Chan Bong[1], Kyungsuk Cho[1,2], Jeffrey Newmark[3], Nat Gopalswamy[3], KASI-NASA Coronagraph Team

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

The Coronal Diagnostic Experiment (CODEX) is a KASI-NASA

joint project to develop a diagnostic coronagraph on the ISS, which is designed to obtain simultaneous measurements of the electron density, temperature, and velocity using multiple filters in the 2.5−10 Rs range. In October 2021, the critical design review (CDR) was completed and now we focus on manufacturing flight models of KASI subsystems; focal plane assembly (FPA), filter wheel assembly (FWA), and mechanism control electronics (MCE) which controls the FWA and aperture door of the coronagraph. The KASI is also responsible for developing the CODEX control electronics (CCE), the flight software, and ground operating software. The CODEX will be deployed on the ISS by the end of 2023. In this presentation, we will introduce recent progress and future plan.

14:35 [I-2-2]

CORIFS2.0: CORonal Integral Field Spectropolarimeter for the Total Solar Eclipse

Heesu Yang[1], Kyuhyoun Cho[2], Su-Chan Bong[1], Seoung-Hwan Choi[1], Jihun Kim[1], Juhyung Kang[1], Donguk Song[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Lockheed Martin Solar Astrophysics Laboratory*

The total solar eclipse is a unique opportunity to observe the faint corona near the Sun. We plan to observe the spectrum of the polarized light near 530 nm using a Coronal Integral Field Spectropolarimetry, CorIFS). The CorIFS uses a micro-lenslet array and a polarizer to get 2-dimensional spectropolarimetry data at a time. The data will provide information on temperature and speed of the electrons at 1-5Rs, as well as the polarization information of the interplanetary dusts from the depth of the Fraunhofer line.

14:50 [I-2-3]

Design and Preliminary Experiment of Integrated Plasma Measurement Payload, AIPIM for CAS500-3

Junchan Lee[1], Kwangsun Ryu[1], Chang-Ho Woo[1], Seunguk Lee[2], Eunjin Jang[1], Jaemin Hwang[1]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

Ionospheric Anomaly Monitoring by Magnetometer And Plasma Probe (IAMMAP), a scientific instruments for CAS500-3 satellite, has been developing to observe ionospheric plasma in equatorial region known as Equatorial electrojet (EEJ) or equatorial ionization anomaly (EIA). Advanced Impedance Probe for Ionospheric Monitoring (AIPIM) is plasma instrument of IAMMAP consisting of Disk type Langmuir Probe (LP) and Impedance Probe (IP) applying Lock-in amplification and super-heterodyne techniques. AIPIM is planned to observe absolute electron density using IP and relative electron density and temperature from LP which will be used as reference for the IP observable. Both instruments are integrated as unit body and will be operated simultaneously according to the operation mode. Prototype model has been developed and this paper shows a prelimiary results of functionaly test and plasma chamber test generating similar plasma properties with ionosphere.

15:05 [I-2-4]

EQM Design Progress Report of the IAMMAP Scientific Instrument for the CAS500-3 Satellite

Kwangsun Ryu[1], Junchan Lee[1], Seunguk Lee[1,2], Chang-Ho Woo[1], Eunjin Jang[1], Jaemin Hwang[1], Jinkyu Kim[1], Wonho Cha[1], Dongkook Kim[1], Bon-ju Koo[1], Seong-Og Park[1], Du-young Choi[2], Jeongrim Choi[2]

[1]*SaTReC, KAIST*
[2]*Chungbuk National University*

The Ionospheric Anomaly Monitoring by Magnetometer And Plasma-probe (hereafter, IAMMAP) is one of the scientific instruments for the Compact Advanced Satellite 500-3 (CAS 500-3) which is planned to be launched in 2024. The main scientific objective of IAMMAP is to understand the complicated correlation between the equatorial electro-jet (EEJ) and the equatorial ionization anomaly (EIA) which play important roles in the dynamics of the ionospheric plasma behavior in the dayside equator region. IAMMAP consists of an impedance probe, Langmuir probe for precise plasma measurement and 4 fluxgate magnetometers for the EEJ current intensity derivation. In this presentation, the EQM (Engineering Qualification Model) design and manufacturing in progress are briefly shown with some preliminary test results. In addition, the plans for the calibration for each component of the instrument to meet the scientific requirements are also introduced.

15:20 [I-2-5]

Spectroscopic Detection of Alfvénic Waves in the Chromospheric Fibrils of a Solar Quiet Region

Hannah Kwak, Jongchul Chae

Seoul National University

We report observations of transverse magnetohydrodynamic (MHD) waves in fibrils of a quiet region using spectroscopic data. Different from previous studies that measured transversal displacements of the fibrils in the imaging data, we investigated the line-of-sight (LOS) velocity oscillations of the fibrils in the spectral data. The observations were carried out by using the

Fast Imaging Solar Spectrograph of the 1.6 meter Goode Solar Telescope of the Big Bear Solar Observatory. By using the spectral data of the Hα and Ca II 8542 Å lines, we measure the LOS velocity of a quiet region including not only the fibrils but also rosettes that correspond to footpoints of the fibrils. From the analysis, we found that Alfvénic waves are pervasive in the quiet region fibrils. The dominant period of the waves is 2 to 4 minutes. From the time-distance maps of the three-minute filtered LOS velocity constructed along the fibrils, it is revealed that the transverse waves in the fibrils are closely related to the longitudinal waves in the rosettes. Our findings are consistent with those of Chae et al. (2021) representing Alfvénic waves in superpenumbral fibrils can be generated by mode conversion of the slow magnetoacoustic waves in sunspot regions.

15:35 [I-2-6]

Propagating Alfvenic Waves Observed in the Chromosphere of a Sunspot Region: Tales of Three-Minute Waves and Ten-Minute Waves

Jongchul Chae

Seoul National University

Recent observations provided evidence that the solar chromosphere of sunspot regions is pervaded by transverse magnetohydrodynamic (MHD) waves (Alfven waves or kink waves) often called Alfvenic waves. In order to systematically investigate the physical characteristics of Alfvenic waves over a wide range of periods, we constructed a time series of line-of-sight velocity maps from the H alpha spectral data of a small sunspot region taken by the Fast Imaging Solar Spectrograph of the Goode Solar Telescope at Big Bear. We identified each Alfvenic wave packet by examining the cross-correlation of bandpass-filtered velocity between two points that are a little apart from each other presumably on the same magnetic field lines. As result, we detected a total of 279 wave packets in the region of superpenumbral fibrils, and examined their statistics of period, velocity amplitude, and propagation speed. An important finding of ours is that the Alfvenic waves in the chromosphere of the sunspot region are clearly separated into two groups: three-minute period (< 7 min) waves and ten-minute period (> 7 min) waves. The three-minute waves have periods ranging from 1.9 to 7.1 min, velocity amplitudes from 0.32 to 1.4 km/s, and propagation speeds from 32 to 620 km/s, and the ten-minute waves, periods from 6.6 to 22 min, velocity amplitudes from 0.25 to 1.6 km/s, and propagation speeds from 12 to 330 km/s. The three-minute waves predominantly propagated outwards from the sunspot, whereas the ten-minute waves kept a statistical balance between outward propagation and inward propagation. We propose two tales on the origin of Alfvenic waves in the chromosphere; the three-minute Alfvenic waves are excited by the upward-propagating slow waves in the chromosphere through mode conversion, and the ten-minute Alfvenic waves represent the chromospheric manifestation of the kink waves driven by convective motions in the photosphere.

15:50 [I-2-7]

Dynamical and Thermal Properties of RBEs and RREs Derived from Fast Imaging Solar Spectrograph

Eun-Kyung Lim[1,2], Jongchul Chae[3], Vasyl Yurchyshyn[4], Heesu Yang[1], Kyung-Suk Cho[1,2], Kyuhyoun Cho[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Seoul National University*
[4]*Big Bear Solar Observatory, NJIT, USA*

A rapid blueshifted excursion (RBE) or rapid redshifted excursion (RRE) is appeared as a 'sudden widening of the line profile' on the blue or red side of the line, following the definition given by Langangen. RBEs are often regarded as on-disk counterparts of Type II spicules based on their rapid upward Doppler speed (~40 km/s) without following downward motion. On the other hand, there are some reports on the transition from RBEs to RREs indicating material falling back after ejections. We observe tiny spicular features that show a spectral shift from RBE to RRE in an enhanced network field of a quiet Sun region, using the fast imaging solar spectrograph built at the Goode Solar Telescope of Big Bear Solar Observatory. Two strong chromospheric lines, Hα and CaII 854.2 nm, are used for spectroscopy. Multi-layer spectral inversion technique is applied to both lines to obtain spectral parameters, including line-of-sight velocities and temperatures in time. Two events of our interests reveal spectral transitions from RBEs to RREs, with corresponding IRIS counterparts that clearly show the parabolic up and down motion. We also detected intensity enhancements in AIA 193 and 304 channels at the early phase of RBEs, indicating possible heating at the time of ejections. The temperature of the spicular structure shows a monotonic decrease during the RBE phase suggesting continuous cooling after the energy deposit. We could not find any heating signatures after the RBE phase that is normally expected from type II spicules, and both RBE events we analyze show typical properties of small-scale jets.

16:05 [I-2-8]

Generation of Coronal White Light Images from Extreme Ultraviolet Solar Images Using Deep Learning

Bendict Lawrance[1], Harim Lee[1], Eunsu Park[1],

Il-Hyun Cho[1], Yong-Jae Moon[1,2], Jin-Yi Lee[1], Shanmugaraju[3], Sumiaya Rahman[2]

[1]*Department of Astronomy and Space Science, Kyung Hee University*
[2]*School of Space Research, Kyung Hee University*
[3]*Department of Physics, Arul Anandar College, Karumathur, India*

The white light observations are important to understand low coronal features of the Sun, but they are rarely made. We generate MLSO K-coronagraph like white light images from SDO/AIA EUV images using a deep learning model based on conditional generative adversarial networks. We train the model using pairs of MLSO K-coronagraph images and their corresponding SDO/AIA EUV (171, 193 & 211Å) images considering the field of view between 1.11 to 1.25 solar radii. For this we made seven (single channels and combination of multiple channels) deep learning models for image translation. We evaluate the models by comparing the pairs of target white light images and those of corresponding AI-generated ones. Our results from the study are summarized as follows. First, the multiple channel 'AIA 193 & 211Å' model is the best among seven models in-view of metrics such as correlation coefficient and normalized root mean square error. Second, major low coronal features like helmet streamers, pseudo-streamers and polar coronal holes are well identified in the AI-generated images by this model. The positions and sizes of the polar coronal holes of the AI-generated images are consistent with those of the target ones. Third, from AI-generated images we successfully identified a few interesting phenomena: coronal jets and CMEs. We hope that our model provides us with complementary data to study the low coronal features in white light during non-observable cases of MLSO K-coronagraph instrument (during night-time, poor atmospheric conditions and instrumental maintenance).

제3발표장 에메랄드

I-3 SS: Energy Coupling in the Heliosphere I

Chair: 곽영실 (천문연)

14:20 [I-3-1]

How Can We Decide a Coronal Mass Ejection will be Geoeffective or Not?

Kyung-Suk Cho

Korea Astronomy and Space Science Institute

Geoeffective Coronal Mass Ejection (CME), which causes a large-scale geomagnetic magnetic storm (Dst < −100 nT), appears mostly in the western part of the Sun, generally accompanied by strong flare, and is ejected at high speed with a large angular width. It has to propagate toward the Earth with a southward magnetic field component. However, in rare cases, it is not very fast and accompanied by a weak flare, but produces a strong geomagnetic storm. Meanwhile, in some cases, it has ejected at high speed with strong flare but causes weak geomagentic storm. In this talk, I will introduce the general and exceptional cases of the CMEs, and then guess if the November 2021 event is geoeffective or not, based on solar observations.

14:35 [I-3-2]

Evidence of CME-CME Interaction in the Interplanetary Space

Rok-Soon Kim[1], Stefaan Poedts[2,3], Brigitte Schmieder[2,4], Jasmina Magdalenic[3]

[1]*Korea Astronomy and Space Science Institute*
[2]*Katholieke Universiteit Leuven*
[3]*Royal Observatory of Belgium*
[4]*Observatoire de Paris, Section Meudon*

To find the evidence of CME-CME interaction in the near-Earth space, we selected 6 isolated CME-CME pairs which are expected to meet near-Earth based on their ejecting time and propagating speed. Then we investigated available in situ observations such as magnetic field, density, velocity, and temperature of solar wind and radio spectrum during their passages near Earth. Assuming that their interaction phase can be inferred from the time difference of preceding and following CMEs' expected arrivals at the Earth, we found that (1) there can be reverse drifting in the radio spectrum meaning density increase for the events in the phase of just before and during the interaction. (2) Also, in that phase, there can be magnetic hole structures separating two magnetic clouds, which are characterized by abrupt change and subsequent recovery in the solar wind condition such as density and magnetic field. (3) The thicknesses of the sheath and magnetic cloud have strong linear relationships with the arrival time difference, and this can be explained by the elongated components due to the interaction. Based on these results, it can be inferred that as the two CMEs get closer, the interaction starts with density increase in the solar wind and a magnetic hole is formed, and then finally the interaction ends as the thickness of the sheath and the magnetic cloud gradually thickens.

14:50 [I-3-3]

Multi-Point Observations of Flux Ropes Using PSP, STEREO, and Wind

Kyung-Eun Choi[1], Dae-Young Lee[1],

Katsuhide Marubashi[2]

[1]*Department of Astronomy and Space Science, Chungbuk National University*
[2]*National Institute of Information and Communications Technology, Tokyo, Japan*

One of the structures of the interplanetary magnetic field (IMF) in the solar wind is the flux ropes (FRs), which are well known to cause the magnetic reconnection with the magnetosphere if they contain the southward components of the magnetic field. The origin of small-scale FRs is not fully understood even though they are observed frequently at 1AU, for frequently as measured by STEREO and Wind. Parker Solar Probe (PSP) observes them in situ near the Sun and allows us to understand the global structure of the IMF by comparing with 1AU observations. In this talk, we introduce promising topics and issues and suggest some ideas to study interplanetary FRs with multi-point observations of FRs using data from PSP, STEREO, and Wind available and modeling techniques such as force free modeling.

15:05 [I-3-4]

Solar Wind and CME Propagations from Sun to 1 AU with MHD Simulation

Junmo An

Department of Astronomy and Space Sicence, Kyung Hee University

The majority of input energy flux to the Earth magnetosphere comes from the Sun. Specifically, coronal mass ejections (CMEs) and corotating interaction regions (CIRs) or stream interaction regions (SIRs), in general are known to be intimately associated with geomagnetic activities. In this study we focus on initial ICME parameters that might affect to the input energy flux ($\epsilon = l_0^2 VB^2 \sin^4(\theta/2)$, referred from Perreault and Akasofu, 1978) at 1 AU, by using a 3-D global heliospheric MHD model with a spheromak-type interplanetary CME (ICME) in a domain 50 Rs to 250 Rs from the Sun. As a result, initial ICME parameters associated with the input energy flux will be discussed. This study will potentially help us understand physical processes between ICME and the Earth magnetosphere.

15:20 [I-3-5]

Effects of Geometries and Substructures of ICMEs on Geomagnetic Storms

Jae-Ok Lee[1], Kyung-Suk Cho[2], Rok-Soon Kim[2], Soojeong Jang[3], Katsuhide Marubashi[4]

[1]*Chungnam National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Kyung Hee University*
[4]*Asia Space Environment Research Consortium*

To better understand geomagnetic storm generations by ICMEs, we consider the effect of substructures (magnetic cloud, MC, and sheath) and geometries (impact location of flux-rope at the Earth) of the ICMEs. We apply the toroidal magnetic flux-rope model to 59 CDAW CME–ICME pairs to identify their substructures and geometries, and select 20 MC-associated and five sheath-associated storm events. We investigate the relationship between the storm strength indicated by minimum Dst index (Dstmin) and solar wind conditions related to a southward magnetic field. We find that all slopes of linear regression lines for sheath-storm events are steeper ($\geq$ 1.4) than those of the MC-storm events in the relationship between Dstmin and solar wind conditions, implying that the efficiency of sheath for the process of geomagnetic storm generations is higher than that of MC. These results suggest that different general solar wind conditions (sheaths have a higher density, dynamic and thermal pressures with a higher fluctuation of the parameters and higher magnetic fields than MCs) have different impact on storm generation. Regarding the geometric encounter of ICMEs, 100% (2/2) of major storms (Dstmin $\leq$ −100 nT) occur in the regions at negative PY (relative position of the Earth trajectory from the ICME axis in the Y component of the GSE coordinate) when the eastern flanks of ICMEs encounter the Earth. We find similar statistical trends in solar wind conditions, suggesting that the dependence of geomagnetic storms on 3D ICME–Earth impact geometries is caused by asymmetric distributions of the geoeffective solar wind conditions. For western flank events, 80% (4/5) of the major storms occur in positive PY regions, while intense geoeffective solar wind conditions are not located in the positive PY. These results suggest that the strength of geomagnetic storms depends on ICME–Earth impact geometries as they determine the solar wind conditions at Earth.

We are grateful to Byeongseok Lee who give us the interesting preliminary results.

15:35 [I-3-6]

Coupling of the Magnetosphere and the Polar Ionosphere during Storms and Substorms from an Observational Point of View

Yukinaga Miyashita[1,2]

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

Solar and solar wind activities affect the magnetosphere, frequently producing severe plasma and electromagnetic disturbances, such as geomagnetic storms and substorms. They are closely related to various plasma instabilities and particle acceleration under coupling of the solar wind, the

magnetosphere, and the ionosphere. In this presentation I will discuss coupling of the magnetosphere and the polar ionosphere during storms and substorms, based on satellite- and ground-based observations.

15:50 [I-3-7]

Global MHD Simulations of the Solar Wind-Magnetosphere-Ionosphere Coupling

Kyung Sun Park

Department of Astronomy and Space Science, Chungbuk National University

Global MHD simulation have been used since the 1980s to study magnetospheric dynamics and ionosphere phenomena. There are many models with spatial resolution high enough to study the effects of solar wind and IMF conditions (including the actual solar wind and IMF). The solar wind-magnetosphere-ionosphere (SMI) simulation has a significant amount of spatial structure and rapid temporal variations and that require a large amounts of memory and disk space. This paper shows a progress of SMI research in understanding these fundamental coupling processes. Also, I report on challenges encountered when computing with a large number of simulations and large data.

제1발표장 그랜드볼룸 I

II-1 달탐사와 우주탐사

Chair: 김주현 (항우연)

16:30 [II-1-1]

MGM Analysis of Shield Volcano with Olivine-Rich in Birt E

Ik-Seon Hong, Yu Yi

Department of Astronomy, Space Science, and Geology, Chungnam National University

Modified Gaussian Model (MGM) is a method to deconvolve mixture spectra. The fit parameters are band strength, band center, and band width as a function of wavelength. Birt E is a shield volcano in Mare Imbrium, an olivine-rich region, considered a dark mantle deposit (DMD). It is speculated that the olivine originated from deep Interior due to the topographical characteristics, but the characteristics of the olivine have not been analyzed. In this study, we analyze the characteristics of olivine in the Birt E region through MGM fitting and determine whether it is of internal origin.

16:45 [II-1-2]

Test Particle Simulations of the Dynamics of Plasmas around Lunar Magnetic Anomalies

Jong Hoon Lee, Ensang Lee, Jongho Seon

School of Space Research, Kyung Hee University

The Moon has small-scale crustal magnetic fields regions, called lunar magnetic anomalies (LMAs). It has been reported that the strength of magnetic field in these regions is strong enough to deflect solar wind particles. However, there have been little studies on high-energy plasmas near LMAs. Lunar Space Environment Monitor (LUSEM) will be landed on the lunar surface in an LMA aboard the Nova-C lander in 2024 and observe high-energy (> 50 keV) particles. In this study, we examine the dynamics of particles in the vicinity of LMAs using test particle simulations. For the solar wind particles, electrons move along the magnetic field, but protons are almost unmagnetized. On the other hand, for the high-energy particles, electrons are also almost unmagnetized, similar to protons. These results show that protons can reach the lunar surface in LMAs. Theses results can help analyze the observations by LUSEM.

17:00 [II-1-3]

Simulation of KPLO Flight Dynamics Subsystem Using Blind Test Data for Operational Readiness Preparation

Young-Joo Song, Jonghee Bae, SeungBum Hong, Jun Bang, Jae-ik Park, Young-Rok Kim

Korea Aerospace Research Institute

For Korea Pathfinder Lunar Orbiter (KPLO) successful flight operation, an operational readiness test for the Flight Dynamics Subsystem (FDS) is being conducted. FDS operational readiness preparation is one of the essential parts while preparing the KPLO launch. In order to ensure the efficiency and integrity of testing, the KPLO flight dynamics team used blind test data provided by Space Exploration Engineering (SEE). SEE is one of the well-experienced U.S companies with lots of experience in a deep space mission, mainly focused on flight dynamics. For the blind test data sets, the simulated tracking data was generated by SEE, which incorporated dynamical model errors, maneuver execution errors, and errors associated with a tracking system, etc. Without knowing the detailed characteristics of these various error sources, the KARI flight dynamics team performed orbit determination, maneuver estimation, maneuver recovery to judge thruster efficiency, and finally, planned upcoming future maneuvers. The results obtained by the KARI team were investigated by the SEE team again for the further supplement. This work will summarize and present the results

of the blind simulations conducted so far. Several additional simulations as well as real-time rehearsals are planned shortly, and through these activities, the ability to respond and overcome challenges in a realistic flight dynamics scenario will be firmly established.

17:15 [II-1-4]

Development of Lunar Underground Detection Mission Using Low Frequency Radar for Korea Lunar Lander (KLL)

Gi-Hyuk Choi, Dae-Yeong Kim

Korea Aerospace Research Institute

Low frequency radar is rather simple instrument but it is very useful and unique method to investigate underground. Recent technology development of pulse type and wide band electronics enables more deep and sharp underground detection. In this study we will show some experiment which has been done last year using 300 MHz pulse type low frequency radar for detecting various pipes and land mines within 1-2 m deep little bit wet soil. Korea will launch Korea Lunar Lander (KLL) by 2030 using Korean launch vehicle. Therefore we are suggesting a low frequency radar of underground detection mission for ISRU activities in the Moon.

17:30 [II-1-5]

Predicting Fast Temporal Changes of Energetic Neutral Atom Flux in the Outer Heliosheath

Ji-Hyeon Yoo, Dae Young Lee

Department of Astronomy and Space Science, Chungbuk National University

Interstellar Boundary Explorer (IBEX) launched in 2008 has provided all-sky Energetic Neutral Atom (ENA) maps since 2009. IBEX discovered the unexpected 'IBEX ribbon' and globally distributed flux, which are the results of interaction between the heliosphere and the very local interstellar medium (VLISM). In particular, ENA maps from the IBEX-Hi sensor covering the energies of 0.7 to 4.3 keV have been widely utilized. However, because ENA data of IBEX has a time resolution of only 6 months, it does not provide faster changes of ENA fluxes throughout the heliosphere. To overcome this limitation, we use an analytic model of the secondary ENA generation model which allows time resolution of Carrington rotation period. From this model, we predict many situations exhibiting fast temporal variations of ENA in response to corresponding solar wind changes that cannot be seen at IBEX's time resolution. We suggest that solar activities that occur in short-term scales in addition to the longer-term effect of solar cycle play an important role in determining fine structure in ENA maps.

17:45 [II-1-6]

The Early Activity of Jupiter Trojans after Their Migration through Exploring a Thermal and Mechanical Evolution

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

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

Jupiter Trojan migration from a planetesimal disk of the outer solar system to L4 and L5 Lagrangian points of Jupiter provided different thermal environments to the bodies. Increased solar energy may have affected the internal condition and the surface both. To explore the thermal and mechanical history of the Trojans after being captured, we use a numerical simulation provided by Prialnik et al. (2004). Because the alterations could be affected by some parameters like dust thermal conductivity, dust to ice ratio, and pore size, we conducted a case study to investigate which parameter considerably affected the status of the Trojans after their migration. We expect to not only contribute to understanding the Trojan history but also suggest a possibility that the early behaviors affected their surface colors. We provide preliminary results in this study.

18:00 [II-1-7]

Gravitational Potential Estimations for the Near-Earth Asteroid Ganymed (1036)

Jinah Lee, Chandeok Park

Department of Astronomy, Yonsei University

This study first presents some representative approaches for estimating gravitational potential of small celestial bodies with irregular shape, such as comets and asteroids, and then applies them to analyzing dynamical environments of the near-Earth asteroid Ganymed (1036). The information on shape, mass, and density, which is required to calculate gravitational potential, is often obtained from observations. Those representative approaches directly integrate the associcated shape model or employ some approximations to calculate the gravitational potential of Ganymed. Each approach has its pros and cons in terms of computing time and accuracy. For example, the direct integration can achieve the highest accuracy, although the computing time is over 300 times long than that of the fastest method. The comparative/combinational analysis with some of those methods can reveal the dynamic characteristics of Ganymed more efficiently, and provide basic strategies for designing the near-asteroid orbit for proxmity operations.

제2발표장 그랜드볼룸 II

II-2 SS: 심우주탐사(BtM공동주관)

Chair: 김방엽 (항우연) / 유광선 (과기원)

16:30 [II-2-1]

A Study on the Characteristics of Space Exploration Mission Orbits Using Domestically Developed Launch Vehicles

Bangyeop Kim[1], Jaemyung Ahn[2]

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

A basic study was conducted on the characteristics of mission trajectories that could be developed with domestic technology and implemented as a space launch vehicle launched from Korean territory. The domestically developed launch vehicle represented by the Nuri is launched from the Naro Space Center located in Goheung, South Jeolla Province, and is mainly launched southward, so its orbital inclination angle is limited to a polar orbit. In this study, the characteristics of mission orbit were analyzed assuming a high elliptical orbit of the Earth that can be made with the launch capability of the Nuri launch vehicle. In addition, space exploration and technology test missions suitable for Earth's high elliptical orbit were investigated, and mission scenarios that could be performed in the future were constructed.

16:45 [II-2-2]

Free Space Optical Communication for Space Communications

Seonghwan Cho[1], Jeong-Yeoll Han[1,2], Sang Yeong Park[3], Joon Huh[4], Kihun Lee[4]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Hanwha System Co., Ltd.*
[4]*Defense Industry Technology Center*

Recent trends in the space industry are an expansion of private investment, expansion of commercial business models, innovation in technology and cost, expansion of demand and scope for satellites, and intensifying competition for space development among countries. Communication is one of the most important space infrastructures in the rapidly changing new space era. In space communications, there are demands and efforts to use Free-Space Optical Communication (FSOC) instead of radio frequencies for high-speed communication. It can be used not only for single satellite communication but also for satellite network communication because of its high speed of over Gbps. This talk will introduce FSOC technology and projects for space communications. Although the FSOC is based on communication technology, it requires Adaptive Optics (AO) to increase data throughput. As one of the major elements of FSOC, it is strategically managed by NASA. We will also introduce the AO to compensate for the distortion of the light due to atmospheric disturbance.

17:00 [II-2-3]

Proposal of Development Perspective for Korean Space Telescope

Jeong-Yeol Han[1,2], Woojin Park[1], Youra Jun[1], Jihun Kim[1], Yunjong Kim[1], Seonghwan Choi[1], Young-Soo Kim[1], Ji-Hye Baek[1], Bongkon Moon[1], Biho Jang[1], Jae-Woo Kim[1], Sungwook E. Hong[1,2], Youn Kil Jung[1], Soojong Pak[3]

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

With the launch of the James Webb Space Telescope (JWST), space telescope has been gradually interested in public. Advanced space agencies such as NASA, which led the JWST, are leading astronomical space observations by conducting planning, design, and prior research for decades based on a long-term roadmap for space telescopes. Korea has been participating in various space missions as an international cooperation partner while developing a small exploration telescope. In this presentation, we will introduce the necessity and background of domestic space telescope development along with overseas cases and suggest a development direction from a long-term perspective.

17:15 [II-2-4]

Heliosphere Observations at Lagrange Points

Kyung-Suk Cho, Junga Hwang, Jeong-Yeol Han, Seonghwan Choi, Eun Kyung Lim, Jungjoon Seough, Young-Soo Kim, Rok-soon Kim, Jongdae Sohn, Jihun Kim, Jaejin Lee, Soyoung Hong

Korea Astronomy and Space Science Institute

There are five Lagrange points where the sun-Earth gravity is offset, allowing the satellite to stay for a long time and perform a stable mission without consuming much fuel. Among them, L1, L4, and L5 are ideal points for observing the sun and the solar wind. ESA-NASA's SOHO (Solar and Heliospheric Observatory, 1995) is operating in L1, which is four times the Earth-Moon distance in the direction of the sun, and in the future, Aditya-L1 (2022) in India and Space Weather Follow (SWFO, 2025) in the United States are in operation. The UK

is scheduled to launch the Space Weather L5 mission in 2024. In this presentation, We would like to review the achievements of the SOHO Mission and introduce future international plans of Heliosphere observations at Lagrange points.

17:30 [II-2-5]

A Multi-Purpose Heliophysics L4 Mission

Junga Hwang[1,2], Kyung-suk Cho[1,2], Jeongreol Han[1,2], Seong-Hwan Choi[1], En-Kyung Im[1,2], Jeoungjun Seo[1], Young-Su Kim[1], Roksoon Kim[1], Jongdae Son[1], Jiheon Kim[1], Jaejin Lee[1,2], Soyoung Hong[2]

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

Sun-Earth lagrangian point L4 is the best location to observe the space weather in response to the solar activity continuously and comprehensively. The space radiation observation at L4 can provide a critical information to the deep space exploration and Mar's manned mission. NASA suggests that KASI should take the initiative for this challenging L4 mission. We need the comprehensive and three-dimensional observation of the solar activity and the solar wind at L1, L4, and L5. The data observed from L4 can directly contribute to the space radiation forecast study by observing the solar protons in advance. So L4 mission can contribute to the advance heliophysics science, improvement of space weather forecasting capabilities, and providing operational space weather observations supporting geomagnetic storm situational awareness, and space exploration radiation safety. So KASI just starts the preliminary study to obtain the feasibility of this L4 mission.

17:45 [II-2-6]

Proposal of Highly Elliptical Magnetosphere and Tail Region Survey Mission as a Step-Stone for Deep Space Exploration

Kwangsun Ryu, BtM Members, SSG Members

SaTReC, KAIST

Once the KSLV demonstration results in success, Korea will be facing a new area when we can think of and prepare for deep space missions beyond the moon. As a preparation for this, members of space-related research institutes and universities have voluntarily organized research groups, BtM (Beyond the Moon) and SSG (Space Science Group) for discussing deep space exploration in the near future. Within the organization, several working groups (WG) has been subsequently proposed for rather detailed discussion about plausible deep space missions or step-stone missions for those at least. In this presentation, we introduce some initial discussions and studies on EASTER (Earth And Solar-Terrestrial ExploreR) mission, a tentative name for Highly Elliptical Magnetosphere and Tail Region Survey project. By using the electric propulsion, a spacecraft can gradually raise the orbit from GTO to mid-tail region (~55 R_E) while executing many science experiments and observation on the interior and exterior of the magnetosphere and tail region. Possible scientific objectives and premature assessment on the potential of the mission in terms of domestic technologies of science instruments and spacecrafts as well as the launch vehicle.

18:00 [II-2-7]

Electron Drift Instrument (EDI) for Future Korean Missions

Jaeheung Park[1,2], The Space Science Group (SSG)

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

Electron Drift Instrument (EDI) is a space-based instrument that can measure electric field perpendicular to the background magnetic field lines. The instrument internally accelerates thermionic electrons and emits them toward surrounding space. By determining 2 specific directions of electron emission that enables recollection, the EDI can derive the magnitude and direction of the perpendicular electric field. The EDI was previously carried onboard Cluster of the European Space Agency and on the Magnetospheric Multi-Scale (MMS) mission of the National Aeronautics and Space Agency (NASA). Those EDIs weighed ~10 kg and consumed ~10 W of electric power. In this presentation, we review the operation principles and design details of the EDIs onboard Cluster and MMS. Additionally, tips and caveats are given for designing future Korean EDIs.

18:15 [II-2-8]

Space Exploration Using Mass Spectrometer

Jingeun Rhee, Ju Woo

Youngin ACE Co., Ltd.

The mass spectrometer, an equipment for measuring and quantifying the amount of gaseous ions, was commercialized in earnest after the development of quadrupole and ion trap by Wolfgang Paul in 1953. In 1962, NASA purchased the first commercial quadrupole mass spectrometer for the purpose of space exploration.

Since then, the mass spectrometer has been used in various forms for space exploration and measurement of the space plasma environment, from the Apollo 15/16 mission in 1971 to the ExoMars mission for Mars exploration, which was recently canceled due to the Russian-Ukraine war.

This presentation introduces the principle of mass analysis technology and the mass analyzer used in the recent LADEE (2013), MAVEN (2018) and ExoMars (2020) missions, and explains the technical challenges to be overcome to develop Korean mass spectrometer for the purpose of future space exploration.

제3발표장 에메랄드

II-3 SS: Energy Coupling in the Heliosphere II

Chair: 양태용 (천문연)

16:30 [II-3-1]

Responses and Changes in the High-Latitude Upper Atmosphere during Solar Activity and Geomagnetic Storms, and Their Global Propagation

Young-Sil Kwak

Korea Astronomy and Space Science Institute (KASI)

In the period of high solar activity, the strong electric field and high-energy auroral particles flow from the magnetosphere to the Earth's high-latitude upper atmosphere due to the interaction of the solar wind and the Earth's magnetic field. As a result, not only the aurora occurs in the high-latitude ionosphere, but also fast plasma convection and strong current are generated. The high-latitude upper atmosphere is greatly influenced by the momentum and energy forcing associated with the coupling of magnetosphere-ionosphere. Especially during magnetic storms, the ensuing high-latitude ionization, Joule heating, and ion-drag forcing of the upper atmosphere, along with penetration of the electric fields to low latitudes, affect the global dynamics and structure of the upper atmosphere. In my talk, responses and changes in the high-latitude upper atmosphere during solar activity and geomagnetic storms, and their global propagation are addressed.

16:45 [II-3-2]

Ionospheric Responses over North-East Asia and Europe during the G3 Extreme Geomagnetic Storm (Nov 4, 2021) Induced by Solar CME Event

Jeongheon Kim[1], Young-Sil Kwak[1,2], Hosik Kam[1], Jae-Wook Lee[1,2], Tae-Yong Yang[1], Woo Kyoung Lee[1], Junseok Hong[1], ChangSup Lee[3], GeonHwa Jee[3], YongHa Kim[4], JongYeon Yun[5]

[1]*Korea Astronomy and Space Science Institute, KASI*
[2]*University of Science and Technology, UST*
[3]*Korea Polar Research Institute, KOPRI*
[4]*Chungnam National University, CNU*
[5]*Korea Space Weather Center, KSWC*

On November 1 and 2, 2021, two Halo CMEs in the Sun ejected an enormous number of high-energy particles into interplanetary space. Its events were directed toward Earth and reached Earth on November 4, generating a G3 level (= Kp 7) extreme geomagnetic storm. In the near-earth-space environment at that time, the north-south component of the interplanetary magnetic field underwent three rapid transitions, and the high-energy particles were intensified the Earth's high-latitude precipitations three times. Simultaneously, the same pattern of transition disturbance was observed in the AE index, which is the aurora jet current index, due to the energy inputting into the ionosphere of the polar region. As a result, we confirmed the positive ionospheric storms with the same transition patterns were observed in the ionosphere using ionosondes and GPS signals around North-East Asia. We speculate that this result is because the equatorward (= meridional) neutral wind also blows in the same pattern due to the heated thermosphere in the polar region. Unfortunately, there was no equipment capable of observing neutral winds around Northeast Asia, so verification could not be performed. To make up for the problem, we simulated the response in the ionosphere according to the change of meridional neutral wind using the ionospheric physics-based model. Although on the other side of the globe, we checked the equatorward neutral wind patterns through ICON/MIGHTI data passing near mid-latitudes in the Northern Hemisphere Atlantic Ocean. Also, the DIAS measurements network observed positive (negative) ionospheric storms in Southern (northern) Europe. Therefore, taking these results together, the intense G3 geomagnetic storm that occurred this time appears to have affected the ionosphere on a global scale. We will display these results in this talk.

17:00 [II-3-3]

Modulation of High-Latitude Ionosphere and Mesosphere in Responding to Energetic Electron Precipitation (〉 30 keV) during Geomagnetic Disturbances

Young-Sook Lee[1], Yong Ha Kim[1], Young-Sil Kwak[2]

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

Geomagnetic disturbance caused by the dynamic pressure enhancement and the fluctuation of the interplanetary magnetic field can induce energetic particle precipitation from the magnetosphere into the atmosphere. The optical phenomena including aurora and mesospheric clouds (PMC: luminous ice

crystal clouds) at high latitudes can be signatures of taking energy input and going through chemical reactions in the atmosphere and the ionosphere.
PMC typically contains the imprints of undertaking severe atmospheric dynamics including convection, surging, wave and etc. The atmospheric source, such as the breaking of upward gravity waves, the dissipation or their interaction with planetary waves, is short of explaining the severe dynamical signature during a storm. However, the evidence of mesospheric modulation in terms of temperature and plasma dynamics to some extent has been observed during geomagnetic disturbance and energetic particle precipitation. Therefore, this presentation will deal with D/E-region responses to energetic electron precipitation driven by high-speed solar wind streams- and solar wind shock-caused geomagnetic disturbances, such as (1) daytime aurora from the measurements of the O(^1S) 557.5 nm emission rate and neutral velocity; (2) VHF radar echoes in terms of echo strength, occurrence and the Doppler shift. The production and modulation of polar mesospheric summer echoes can be useful to determine the D-region dynamics subjected to the geomagnetic disturbance.

17:15 [II-3-4]

Polar Middle Atmospheric Responses to High-Speed Solar Wind Streams and Geomagnetic Stroms

Geonhwa Jee[1,2], Ji-Hee Lee[1], In-Sun Song[3]

[1]*Korea Polar Research Institute*
[2]*University of Science and Technology*
[3]*Yonsei University*

During high-speed solar wind stream (HSS) events and associated geomagnetic storms, energetic electrons from the Earth's inner magnetosphere transfer solar wind energy to the high-latitude upper and middle atmospheres, which may affect chemical compositions and dynamical precesses in the region. We conduct a study on the production of nitrogen oxides (NOx) in the polar middle atmosphere by energetic electron precipitation (EEP) during HSS events in the period of international polar year 2007–2008 northern winter. A numerical modeling study is also performed to investigate the atmospheric responses to the precipitation of medium-to-high energy electrons (MEEs) using the Specific Dynamics Whole Atmosphere Community Climate Model (SD-WACCM). The EEP and MEE induced NOx shows large variations in winter, which is associated with vertical transport and horizontal mixing. The resulting changes of O_3 in the polar middle atmosphere can have significant impacts on the thermal and dynamical structures in the polar region.

17:30 [II-3-5]

Geomagnetic Activity Impacts on Meteor Plasma Trails in the Mesosphere and Lower Thermosphere

Hosik Kam[1], Young-Sil Kwak[1,2], Jeong-Heon Kim[1], Junseok Hong[1], Yong Ha Kim[3], Changsup Lee[4], Jeong-Han Kim[4], Tae-Yong Yang[1], Jaewook Lee[1,2], Seonghwan Choi[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Department of Astronomy and Space Science, Korea University of Science and Technology*
[3]*Department of Astronomy, Space, and Geology, Chungnam National University*
[4]*Division of Polar Atmospheric Sciences, Korea Polar Research Institute*

We investigated the effect of meteor echoes by geomagnetic activity using long-term data from VHF meteor radar at the King Sejong Station, Antarctica. This study focused on an altitude range from 85 km to 95 km, known as the region where an ambipolar diffusion is dominant. An anomaly analysis for parameters observed from the meteor radar revealed that decay profiles of meteor echo were affected by the intensification of the geomagnetic activity. In particular, the decay time tended to decrease as the geomagnetic activity increased. The received signal power, SNR value, and radial velocity error tended to increase as the geomagnetic activity increased. The analysis results of these parameters suggest that using the meteor radar to derive the parameters as neutral temperatures and winds requires attention when the intense geomagnetic activity duration. In addition, we confirmed that the decay profile analysis results also varied according to geomagnetic activity, which also can be interpreted as results of strong geomagnetic activity and its induced electric field affecting meteor plasma echoes.

17:45 [II-3-6]

Investigation on Ionospheric and Thermospheric Variability Using Specified Dynamics WACCM-X 2.0

In-Sun Song, Ja Soon Shim, Wonseok Lee

Department of Atmospheric Sciences, Yonsei University

Impacts of the lower atmosphere in ionospheric and thermospheric (IT) variability are examined using the Whole Atmosphere Community Climate Model with Thermosphere and Ionosphere Extension (WACCM-X 2.0). Model simulations are carried out for moderate geomagnetic storm events in 2010 and 2013. In the simulations, lower atmospheric dynamics are specified by the meteorological dynamical variables obtained from the

NASA Goddard Modern-Era Retrospective analysis for Research and Applications (MERRA) version 2. IT variability is examined by comparing model results when the lower atmospheric dynamics is specified or not. In the two kinds of simulations, initial conditions are identical and given by previous specified dynamics WACCM-X simulations. More results will be presented in conference.

18:00 [II-3-7]

Development of Space-Borne Wide-Field Auroral/Airglow Imager

Woo Kyoung Lee[1,2], Seonghwan Choi[1], Kyoung-Min Roh[1,2], Young-Sil Kwak[1,2], Jihun Kim[1], Yunjong Kim[1], Jongyeop Park[1], Jihye Baek[1], Jong-Kyun Chung[1], Jaeheung Park[1,2], Tae-yong Yang[1], Dukhaeng Lee[1], Hyosub Kil[3], Larry J. Paxton[3], Geonhwa Jee[4], Yongha Kim[5]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*Johns Hopkins University Applied Physics Laboratory*
[4]*Korea Polar Research Institute*
[5]*Chungnam National University*

KASI has been developing a wide-filed auroral/airglow imager, the ROKITS (Republic of Korea Imaging Test System) since 2021. ROKITS will be on-board in CAS500 (Compact Advance Satellite 500)-3 satellite, a new satellite series providing earth observation. The satellite mass is ~500 kg. Nuri (a Korean launch vehicle) will launch CAS500-3 in 2024. ROKITS observes aurora and airglow emission of the Earth's ionosphere/upper atmosphere in two spectral bands: OI 557.7 nm and OI 630.0 nm. The field of view of ROKITS is 90 degrees, so the swath width will be over 700 km at 100 km in altitude when the satellite orbit altitude is 600 km. The main scientific objective of ROKIS is identifying the boundary of the auroral oval and auroral shapes. Observations in two wavelengths enable us to study energy input from outer space into the Earth's atmosphere. In addition, ROKITS first attempts to detect global atmospheric gravity waves in airglow emission from space. If the mission is successful, ROKITS could provide global distribution of atmospheric gravity waves.

4월 28일(목) 제1발표장 그랜드볼룸 I

Invited Talk I

Chair: 이 유 (충남대)

09:00 [IS-I]

Outer Space and International Order

Chin-Young Hwang

Korea Aerospace Research Institute

Since the launch of Sputnik, mankind's first artificial satellite, the international community has reached an agreement that can be shared with the international order of outer space. These include the UN's Outer Space Treaty, Rescue agreements, Liability convention, Registration convention, Moon treaty. In addition, international order in space is still underway, with discussions on space debris mitigation guideline, space traffic management and long-term sustainability of outer space activities, UNIDROIT, Use of nuclear power sources in outer space, and space disarmament negotiations. In addition, due to the military-strategic importance of the space sector, countries around the world have enacted and operated laws on the import and export of space products and technologies.
In this presentation, I would like to introduce "outer space" and related space laws and orders, and their effects.

제1발표장 그랜드볼룸 I

III-1 SS: 달 착륙선 과학기술임무

Chair: 문봉곤 (천문연)

09:40 [III-1-1]

Overview of Planning Research on the Korean Lunar Lander Project

Yee-Jin Cheon

Korea Aerospace Research Institute

Korean government formed the Korean Lunar Lander Project Formulation Tiger Team with specialists, experts and researchers from various universities, industries and research institutes to prepare the project proposal. The tiger team consists of Science and Technology Mission Formulation (STMF) working group (WG) and Lunar Lander Systems and Architecture Design (LLSAD) working group. The key role of STMF WG is to draw the lunar surface mission of Korean lunar lander which adequately reflects the global trends of lunar missions in 2030s. As its name says, the LLSAD WG will output the Korean lunar lander which will be expected to be utilized in successive lunar landing mission and other planetary (e.g., Mars) landing mission. The key phrase of the planning research is 'achievable, detailed and specific technology trees, costs, and schedule reflecting global trends of lunar missions in 2030s.

09:52 [III-1-2]

Introduction to Science & Technology Mission

Formulation (STMF) Working Group Activity for Korean Lunar Lander in 2030s

Bongkon Moon

Korea Astronomy and Space Science Institute

South Korea plans to send a lunar lander in the 2030s. The STMF WG was created to efficiently select the establishment of scientific and technological missions for this lunar lander, and this presentation introduces the main activities of the STMF WG. The science and technology missions of the lunar lander are divided into four main areas: lunar science, in-situ resource utilization, lunar infrastructure/residence, and local transport/ movement.

The main process of selecting science and technology missions are performed through three steps. First, mission demand surveys are proposed by domestic experts for a certain period of time. Second, the proposers must do the workshop presentation and go through review from WG members. Third, mission trade-off study is finally performed for final selection of science and technology missions seven days after the workshop.

This special session is also a process of gathering opinions from the society for lunar lander mission.

10:04 [III-1-3]

Korean Lunar Lander for Exploration: Preliminary Design of System and Architecture

Hyungjoo Yoon

Korea Aerospace Research Institute

A brief introduction and preliminary design of the system and architecture of Korean Lunar Lander for Exploration are presented. The preliminary design has been conducted by Lunar Lander System and Architecture Design (LLSAD) Working Group, which is organized mainly with engineers of Korea Aerospace Research Institute (KARI) with deep experience in development of various satellites and space explorer programs, as well as other experts in aerospace industry and academy. The lunar lander in the preliminary design has a launch mass of 1.5 ton, based on the expected capacity of KSLV-III launch vehicle, and the total weight of payloads is about 30 kg. The lander is equipped with bi-propellant propulsion system for maximum efficiency, and it will have navigation and control system to acheive autonomous pin-point soft landing with hazard avoidance. The lander is thermally controlled to operate during the mission period in lunar daylight, and it will provide telecommunication link between its payloads and Earth ground station. The development of the lunar lander will be accompanied by many new technologies and will be good opportunity to make a great leap in Korea space exploration technology.

10:16 [III-1-4]

Potential Science Topics for Future Lunar Explorations

Chae Kyung Sim

Korea Astronomy and Space Science Institute

Starting this year, several countries/institutes are putting a step forward to a new era of lunar exploration. Getting to the Moon itself is a crucial challenge leading to immense technological innovation. On top of it, understanding the Moon is an excellent science motif that enables us to trace the Earth's evolutionary history and the solar system. Here, we will review the science goals for lunar explorations recognized and suggested by forerunners and the science community over the last two decades. We will also look over the general properties of the Moon and scientific instruments aboard the near-future lunar landers. This recapitulation would lead to a hint on our future exploration mission.

10:28 [III-1-5]

Technology Demonstration Trends in Recent Robotic Lunar Surface Missions

Dong Young Rew

Korea Aerospace Research Institute

Most common keyword of 2020s' lunar mission is technology demonstration in preparation for resource utilization, lunar outpost, and long-term human existence in the Moon surface. Several robotic lunar mission are being prepared wordwide including Commercial Lunar Payload Services (CLPS) -based missions, Chandrayaan-3, Luna-25, etc. This paper sumarizes technology demonstrations included in recent robotic lunar surface missions and analyze their trends in view of preparing Korean lunar landing mission targeted early 2030s.

10:40 [III-1-6]

Proposal of Multi-Band Imager for Lunar Lander

Jeong-Yeol Han[1,2], Youra Jun[1], Chae Kyung Sim[1], Young-Soo Kim[1], Bongkon Moon[1], Hyoungkwon Lee[3]

[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*
[3]*LeO SPACE Inc.*

Understanding the environment of the landing site after the lunar lander lands is critical because the site affects their mission goal. In addition, observing a large number of dust, dust distribution, and variations in the density of dust due to the repulsive force of the lander during the landing process is

related to analyze physical changes on the lunar surfaces. It will be a very important indicator in the process of selecting a landing site and establishing an exploration plan when planning the next mission. Besides, precise/enlarged observation of the surface will be able to be utilized as various scientific analysis data by analyzing the particle size distribution and brightness change of the soil by color filter with spectroscopic characteristics. Moreover, when moving on the lunar surface, a video camera is essential to secure a field of view and precisely observe an area of interest. In this presentation, we would like to introduce overseas examples of video cameras to be mounted on landers of Mars, and propose the development of cameras that can be mounted on lunar landers in Korea.

11:04 [III-1-7]

Active Neutron Spectroscopy to Measure Abundance of H/OH-Bearing Materials and Rare-Earth Elements on the Lunar Subsurface

Sung-Joon Ye[1], Sukwon Youn[1], Uk-won Nam[2], Won-Kee Park[2], Jongdae Sohn[2], Hongjoo Kim[3], Sunghwan Kim[4], Jintae Hong[5], Insoo Jun[6]

[1]*Department of Applied Bioengineering and Research Institute of Convergence Science, Graduate School of Convergence Science and Technology, Seoul National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Department of Physics, Kyungpook National University*
[4]*Department of Radiological Science, Cheongju University*
[5]*Korea Atomic Energy Research Institute*
[6]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA*

As a science payload for Korea lunar lander mission of Y2030s, Seoul National University (SNU) suggests to develop an active neutron spectrometer to measure the abundance of H/OH-bearing materials and rare-earth elements on the lunar subsurface. It is mainly composed of an active neutron source, radiation detectors and operating power. Korea Atomic Energy Research Institute has a heritage to develop not only an active neutron source based on D-T reaction but radioisotope thermo-electric generators for the lunar mission. On the other hands, the LVRAD team consisting SNU, KASI, KNU, and CJU has developed neutron and gamma detectors as part of the NASA CLPS project planned in Y2025. Furthermore, the knowledges and experience from the JPL scientists who operated the DAN (dynamic albedo neutrons) instrument in the Mars land rover (i.e., Curiosity) of Y2013 could be a great asset for this suggested mission. The active neutron spectrometer consists of a D-T neutron generator and a neutron detector. The D-T neutron generator produces 14 MeV neutrons by nuclear fusion reaction between the deuterium source and the tritium target, which can penetrate about 1 m depth from the lunar surface. The neutron detector measures the albedo neutron flux of thermal and epithermal energy range produced by the reactions of the 14 MeV neutron with the lunar subsurface soil. Since the albedo neutrons are thermalized by hydrogen in the soil, the thermal/epithermal neutron flux differs according to the hydrogen abundance in the soil. The hydrogen abundance on the lunar subsurface measured by the neutron detector can provide an evidence of water ice. In addition, gamma-rays of specific energy are emitted through the (n, γ) reactions between thermalized neutrons and rare-earth elements, such as Nd, Sm, Eu, and Er. Therefore, the combination of the active neutron spectrometer and the gamma-ray spectrometer enables to estimate the existence or abundance of the rare-earth elements on the lunar subsurface.

11:16 [III-1-8]

Dosimetry of Human Exploration on the Lunar Surface Using Si-Sensors

Sunghwan Kim[1], Uk-won Nam[2], Won-Kee Park[2], Jongdae Sohn[2], Hongjoo Kim[3], Sincheol Kang[3], Sung-Joon Ye[4], Sukwon Youn[4], Insoo Jun[5]

[1]*Department of Radiological Science, Cheongju University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Department of Physics, Kyungpook National University*
[4]*Department of Applied Bioengineering, Graduate School of Convergence Science and Technology, Seoul National University*
[5]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA*

Human exploration of the Moon is associated with substantial risks to astronauts from space radiation. On the surface of the Moon, this consists of chronic exposure to galactic cosmic rays and sporadic solar particle events. In addition, the interaction of this radiation field with the lunar soil leads to a third component that consists of neutral particles, i.e., neutrons and gamma radiation. In the radiation environment of the Moon's surface, radiation dosimetry is very important for the safety of the space crew from the radiation. We designed and developed a spectrometer based on a Si-Csi-Si stacked detector to measure protons' energy spectrum and estimate the equivalent dose on the Moon in LVRAD project. The used pin silicon sensor in the spectrometer was produced by Kyungpook National University and had an effective area of 20 mm × 20 mm and a thickness was 650 μm. This sensor is more sensitive to radiation than the Si sensor (thickness 500 μm) of Hamamatsu because of the Si thickness. The sensor was also developed in a project on ISS-CREAM (Internationa Space Station - Cosmic Ray Energetics And Mass (CREAM) and then installed on the International Space Station and used as a space radiation detector to verify its performance. The proton energy spectrometer and the dosimeter were designed in 1−500 MeV and 0.2−1,000

keV/μm, respectively. Using the GEANT4 Monte Carlo simulation, the design of the detector was optimized and confirmed. The 50 MeV proton MC-50 cyclotron in KIRAMS and 100 MeV proton in KOMAC with Al degraders were used to calibrate the proton beam's energy. Moreover, the results were compared to the calculated results by GEANT4 simulation and measured results by the scintillation detector.

This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korea government (MSIP) (NRF-2017M1A3A4A01077173) and (NRF-2020M1A3B7108845). The authors express their sincere thanks to the staff of the MC-50 Cyclotron Laboratory (KIRAMS), for the excellent operation and their support during the experiment.

11:28 [III-1-9]

Good Energy Resolution and High Gamma Detection Efficiency Crystal Scintillators for Space Mission

Hong Joo Kim[1], Phan Quoc Vuong[1], Arshad Khan[1], Nguyen Thanh Luan[1], Sinchul Kang[1], Uk-Won Nam[2], Sunghwan Kim[3]

[1]*Kyungpook National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Cheongju University*

Crystal scintillators have several advantages of gamma radiation detection for space exploration including lunar missions. Even if it has worse energy resolution, it can have a larger size detector with better gamma stopping power, better radiation hardness, reliability and robustness compared with HPGe detector. We can identify radioactive nuclides and nuclear reactions by using gamma-ray spectroscopy. Scintillation community are trying to improve energy resolution as good as 2% and improve gamma detection efficiency. I will present several novel scintillators with high light output and good energy resolution such as LaBr3:Ce, CeBr3, SrI2:Eu, CaI2:Eu, and co-doping scintillators. Also I will show newly developed high gamma detection efficiency and good energy resolution Tl-based scintilaltors such as Tl2LiYCl6:Ce, Tl2LaCl5:Ce, Tl2LaBr5:Ce, etc developed by our group. Prospect and limitation of currently developed scintillators will be also discussed.

This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korea government (MSIP) (NRF-2020M1A3B7108845).

11:40 [III-1-10]

Lunar Architecture ISRU System & Role of Private Sector in the Field of ISRU in Korea

Kwang-Soo Jung[1], Won-Suk Lee[1], Koo-Young Kwon[1], Sun-Kyu Lee[2]

[1]*Hanwha Aerospace*
[2]*Hanwha Systems*

Leaving behind Old Space, where space development was centered on countries such as the United States and the Soviet Union in the past during the Cold War, the New Space centered on private companies such as SpaceX and Blue Origin is approaching at a rapid pace. It is emerging as a representative keyword for New Spaces such as reusable launcher, moon base construction, Mars exploration, and In-Situ Resource Utilization (ISRU).

Among them, ISRU refers to all activities to build and produce/ supply facilities to utilize in-site resources such as the moon and Mars, and covers a wide range of technologies such as power supply, space construction, robot/automation systems. It is attracting attention as a very important key technology field in terms of performing missions on Earth's orbit and laying the foundation for deep space exploration.

Extracting and supplying fuel from the moon based on ISRU is expected to generate cumulative annual returns of $2.4B$ to up to $49.6B$ in the short term around 2040 [1, 2], and efforts based on international cooperation are continuing to develop technologies by sector [3].

In Korea, the technology readiness level (TRL) of ISRU-related technologies is 2–3 levels, and technology development centered on government-funded research institute has been carried out. In the future, technology maturity is expected to be secured at 6 to 7 levels through lunar exploration plans, and private companies will play an important role in improving to 8 to 9 levels through so-called Public Private Partnership (PPP).

Hanwha Aerospace is working with the Korea Institute of Geoscience and Mineral Resources, the Korea Atomic Energy Research Institute, the Korea Institute of Civil Engineering and Building Technology, the Korea Research Institute of Standards and Science, and the Korea Institute of Energy Research to establish such a public-private partnership.

Therefore, this study introduces the mid- to long-term roadmap established through the above public-private partnership in the development of ISRU technology in Korea, and discusses the role of private companies to realize it.

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[2] Scatteia, L., and Perrot, Y., “Lunar Market Assessment: Market Trends and Challenges in the Development of a Lunar Economy,” Research Paper Published by Pricewaterhouse Coopers (PwC), 2021.

[3] International Space Exploration Coordination Group, “In-situ Resource Utilization Gap Assessment Report,” 2021.

11:52 [III-1-11]

Lunar Science Expected from Magnetometers on the Surface of the Moon

Seul-Min Baek[1], Ho Jin[2], Khan-Hyuk Kim[2], Young-Jun Choi[1,3]

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

The discovery of dispersed crustal magnetic anomalies and the detection of surface magnetic fields of up to hundreds of nT at the landing sites were major surprises of the Apollo program. Lunar magnetism has been investigated for the last several decades concerning three main targets: (1) crustal magnetic fields of the Moon, (2) electromagnetic and plasma environment around the Moon, and (3) electrical conductivity structure of the Moon. However, despite of several studies, the understanding of lunar magnetism is one of the most important and debatable issues of lunar science. Therefore, the new magnetometer on the Moon should be more widely integrated into future lunar missions. Especially, magnetic investigation on the surface of the Moon can provide new insight into the lunar magnetism, surface-plasma interactions, and the internal structure and composition. Also, the study of lunar magnetism will seek to answer the fundamental questions in terms of solar system origin and planetary processes. Furthermore, the magnetometer measurements will be performed in at least four landing sites through other lunar missions. It is a good chance for us to understand lunar science. In this presentation, we introduce the lunar science expected from magnetometers on the lunar surface.

12:04 [III-1-12]

Particles-and-Fields Instrument for the Korean Lunar Lander Mission

Woo-Hyeong Seol, Jongho Seon, Ho Jin, Khan-Hyuk Kim

School of Space Research, Kyung Hee University

We propose a conceptual design of a set of instruments to monitor spatial and temporal variations of lunar magnetic field and population of charged particles originated from the solar wind and the moon on the lunar surface for the Korean lunar lander mission envisioned in 2030. The proposed instrument suite will provide information on the space environment of the lunar surface related to the various science topics including the solar wind-moon interaction, the origin of the lunar magnetic field, geomagnetic activity, their interactions with the spacecraft and the space weathering effects on the lunar surface. The instruments are based on the predecessor instrument design for the Commercial Lunar Payload Service (CLPS) to be launched near 2024-2025 by NASA, but significant reduction of mass and power will be made in consideration of potential limitation on the allocated resources for science payloads. A summary of science topics and instrument descriptions will be provided in this talk.

제2발표장 그랜드볼룸 II

III-2 태양 및 우주환경 II

Chair: 이진이 (경희대)

09:40 [III-2-1]

Revisiting the Source Regions of Solar Energetic Particles by Synchronic Potential Field Source Surface Model

Jinhye Park[1], Hyun-Jin Jeong[2], Yong-Jae Moon[1,2]

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

We revisit magnetic field configurations of the source regions of 6 solar energetic particle (SEP) events accelerated near or behind the limbs. For this, we use a new potential field source surface model (AI-PFSS) at 2.5$R_\odot$, on a near real-time basis using AI-generated farside magnetograms by Jeong et al. (2020). By comparing AI-PFSS and conventional PFSS from HMI synoptic data (HMI-PFSS), we find several interesting differences on the SEP source regions and their magnetic field configurations between them.
1) The structure and size of source active regions (ARs) are significantly changed. The total unsigned magnetic field fluxes of the ARs are mostly stronger in AI-PFSS rather than HMI-PFSS except for one case. 2) In particular, newly emerging ARs are observed near the SEP source regions in the AI-PFSS for two cases. The locations of the emission features in the full-sun EUV synchronic maps are consistent with ARs in the AI-PFSS. 3) The inversion lines are changed due to the appearance and/or disappearance of ARs. The propagation directions of the source eruptions in the running difference EUV images are consistent with the configurations of the inversion lines in the AI-PFSS. This study shows that AI-PFSS is able to give a better understanding of SEP source regions and their magnetic field connections.

09:52 [III-2-2]

Study on Plasma Heating along a Current Sheet in Nonequilibrium

Jin-Yi Lee[1], John C. Raymond[2], Katharine K. Reeves[2], Chengcai Shen[2], Stephen Kahler[3], Yong-Jae Moon[1], Yeon-Han Kim[4,5]

[1]*Kyung Hee University*
[2]*The Center for Astrophysics | Harvard & Smithsonian*
[3]*Air Force Research Laboratory*
[4]*Korea Astronomy & Space Science Institute*
[5]*University of Science and Technology*

We investigate heating rates along a current sheet plasma considering nonequilibrium states in both nonequilibrium ionization and non-Maxwellian electron velocity distributions. We assume rapid heating at the beginning of eruption and continuous heating with its expansion. We calculate ion fractions solving by a time-dependent ionization equation with various Kappa values, representing non-Maxwellian electron velocity distributions, with the heated temperatures. Then, we simulate the DNs using the calculated ion fractions and compare them with the observations on 2017 September 10 by the Atmospheric Imaging Assembly on board the Solar Dynamic Observatory. Finally, we discuss the heating rates and Kappa values for satisfying the observations. This study would guide for the studies on other solar events considering the nonequilibrium states.

10:04 [III-2-3]

Toward Accurate Ai-Generated Solar Farside Magnetograms and Their Applications

Hyun-Jin Jeong[1], Yong-Jae Moon[1,2], Eunsu Park[2], Harim Lee[2]

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

Here, we have greatly improved AI-generated solar farside magnetograms from STEREO Ahead (A) and Behind (B) EUV observations than before. We have modified our previous deep learning model and configuration of input datasets to generate more realistic magnetograms. First our model, which is called pix2pixCC, uses an updated loss function which includes correlation coefficients between the real and generated data. Second, we construct input datasets of our model: solar farside EUV observations together with frontside data pairs of EUV observations and magnetograms. We expect that the frontside data pairs give the model the historic information of magnetic field polarity distributions. Our results show that the present model is much better than our previous model (Jeong et al., 2020, ApJ Letter) in view of several metrics. In addition, the AI-generated farside magnetograms produce consistent polar field strengths and magnetic field polarities with those of nearby frontside SDO/HMI magnetograms for solar cycles 24 and 25. Our AI-generated Solar Farside Magnetograms (AISFMs) are now publicly available at Korean Data Center for SDO. We present several applications and results using AISFMs. We construct synchronic global magnetic field maps with SDO/HMI and AISF magnetograms, and extrapolate solar coronal magnetic fields from them. We show that our results are much more consistent with EUV observations than those of the conventional method in view of solar active regions and open field regions (coronal holes). The results show more consistently the sequences of coronal structure changes over several solar rotation. Finally we suggest several prospects to study global magnetic connectivity with multi-view point observations, e.g., STEREO, Parker Solar Probe, and Solar Orbiter.

10:16 [III-2-4]

3-Day Time Series Forecasting of Solar Wind Speed by Deep Learning

Jihyeon Son[1], Suk-Kyung Sung[2], Yong-Jae Moon[1,2], Harim Lee[2]

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

In this study, we forecast solar wind speed for the next 3 days with 6 hours interval by deep learning. For this, we use SDO/AIA 211 Å images and the solar wind speed themselves as input data. Total period of the data is from 2010 May to 2020 December. We divide the data into training set (January–August), validation set (September), and test set (October–December) to consider the solar cycle effect. Our main results are as follows. First, our model successfully predicts the solar wind speed for the next 3 days. Second, root mean square error (RMSE) of our model is from 41.0 km/s (for 6 h prediction) to 66.5 km/s (for 72 h prediction), and correlation coefficient (CC) is from 0.90 to 0.69. These values are much better than those of the previous models. Third, the model can predict sudden increase of solar wind speed such as corotating interacting regions, which are caused by large equatorial coronal holes. We have a plan to consider additional input data such as CME information to improve the performance of the model.

10:28 [III-2-5]

Determination of Three-Dimensional Parameters of Coronal Mass Ejections Using a Deep Learning Method

Hyeoncok Na[1], Yong-Jae Moon[1,2]

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

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

In this study, we present a new method to determine three-dimensional parameters of coronal mass ejections (CMEs) using a deep learning method. For this study, we consider a Convolutional Neural Network (CNN) method which is a popularly used algorithm in image recognition. As a first step, we develop a deep learning model using synthetic CME images. A synthetic CME image is generated by a full ice-cream cone model and a power-law density distribution for given three-dimensional parameters set (radial height, angular width, latitude, longitude). We generate 110,000 synthetic CME images with different three-dimensional parameters: 80,000 for training, 20,000 for validation, and 10,000 for test. As a preliminary results, we obtain root mean square errors between the three-dimensional parameters of the test data set and those of our model: 3 Rs for the radial height, 13.4 for the angular width, 6° for the latitude and 12° for the longitude. We are improving the model by optimizing hyper parameters and modifying input images.

10:40 [III-2-6]

Fast Reconstruction of 3-D Solar Parameters Based on MAS by Deep Learning

Sumiaya Rahman, Seungheon Jeon, Hyun-Jin Jeong, Yong-Jae Moon

School of Space Research, Kyung Hee University

Magnetohydrodynamic (MHD) models have provided the global configuration of the magnetic field and the plasma parameters (i.e., density, temperature, and magnetic field) in the corona. However, this simulation process is quite a complicated process and requires a lot of computing resource and time. We have made a first attempt to generate solar coronal parameters based on MHD simulations by deep learning. We consider synoptic photospheric magnetic fields as an input to obtain 3-D solar coronal parameters such as density and magnetic field. 4272 pairs of inputs and outputs are considered for training, validation, and testing from 2010 June to 2020 May, which is simulated with the MHD Algorithm outside a Sphere (MAS) model. We train 54 separate deep learning models to cover from 2 to 30 solar radii for solar coronal parameters. The generated 3D solar parameters (density, magnetic field) are consistent with those of the simulated ones at not only lower solar radii but also higher radii: specifically, high mean correlation coefficient (0.98). The most impressive result is that the computing time of the 54 models for each solar coronal parameter is about 35 secs under NVIDIA TITAN XP GPU, which is much less than a typical simulation time of MAS. Our study shows that the synthetic coronagraphic images estimated from the deep learning models are similar to the SOHO/LASCO C3 images, especially during solar minimum period. We have a plan to use synchronic magnetic field data from SDO/HMI and AI-generated farside magnetograms as input data. The generated coronal density distribution can be used for space weather models on a near real-time basis.

11:04 [III-2-7]

Observation of Auroral Electrojet Echoes Expanding to Middle Latitude by Fort Hays SuperDARN during Sudden Enhancement of Solar Wind Dynamic Pressure

Seok-Min Song, Young-Sook Lee, Ram Singh, Y. H. Kim

Department of Astronomy and Space Science, Chungnam National University

We investigated the signature of auroral electrojet expanding equatorward to reach sub-auroral and mid-latitude regions in the post-midnight sector (MLT 2.5 hr) at solar wind dynamic pressure pulse (~25 nPa at ~09:15 UT) during a geomagnetic storm on November 4, 2021. The observation was made with the mid-latitude SuperDARN radars of Fort Hays (FH) east/west (FHE/FHW: 38.86°N, −99.39°E; MLAT 48°N), together with ground-based magnetometers and THEMIS all sky camera network, and DMSP (Defense Meteorological Satellite Program) satellite observation. For this event, the auroral electrojet echoes were observed to approach from a distance 1,500 km to 500 km as their line-of-sight (LOS) velocities decreased from ~400 to 200 m/s, respectively. The velocity became under the ion-acoustic velocity near the FH sites. Auroral lights observed by THEMIS extended to as low as MLAT of 60°N, 1,000 km away from Fort Hays, and were overlapped with the radar observation. At the same time DMSP/SSJ5 observed proton precipitation reaching as low as MLAT of 45°N. The magnetometers recorded mild disturbances (~$\triangle H \approx$ 100 nT) through the meridional chain. We suggest that the E-region echoes approaching to the radar can be a signature of proton aurora expansion triggered by the strong dynamic pressure impingement on the magnetosphere. We will discuss more about the auroral event in terms of energy flux input, electric current and magneto-tail reconnection.

11:16 [III-2-8]

First Observation of D-Region Eastward Plasma Flow Channel Participating in Ionospheric Plasma Convection in the Post-Midnight of the Dawn-Cell

Young-Sook Lee[1], Yong Ha Kim[1], Ram Singh[1], Young-Sil Kwak[2], Seok-min Song[1]

[1]*Chungnam National University*

[2]*Korea Astronomy and Space Science Institute*

We report the first observation of post-midnight plasma flow channel appearing in the summer D-region ionosphere during a moderate substorm event. The observation was made with the high frequency (HF) Super Dual Auroral Radar Network (SuperDARN) radar located at Pykkvibaer (pyk) and Stokkseyri (sto) in Iceland. The near gates of the radar can be used for the D-region echo observation at a slant range of 180–315 km. The onset of local magnetic field disturbance was followed by increasing of echo intensity and occurrence, turning the velocity direction from westward to eastward. The eastward flow persisted for ~50 min with keeping at a level of 100–200 m/s for ~40 min at heights of 60–100 km, which was overlapped with the polar mesospheric summer echo (PMSE) layer.
The persisting eastward flow in D-region appeared over 1–3 range gates, called plasma flow channel, aligned to the dawn-cell sunward ionospheric plasma convection in the auroral zone. We discuss the distinctive features of the D-region flow channel, the space weather condition, and the energy input.
This study suggests that the electric field exerting the ionospheric convection can map down to the D-region ionosphere along the magnetic field lines based on the flow channel occurring in the PMSE region.

11:28 [III-2-9]

Ionospheric Density Responses to the Prompt Penetration Electric Field during the Space Weather Event over the East-Asian Sector

Ram Singh[1], Young-Sook Lee[1], Seok-Min Song[1], Y. H. Kim[1], Jong-Yeon Yun[2], S. Sripathi[3], B. Rajesh[3]

[1]*Department of Astronomy and Space Science, Chungnam National University*
[2]*Observation Division, Korea Space Weather Center (KSWC)*
[3]*Indian Institute of Geomagnetism (IIG), Mumbai, India*

In this work, we report ionospheric density responses to the prompt penetration electric fields (PPEFs) during a space weather event. Our observations show the signatures of the multiple penetration electric fields and the disturbance dynamo (DD) electric field having impacted the ionosphere in the East Asian sector along the meridional chain thoroughly from the equator, low-mid to high latitudes. The observation is made on GPS-TEC, digisonde, and magnetometer stations. In the main phase of the storm, intense modulations of VTEC (vertical total electron content) and foF2 (critical frequency) are observed as coherently fluctuating with interplanetary electric field (IEF) fluctuations, so that the oscillations in the DP2 current system can directly penetrate to lower latitudes in order to change ionospheric electrodynamics to induce electron density fluctuation. In addition, the oscillations of foF2 and virtual height (h'F) are observed during the recovery phase, which are associated with the disturbance dynamo (DD) electric field or traveling ionospheric disturbances (TIDs). The wavelet spectra of VTEC, foF2, h'F (virtual height), H-components and IEF give a result of common and dominant periodicity occurring at ~1 hr. This result suggests that the wavelike oscillations of VTEC and foF2 and H component are associated with PP electric fields.

11:40 [III-2-10]

A Comparison of MLT Winds Observed from the Ground- and Satellite-Based Observations over South Korea

Jaewook Lee[1,2], Young-Sil Kwak[1,2†], Hosik Kam[1], Hyosub Kil[3], Jaeheung Park[1], Jeongheon Kim[1], Junseok Hong[1], Tae-Yong Yang[1], Woo Kyoung Lee[1], Changsup Lee[4]

[1]*Division of Space Science, Korea Astronomy and Space Science Institute*
[2]*Department of Astronomy and Space Science, Korea University of Science and Technology*
[3]*Johns Hopkins University Applied Physics Laboratory*
[4]*Division of Atmospheric Sciences, Korea Polar Research Institute*

In the Mesosphere and Lower Thermosphere (MLT) region, neutral horizontal winds play an important role in the dynamics. To measure the winds in the MLT region by ground-based observation, Korea Astronomy and Space science Institute (KASI) has operated VHF Meteor Radar (MR) in Daejeon (36.18°N, 127.14°E) since October 2017. Moreover, the Michelson Interferometer for Global High resolution Thermospheric Imaging (MIGHTI) onboard the Ionospheric Connection Explorer (ICON) satellite has measured the mid-latitudinal neutral horizontal winds in an altitudinal range between ~94 to ~300 km since December 2019. We have tried to vertically link and extend wind profiles using MR and MIGHTI over Korean Peninsula. In this study, we derived MR winds using meteor echoes observed within 6-time segments (5, 10, 15, 20, 25, and 30 minutes before and after MIGHTI observing onset time) at 94 km and 97 km. We carried out the orthogonal distance regression (ODR) analysis between the MR and MIGHTI winds in day and night time. From the ODR analysis with the 6-time segments, we found that the horizontal and line-of-sight winds measured by MR with temporally short sampled echoes centered on the MIGHTI observing time were closer to those of MIGHTI. In other words, compared to MIGHTI winds, which capture the instantaneous winds at the observing onset time, we can infer that variability such as atmospheric waves or turbulence exists during the sampling time of MR winds, which led to the discrepancies between MR and MIGHTI winds. Furthermore, we noticed that the differences between MR and MIGHTI meridional winds in the daytime were larger than those in the nighttime. This study will help us integrate MR winds (80 km–100 km) with MIGHTI

winds (94 km–300 km) to extend the wind profile from 80 km to 300 km.

11:52 [III-2-11]

Ionospheric Disturbances near the Korean Peninsula Related to 2022 Tonga Volcanic Eruption

Junseok Hong[1], Hyosub Kil[2], Wookyoung Lee[1], Young-Sil Kwak[1,3], Byung-Kyu Choi[1]

[1]*Korea Astronomy and Space Science Institute*
[2]*Johns Hopkins University Applied Physics Laboratory*
[3]*University of Science and Technology*

The strong oceanic volcanic eruption at Tonga occurred at UT 04:15 on January 15, 2022. Extensive energy was released into not only the atmosphere but also the ocean, so that atmospheric shock waves and tsunami traversed globally. The atmospheric pressure changes induced by shock waves associated with the volcanic eruption were observed by meteorological automated weather stations (AWS) at South Korea about UT 12:30. Atmospheric shock wave speed, about 301 m/s, was derived from the distance and arriving time between the Tonga volcano and South Korean AWS. Simultaneously with observations of tropospheric pressure changes, near real-time ionospheric monitoring system using global navigation satellite system (GNSS) over South Korea by Korea Astronomy and Space Science Institute (KASI) also detected total electron content (TEC) perturbations as well as ionospheric scintillations associated with the Tonga volcanic eruption near Korean peninsula. The weak ionospheric perturbations about 0.2 TEC unit passed through the Korean peninsula, and they had similar propagation speed to the shock wave speed derived from the atmospheric pressure changes. On the other hand, the strong ionospheric perturbations causing scintillations were broken off near southern part of the Korean peninsula, and they are presumed to be extraordinarily large plasma bubble. Even though the plasma bubble is very rare in January at East-Asian sector, the strong shock waves induced by the volcanic eruption might trigger the ionospheric instability at this region during nighttime. In this presentation, we show the ionospheric disturbances including scintillation associated with 2022 Tonga volcanic eruption near Korean peninsula.

12:04 [III-2-12]

Seasonal Variation of Quasi-10-Day Wave Activity during 2012–2016 in the Southern High-Latitude MLT Region

Wonseok Lee[1], In-Sun Song[1], Yong Ha Kim[2]

[1]*Department of Atmospheric Sciences, Yonsei University*
[2]*Department of Astronomy and Space Science, Chungnam National University*

In the present study, we investigate the seasonal variation of westward-propagating quasi-10-day wave (Q10DW) in the mesosphere and lower thermosphere (MLT) in the southern high-latitude region. We analyzed zonal wind data from zonally separated meteor radars, located in Davis (68.6°S, 77.9°E) and King Sejong Station (62.2°S, 58.8°W), during the period of 2012–2016. To estimate the horizontal scale and propagating direction of Q10DW, we applied a phase difference technique to the zonal wind data. We have extracted westward-propagating Q10DW with wavenumber 1 (W1) from the wind database. In addition, we utilized the specified dynamics of the Whole Atmosphere Community Climate Model with thermosphere and ionosphere eXtension (SD-WACCM-X) to compare with the observed Q10DW W1 and to examine the background atmospheric condition. The detailed comparison results will be presented, including a possible source of Q10DW.

제3발표장 에메랄드

III-3 우주감시

Chair: 노동구 (천문연)

09:40 [III-3-1]

All-Sky Space Object Monitoring System: Data Reduction Process and Some Preliminary Results

Yun Hak Kim[1], Dong-Goo Roh[1], Jang-Hyun Park[1], Sungki Cho[1], Jung Hyun Jo[1], Jeong Yoo Hong[1], Hong-Suh Yim[1], Mansoo Choi[1], Myung-Jin Kim[1], Eun-Jung Choi[1], Jin Choi[1], Jiwoong Yu[1], SeongHo Son[2]

[1]*Korea Astronomy and Space Science Institute*
[2]*Open Sky Partners Inc.*

All-sky space object monitoring system plays a surveillance role in large-sized artificial space objects possibly falling onto the ground and, detect and analyze the trajectories of falling meteors. this monitoring system consists of two sub-systems which are called Space Object Sky Monitoring System (SOSMS) and Korea Meteor Monitoring and Observation Network (K-M^{2}ONet). Whereas SOSMS plays roles that monitors trajectories of large-sized satellites and detects signs that falling onto ground from their orbits, K-M^{2}ONet detects falling meteors and generates their information to estimate their trjajectories and potential crash areas.
As a follow-up presentation of the previous introduction which is about the overview of Meteor Monitoring Network, we show the data reduction process and present some preliminary results.

09:52 [III-3-2]

Real-Time Conjunction Assessment and Maneuver Optimization in SPACEMAP

Seunghwan Choi[1,2], Mohamed Elsadig Osman Abdelkarim[1,2], Joonghyun Ryu[1,2,3], Deok-Soo Kim[1,2,3]

[1]*(주)SPACEMAP*
[2]*Department of Mechanical Engineering, Han Yang University*
[3]*Voronoi Diagram Research Center, Han Yang University*

The busy orbital space is getting busier in the New Space Age. This phenomenon causes the probability of collisions between resident space objects (RSOs) rather rapidly. As RSOs fly at the speed of several times of bullet, e.g. 7 to 8 km/s or higher than 27,000 km/h, the consequence of the collision is catastrophic. However, an accurate and efficient prediction of conjunctions has long been a challenge even with the space catalogue of moderate size. It will remain so with the catalogue of anticipated extreme size in the New Space Age due to many launches and enhancement of measurement technology in addition to the Kesseler syndrome. Here we present a web server called SpaceMap which can solve conjunction assessment based on both miss distance and collision probability and maneuver optimization in (near) real-time. SpaceMap reports the conjunctions of an object-of-interest (OOI) in real-time and can report the manuever optimization of a predicted conjunction from a set of user-supplied alternatives in near real-time. A consensus is that maneuver optimization is computationally hard because objects fly extremely fast and a walkaround object necessarily causes side-effects called secondary and tertiary conjunctions. What causes computational challenge is the tertiary conjunction which may be defined between OOI and other fast-flying RSOs in the neighborhood. Using conventional algorithms, this will almost probably take a significant amount of time even if the powerful computational resources are used. SpaceMap, however, takes advantage of computationally powerful, new geometric theorems called Voronoi diagrams and facilitates near real-time efficiency. In addition, SpaceMap runs on AWS. Its computational efficiency and accuracy might enable it as a potential platform for constellation planner and evaluator. Currently, SpaceMap uses the TLE data from Space-track. Incorporating other data types such as telemetry data (e.g. GPS), measurement data (e.g. radar), etc. is rather straightforward.

10:04 [III-3-3]

Conjunction Assessment Based on GPU CUDA

Jiwoong Yu, Sungki Cho, Jung Hyun Jo, Eun-Jung Choi, Jin Choi

Korea Astronomy and Space Science Institute

The Korea Astronomy and Space Science Institute (KASI) is designated as a National Space Situational Awareness Organization (NSSAO) and is in charge of space hazard monitoring and analysis. Due to the space development competition, the number of space objects is increasing dramatically, and the risk of collision between space objects is also increasing. This study analyzes the conjunction assessment between space objects by performing parallel computing of Simplified General Perturbations (SGP4) based on GPU CUDA kernel. The analysis precision was improved by using less interpolation and calculating at shorter time intervals. Nevertheless, it was possible to shorten the calculation time than before. The propagation result was verified by comparing it with the System Tool Kits (STK), and the collision risk assessment is compared with the Conjunction Data Message (CDM) of Combined Space Operations Center (CSpOC).

10:16 [III-3-4]

Space Object Conjunction Assessment Activities for KARI Satellite Constellation in 2021

Jaedong Seong, Okchul Jung, Youeyun Jung, Sae-Han Song

Korea Aerospace Research Institute

As of March 2022, KARI operates five low-orbit satellites and three geostationary satellites. Space object collision monitoring activities are carried out 24 hours a day for safe mission performance of operating satellites, and this paper shows the current status of collision monitoring activities and major events and statistical analysis results for 2021. It also included the results of optical observation campaigns conducted with foreign private companies.

10:28 [III-3-5]

Case Study of Tracking Space Object Using the OWL-Net: Abnormal Public Space Data

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

Korea Astronomy and Space Science Institute

The Optical Wide-field patroL-Network (OWL-Net) is global network of robitic telescopes for observing Korean Low Earth Orbit (LEO) satellites and monitoring Geostationary Earth Orbit (GEO) region as Space Situational Awareness (SSA) facility. The main target of the OWL-Net is domestic LEO satellites. The domestic LEO satellites can be easily tracked with publicly released orbital ephemeris, Two Line Elements (TLEs). However, the uncertainty of TLE sometimes exceeds the field of view of

OWL-Net optics. We present the quality check results of TLEs for some LEO satellites and tracking results of them with the estimated orbital ephemeris using the OWL-Net.

10:40 [III-3-6]

Orbit Determination Strategy Using Optical and Radar Data for Space Situational Awareness

Eun-Jung Choi, Jin Choi, Jiwoong You, Sungki Cho

Korea Astronomy and Space Science Institute

The estimation of the orbital state of the space objects and the propagation of its evolution are the key elements of the space situational awareness system. The orbit determination process consequently provide space situational awareness services such as the risk assessment of conjunction and re-entry prediction. This paper presents the results of an orbit determination using a combination of observations acquired by OWL-Net, ground-based optical telescopes network and LeoLabs, ground-based global phased-array radar network. Orbit determination accuracy mainly depends on the tracking data accuracy, its density and frequency, on the orbit determination methodologies and propagation methods. The Korea Astronomy and Space Science Institute (KASI) has independently developed its own orbit determination system, KASIOPEIA (KASI's Orbit Propagation & Estimation, Integrated Analysis System). Through this study, it is possible to analyze the orbit determination results of optical and radar data and establish an integrated analysis strategy.

10:52 [III-3-7]

Operational Status of Space Situational Awareness Observation System in Korea National SSA Organization (NSSAO)

Jung Hyun Jo

Korea Astronomy and Space Science Institute

We, the members of Korea National Space Situational Awareness Organization (NSSAO) have developed and been operating several Space Situational Awareness (SSA) sensors from 2016 except decommissioned equipments developed previously. A globally networked optical sensors (OWL-Net) and domestically networked optical sensors (MET-Net) are the current main SSA sensor in Korea. The OWL-Net is in normal operation mode in spite of COVID-19 situation and MET-Net is in test mode. In this presentation, we will briefly present the current status in operation of the observation equipments and infra-structure, and near term activities.

제1발표장 그랜드볼룸 I

특별포럼

Chair: 임종빈 (과학기술정책연구원)

제1발표장 그랜드볼룸 I

Invited Talk II

Chair: 김록순 (천문연)

15:20 [IS-II]

Modelling CME Evolution from the Corona to the Earth and Beyond

Stefaan Poedts

KU Leuven (Belgium) & UMCS (Poland)

Solar Coronal Mass Ejections (CMEs) are large-scale eruptive events in which large amounts of plasma (up to 10^{13}–10^{16} g) and magnetic field are expelled into interplanetary space at very high velocities (typ. 450 km/s, but up to 3,000 km/s). When sampled in situ by a spacecraft in the interplanetary medium, they are termed Interplanetary CMEs (ICMEs). They are nowadays considered to be the major drivers of "space weather" and the associated geomagnetic activity. The detectable space weather effects on Earth appear in a broad spectrum of time and length scales and have various harmful effects for human health and for our technologies on which we are ever more dependent. Severe conditions in space can hinder or damage satellite operations as well as communication and navigation

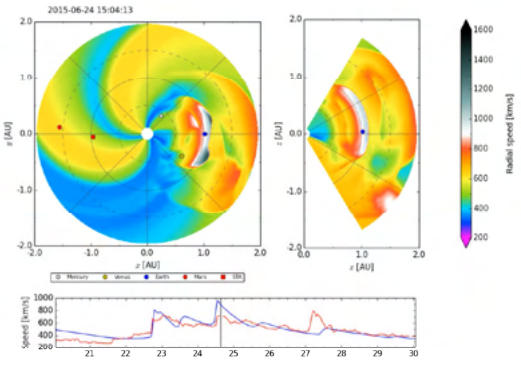

Fig. 1. Snapshot of a forecast simulation with EUHFORIA, showing the radial velocity in the equatorial plane (top left, viewed from above) and in the meridional plane through the position of Earth (top right, side view). Bottom: comparison of simulated (in blue) and measured (ACE, in red) radial velocity at L1 [from Pomoell & Poedts 2018].

systems and can even cause power grid outages leading to a variety of socio-economic losses.
We aim at developing an advanced space weather forecasting tool, combining the MHD solar wind and CME evolution model **EUHFORIA** [1] with the Solar Energetic Particle (SEP) transport and acceleration model **PARADISE** [2]. We will first introduce EUHFORIA and PARADISE and then elaborate on our plans of to model the geo-effectiveness of impacts and mitigation to avoid (part of the) damage, including that of extreme events, related to solar eruptions, solar wind streams, and SEPs, with particular emphasis on its application to forecast Geomagnetically Induced Currents (GICs) and radiation on geospace. The novel tool will be accessible by the whole space weather community via the ESA Space Weather Service Network as it will be integrated in the Virtual Space Weather Modelling Centre (VSWMC) [3].

[1] J. Pomoell and S. Poedts: "EUHFORIA: EUropean Heliospheric FORecasting Information Asset", J. of Space Weather and Space Climate, 8, A35 (2018). DOI: https://doi.org/10.1051/swsc/2018020
[2] N. Wijsen, "PARADISE: a model for energetic particle transport in the solar wind". Dissertation presented in partial fulfilment of the requirements for the degree of Doctor of Science (PhD): Mathematics (KU Leuven) and the degree of Doctor of Physics (Universitat de Barcelona). April 2020.
[3] S. Poedts, A. Kochanov, A. Lani, C. Scolini, C. Verbeke, S. Hosteaux, E. Chané, H. Deconinck, N. Mihalache, F. Diet, D. Heynderickx, J. De Keyser, E. De Donder, N.B. Crosby, M. Echim, L. Rodriguez, R. Vansintjan, F. Verstringe, B. Mampaey, R. Horne, S. Glauert, P. Jiggens, R. Keil, A. Glover, G. Deprez, J.-P. Luntama: "The Virtual Space Weather Modelling Centre", J. of Space Weather and Space Climate, 10, Art. 14 (2020). Open Access DOI: 10.1051/swsc/2020012

16:00~18:00 포스터 발표

4월 29일(금) 제1발표장 그랜드볼룸 I

IV-1 SS: Rendezvous Mission to Apophis
Chair: 이덕행 (천문연)

09:00 [IV-1-1]
Rendezvous Mission to Apophis: I. Mission Overview

Young-Jun Choi[1,2] on behalf of the RMA Team
[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*

An asteroid is important for understanding the condition of our solar system in early-stage because an asteroid, considered as a building block of the solar system, preserves the information when our solar system was formed. It has been continuously flowing into the near-Earth space, and then some asteroids have a probability of impacting Earth. Some asteroids have valuable minerals and volatiles for future resources in space activity. Korean government clarified, in the 3rd promotion plan for space activity, an asteroid sample return mission by the mid-2030s. However, it is almost impossible to do so based on only a single experience of an exploration mission to the Moon, Korea Pathfinder Lunar Orbiter, which will be launched in mid-2022. We propose a Rendezvous Mission to Apophis (RMA), beneficial in terms of science, impact hazardous, resource, and technical readiness for the space exploration of Korea.

09:15 [IV-1-2]
Rendezvous Mission to Apophis: II. Science Goals

Myung-Jin Kim[1], Hong-Kyu Moon[1], Young-Jun Choi[1,2], Minsup Jeong[1], Masateru Ishiguro[3], Youngmin JeongAhn[1], Hee-Jae Lee[1], Hongu Yang[1], Seul-Min Baek[1], Jin Choi[1], Chae Kyung Sim[1], Dukhang Lee[1], Dong-Heun Kim[1,4], Eunjin Cho[1,2], Mingyeong Lee[1,2], Yoonsoo Bach[3], Sunho Jin[3], Jooyeon Geem[3], Hangbin Jo[3], Sangho Choi[5], Yaeji Kim[6], Yoonyoung Kim[7], Yuna Kwon[7]
[1]*Korea Astronomy and Space Science Institute*
[2]*Univ of Science and Technology*
[3]*Seoul National University*
[4]*Chungbuk National University*
[5]*Yonsei University*
[6]*Auburn University, USA*
[7]*Technical University of Braunschweig, Germany*

99942 Apophis is the primary target of Rendezvous Mission to Apophis in Korea, which is currently under pre-Phase A study. It is an Sq-type asteroid with an estimated diameter of 370 m. Apophis will approach the Earth down to 31,000 km from the surface during the encounter on April 13, 2029 UT, which is closer than geostationary satellites. This once-in-a-20,000 year opportunity would further expand our knowledge on the physical and dynamical processes which are expected to occur due to the gravitational tidal forces when an asteroid encounter with a planet. It will also provide an opportunity to promote

great knowledge of the science of planetary defense. In this talk, we will present science goals of the mission.

09:30 [Ⅳ-1-3]

Rendezvous Mission to Apophis: III. PolACam and Operation Scenario

Minsup Jeong[1], Young-Jun Choi[1,2], Hong-Kyu Moon[1], Myung-Jin Kim[1], Jin Choi[1], Bongkon Moon[1], Dukhang Lee[1]

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

We plan to visit Potentially Hazardous Asteroid (PHA) Apophis during the encounter with Earth in April 2029. Apophis will come close within the orbit of geostationary satellites, as close as 31,000 km. With this Rendezvous Mission to Apophis (RMA), we operate a suite of scientific instruments before and after the Earth encounter when the surface is expected to experience alteration, e.g., landslide, space weathering and particle ejection. Polarization measurement is a useful tool to detect and to analyze such alterations through changes in surface roughness, median grain size and porosity. For this purpose, Multi-band Polarization Asteroid Camera, PolACam will be installed on the spacecraft. It will measure the polarization properties of Apophis employing seven visible bandpass filters centered at 320 nm, 430 nm, 545 nm, 705 nm, 860 nm, 955 nm, and 1,055 nm. In this talk, we will discuss the details of the PolACam and their operation scenario for the mission.

09:45 [Ⅳ-1-4]

Rendezvous Mission to Apophis: IV. Trajectory Design

Pureum Kim, Sang-Young Park

Astrodynamics and Control Lab., Yonsei University

Updated progress of interplanetary trajectory design for Rendezvous Mission to Apophis is discussed. We first introduce the updated trajectory constraints and correspondingly updated trajectory model. Using the updated constraints and trajectory model, we explore the feasibility of 2028 launch in case of delayed development, although we had already found that late 2027 would be the optimal launch date for the mission in order to allow the rendezvous of the spacecraft with Apophis before the close approach event in April 2029. Several trajectory options that are focused on either maximum spacecraft dry mass or minimum fuel usage of spacecraft will be shown. We also take a look into the effect of maneuver placement on overall trajectory. In addition to interplanetary trajectory design, we briefly discuss the development of proximity operation simulation tool for Apophis. The tool, which will be used to simulate Apophis proximity operation in the future, is designed to take into several major perturbations that are more dominant in the nearby of an Apophis-sized near-Earth asteroid.

10:00 [Ⅳ-1-5]

Rendezvous Mission to Apophis: V. Changes of the Spin State of Apophis during the 2029 Earth Encounter

Youngmin JeongAhn[1], Hee-Jae Lee[1], Myung-Jin Kim[1], Hong-Kyu Moon[1], Young-Jun Choi[1,2]

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

The Korean spacecraft for the exploration of Apophis will observe the surface changes during the close encounter with Earth in 2029. During the encounter, Earth's gravitational torques will modify the spin state of Apophis while changing Apophis' orbit from the Aten to the Apollo class. The orientation of principal axes of Apophis at the time of flyby is crucial to predict outcomes exerted by Earth's tidal torques, which has not been determined due to the lack of precise measurements of lightcurves of Apophis over the long time periods; the prediction is particularly difficult as it shows a complex non-principal axis rotation. We will predict the variation of the spin state of Apophis based on our recent estimate of its body axis orientation just before the encounter, and discuss the implication of our results.

10:15 [Ⅳ-1-6]

Rendezvous Mission to Apophis: VI. Physical Properties of Apophis Revealed from the Observations in 2021

Hee-Jae Lee[1], Myung-Jin Kim[1], Dong-Heun Kim[1,2], Hong-Kyu Moon[1], Young-Jun Choi[1,3] on Behalf of the Apophis Observation Team

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

In this presentation, we report the basic physical properties of (99942) Apophis obtained and analyzed from our extensive time-series observation campaign during its 2021 apparition. Our photometric and spectroscopic campaign was conducted from January 2021 until April 2021 over 218 nights. It was a collaboration among 49 observers from 16 different countries using 32 facilities with their aperture sizes ranging from sub-meter to 8.1 meters. As a result of our observation, we refined the convex shape model and spin state of Apophis. At the same

time, we detected its different taxonomic signatures in the different phases based on its VIS-NIR spectra. Its physical model and taxonomic properties obtained here are expected to be used not only for predicting surface alterations due to tidal effect during the upcoming encounter but for mission planning for this scientifically interesting target.

10:30 [Ⅳ-1-7]

Asteroid Exploration Mission and Trajectory Design: Formulations, Charateristics, Solution Approaches and Analysis

Jin Haeng Choi, Chandeok Park

Yonsei University

This paper presents mission design and trajectory optimizations for asteroid exploration missions. Mission and trajectory designs for asteroid explorations tend to be extremely sensitive to small changes in the dynamical system and design parameters, compared with those for lunar or near-Earth explorations, Thus, the associated spacecraft trajectory optimizations are significantly complicated and challenging to solve. Many asteroid mission designs have been presented to meet the complicated mission requirements and achieve the complex mission goals. This presentation overviews the overall issues relevant with mission/trajectory designs for asteroid explorations; considered are problem formulations, problem-specific characteristics, appropriate solution approaches, and feasibility/optimality analysis with non-trivial illustrative examples.

제2발표장 그랜드볼룸 II

Ⅳ-2 태양 및 우주환경 III

Chair: 김정헌 (천문연)

09:00 [Ⅳ-2-1]

Assessment of Polar Ionospheric Observations by VIPIR/Dynasonde at Jang Bogo Station, Antarctica: Ionospheric Densities

Eunsol Kim[1], Geonhwa Jee[1,2], Young-Bae Ham[1,2], Changsup Lee[1,2], Hyuck-Jin Kwon[1], Junseok Hong[3], Nickolay Zabotin[4], Terrence Bullett[5]

[1]*Korea Polar Research Institute*
[2]*Korea Uiversity of Science and Technology*
[3]*Korea Astronomy and Space Science Institute*
[4]*Department of Electrical and Computer Engineering, University of Colorado*
[5]*Cooperative Institute for Research in Environmental Sciences, University of Colorado*

Vertical incidence pulsed ionospheric radar (VIPIR) has been operated to observe the polar ionosphere with Dynasonde analysis software at Jang Bogo Station (JBS), Antarctica since 2017. The JBS-VIPIR-Dynasonde (JVD) provides the ionospheric parameters, such as height profile of electron density with NmF2 and hmF2, ion drift velocity, and ionospheric tilt in the bottomside ionosphere. The JBS (74.6°S, 164.2°E) is located in the polar cap, cusp, or auroral region depending on the geomagnetic activity and local time (Jee et al., 2021), which allows us to observe various aspects of the polar ionosphere. The JVD is the first ionospheric sounding system operated with the Dynasonde in the southern polar region. In the present study, the initial validations of the ionospheric densities from JVD are attempted by the comparison with GPS TEC measurements which are simultaneously obtained from the GPS receiver at JBS during the solar minimum period of 2017–2019. It is found that the JVD foF2 and bottomside TEC (bTEC) show relatively a good correlation with GPS TECs for geomagnetically quiet condition although there are large scatters in the JVD bTEC. However, there are systematic differences in the diurnal and annual variations between the two measurements, which seems to be associated with the characteristics of the polar ionosphere such as energetic particle precipitations and large density irregularities. It is also found that the Dyansonde shows some limitations to handle these characteristics of the polar ionosphere and needs to be improved to produce proper ionospheric density profiles even during disturbed conditions.

09:15 [Ⅳ-2-2]

Reconstruction of the Regional Total Electron Content Maps over Korean Peninsula Using Deep Convolutional Generative Adversarial Network (DCGAN) and Poisson Blending

Se-Heon Jeong[1,2], Hyosub Kil[3], Woo Kyoung Lee[2], Soojeong Jang[4], Yong Ha Kim[1], Junseok Hong[2], Byung-Kyu Choi[2]

[1]*Chungnam National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Applied Physics Laboratory, Johns Hopkins University*
[4]*Kyung Hee University*

This study reconstructs total electron content (TEC) maps in the vicinity of the Korean Peninsula by employing the Deep Convolutional Generative Adversarial Network and Poisson Blending (DCGAN-PB). Our interest is to rebuild small-scale structures of the ionosphere on the TEC map on which distinguishable ionospheric structures such as the equatorial ionization anomaly may not appear due to the embedded interpolation algorithm. To do this, we first generate synthetic TEC maps by training the DCGAN with the International

Reference Ionosphere-based TEC maps in 2002–2019 (except for 2010 and 2014) and then optimize the synthetic TEC maps using TEC observations. Finally, we produce complete TEC maps by implementing TEC observation onto the optimized synthetic TEC maps using Poisson Blending. The performance of the DCGAN-PB model is evaluated by testing its regeneration of masked TEC observations in 2010 (solar minimum) and 2014 (solar maximum). The correlation coefficients between the masked and model-generated TEC values gradually decrease with increasing the masking percentage. However, a good correlation between them maintains despite a significant increase in the masking (~80%). The performance of the DCGAN-PB model is not sensitive to local time, solar activity, and magnetic activity. Our results demonstrate that the DCGAN-PB model is applicable to reconstructing fine ionospheric structures in local TEC maps. The DCGAN-PB model can contribute to near real-time monitoring of the ionosphere by providing complete TEC maps immediately.

09:30 [Ⅳ-2-3]

The Plan of Ionospheric Alerts & Forecast Services by the KSWC

Jong-Yeon Yun

National Radio Research Agency, Korean Space Weather Center

KSWC plans to implement a domestic ionospheric disturbance forecast and alert service within this year to minimize damage to ionosphere users in preparation for the 24th cycle of solar maximum. The Ionospheric forecasts service is predicts the state of the ionosphere for the next three days using the Korean Ionospheric assimilation model developed with the KASI, and includes the MUF (Maximum Usable Frequency) prediction in the RSG 3-day forecasts for HF communication users. Also, In order to on phenomena that may affect communications, the Ionospheric alert service is being prepared to provide informaion on the occurrence of domestic Dellinger phenomenon and the Sporadic-E layer (foEs $\geq$ 7 MHz), will be serviced in October 2022.

09:45 [Ⅳ-2-4]

In-Situ Energetic Particles Flux Measurements in 2021 Using KSEM on the GK2A Geostationary Satellite

Daehyeon Oh, Jiyoung Kim

National Meteorological Satellite Center, Korea Meteorological Administration

The Korean Space wEather Monitor (KSEM) is a space weather payload of the GeoKompsat-2A (GK2A) geostationary satellite. KSEM's particle detector (PD) has been measured energetic particle flux in geostationary orbit for more than two years since July 2019. KSEM PD consists of 6 sets of electron and proton sensors, and they provide real-time particle flux with an energy range of 100 keV to 2 MeV. Here, we present the recent measurements of KSEM PD and their responses to several space environment situations, quiet and enhanced, including intercomparisons with those of other in-situ satellite-based particle flux sensors on Himawari-8, GOES-16, and GOES-17. Also we report on the issue on the reduction process of low energy (~100 KeV) flux data, and its possible solutions.

10:00 [Ⅳ-2-5]

Statistical Study of Low Energy Ions Originated from the Dayside of the Moon in the Geomagnetic Tail

Jaehee Lee[1], Khan-hyuk Kim[1], Seul-Min Baek[2], Ho Jin[1]

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

We have studied the statistical properties of low-energy ions originated from the dayside of the Moon using ~1.5-year (2008–2009) Kaguya data during intervals when the Moon was in the terrestrial magnetotail lobes. These lunar origin ions were detected in the energy range of 20–2,000 eV when the Kaguya was on the dayside of the Moon at ~100 km altitude. They are mostly distributed in a direction perpendicular to the background magnetic field. In order to understand the source mechanism of the lunar origin ions, we examine the relationship between energy and pitch angle and between energy and solar zenith angle. We also examine whether the lunar origin ions occur in a localized region on the dayside of the Moon.

10:15 [Ⅳ-2-6]

Observations of Ion Flattop Distributions at the Quasi-Perpendicular Bow Shock

Hee-Eun Kim[1], Ensang Lee[1], George K. Parks[2]

[1]*School of Space Research, Kyung Hee University*
[2]*Space Sciences Laboratory, University of California, Berkeley, CA, USA*

The solar wind electrons crossing the Earth's bow shock typically have nearly flattop or slightly concave upward shaped distributions in the downstream region of the shock. On the contrary, the downstream ions usually have Maxwellian or Kappa distribution functions and there have not been any previous reports of the ion flattop distributions. Here we present the first report of the ion flattop distributions at the Earth's bow shock observed by Cluster spacecraft on 22 December 2002.

We previously reported that the solar wind ions crossing the shock boundary are divided into the core and hot components. The observation introduced in this study shows that the hot component exhibits flattop distributions as observed in the electrons. Although the electron flattop distribution is almost isotropic, the flattop distributions of the hot component form only in the direction perpendicular to the magnetic field. During the observation time of the hot component flattop distributions, the magnetic field perturbations show ultra-low frequency (ULF) waves with the frequency of ~0.59 Hz and right-handed circular polarization in the spacecraft frame. We suggest that the wave-particle interaction could be a responsible mechanism for the formation of the ion flattop distributions.

제3발표장 에메랄드

Ⅳ-3 초소형 위성

Chair: 김해동 (향우연)

09:00 [Ⅳ-3-1]

Dynamic Simulation for Verifying Control Algorithms of the SNIPE Cubesat

Won-Sub Choi, Ki-Duck Kim, Hae-Dong Kim

Korea Aerospace Research Institute, KARI

SNIPE is a 6U cubesat mission to identify temporal and spatial variation of small scale plasma structures in ionosphere and magetosphere in LEO (Low Earth Orbit). The satellite will require various attitude control mode for performing missions. In this paper, we will explain the process and results of a dynamic simulation for verifying the attitude control algorithms of the satellite. the control algorithms developed with Matlab Simulink were translated into C-code using auto-code generation function of Matlab and integrated with the flight software. Dynamic simulation for verification was done with NASA's 42 simulator. Simulations were performed for a total of 7 control algorithm such as detumbling, initial sun-pointing, sun-pointing, ground contact, mometum dumping, magnetic vector aligning, thruster firing and completed verification of each algorithms.

09:15 [Ⅳ-3-2]

Development of the Solid State Telescope Instrument for Measuring Spatial Scale and Energy Dispersion of Electron Microbursts

Jongdae Sohn, Jaejin Lee, Junga Hwang, Young-Sil Kwak, Jaeheung Park, Tae-Yong Yang, Uk-Won Nam, Won-Kee Park, SNIPE Payload Team

Korea Astronomy and Space Science Institute

In this time, we report the development of Solid State Telescope, Solid State Particle Detector instrument onboard the Korea Astronomy and Space Science Institute satellite-1 (KASISat-1) to measure spatial scale and energy dispersion of electron microbursts. Electron microbursts are the short duration less than one second energetic electron precipitation into the Earth's atmosphere. They are mainly observed in the recovery phase of geomagnetic storms. Microbursts are thought to be caused by chorus waves produced by equatorial plasma instabilities. The SST developed to measure energetic electrons in the energy range from 100 to 400 keV with the geometrical factor, G = 0.02 cm^{-2} sr^{-1}. The particle detectors have a two-direction view; one is field-aligned upward and the other is perpendicular to the geomagnetic field. They have the energy resolution of within 10% (ΔE / E) and the time resolution of within 0.01 s. We developed the SST instrument and performed energy calibrations using radioisotopes. As a result, we got an excellent linearity value like the Channel-Energy curve slope and Energy responses. We describe the results of the development and the calibration for the instrument.

09:30 [Ⅳ-3-3]

Implementation of 6U Nanosatellite Separation Switch

Min Ki Kim[1], Won Sup Choi[1], Jin Hyung Kim[1], Jong Dae Sohn[2], Jae Jin Lee[2]

[1]*Korea Aerospace Research Institute*

[2]*Korea Astronomy and Space Science Institute*

Separation switch of nanosatellite has the main role to boot the overall system after the deployment from satellite deployer to space. Many kind of separation switch has two components. One is a electric switch connected to power system to sleep the satellite, and another is mechanical pusher with spring to push the electric switch. This paper introduces the a case for implementation of separation switch without mechanical pusher for 6U nanosatellite. In the present work, the electric switch is directly contacted on the inner wall of satellite deployer. Such implementation of separation switch should consider the exact gap between the swtich and the inner wall. This type of separation switch has been implemented in SNIPE.

09:45 [Ⅳ-3-4]

Very-Low-Earth-Orbit (VLEO) Cubesats for Monitoring Atomic Oxygen Fluence

Jaeheung Park[1,2], Ji-Hye Baek[1], Seonghwan Choi[1], Yougwang Kim[3], YunKyong Hyon[4], Keunyoung Park[3], Sunju Lee[4], Sukhoon Lee[5]

[1]*Korea Astronomy and Space Science Institute*

[2]University of Science and Technology
[3]Korea Aerospace Research Institute
[4]National Institute for Mathematical Sciences
[5]Chungnam National University

Atomic oxygen in the terrestrial upper atmosphere is known to erode and contaminate spacecraft subsystems. The mission degradation by oxygen atoms has been widely reported in the previous space science missions, for example, Van Allen Probes and THEMIS in the near-Earth space and MAVEN at Mars. The effect becomes more deleterious at Very-Low-Earth-Orbit (VLEO) below about 400 km altitude, where oxygen density is > 100 times higher than at normal spacecraft orbits. In this study, we first review previous studies on the atomic oxygen effects on spacecraft. Second, application prospect of VLEO CubeSats for monitoring oxygen atom is discussed. Finally, we introduce an on-going consortium of KARI, NIMS, and KASI for this topic.

제2발표장 그랜드볼룸 II

V-2 태양 및 우주환경 IV

Chair: 김관혁 (경희대)

11:00 [V-2-1]

Statistical Analysis of Pc1 Wave at Mid-Latitude Detected by BOH Magnetometer during Solar Cycle 24

Jaeyoung Kwak[1,2], Junga Hwang[1,2], Jaeheung Park[1,2], Jiwoo Kim[3]

[1]Korea Astronomy and Space Science Institute
[2]Department of Astronomy and Space Science, University of Science and Technology
[3]Department of Astronomy, Space Science and Geology, Chungnam National University

We statistically analyze Pc1 waves detected by magnetometer located in BOH (Bohyunsan, L~1.3) during solar cycle 24 (August 2009~November 2021). The Pc1 waves detected at a mid-latitude ground station are known to be generated at ring current region, and propagated along the geomagnetic field line and ionospheric wave guide. (H. Kim et al., 2020) In order to detect the waves, we apply automatic wave detection algorithm based on Bortnik et al.(2007). A similar study was carried out in J. Kim et al.(2020), but wave detection period is elongated by three years and there are some changes with the wave detection algorithm including application of sliding average window in freauency domain. Overall, this study strengthen results of previous study, J. Kim et al.(2020). We conclude that most of the waves were occurred in declining phase of solar cycle, and recovery phase of geomagnetic storm. In order to investigate characteristics of the waves, analysis of property about wave polarization will be carried out using compressional mode pulsations in future study.

11:15 [V-2-2]

Hybrid Simulations of Cold Protons and Helium Ions Energized by EMIC Waves in the Inner Magnetosphere

Jong-Woo Kwon[1], Khan-Hyuk Kim[1], Kyungguk Min[2]

[1]School of Space Research, Kyung Hee University
[2]Chungnam National University

Recent observations provide that cold (< 1 eV) protons (H^+) and helium (He^+) ions are energized by electromagnetic ion cyclotron (EMIC) waves in the inner magnetosphere (L < 6). We examine how EMIC waves interact with cold H^+ and He^+ ions by using a hybrid simulation code. The simulation results show that the cold ions are energized in two steps. In the first step, EMIC waves are excited in the H-band (ω/Ω_H ~0.4) and interact with cold H^+ and He^+ ions. The cold ions are mostly energized in the direction perpendicular to the background magnetic field. The energization in this step is not associated with high-energy tail formation but bulk heating, a picture consistent with recent observations in the inner magnetosphere. In the second step, the dominant frequencies of H-band EMIC waves shift toward lower frequencies and lower wave numbers as the hot proton temperature anisotropy decreases. The dominant waves occur in the He-band (ω/Ω_H ~0.2). During this stage, energization occurs during nonlinear evolution of EMIC waves, which is seen after about 150 ion gyroperiods. Cold He^+ ions are much more energized than cold H^+ ions. The He^+ energization is associated with thermalization of He^+ ions and occurs preferentially in the parallel direction. By comparing recent observations and the present simulation results, we suggest that low-energy particle energization by EMIC waves occurs at early stage of wave generation without nonlinear evolution of EMIC waves in the inner magnetosphere.

11:30 [V-2-3]

Low-Energy Ion Flux Enhancement and a Positive Spacecraft Charging inside the Plasmasphere

Junhyun Lee, Khan-hyuk Kim, Hee-Eun Kim, Ensang Lee

School of Space Research, Kyung Hee University

In this study, we report an unusual low-energy (< 10 eV) ion flux enhancement measured by Helium Oxygen Proton Electron (HOPE) instruments onboard Van Allen Probes A and B

satellites on 14 April 2015. The event was observed when both satellites were in the midnight sector inside the plasmasphere on each inbound path at L = 2.6–4.5 and MLAT = −10°–-4° EMIC waves occurred for a small fraction of the event interval, indicating that there is little relationship between the low-energy ion flux enhancement and the occurrence of the EMIC waves. The ion flux enhancement was accompanied by the spacecraft potential dropped to the minimum of −8 V, which implies a positive charging of the spacecraft body. From these observations we suggest that positive spacecraft charging is associated with enhanced ion flux. Using fitting analysis, we confirmed that the distribution of the enhanced ion flux was thermalized and fits well to the Maxwellian distribution. We discuss how the unusual low-energy ion flux enhancement occurred inside the plasmapause by comparing the spatial and temporal variations of physical properties observed around the Van Allen Probes satellites.

11:45 [V-2-4]

Spacecraft Potential Changes Associated with EMIC Waves in the Inner Magnetosphere

Khan-Hyuk Kim, Junhyun Lee

Kyung Hee University

Although electromagnetic ion cyclotron (EMIC) waves are commonly observed in the magnetosphere and are believed to energize background cold ions, it is not clear whether the energized ions play a significant role in determining spacecraft potential change. In this study, we present two strong He-band EMIC wave events observed by the Van Allen Probe-B spacecraft inside the plasmasphere. When strong He-band EMIC wave activity was detected, low-energy ion flux enhancements occurred nearly simultaneously with the EMIC wave power enhancements. Both events presented in this study are clearly unique in that He-band wave power and enhanced proton flux are extremely high. During the wave activity interval, we found that the spacecraft charged more positively without significant change in ambient electron density. This indicates that low-energy ions energized by EMIC waves mainly contribute to spacecraft potential change rather than background clcctrons.

12:00 [V-2-5]

Origin of Banded Chorus: The Role of Parallel Electron Plateau on the Nonlinear Growth of Chorus

Kyungguk Min

Chungnam National University

One of the earliest plasma waves observed in Earth's magnetosphere is chorus. Often, chorus arises in two spectral bands in frequency with a gap in intensity at half of the electron cyclotron frequency (fce/2), in which case it is called banded chorus. This phenomenon has been known for more than half a century and yet scientists are still grappling to understand the fundamental physics driving banded chorus. One simple idea is that the two bands are generated by two different electron populations with different temperatures. A small, but key, feature in this configuration is found in between these two populations where the electron distribution is rather flat at energies of 1–10 keV, called colloquially a plateau. This plateau at this particular energy range is believed to suppress nonlinear growth of chorus at fce/2. In this study, we investigate the role of the electron plateau using a one-dimensional particle-in-cell code in a geometry that closely represents the near equatorial region of the magnetosphere where chorus is believed to be generated. The simulation results show that even a small fraction of parallel plateau is effective in suppressing the growth of chorus elements. The gap in intensity at fce/2, as a consequence, resembles quite closely banded chorus from satellite observations.

제3발표장 에메랄드

V-3 SS: 과학문화

Chair: 황정아 (천문연)

10:40 [V-3-1]

Boundary of Public Activities on the Promotion of the Korea SSA Amid Making Cocktail of Civil and Government Policy: Difficulties on Public Science Communication

Jung Hyun Jo

Korea Astronomy and Space Science Institute

We have had a faint and unclear boundary of public science communication as government funded research entities in Korea. That boundary has a fuzzy domain on multiple variables. It can consist of releasability, understandability, priority, public curiosity, personal selectability, and many others. Korea is still a government driven nation specially on the resource and distribution of budget. The main policy on science in Korea has been swayed big time by each regime, no exception. The direction or trend of the public science communication in Korea has also been strongly effected by the change of regime's agenda not by the consensus of science communities. The public activities on SSA is not much different, rather more sensitive due to its origin. In this presentation, authur will talk about real situation on the public activities on Korea SSA

regarding public science communication.

11:00 [V-3-2]

Science, Taking It to Public: Sow Your Own Kind of Seeds

Sojeong Yim

Pohang University of Science and Technology

In recent years, even in Korea, there has been a growing awareness that science communication for the public is as important as scientific research. Most obviously, public demands on science communication have been increased in both quantitative and qualitative aspects. However, for now, the supply from the scientist and science communicator cannot meet such demand from both quantitative and qualitative aspects. In this talk, comparing the conventional science communication and recent new attempts, it is expecting that the clues for the direction in which future science communication should go through. Most importantly, each science communicator should develop his/her own way of communication, thus increasing the diversity of scientific communication.

11:20 [V-3-3]

A Scientist Who Writes the Narrative 'The Life of a Scientist'

Eun-ji Jun

Korea Advanced Institute of Science and Technology

One of the key goals of scientific popularization is the development of content that can gain public consensus. The unique story draws the public in a captivating way and leaves them feeling a lot of curiosity and wonder. Most of the existing science culture contents focus on science that anyone can easily understand. Of course, it is a necessary part, but if you look at science culture from a broad perspective, the area that can be created is much wider. Through this presentation, I would like to share the various moments experienced from the perspective of a young researcher who is starting to popularize science, and the various misunderstandings and problems that emerged in the process. In particular, when the subject of a scientist's life is translated into text or video, we will talk about how valuable the changes in the public are. Another focus is to discover potential researchers who can create such content. Even if the individual researcher does not do a great job, it is also science communication to tell the scientific story to the people around them. When everyone feels the relief that comes from sharing a researcher's life with the public, let's discuss whether it will really be an opportunity to participate in more scientific popularization activities.

11:40 [V-3-4]

Current Status of Space Education for the Students in the Republic of Korea and Consideration of Researcher Participation

Jeongwon Lee

Korea Aerospace Research Institute

It has been 33 years since KARI was established, and our space technology has developed enough to launch a space projectile in the development of Nuri (Korea Space Launch Vehicle-II), but the public's interest in space and the reality of space education for students cannot keep up with the technological development. In particular, the content related to the space field in textbooks has not changed in science textbooks for more than 10 years. It is mainly limited to the astronomical field, and there is almost no reference to space technology, and it is described only as one of the means of transportation. It is time to discuss the need for artificial satellites and the role of satellites. In addition, the movement of institutions that provide space education, such as the Korea Aerospace Research Institute, should be active, but it has not spread nationwide as much as necessary. In this presentation, we analyze the proportions of the contents of the space field in textbooks, look at the educational contents of domestic space education institutions such as KARI, and give a glimpse of the contents of space education in the developed countries of the United States and Japan. Finally, we will introduce the reasons why researchers need to actively participate in the dissemination of youth space education and how to encourage their participation.

포스터발표 논문 초록

4월 28일(목)
16:00~18:00

[P-1] Analysis of Station Keeping Performance Based on the Use of Electric Thruster

Wooyong Kang, Jun-Won Son

Korea Aerospace Research Institute

GEO-KOMPSAT3 (GK3) use electric thruster for north south station keeping. The electric thruster generate thrust to adjust the velocity of a spacecraft uses electrostatic or electromagnetic fields. Electric thrusters use much less propellent than chemical thruster. But electric thrusters have a small force, so they need to be used for a long time to station keeping. Attitude control should be performed using a reaction wheel during station keeping. In this paper, we will briefly present the station keeping performance based on the use of electric thrusters.

[P-2] A Study on the Management Efficiency Plan through Definition of Identification Code System and System Application for Multipurpose Utility Satellite Configuration Document

Chul Kang

Korea Aerospace Research Institute

Multipurpose Satellites In order to efficiently develop satellite development, it is necessary to perform configuration management tasks. For this purpose, it is necessary to conduct a configuration identification activity to identify and document the technical and physical characteristics of the configuration item, which is the basis for management. Configuration identification requires information such as identification number, type of configuration document, serial number, etc. recorded in the technical document defining the configure of the configuration item, and a system for defining such information should be defined. In this paper, the document format and identification code system of multi-purpose satellites are investigated, and methods for efficient document management are proposed by applying them to the management system.

[P-3] Overview of Inter Satellite Link to Support Multi Satellite Formation Flying

Kiho Kwon

Korea Aerospace Research Institute

Modernized Satellite system has enhanced capability with multi satellite formation flying. The main satellite consist of the bus platform and high performance payload. Each companion satellite consist of the bus platform and mid or low performance payload.

It is necessary Inter Satellite Link (ISL) which communicate between main and companion satellite to provide better performance with the multi satellite configuration.

The main satellite follows the close formation of companions at a specific distance. For multi satellite mission, the main satellite transmits a sync pulse to the companions. After receiving sync pulse in companion satellites, provide payload data and sync pulse to main satellite.

This paper contains the overview of Inter Satellite Link to support multi satellite formation flying.

[P-4] The Development of Mission Planning Rules for Korea Pathfinder Lunar Orbiter

Dong-Gyu Kim[1], Younju Jo[2]

[1]*Korea Aerospace Research Institute*
[2]*HANCOM inSPACE*

Korea Pathfinder Lunar Orbiter (KPLO) Program Office of KARI has been developing the Korea Pathfinder Lunar Orbiter (KPLO) Mission Operation Center and one of its major function is the bus and payload mission planning. In order to do generate mission timeline, there should be the schedule generation rule, conflict detection rule, and conflict resolution rule. The authors has been developing those rules based on the KPLO mission mapping rule. This paper describes the developed results of MPS mission planning rule and the relationship between KPLO mapping rule and MPS mission planning rule.

[P-5] How to Downlink Plan for Division Reception of Satellite Imaging Data

Dong-Oh Kim, Jun-Yeong Bok, Jong-Bum Park

National Satellite Operation & Application Center, Korea Aerospace Research Institute

The Korea Aerospace Research Institute is performing Mission control, Imaging reception, Data processing functions for various LEO satellites such as KOMPSAT and CAS500.

Various compression methods can be selected when satellite imaging. There are compression methods a non-compression method and a method in which a compression ratio is applied. The imaging data in which the compression rate is applied can transmit to the ground station using one reception path. In the case of imaging data in which non-compression, it may be necessary to use multiple transmit to the ground station. In this case, division reception is performed.

In this paper, the contents of divided reception are summarized.

[P-6] RFI Analysis and Frequency Management between KOMPSAT-3 and SkySat

Myungmuk Kim, Okchul Jung, Jaedong-Seong
Korea Aerospace Research Institute

Korea Aerospace Research Institute performs satellite network registration and frequency management for stable operation of satellites.
Frequency management is one of the important factors for the success of satellite missions, and as the number of satellites and earth stations is rapidly increasing as the space industry enters a new space era, satellite network registration and frequency management for frequency management are essential. In this situation while the series satellite SkySat was operated in Korea, it RFI (Radio Frequency Interference) to KOMPSAT-3 causing the mission to fail. There are a total of 21 SkySat series and they are operated in low orbit, and the operation of the Skysat earth station and the KOMPSAT-3 earth station are adjacent to each other. In this paper, we will perform RFI analysis between KOMPSAT-3 and SkySat and look into frequency management.

[P-7] Quick Check of Non Explosive Actuator (NEA) Status of CAS500 on Launch Site

Young-Yun Kim, Sung-Woo Park
Korea Aerospace Research Institute

CAS500 series use NEA for holding solar array and antenna during launch. In this paper we introduce how to check NEAs and how to evaluate the measured values at lunch site. Satellite should be checked and evaluated whether there are no abnormalities in the condition during transportation. The status of satellite electrical equipment is evaluated through actually operation by supplying power. On the contrary, the state of NEA, which cannot perform the actual operation due to its one time usage, should also be checked through another method. Good NEAs status are the first step of the success of the launch.

[P-8] Predicted Simulation of Atomic Oxygen Erosion Using Machine Learning Technique (LSTM Method) for LEO-Satellite

You Gwang Kim[1], Guen Young Park[1], Jong Hwi Choi[1], Seo Hyun Lee[2]
[1]*Korea Aerospace Research Institute*
[2]*Insight Mining*

In this paper, we compared the results of predicting the effects of atomic oxygen erosion using LSTM, which is one of the machine learning methods, with the results of using the previous technique (robust design methodology using the maximum value).
As a result of the research, it was predicted that the result value using the LSTM model would show a difference of up to 2.6 times in the desired prediction period compared with the robust design technology using the previous maximum value.
In the future, as a measure to perform such a substantial prediction simulation, we will develop an implementation of an AI (artificial intelligence) type atomic oxygen erosion prediction model by utilizing past real space environment data.

[P-9] Interference Rejection Mask Design of Satellite Receiver

Joong-Pyo Kim, Won-Gyu Lim, Sun-Ik Lee
Korea Aerospace Research Institute

The receiving performance of the satellite receiver for receiving the uplink telecommand signal is degraded by the interference signals including the payload uplink signals, the other uplink telecommand signals and the telemetry signals. For protecting those interferences, it is necessary to derive the proper interference rejection mask against all interferences. In this paper, all interference sources are identified and the interference level of each source is calculated using the satellite RF link parameters. Based on the obtained interference level, the interference rejection mask including the protection margin is derived. The obtained interference rejection mask is used to perform the RF compatibility analysis.

[P-10] Test Configuration and Procedure for Electrical Interface Check-Out between Spacecraft and Launch Vehicle of Low Earth Orbit

Jin-Hyuck Kim, Jin-Ho Lee
Korea Aerospace Research Institute

It is necessary to check the status of health (SOH) for spacecraft according to each configuration and check the function of external electrical interface at launch site. Considering the characteristics of a spacecraft, a launch vehicle, and its facility, it should be carried out quickly by predefined configuration and procedure within a limited time.
In this paper, we suggest the test configuration and procedure for electrical test items after arriving at the launch site.

[P-11] Sine Vibration Test for Geo-Stationary Satellite Having Two High Resolution Optical Payloads

Chang Ho Kim
Korea Aerospace Research Institute

Satellite structure should be designed to accommodate and

support safely the payload and equipments necessary for its own missions and to secure satellite and payloads from severe launch environments. During launch, environmental loads such as quasi-static acceleration, sinusoidal vibration, acoustic loads and shock loads are imposed on satellite. Sinusoidal vibration is typically the main factor for the design of interface for payloads and heavy equipment. For the geo-stationary satellite with two high resolution heavy optical payloads, the interface of payloads shall be designed and verified for the sinusoidal vibration. This paper deals with sinusoidal vibration test and the assessment of satellite safety.

[P-12] Status of the Fully Automated Operations for GK-2A Mission Planning Subsystem

Hye-Won Kim, Sang-Cherl Lee, Myoung-Shin Lee

Korea Aerospace Research Institute

In order to be scheduling timeline for operating the satellite and imaging through the satellite payload, the ground system has to be completely settled before the satellite launched. Mission Planning Subsystem (MPS) for Geo-KOMPSAT-2A (Geostationary-KOrea Multi Purpose SAtellite-2A, GK-2A), one of the significant ground systems for operating the satellite, has been already developed and tested before GK-2A launched in December 2018. The automatic function for scheduling daily missions has been included to the initial MPS indeed. However, some specific circumstances cannot be applied with this initial automatic function. For example, AMI (Advanced Meteorological Imager), which is loaded on GK-2A, is possible to calibrate each spectral channels with several calibration imaging types. The automatic function to be planning the satellite mission schedule is unavailable for these special missions. GK-2A operations team of KARI (Korea Aerospace Research Institute) has been continuously tried to improve the ground system, especially MPS, to be automatically operated with the limited human intervention. In this study, overall of GK-2A MPS is indicated including the upgraded automatic function.

[P-13] Improvement of Thermal Performance on Design of Spacecraft Radiator

Hui-Kyung Kim[1,2]

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

A spacecraft radiator is a thermal path to dissipate its internal heat for managing the spacecraft temperatures within allowable limits. The basic optical properties of the radiator are low absorptivity and high emissivity, that is, reflecting solar incidence and irradiating IR as much as possible. However, there are some environmental degrading cases for the radiator performance from the orientation of the spacecraft relative to the external heating environments in space. In these cases, they could be obstructed by designing a reflector additionally. The reflector attached on the side of the radiator takes roles in obstructing the external heat incidence and changing the path of heat transfer for IR which should be dissipated into the space from the radiator. The parabolic reflector is the best figure, which reflects the externally incident heat source perfectly and irradiate the IR on the radiator surface through another designed thermal path. These are originated from the general characteristics of reflection on a parabola.

In this study, the thermal path of the radiator with a single parabolic reflector would be investigated firstly. And then, the radiator with two types of a multiple parabolic reflector, that is, one has two parabola cascaded figures and another has two parabolic reflector on opposite sides of the radiator, would be studied analytically with assuming the ideal conditions and their dedicated characteristics could be understood.

[P-14] Development for Energy Balancing Analysis Program Based upon Eclipse Generation

Hwan-chun Myung, Hyoung-yoll Jun

Korea Aerospace Research Institute

As a key tool to design an electrical power system of a satellite, the energy balancing analysis program is developed in Python. The proposed analysis program is designed to consider only two main inputs under the ancillary device (solar array and battery) parameters: date-time and daily power profile of a satellite, in which a date-time decides a solar intensity directly dependent upon a solar eclipse (by Earth and Moon), a solar distance, and a solar altitude. The program largely consists of three parts: GUI, eclipse-generation, and energy balancing analysis. Using the relevant libraries (such as skyfield etc), the core functions of the developed program are coded in Python. Furthermore, Python is also applied to GUI, coming up with the compiled and executable file of the Python-based parts. For the eclipse-generation, all the related objects (Sun, Moon, Earth, and satellite)' relative positions are simulated. The simulation accuracy is reviewed in comparison with STK (System Took Kit by AGI). Given the eclipse information on the specified date-time, the energy balancing analysis is performed along with the daily power profile of a satellite. Moreover, the developed GUI enables users to easily change and set the required satellite parameters for a solar array and a battery.

[P-15] On-Ground Cell Balancing of the P-S Configured Flight Model Battery

Sung-Woo Park[1], Hyung-Jun Jang[2]

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

Typically, batteries for LEO Satellites applications supply operational power during the period from the launch of a satellite to the deployment phase of solar panels and during the daytime where the peak output power of the solar panels exceed the required system operational power. The on-ground maintenance of a flight mode battery including their usage for a flight model satellite tests from the phase of performing acquisition tests to launch is very important to maintain optimal performance during the orbit mission operations. Generally, a battery system is configured in the form of serial-parallel (S-P) or parallel-series (P-S) depending on individual cell capacity and configuration used for building the packages. And, the protection circuit and on- ground maintenance scheme shall also be different depending on their configurations. This paper mainly focuses on the development of a on-ground maintenance equipment, especially optimized for a P-S configured battery and also includes balancing results performed using a flight model battery.

[P-16] Improvement of Image Processing Failure due to Non-Reception of GK-2A AMI Ancillary Data

Eun-Bin Park[1†], Sae-Han Song[1], Sang-Cherl Lee[1], Un-seob Lee[2], Sung-do Park[2]

[1]*Korea Aerospace Research Institute, KARI*
[2]*Setrec Initiative, SI*

Geostationary satellites are affected by the Sun eclipse period every spring and autumn when the Sun-Earth-satellite is located in a straight line. Since some telemetry were not received from the GeoKompsat-2A (GK-2A) Advanced Meteorological Imager (AMI) during this period, it was not possible to process the GK-2A Earth observation images in ground station. Therefore we planed to perform image processing without using corresponding the telemetry, and test operation was performed by applying it to the real-time image processing system. The test operation was conducted as the target period for the 2021 autumn Sun eclipse, and was monitored by applying it to an image processing system in Korea Aerospace Research Institute (KARI). As a result of the test operation, image processing was successfully performed in the image processing system implementing the corresponding function.

[P-17] Compact Advanced Satellited 500-2 (CAS500-2) Direct Ingestion Subsystem Loopback Test Verification

Jong-Bum Park

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

Korea Aerospace Research Institute (KARI) is developing a ground system for Compact Advanced Satellited 500-2 (CAS 500-2), which is scheduled for launch in 2022.
The ground system consists of three elements Mission Control and Image Reception (MCIRE), Image Processing Element (IPE) and Calibration/Validation Element (CVE), as is CAS 500-1. This paper describes the direct ingestion subsystem (DIS) loopback test verification, which is a subsystem of MCIRE.

[P-18] Derivation of the Power System Design Requirements on a Telecommunication Satellite

Jong Seok Park, Keun Joo Park, Hyoung Yoll Jun

Geostationary Satellite Program Office, KARI

A geostationary satellite has been proposed based on the inherited platform from GEO-KOMPSAT-2 to carry out multiple public communication missions through the FBCS, SBAS and DCS payload. Generally, communication payloads are equipped with higher power consumption transponders and more heaters installed due to the enlarged radiators for their high heat dissipating components.
In addition, an electrical propulsion system is introduced in this satellite for NSSK maneuver. These features need to be reflected in the platform design so that it would accommodate higher power capacity in the power system.
This paper presents the power budget analysis to perform an initial design of its power system, and shows the result derived from the trade-off study on the solar array and battery sizing considering the satellite operation during the eclipse as well as the NSSK maneuver.

[P-19] Operation Progress of CAS500-1

Jong-Oh Park

Korea Aerospace Research Institute

The CAS500-1 is a 500 kg-class satellite for national territory management, agriculture and forestry management, disaster monitoring & control, Korean peninsula observation etc. The CAS500-1 satellite was launched by Soyuz launcher on March 22, 2021, at the Baiconur launch site in Kazakhstan.
After launch CAS500-1 Satellite, the function and the performance were checked almost 3 months and the calibration of image data was performed almost 3 months successfully. In this paper, I will introduce the operation progress of CAS500-1 Satellite for one year after launch.

[P-20] Study of MOI-Based Thruster Cant-Angle Optimization for Spacecraft Attitude Control

Jooho Park

Korea Aerospace Research Institute

Thruster is one of actuators for spacecraft attitude control. Unlike other actuator such as reaction wheels (RW), Control Moment Gyro (CMG) and magnetic actuator, it totally depends on fuel of spacecraft. In other words, the number of thruster firing is limited. The reason why we have still adopted this kind of actuator is that there are several advantages which others do not have. For example, the propellent-based actuators can change spacecraft velocity and unload spacecraft angular momentum.

This propellent-based thrusters are generally installed on each axis as a pair. For instance, two opposite direction thrusters can be equipped and used for two-way rotation. As a result, 6 thrusters are generally required for 3-axis attitude control. However, fewer thrusters with adequate cant angle can carry out 3-axis attitude control in the same manner. Based on this optimal configuration, weight saving and more fuel can be applied to spacecraft design. Now, the problem is changed from 'how many thrusters' to 'how much cant angle' for spacecraft. This paper will present cant angle optimization at perspective of performance for attitude control.

[P-21] Development of Satellite Packet Data Receiving Test System for GEO-KOMPSAT-3

Jinhyung Park, Junyeong Bok, Jongbum Park

Korea Aerospace Research Institute

The Korea Aerospace Research Institute is developing GEO-KOMPSAT-3 (GK3). The GK3 satellite is a communication satellite that is the successor to the Chollian satellite (COMS) and it is scheduled to be launched in 2027. This paper introduces the Satellite Packet Data Receiving Test System for GK3 ground segment. For satellite ground stations, it is necessary to test the connection between the antenna subsystem and other ground subsystems. Cortex CRT/HDR is used for antenna system in ground segment. This system consists of a CRT/HDR simulation program and a CRT/HDR receiving program. CRT/HDR simulation program imitates Cortex CRT/HDR to receives connection and request message and sends data. The CRT/HDR receiving program connects to the CRT/HDR (or CRT/HDR simluation program), sends a request message, and receives and stores data. This system will be used to connection test before launch and LEOP/IOT after launch to receives data and verification.

[P-22] Introduction of EGSE Design according to Increase in Satellite Power Supply Requirements

SuWan Bang[1], Hyoungho Ko[2]

[1]*Korea Aerospace Research Institute*

[2]*Professor, Department of Electronics Engineering, Chungnam National University*

The most important thing in manufacturing satellites such as low orbit satellites and geostationary orbit satellites is the verification process during production.

During the satellite manufacturing process, the electric signal and power supply of the satellite is made through EGSE (Electronic Ground Support Equipment). And the satellite development and verification is carried out using EGSE. As the demand for high-accuracy optical payload performance increases through satellites, and additional sensors and communication towers increase, the power consumption of satellites increases. As the power required to supply satellites increases, high power that is difficult to implement with the existing EGSE design is required, and high power supply accuracy and response speed are required even in the actual initial power supply operation procedure.

Therefore, in this paper, we discuss changes in satellite EGSE configuration and methods for initial power supply due to the increase in power consumption.

[P-23] Receiver Signal Analysis for Low Earth Orbit Satellite

Jun-Yeong Bok, Dong-Oh Kim

Korea Aerospace Research Institute

In this paper, we analyze the received signal in X-band of low orbit satellite according to change of elevation angle between satellite and ground station. Satellite sometime use directional X-band antenna for high capacity transmission. Satellite operator has to control a satellite attitude for earth observation and create a tracking profile in order that X-band antenna is directed toward ground station. This paper shows the signal to noise ratio of the ground receiver according to satellite altitude and the dictation of antenna.

[P-24] An Analysis of the Result for Recent BDS Map Updates for GK2A AMI

Sae-Han Song, Eunbin Park, Okchul Jung

Korea Aerospace Research Institute

Geostationary Korea Multi-Purpose Satellite 2A (GK-2A) is launched in 2018 and performs meteorological mission with Advanced Meteorological Imager (AMI) successfully. AMI can support 16 channels including 3 visible channels and consists of about 70,000 detectors.

Among 70,000 detectors, developers determined the Best Detector Select (BDS) map through the test results before launch and from IOT period. However, the detector characteristics can change due to complex causes such as space environment and radiation during the normal operation period. As a result, the product of AMI can be degraded, then the BDS map update should be carried out to remove stripes of AMI product.

In this paper, we briefly introduce the AMI and detectors, analyze the quality of the AMI product and results of BDS map update.

[P-25] Overview of National R&D Performance Evaluating System Regarding CAS500 Program

Keun-Woong Shin, Ji-Mo Yang, Dong-In Han, Eung-Sik Park

Korea Aerospace Research Institute

Evaluation related to national R&D programs takes various forms. Generally, evaluation can be divides “Program evaluation” for “national R&D programs” promoted and implemented by government ministries and “Progect evaluation” for “national R&D projects” performed by R&D entities such as companies, universities, and research institutes. In addition, “institution evaluation” is conducted on R&D program (or project) and institutional operations conducted by government-funded research institutes.

This study targets the “Program evaluation system” applied to the “CAS (Compact Advanced Satellites)-500 development program”. The “CAS-500 development program” promoted as a national R&D program, received “the first interim-evaluation” in 2018 after the program started in 2015, and “the second interim-evaluation” in progress in 2022. In this study, overview of the national R&D program evaluation system (incl. the laws related to the evaluation for national R&D program) will be briefly examined. Then we will compare the evaluation system in 2018, which was conducted for the “CAS-500 program”, with the evaluation system in 2022, which is currently being implemented.

[P-26] Flight Software Architecture for Improving Satellite Mission Availability

Hyun-Kyu Shin

Korea Aerospace Research Institute

On-board flight software (FSW) manages the satellite’s overall behavior including FDIR (Fault Detection, Isolation and Recovery). In general, satellite on-board equipment has redundancy to handle failures. Redundancy can be implemented in several ways such as cold, warm and hot by its requirements and design. FSW operates on the on-board computer (OBC). As a necessity, OBC’s redundancy design affects the architecture and design of FSW. Also, this design is closely related to the satellite mission availability. Availability depends on how to treat the fault and failure. This paper introduces the flight software architecture and FDIR design for improving satellite mission availability with enhanced OBC design.

[P-27] The Feasibility Study of Doppler Value and Its Time-Tagging Accuracy in K13 TTC Log

Sangil Ahn

Korea Aerospace Research Institute

During TTC supports with K13 antenna system, all ground system status are recorded with time information for further analysis and anomaly investigation in CAMNT log. The one-way doppler value of S-Band downlink signal are also included with time information.

The time-tagging accuracy can be critical when this is planned to be used for time-critical application.

If both doppler accuracy and time-tagging accuracy are guaranteed, on-board clock stability can be calculated. Key issue is if we can identify the two uncertainty in time-tagging and doppler measurement. This paper shows the key feasibility study and its initial results.

[P-28] An Introduction of a Satellite Command Protocol and Processing Method

Seung-Eun Yang

Korea Aerospace Research Institute

A tele-command is applied as ground to satellite interface to control the OBC (On-Board Computer) and multiple subsystems in the satellite. Normally, a command consists of a sync-mark, address data, command message data, and error check data. The command window is limited for the LEO (Low Earth Orbit) satellite because of the speed difference between earth rotation and satellite revolution. Therefore, multiple ground stations are required to achieve the up-to-date information from the satellite and transmit appropriate tele-command. To accommodate the requirement, a standard command protocol is defined by CCSDS (Consultative Committee of Space Data System). In this paper, the standard command protocol is introduced. Also, two different command processing methods (central processing and serviced oriented) are described.

[P-29] Fault Management of Electrical System for Low Earth Orbit Satellite

Jeong-Hwan Yang

Korea Aerospace Research Institute

A Low Earth Orbit (LEO) satellite is a satellite orbiting the Earth at an altitude of about 500 km to 1,500 km in space. The LEO satellite is constantly exposed to cosmic radiation in space, and the cosmic radiation can cause malfunction in electronics components of the electrical system of LEO satellite. High energy particles cause permanent damage to electronic components, and low energy particles change temporary

information on electronic components or cause noise in signal lines. In addition to cosmic radiation, electronic components may malfunction due to unexpected fault such as aging of electronic components. These malfunction of electronic components can propagate throughout the electrical system and affect satellite operation. Since satellite cannot be maintained externally while it is in operation after launch, it must be designed in consideration of countermeasures against fault. This paper describes a fault management design that prevents malfunction of electronic components from propagating throughout the electrical system.

[P-30] Summary of R&D Expenditure Usage Standard of the National R&D Innovation Act

Ji-Mo Yang, Keun-Woong Shin, Jong-Hwi Choi, Eung-Sik Park

Korea Aerospace Research Institute

In '21, the 'National R&D Innovation Act' was enforced. The 'Innovation Act' is a law to integrate and systemize national R&D-related regulations that are operated differently by department and to create an autonomous and responsible R&D environment. Although regulations have been operated by each department to promote national R&D projects, opinions have been continuously raised that the administrative burden on the research site is increasing due to complex regulations. By comparing the existing 'Regulations on the Management of National R&D Projects, etc.' and the 'Innovation Act', the terminology and usage standards for the payment and management of R&D expenses that have changed are to be organized to induce the use of research funds that fit the budget.

[P-31] Studies about Shock Response Spectrum of Shock Generating Unit at Its Interface

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

Korea Aerospace Research Institute

Spacecrafts and satellites have many shock generating units of releasing and deploying functions. The assessment of the shock magnitude and its impacts on the other unit is important for the verification of the structural endurance of the whole system. In general, Shock Response Spectrum (SRS) is used for the assessment of the shock magnitude. SRS is defined as the maximum response of a single degree of freedom system to that shock input with respect to the natural frequencies of the SDOF. SRS assumes no mass loading effect on the base input. The unit level shock measurement is usually done on the rigid interface and accelerometers are positioned on the interface. However, in the spacecraft level test, the unit is installed on the panel which is somewhat flexible than rigid. The differences of the boundary flexibilities can lead to the differences of the measured SRS values even for the same shock energy generated. These studies will help for the interpretation of the system level shock test results.

[P-32] Temperature Estimation Method for Low Earth Orbit Satellite System Using Data-Based Learning

SeokTeak Yun, Day-Young Kim, Sang-Kon Lee

Korea Aerospace Research Institute

For system design of low Earth orbit (LEO) satellites, prediction of the operation of satellites in orbit is required. However, it is difficult to accurately predict the operation of a satellite because it fluctuates according to orbit, attitude, mission, operation period, etc., and there are many uncertain factors. Among them, the temperature of the main system of the satellite is predicted at the design stage by inputting orbit and attitude. Such predictions are generally used in the design stage and have a large margin of error. Therefore, in this paper, a method for more accurate temperature prediction through a data learning-based prediction model was studied. By applying the analysis result of this paper is to several satellites, it is expected that it will be helpful in predicting the temperature of various satellites.

[P-33] Practice for Unused Pins of Electrical Units in the Space Environment

Young-Su Youn[1], Jae-Nam Yu[2]

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

Mostly driver outputs or inputs for active parts of electrical units could be left floating because they have precautions to prevent charging in the space environment. There is an internal resistor clamping to output to ground if not used. This is done to prevent electrostatic discharge damage and therefore the pins can be left open. The thermistor return signals should connect to ground for safefy reasons if they are not used. The thermistors are isolated from the rest of the electrical units so it is up to the system how it is grounded. Typically, if the thermistor is used, the return is grounded on system level. If the thermistor is not used, it should be grounded with a resistance 0 to 1 MOhm.

[P-34] Analysis of the Magnetic Moment of Satellite

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

Korea Aerospace Research Institute

The satellite uses a magnetic field sensor (TAM) to acquire information about the Earth's magnetic field. The obtained information is used for attitude control. For the proper operation of the TAM, it is necessary to keep the strength of the magnetic field generated by the electronic components of the satellite below an appropriate level. Magnetic field measurement by the electronic components has difficulties in facility construction and measurement. Instead, it can be replaced by an analytic method. For analysis, it is necessary to consider the distance between electronic components, current consumption, and size. Efficient analysis is possible when considering the ratio of factors contributing to the formula for calculating magnetic moment together with the above factors. This paper deals with the efficient magnetic moment analysis of satellite.

[P-35] Acquiring Frequency Resources for Earth Stations in a Geostationary Satellite Program

Seorim Lee

Korea Aerospace Research Institute

A satellite network consists of a space station ('satellite') and a corresponding Earth station(s). As such when acquiring frequency resources for geostationary satellite programs, frequency resources for both the space station and the Earth station(s) must be acquired. The process of acquiring frequency resources for Earth stations is similar to the process for space stations consisting of the coordination process, the notification process, and the bringing into use process. This paper provides an overview of the status and process for acquiring frequency resources for Earth stations in a geostationary satellite program.

[P-36] Installed Performance Analysis of S-Band TC&R Antenna on a GEO Satellite Platform

Sun-Ik Lee, Joong-Pyo Kim, Won-Gyu Lim

Korea Aerospace Research Institute

We will introduce one of the next geostationary satellites of COMS-1/2 at the initial developing phase. The satellite is planned to provide the communication services such as satellite based augmentation service, data collection service, fixed communication service, respectively in L, C and Ka-bands, at the end of 2027. The Telemetry, Command and Ranging (TC&R) communication service of the satellite will be implemented in the S-band frequency. At the design phase, it is necessary and important to evaluate S-band antenna radiation performance in a given antenna position or some candidate positions. In this perspective, we analyzed the impact of satellite structure and adjacent payloads on the S-band antenna radiation performance, and presented results.

[P-37] RF Front-End Structure in the Satellite

Won-Gyu Lim, Ki-Ho Kwon, Joong-Pyo Kim, Sun-Ik Lee

Korea Aerospace Research Institute

In this paper, we investigate and analyze the RF front-end structure in the Satellite. RF front-end means antenna, transponder and RF passive path to connect them. This paper mainly focused the RF passive path rather than antenna or transponder. According to the investigation and analysis about the structure, the LEO and GEO mission use the hybrid coupler type in the front-end in which mission have enough communication link margin and so the mission select to receive/transmit via all antenna. Compare to them, the deep space mission prefer to select the communication path, especially for transmit the signal. The reason to use the switch is that the communication link margin is not enough. In this paper, we present the rational to select the structure according to the mission.

[P-38] Automated Planning Method of Imaging and Downlink for KOMPSAT

Eunsook Lim[1], Euna Cho[2], JungNam Jun[1], MyeongShin Lee[1]

[1]*Korea Aerospace Research institute*
[2]*SI-Imaging Service, SIIS*

In the image Collection Planning Subsystem, the operator checks and plan the satellite's maneuvering posture and section where downlink is possible. If an error occurs during the imaging and downlink planning, the operator adjusts imaging and downlink planning by repeating the same process such as adjusting the tilt angle of imaging until the error is resolved. This paper describes how to efficiently automated planning of imaging and downlink for acquiring images. First, areas of interest included in the possible imaging area are selected. Then, the imaging plans are established in the order of AOIs from the lowest latitude to the highest latitude among the AOIs. In this case, the maneuvering time according to the maneuvering angle of the satellite is considered. To automatically establish downlink plan, downlink plan is established in the order of imaging end time to satisfy the minimum interval between imaging and first downlink mission.

[P-39] A Study on the Error Impact on Geolocation Accuracy of KPLO LUTI Images

Jo Ryeong Yim

Korea Aerospace Research Institute

The optical payload LUTI is one of the main payloads of the

lunar probe KPLO, which is scheduled to be launched in August 2022. When the KPLO is launched and enters the mission orbit after a long journey to the moon, a commissioning phase is assigned for about a month before performing the normal mission. During this period, geometrical calibration is performed on the orbit. Geometric calibration results performed on the ground are already implemented when developing LUTI's image processing system (ICAS: Image Calibration and Analysis Subsystem). Nevertheless, unlike the ground verification results, unexpected errors are encountered in the geometric calibration process due to the influence of the launch environment and on-orbit environment, and the various errors are expected to deteriorate geolocation accuracy. The main causes of geolocation errors in images are time errors, orbital prediction and determination errors, attitude control and determination errors, and sensor alignment errors and so on. Geometric calibration of the LUTI sensor should be performed for an relatively short period of time compared to the calibration period for low earth orbit satellites. This study is to perform preliminary study to gain insight into the expected causes and effects of the errors in advance to expedite post-launch geometrical calibration conducted for a short limited time. The results from this study will be applied to error-solving of actual on-orbit geometric calibration.

[P-40] Applying AI to Satellite Ground System Operations

Hyun-Su Lim

Korea Aerospace and Research Institute

The satellite ground station consists of a lot of equipment and software to continuously monitor the operational status of satellites and ground system operators are needed to control and monitor them as well. As the number of operating satellites increases, various automation techniques are being applied to ground systems to ease routine burdens of operators, but simple automation has been prone to be fragile when any failures occur. In the real world, it's difficult for the operators to always keep their eyes on all generated information, and not easy to find the root cause quickly even if with the alerting sounds, error logs that occur simultaneously in several systems. Applying AI (Artificial Intelligence) to satellite ground system operations can help support system operations easier and more stable like a experienced senior operator. AI can perform monitoring and detect failure occurrence in real-time. Based on the sequences of data files, systems, error logs, AI-based monitoring system can infer the root cause and provide information on the action to be taken by the operator.

[P-41] Comparative Analysis of EMC Verification Requirement for Satellite System Level of KARI and ESA Standard

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

Korea Aerospace Research Institute

EMC requirements for satellites are generally classified into design requirements and verification requirements. The design requirements provide guidance to minimize EMC problems in advance at design and manufacture phase of satellite, and verification requirements provide methods and requirements for verifying electromagnetic compatibility of satellite through testing or analysis.

Verification is usually performed by analysis or test, and is carried out step by step in the order of parts, assemblies, units, subsystems, and systems. The electromagnetic compatibility of satellites is verified with various items, and the items are similar according to EMC standards but slightly different. In this paper, the verification requirement of KARI and ESA [1] standard for satellite system level studied. Requirements and test methods were compared and analyzed in representative test items for satellite system such as EMC, LVC, RFC, etc.

[1] ECSS-E-ST-20-07C, Space engineering - Electromagnetic compatibility, ESA-ESTEC, 2012

[P-42] A Study on the Conceptual Design of the KPS Platform with Full Electric Propulsion System

Sung-Soo Jang

Korea Aerospace Research Institute

The recent development trend of the global geostationary satellites is gradually considering spacecraft platform with electric propulsion systems. Geostationary satellites with a fully electric propulsion system can significantly reduce the amount of propellant fuel compared to general chemical propulsion system, so the mass of the satellite can be significantly reduced. Therefore the launch cost of the satellite can be greatly reduced or more payloads can be mounted to the satellite. In this paper, the concept design of a spacecraft platform with a fully electric propulsion system is being studied for the development of Korean Navigation Programs (KPS). Based on the bus platform of Geo-KOMPSAT-2 (GK2), a fully electric propulsion system will be reviewed by replacing the chemical propulsion system. The electric thruster has a maximum output of 300 mN, and two or more thrusters will be mounted on the satellite to have an output of up to 600 mN during transfer orbit. And in order to operate electric thruster, maximum 5 kW will be required. Therefore it is expected that at least 10 kW of power system shall be designed to operate two or more electric thrusters at the same time.

[P-43] Analysis for Pyro-Shock Test System in KARI

Jong-Hyub Jun, Sung-Hyun Woo

Korea Aerospace Research Institute

The purpose of shock test is to verify the shock environment as satellite separation from launch vehicle, solar array deployment, and activation of payload mechnism in satellite. KARI space test division operates the self-designed test system. The system produces the characteristic frequency (1,000 Hz or 1,500 Hz) using specific part named resonator. The frequency is only for satellite parts. The resonator is assembled with plate in which test fixture is installed and impact energy is transferred.
Analysis of the test system is performed through FEM simulation to understand the test system deeply and to improve the test skill. And the idea for upgrade of the test system can be obtained in the process. This study is just for 1,000 Hz resonator system.

[P-44] A Study on Direction and Number of Low Gain Antennas (LGAs) for a Lunar Lander

Hyeon-Jin Jeon

Korea Aerospace Research Institute

Low gain antenna (LGA) direction for a lunar lander is very crucial because anytime communicablility between Earth and a lunar lander at any mission phases is essential for successful lunar lander operation. If anytime communicablility is not secured, efficient and effective lunar lander operation, immediate fault management, etc. might not be achieved.
For cases where fixed antenna configuration is adopted for light-weighting of lunar lander, increasing number of antennas can be required for continuous communication.
This paper discussed direction and number of LGAs for a lunar lander by considering every mission phases. This can be a good guideline for designing future lunar landers.

[P-45] Analysis on the Architecture of Space Traffic Management

Okchul Jung, Jaedong Seong, Youeyun Jung

Korea Aerospace Research Institute

As the number of active satellites and space debris in space keeps on increasing, physical congestion has become a growing concern with many space programs including New Space and mega constellations. Space situational awareness and space traffic management are getting more and more attention, in order to secure space assets. Space traffic management is essential to coordinate space operations including collision avoidance process by linking owners/operators of space assets during all phases (in orbit, at launch, and at post mission disposal, as well). In this paper, scope and technology with respect to the space traffic management are introduced and the architecture of it as a current and future service is also analyzed.

[P-46] Flight S/W Build and Loading Procedure

Dong-Seok Chae

Korea Aerospace Research Institute

After finishing unit test and integration test, the completed codes are integrated as a whole, and the entire integrated build binary file is generated through compiling, linking, and locating process. And there is a special data area that need to be merged into specific parts of the build binary file after building the flight software. The location and size of the area for the special data should be determined in advance. After combining the special data, the final completed flight software build is loaded onto the satellite onboard computer. The satellite onboard computer has two P/R processor boards, and each processor board has two NVMEMs (Non-Volatile Memories) on which flight software is loaded. There is a program for loading flight software in the PROM area of the onboard computer, and it is connected to a loading PC through the UART interface. The flight software is loaded into the NVMEMs through interaction with the program on the loading PC. This paper introduces the flight software build and loading procedure.

[P-47] Chemical and Hybrid Propulsion Systems

Cho Young Han

Satellite Research Directorate, Korea Aerospace Research Institute

In terms of satellite propulsion systems the chemical propulsion is by far popular from small to very large satellites. When large forces are required for periods of several minutes to accomplish a specific mission, the chemical propulsion do well and relatively cheaply. By the way more half of the launch weight is determined by the on-board propellant for all-chemical propulsion system, Especially for geostationary application it is very import to reduce the on-board propellant mass as much as possible, in order to increase the portion of other useful payloads. It could be realised by incorporating an electrical propulsion partly, that is the hybrid propulsion system.

[P-48] A Study on the Implementation of Ground Test Support Equipment for Thermal Design and Verification of Electro-Optic System

Jong-Euk Park, Eung Shik Lee, Haeng-Pal Heo

Korea Aerospace Research Institute

The satellite payload electro-optic camera system goes through various development stages, and final design and verification are performed.
Thermal design for camera system protection in the space environment is in progress, and the design is verified through various ground environment tests.
Electro-optic system that have completed development, alignment, assembly, performance, and environmental tests of large-diameter mirrors, telescope structures, and camera electronics are thermally designed so that they can be used in space environments, and final verification tests are performed.
In the development process, it is required to implement ground test support equipment that supports thermal design ground verification.
According to the operating state of the electro-optic system, a function to support various operating modes should be implemented, and for that operation, information from various sensors mounted on the payload is obtained with high reliability. It supplies power to various installed heaters according to the defined operating mode, and performs the function of supporting the optimal maintenance of the mounted camera.
In this paper, apart from checking the general function of the electro-optic system, we proposed the implementation method and operation method for the ground test support equipment implemented for thermal design verification and testing.

[P-49] Development of the Reduced Model for the Super Large Aperture Camera

Won-Beom Lee, Jeoung-Heum Yeon, Haeng Pal Heo
Korea Aerospace Research Institute

Electro-optical camera that performs high-resolution observation in low orbit is rapidly developing, and in recent years, there is high interest in high-resolution electro-optical camera that utilize the advantages of geostationary orbit. Lightweight thin film optical systems and foldable structure technologies have been developed to implement high-resolution super large aperture camera. The purpose is to develop a geostationary orbit electro-optical camera with a resolution of tens of meters, which is the goal of designing a foldable structure for future electro-optical camera.
This paper describes the development and deployment test of reduced model based on the conceptual configuration designed to secure foldable structure technology, one of the key areas necessary for the development of electro-optical camera on the geostationary orbit.

[P-50] Validation of Thermal Analysis Results through Measurement in the Electrical Qualification Model of Space-Born Electronic Equipment

Jong-Tae Lee, Eung Shik Lee, Haeng-Pal Heo
Korea Aerospace Research Institute

Before manufacturing space-born electronic Equipment, thermal analysis is conducted to determine whether the equipment will operate properly in the given space environment. Through this analysis, it is possible to check the equipment operational availability by calculating the stress that each element constituting the equipment will receive during its mission life. In the thermal analysis method, the analysis result may vary depending on various variables such as the boundary condition setting used, and it is necessary to check whether the analysis result matches the behavior of the real model. This becomes more necessary when developing completely new equipment without heritage. This paper shows an example of verifying the validity of the thermal analysis through measurement during the thermal cycle test of electrical qualification model prior to the manufacturing the flight model.

[P-51] 3D Printing Method for Mirror Manufacturing

Young-Soo Kim, Yunjong Kim, Jihun Kim, Seonghwan Choi, Jeong-Yeol Han
Korea Astronomy and Space Science Institute

3D printing method has been applied in many manufacturing areas, Metal 3D printing method has been developed to fortify the hardness of the products. Furthermore, ceramic 3D printing method is being developed to utilize the merits of ceramics, such as high temperature endurance or low thermal expansion. Production of mirrors by using ceramic 3D printing is being developed. Alumina was first used as a sample mirror basis. In this paper, the process and status of the development is presented.

[P-52] Properties of the Stone Angbu-Ilgu Made in the Late Joseon Dynasty

Byeong-Hee Mihn[1,2], Sang Hyuk Kim[1], Jae-Young Kim[3]
[1]*Korea Astronomy and Space Science Institute*
[2]*Korea University of Science and Technology,*
[3]*National Meteorological Museum of Korea*

We explored the stone Angbu-ilgu (scaphe sundial) of the Korea Meteorological Administration (KAM) and the Seoul Museum of History (SMH). In the era of the reign of King Sejong, an Angbu-ilgu was first created in 1434. Angbu-ilgu has been reproduced with various materials in the late Joseon. The upper surface of these two stone Angbu-ilgus symbolizes

the horizon like the horizontal ring of the metal Angbu-ilgu. On the hemisphere concave at the center of the horizon are engraved the South Pole, the time line, and the season line (or season line). On the horizon of both the KAM and SMH Angbu-ilgus, the schematic, typeface, and composition of the inscription completely coincide with each other. In this study, the KAM Angbu-ilgu, which was damaged as the present appearance, was the similar cube of the SMH Angbu-ilgu, and this means that it is superficially identical with Treasure No 840, the horizontal stone sundial. In the concave hemisphere of both the stone Angbu-ilgus of the KMA and SMH, there are hour lines and 24 solar-term lines, and there is an intersection point where these lines meet the horizon, respectively. We find out that the hour-line and solar-term-line of these two Angbu-ilgus is engraved by calculation with a latitude of +37° 39' 15".

[P-53] Characteristics of Ground-Based Observation Sensors for Space Object Detecting and Tracking

Youeyun Jung, Saehan Song, Jaedong Seong, Okchul Jung

Korea Aerospace Research Institute

The issue that the rapidly increasing number of space objects threatens the space environment around the Earth has been continuously raised. Therefore, systems for detecting these space objects and identifying their orbits have been continuously studied and developed to ensure safe, stable and sustainable space activities.

Ground-based observation sensors used in the space object detecting and tracking system are typically classified into radar, passive optics, and laser. In this paper, characteristics of the system depending on the principle of each sensor and examples for currently operating system are described.

[P-54] Alignment of Aspheric Mirror and Lens in 1U Size Cassegrain Telescope Using MTF Measurement for Minimizing Tilt and Decenter

Hanik Kim, Hyochoong Bang

Aerospace Engineering Department, Korea Advanced Institute of Science and Technology

One-unit sized Cassegrain telescope has been developed for space application. The optical design of the payload was assessed using Modulation Transfer Function (MTF) variation to optimize the performance and tolerance of possible drawings in constraints. The optical components were fabricated and the alignment of aspheric mirrors and lens was conducted with controlling tilt and decenter of the components. The distance error range between the optical components is set to ± 10 micrometer and realized with high precision fabrication for its structures and optical components. The MTF experiments are conducted by changing the tilt angle of 2nd mirror structure and decenter control of the optical components. The experiment results show MTF enhancement after change the 2nd mirror tilt angle and the center positions of the optical components, and the MTF graphs and charts of the experiments are compared with the theoretical analysis by CODE-V software.

[P-55] The Ray-Tracing Simulation of Light Field Camera Systems for CLPS/GrainCams

Minbae Kim[1], Minsup Jeong[1], Young-Jun Choi[1], Sungsoo S. Kim[2]

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

In general, Light Field Camera (LFC) can be designed by adding the microlens array (MLA) to typical camera system, the main lenses and sensor. It can obtain directional and spatial light information as well as light intensity information. It needs to find appropriate trade-off calculations between spatial and directional resolutions through image test with various diameter sizes of microlens, in order to design a custom light field camera for scientific purpose. Custom MLAs can be rather expensive, thus an accurate light field camera simulation could allow to reduce production costs. From this study, we will introduce our ray-tracing simulation for CLPS/GrainCams composed of two light field cameras, SurfCam and LevCam. It will help to obtain predicted images through MLAs of various specifications.

[P-56] Study on Baseline Design and Mission Analysis of Lunar ISRU Rover

Younkyu Kim, Jongwon Lee, Dong Young Rew

Korea Aerospace Research Institute

A software development for baseline design and mission analysis of rover for lunar surface exploration and ISRU (*In-Situ* Resource Utilization) is conducted in this study. Several researches for ISRU on the moon are being actively conducted for the purpose of the Artemis program in several countries and lunar lander mission is also planned for lunar surface activities in the 2030s in Korea. In realizing these missions, it is essential to develop a rover system capable of active activities on the lunar surface. In this study, the software is developed, which enables the baseline design of the lunar rover by system designers, the rover's path planning, and the rover's preliminary operation plan according to the lunar surface environment and system performance by baseline design in the top-level mission determined by mission designer. This also provides an environment that simulates the activities of the rover in a virtual lunar surface environment according to the rover's automatic

operation plan and user's manual operation. This system can be utilized for the base line design and mission verification of the rover in developing lunar exploration rover, as well as for developing the base system for actual rover operation on ground station in the future.

[P-57] Acceptance Tests of KPLO Science Data Management Subsystem

Joo Hyeon Kim

Korea Aerospace Research Institute

KPLO will carry out four major scientific missions with the Korean domestic science instruments. The scientific missions are the gamma ray spectroscopic observations on the lunar surface, the measurement of magnetic fields of the Moon, the polarimetric observation on the lunar surface and the high resolution imaging of the Moon.
The data acquired by the scientific missions will be archived, released, and managed by Science Data Management Subsystem which is one of subsystems of KPLO Deep-space Ground System.
Science Data Management Subsystem consists of two modules which are Science Data Management Module and KARI Planetary Data System.
We implemented a Factory Acceptance Test and a Site Acceptance Test of each module of the SDMS software in order to install the SDMS software on servers and client computers at the KPLO Mission Operation Center.
In this paper, we present the physical and logical environments test procedures and test items for the Acceptance Tests of the SDMS software. We also present the results of the Acceptance Tests.

[P-58] X-Band Downlink Test Signal Safety Margin Analysis for Radiation Wireless Test

Sangman Moon, Changkyoon Kim, Hyun-Chul Lee

Korea Aerospace Research Institute

Korea Pathfinder Lunar Orbiter (KPLO) X-band communication system is verified with X-band Test DownLink Test Set (X-DLTS). This equivalent ground support equipment (EGSE) uses when the non-radiated RF loop test and radiated wireless test. The RF wireless test use the standard test antenna and KPLO owned high gain antenna. And the distance between two antennas is far field condition. This paper is shown the test configuration set for test equipment safety as RF signal.

[P-59] Global MHD Simulation of Planetary Magnetosphere: Uranus and Neptune

Kyung Sun Park

Department of Astronomy and Space Science, Chungbuk National University

Global magnetohydrodynamic (MHD) has been quite successful in reproducing overall magnetospheric dynamics and ionospheric phenomena for the Earth. However, understanding how the energy and momentum transfer from the Sun to the Uranus and Neptune are a complex problem with many different aspects. The surface magnetic field at dipole equator of Uranus and Neptune have smaller than Earth. Also, one of the significant characteristics of Uranus and Neptune are that the rotation axis and the magnetic dipole axis are separated by a large angle. The simulation results show the large scale configuration and plasma flow in outer planetary magnetospheres during the solar wind conditions. The main differences between the two planetary configurations will be discussed in this study.

[P-60] Investigation of Demagnetized Lunar Caters

Hyeonhu Park[1], Ian Garrick-Bethell[2], Ho Jin[1], Kwan-Hyuk Kim[1], Jehyuck Shin[1], Yunho Jang[1], Woohyun Jo[1], Wooin Jo[1]

[1] *School of Space Reseach, Kyung Hee University*
[2] *University of California, Santa Cruz*

Demagnetized craters of magnetic anomalies in the Moon's crust are important in the study of lunar magnetism because they can constrain whether crustal rock was demagnetized by: i) shock waves peripheral to the crater, or ii) simply by the destruction of magnetized rock inside the crater. Demagnetized lunar craters have only been studied once before. Previous study, Lunar Prospector (LP) electron reflectometer data was used, but in this study, Kaguya Surface Vector Mapping (SVM) data is used. Also, we used high-resolution global topography data (LRO) to support SVM data. The highly variable magnetic field pattern across the Moon makes it difficult to distinguish if some local lows in the magnetic field were truly caused by a crater. Hence, we have developed a new statistical method to determine if a crater is associated with a low magnetic field by chance. we calculated the regional background ratio between fields exterior to a circular region of radius (R), and fields interior to this circular region. Also, we calculated this ratio for three different exterior distances: 1.4R, 2.0R, and 3.0R. Gauss, Fermi, Keeler, and Chaplygin craters show strong demagnetization states, with weak magnetic fields in the interior of the crater that are at least two standard deviations from the regional value. Gauss crater is located near the antipode of the Orientale basin, and Fermi, Keeler, and Chaplygin crater is close to the western edge of the South Pole-Aitken (SPA) basin. This suggests that these craters may have disrupted magnetized surface deposits from the Orientale and SPA impacts.

[P-61] Orbit Determination Performance Analysis according to the Ground Tracking Support Condition in Trans-Lunar Orbit for Korea Pathfinder Lunar Orbiter

Jonghee Bae, Young-Joo Song, Young-Rok Kim, SeungBum Hong, Jun Bang, Jae-ik Park

Korea Aerospace Research Institute

KPLO (Korea Pathfinder Lunar Orbiter) will be launched and fly to the Moon along the WSB/BLT (Weak Stability Boundary/ Ballistic Lunar Transfer) trajectory in the middle of 2022. During the trans-lunar cruise phase, the farthest distance from the ground station to KPLO is more than one million km. For the nominal operation, FDS (Flight Dynamics Subsystem) of KPLO estimates the trans-lunar trajectory using two DSN (deep space network) and KDSA (Korea Deep Space Antenna).
The ground tracking support has a significant impact on the navigation performance of spacecraft. Therefore, this study analyzes the orbit determination performance of KPLO considering the ground tracking support condition in the trans-lunar trajectory. For orbit determination of KPLO, a sequential estimation algorithm is used in KPLO FDS, and the position uncertainty is analyzed to evaluate the orbit determination performance. In this study, the tracking failure case is considered in the nominal operation. From this study, the orbit determination performance in a tracking failure situation can be investigated. Moreover, the strategy can be established to improve the orbit determination performance.

[P-62] Opposite Trends of Optical Maturity in Northern and Southern Hemispheres on the Lunar Surface

Kilho Baek[1], Sungsoo S. Kim[1], Chae Kyung Sim[2]

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

The wall-quadrants of lunar craters are good tools for analyzing the optical maturity (OMAT) difference caused by the flux of space weathering agents such as solar wind particles and micro-meteorites. They had been exposed on the surface for the same duration and the walls facing each other have different incident angles of the aging agents depending on the location. In this study, we use the equator-facing (EF) and pole-facing (PF) walls of 26,802 craters to show the relative influence of the flux difference in latitude. We find that the OMAT difference between the EF and PF walls has opposite trend in the northern and southern hemispheres at lower latitude. Below 25 degrees, the EF wall is more mature than the PF wall in the northern hemisphere, but it is the opposite in the southern hemisphere. Unlike previously known, the hemispheres seem not to be symmetrically affected along the ecliptic plane. Similar trends are confirmed with wall slope and rock abundance estimated using Lunar Orbiter Laser Altimeter and Diviner data of the Lunar Reconnaissance Orbiter, respectively.

[P-63] Historical Footprints of Schedule Management for the Korea Pathfinder Lunar Orbiter (KPLO) Program in 2021

Jae-Hoon Song

Korea Aerospace Research Institute

In 2021, successive development has been accomplished in the Korea Pathfinder Lunar Orbiter (KPLO) Program after change of execution organization since November 2019. In this article, historical footprints of schedule management for the KPLO Program in 2021 are presented especially for the critical path of the KPLO Integrated Master Schedule (IMS).

[P-64] A Method to Improve the Solar Panel Rotating Angle Calculation Accuracy for KPLO

Hanwoong Ahn

Korea Aerospace Research Institute

The Korea Pathfinder Lunar Orbiter (KPLO) has two solar panels on either side. The solar array can always be directed toward the sun through rotation of solar panels by solar array drive assembly. The rotation angle of the solar panel is measured through a potentiometer of the solar array drive assembly. The potentiometers consist of a primary potentiometer and a redundant potentiometer, and are phase shifted by 180 degrees to each other so that the dead zone positions of the two potentiometers are not identical. In order to calculate the rotation angle of the solar panel from the potentiometers, it is necessary to define the alignment angle of the potentiometers, the dead zone of the potentiometers, the rotation direction of the solar panel, and the null position of the solar panel. This paper deals with a method to improve the accuracy of calculating the solar panel rotation angle from a potentiometer.

[P-65] An Analysis of Shackleton Crater as a Future Lunar Landing Site

Joohee Lee, DongYoung Rew, JooHyeon Kim

Korea Aerospace Research Institute

Recently, Shackleton Crater, located in the south polar region of the Moon, has been widely mentioned as a candidate area for future lunar lander missions and a candidate area for manned exploration landing missions. After the unmanned and manned moon exploration led by the United States and the former Soviet Union from the 1960s to the early 1970s, unmanned lunar exploration missions resumed in the late 1990s,

and the lunar south polar region has also been continuously observed. The Moon has a rotation axial tilt of only 1.5°, so peaks at the South Pole can experience almost constant sunlight, and pit areas such as craters remain permanent shaded areas where sunlight does not shine. Water in the form of ice can also be found in permanent shaded areas. So, Shackleton Crater is an area with all these characteristics and is widely mentioned as a candidate area for manned exploration landing sites in the future. In this paper, the physical characteristics of the Shackleton Crater with various advantages and the characteristics as a candidate area for landing mission were investigated and analyzed.

[P-66] Data Archive of KMAG Scientific Instrument by PDS4 Standard Format

Wooin Jo[1], Ho Jin[1], Hyeonhu Park[1], Jehyuck Shin[1], Yun-Ho Jang[1], Woohyun Jo[1], Joohyeon Kim[2]

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

KPLO MAGnetometer (KMAG) is one of the scientific payloads of Korea Pathfinder Lunar Orbiter (KPLO). The scientific objectives are investigation of the lunar magnetic field and near moon space environment. KMAG has three tri-axial fluxgate magnetometer and the data is obtained by 10 Hz sampling rate. The science data acquired by KMAG will be released to the public users through KARI Planetary Data System (KPDS). And, KPDS is complied with PDS4 standards to be managed efficiently. KMAG Science Operation Center (SOC) reproduces Raw, Partially Processed (PP), and Calibrated (CAL) data sets from the raw Telemetry (TM) data received from the Korea Aerospace Research Institute (KARI). In addition, KMAG SOC generates the metadata which has the KMAG data information. It allows users to easily access each level of data products with the metadata. Therefore, KMAG SOC may provide two types of processed data sets: the magnetometer data and the related metadata finally. In this study, we introduce KMAG data archive pipeline to provide data sets to public users with PDS4 standard format.

[P-67] Study on Thermal Model Correlation Using Multi-Objective Optimization Algorithm for 6U Nanosatellite with Multiple Payloads

Ji-Seok Kim[1], Hae-Dong Kim[1,2]

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

With opening of the New Space era, the mission area of nanosatellite is expanding and diversifying beyond educational purposes. As the role of nanosatellite grows, the stability of nanosatellite thermal system is also becoming important to perform its missions successfully. For this reason, the accuracy and reliability of nanosatellite's thermal model can have a critical influence of mission. In order to increase the reliability of the thermal model, we should conduct thermal model correlation (TMC). However, the TMC is usually carried out manually, so it is a time-consuming process and requires a lot of trial and error. In addition, the conventional correlation usually proceeds according to the subjective criteria of the engineer, it is difficult to know whether each correlation result is an optimal value. The TMC for nanosatellite is more difficult, because of the characteristics of nanosatellite. And there is even rare to find a study about performing the TMC of nanosatellite for increasing thermal model reliability. In this presentation, we built a highly reliable thermal model by optimizing the TMC for 6U nanosatellite that have a scientific mission of observing the near-Earth space environment, called SNIPE (Small scale magNetospheric and Ionospheric Plasma Experiment). The TMC optimization, which was performed via the multi-objective optimization algorithm NSGA-II (Non-dominated Sorting Algorithm-II), has two objective functions that minimize temperature deviations and temperature differences based on the results of thermal balance test (TBT). MATLAB was used to interface optimization algorithm with SINDA, a commercial software that calculates heat transfer. For efficient optimization, we also conducted a simplification of the existing thermal model with more than 2,000 thermal nodes to less than 200 in terms of minimizing the impact on the TMC progress. And the validity of optimization was proven by applying the optimal values obtained through the simplified model to the existing model. The thermal model was correlated faster and more accurately than the conventional method. It could be advantageous in increasing the accuracy of the thermal model of nanosatellite platforms with similar structures and characteristics. Furthermore, this study is expected contribute to nanosatellite mass production for mega constellation and space exploration missions in the New Space era.

[P-68] Review on the Methodology of Lunar Gravity Simulation for System-Level Test of Lunar Lander

Choon-Woo Lee

Korea Aerospace Research Institute

For the system-level design verification of lunar lander, various methodology researches on how to simulate the lunar environmental conditions such as vacuum, lunar dust, lunar regolith, lunar low gravity, extreme high and low temperature has been done. From the initial design phase, lunar environmental effects on system design shall be intensively reviewed for the optimized design of lunar lander and then the system-level verification tests of lunar lander have been implemented as the

cost-effective solution, depending upon the lunar lander development strategy.
In particular, because the average gravitational acceleration on lunar surface is 1.62 m/s^2 equivalent to 1/6 of the earth gravitational acceleration, lunar gravity simulation device is absolutely required to perform the integrated system landing performance test of lunar lander on earth ground.
Generally, several methods of simulating the 1/6 g gravity environment on earth ground have been used for system-level landing performance test of lunar lander. Up to now, there are several methods such as using helicopter or ballon, aero-engine dedicated for earth gravity cancellation, gantry with servo actuator moving mechanism and etc.
In this paper, the characteristics of several methods for lunar gravity simulation on ground are reviewed. Finally design considerations and alternative method about how to perform system-level verification test of lunar lander as the cost-effective solution are presented.

[P-69] Performance Characteristics of a Navigation Camera for Autonomous Lunar Landings

Dawoon Jung

Korea Aerospace Research Institute

An autonomous robotic lander is being proposed for a future Korean lunar mission. To mitigate inertial sensor drift and increase navigation accuracy, an onboard visual navigation camera is being studied. This work investigates, on a conceptual level, the required performance characteristics of such a camera and high-level design tradeoffs required.

[P-70] Application of Image Translation Methods Base on Deep Learning to Denoising SDO/HMI Magnetograms

Eunsu Park[1,2], Yong-Jae Moon[1,2], Harim Lee[1]

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

In astronomy, long exposure observations are one of important ways to improve signal-to-noise ratios. In this study, we apply image translation methods based on deep learning to denoising solar magnetograms. For the input magnetogram, we use SDO/HMI line-of-sight magnetograms at the center of solar disk. For the target magnetogram, we make 21-frame-stacked magnetograms considering solar rotation at the same position. We train a model using 7004 pairs of the input and target magnetograms from 2013 January to 2013 October. Then we validate the model using 707 pairs on 2013 November and test the model using 736 pairs on 2013 December. Our results from this study are as follows. First, our model successfully denoise SDO/HMI magnetograms and the denoised magnetograms from our model are mostly consistent with the target magnetograms. Second, the average noise level of the denoised magnetograms is greatly reduced from 8.66 G to 3.21 G, and it is consistent with that of the target magnetograms, 3.21 G. Third, the average pixel-to-pixel correlation coefficient value increases from 0.88 (input) to 0.94 (denoised), which means that the denoised magnetograms are more consistent with the target ones than the input ones. Our results can be applied to many scientific fields in which the integration of many frames (or long exposure observations) are used to improve the signal-to-noise ratio.

[P-71] Statistical Analysis of Artifact Occurrence in Electron Density Data of the Swarm Satellite

Hosub Song[1,2], Jaeheung Park[1,3], Jaejin Lee[1],Yu Yi[2]

[1]*Space Science Division, Korea Astronomy and Space Science Institute*
[2]*Department of Astronomy, Space Science and Geology, ChungNam National University*
[3]*Department of Astronomy and Space Science, University of Science and Technology (UST)*

We research artifacts found in electron density data observed by the Swarm satellite with the Langmuir probe. These small peaks occur at the dayside dip equator, regardless of seasons, solar activity, and satellite movement directions. This phenomenon does not occur in TEC that do not use electrodes or satellites that are not in polar orbit. Specifically, this peak occurs when the ram direction of the swarm satellite is almost aligned with the Earth's magnetic field under sunlight. Therefore, we consider that the cause of this phenomenon is the effect of secondary electrons escaping from the electrode according to the photoelectric effect. Since the size of this artifact is only a few percent, there is no considerable impact to scientific research, but specific future research is needed to determine the cause to improve data quality and reliability.

[P-72] Revisit of Occurrence Climatology of F-Region Field-Aligned Irregularities in Middle Latitudes as Observed in South Korea

Tae-Yong Yang[1], Young-Sil Kwak[1,2], Jaewook Lee[1,2], Jeongheon Kim[1], Hosik Kam[1]

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

In 2015, we analyzed the field-aligned irregularities (FAIs) of the F-region ionosphere observed by the VHF ionospheric radar installed in Daejeon, South Korea, for 5 years from 2010 to 2014, and reported the seasonal and local time occurrence. The F-region FAIs phenomenon over the mid-latitude Korean

Peninsula could be classified into four types (Post-sunset, nighttime, pre-sunrise, and post-sunrise) according to their occurrence. Post-sunrise FAI occurred most frequently in equinoxes, and nighttime FAI occurred most in summer. 2010-14 was the period when solar activity increased in the 24th solar cycle, and it was confirmed that the FAI of the F-region increased as the solar flux increased. This is the opposite of the fact that MSTIDs, which are known as the most important source of mid-latitude F-region FAIs, occur when solar activity is weak. We would like to analyze and report the relationship between the F-region FAI occurrence trend and solar flux during one solar cycle by additionally analyzing the VHF ionospheric radar data from 2015 to 2021.

[P-73] Characteristics of Plasma Sheath of the Planar Type Langmuir Probe for Changes in Probe Potential

Changho Woo[1], Kwangsun Ryu[1], Junchan Lee[1], Seunguk Lee[1,2], Eunjin Jang[1], Jaemin Hwang[1]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

The Langmuir probe is one of the fundamental instrument for plasma measurement. Since the characteristics of a plasma are estimated through theoretical modelling, theoretical understanding of the Langmuir probe is directly related to measurement accuracy. In this study, the characteristics of plasma sheath for the probe voltage of the planar type Langmuir probe are analyzed using the plasma two fluid model. For example, the relationship between the probe potential and the plasma sheath thickness is derived analytically. In the case of a positive probe potential, the effect of the sheath expansion on the probe current is discussed. This study can be applicable on the improvement of the error due to the modelling of the Langmuir probe of IAMMAP (Ionosphere Anomaly Monitoring by Magnetometer And Plasma-probe), one of science payloads of the CAS500-3 (Compact Advanced Satellite 500-3).

[P-74] Forecast of Major Solar Flare Using Deep Reinforcement Learning

Kangwoo Yi[1], Yong-Jae Moon[1,2]

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

In this study, we have applied deep reinforcement learning to solar major flare forecast. For this, we use full-disk magnetograms at 00:00 UT from Solar and Heliospheric Observatory/Michelson Doppler Imager (1996 August–2010 December) and Solar Dynamics Observatory/Helioseismic and Magnetic Imager (2011 January–2019 December) and Geostationary Operational Environmental Satellite X-ray flare data. The solar cycle 23 and the solar cycle 24 data are used for training and test, respectively. Our deep learning flare forecast model based on the Convolutional Neural Network (CNN) predicts "Yes or No" of daily flare occurrence for M- and X-class. We adopt a deep Q-learning network (DQN), a method of deep reinforcement learning, for model training. We test the DQN model performance using various reward guidance and compare them with the other models based on different methods, in view of various skill scores such as true skill statics (TSS) and Appleman's skill score (ApSS). Our results show that the reinforcement learning could improve flare model performance under the guidance of proper rewards.

This research was supported by the Korea Astronomy and Space Science Institute under the R&D program (Project No. 2021-1-850-05) supervised by the Ministry of Science and ICT.

[P-75] Solar Abundance Fractionation in an Active Region Related to the Existence of the Alfvén Wave in the Chromosphere

Kyoung-Sun Lee, Jongchul Chae

Seoul National University

The elemental abundance in the solar corona is different from the photosphere. The fractionation between photospheric and coronal abundances is related to the "First Ionization Potential (FIP) effect." In the corona, the low FIP (FIP < 10 eV) elements are enhanced by factors of 3–4 relative to the photospheric abundances. In contrast, the high FIP elemental abundance ratio to photospheric is approximately equal. Still, it is not revealed how the solar abundance is fractionated. Recently, the most probable model is "Abundance fractionation by the Pondermotive force". The pondermotive force induced by the Alfvén wave preferentially affects the ionized elements (low FIP element), not the neutral in the chromospheric plasma, which is partially ionized. Then, the force drags up (or down) the low FIP elements depending on the Alfvén wave existence and their energy density in the chromosphere. For investigating the relations between the abundance fractionation and wave energy density in the chromosphere, we analyze the H alpha and Ca II data from GST/FISS for the Alfvén wave detection and Si X (low FIP element) and S X (high FIP element) spectra from Hinode/EIS for determining the relative abundance in an active region. We present the preliminary result of the detecting Alfvén waves in the chromosphere compared to the spatial distribution of the abundance fractionation.

[P-76] Initial Test of AIMAG (Adaptive Inphase MAGnetometer) Onboard CAS-500-3

Seunguk Lee[1,2], Kwangsun Ryu[1], Dooyoung Choi[2], Junchan Lee[1], Chang Ho Woo[1], Eunjin Jang[1],

Jaemin Hwang[1], Wonho Cha[1], Cheong Rim Choi[2], Dae-Young Lee[2]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

AIMAG (Adaptive Inphase MAGnetometer) is one of the IAMMAP packages onboard the CAS-500-3 (Compact Advanced Satellite 500-3) scheduled for launch in 2024. IAMMAP is a scientific package to investigate the correlation between EIA (Equatorial Ionization Anomaly) and EEJ (Equatorial Electrojet) in the ionosphere, and consists of AIMAG and AIPIM (Advanced Impedance Probe for Ionospheric Monitoring). AIMAG is a voltage output type ring core fluxgate. AIMAG's driving coil circuit employs a current pump method, and the adaptive in-phase circuit of the pick-up coil circuit actively adjusts the phase of the second harmonic signal that can be changed by temperature variation. By applying a feedback circuit, linearity and temperature dependence were improved. In this paper, we present the design functional test results and performance test results of AIMAG. It is designed with a noise level of <a few nT_s.

[P-77] A Study of Path Gain Measurement Method for Satellite Radiated Emission Test

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

Korea Aerospace Research Institute

Satellite Radiated Emission (RE) test consists of Receiver, Receiving Antenna, RF Cable, and Low Noise Amplifier (LNA). The generated path gain is calculated by measuring it in advance, and Receiver and Receiving Antenna update the calibration factor periodically. However, in the case of RF Cable and Low Noise Amplifier (LNA), the gain is measured before performing the test because the configuration changes according to the test.

This paper explains the measurement configuration and optimization settings of measuring equipment when using only Network Analyzer among the methods of measuring gain through tests. Network Analyzer can measure accurate values when equipment is calibrated well, but set values such as number of point and IF bandwidth are important, and recommended values are not determined according to the measurement frequency range, so an appropriate value must be found through several tests.

In this paper, the setting of Network Analyzer to measure the accurate path gain within the frequency range commonly used in satellite RE tests is discussed through the test.

[P-78] The Evolution of Long-Term Sunspots Using SDO/HMI and AI-Generated Magnetograms

Harim Lee[1], Hyun-Jin Jeong[2], Eunsu Park[1], Yong-Jae Moon[1,2]

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

Solar magnetic flux observations are generally only reliable while sunspots are within several days of the central meridian. For the first time, we have made an attempt to study the entire evolution of long-term sunspots from appearance to disappearance without a gap using Solar Dynamics Observatory (SDO) /Helioseismic and Magnetic Imager (HMI) and AI-generated farside magnetograms. The farside magnetograms are reconstructed from the Solar TErrestrial RElations Observatory (STEREO) / Extreme UltraViolet Imager (EUVI) 17.1, 19.5, 30.4 nm passband images by a deep learning model based on conditional Generative Adversarial Networks (cGAN). We monitor the evolution of total unsigned magnetic fluxes of the NOAA AR 11504 from 2012 June 8 to July 31. Our preliminary results show that the magnetic fluxes have two peaks, showing that the growing and decaying process took place two times at the same active region.

[P-79] Analysis of Monthly, Seasonal, and Annual Variations in International Quiet Day & International Disturbed Day Periods by Using BOH Magnetometer

Hojin Lee[1,2], Junga Hwang[1,2], Jaeyoung Kwak[1,2], Jongdae Son[2]

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

From 2007 to the present, for more than one solar cycle, Korea Astronomy and Space Science Institute has installed and operated a fluxgate magnetometer in Bohyunsan Observatory. This study analyzed the H, D, and Z components measured by fluxgate magnetometer from 2009 to 2021. In order to know the monthly, seasonal, and annual variations, dH, dD, and dZ values obtained by subtracting the daily average from each observation were used. In addition, to see geomagnetic response to the space weather, five days when solar activity was quiet in each month (International Quiet Day, IQD) and five days when solar activity was disturbed in each month (International Disturbed Day, IDD) were selected and analyzed.

[P-80] A Solar Flare Forecast Model with Probability, Mean, and Standard Deviation of Daily Peak Flux

Daye Lim[1], Yong-Jae Moon[1,2], Hyun-Jin Jeong[2]

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

We present a new solar flare forecast model with probability, mean, and standard deviation of daily peak flux. For this, we consider line-of-sight (los) magnetic flux from the SOHO/MDI and SDO/HMI, and flare lists from GOES from 1996 to 2021. Our model predicts two types of forecast results when a magnetic flux of an active region (AR) is given. First, a probability of flares greater than C-class and a probability of flares greater than M-class within a day are predicted respectively. Second, statistical parameters such as mean and two times standard deviation ($\pm 2\sigma$) of x-ray peak flux of the strongest flare within a day is predicted. We consider verification of two forecast results as follows. First, the probability results are verified by calculating various skill scores after changing to binary classification using thresholds. Second, we evaluate the statistical parameters by defining that the predicted result is true positive when an observed x-ray peak flux of the strongest flare is within the range from -2σ to $+2\sigma$. Our model provides information on daily observation of different flare magnitude, which is expected to be practical for flare forecast operators. For improvement we are also considering magnetic fluxes calculated from radial fields inferred from los ones.

[P-81] 72-Hours Forecasting of Global TEC Maps Using a Set of Deep Learning Models

Jinkoo Yim[1], Yong-Jae Moon[1,2], Hyun-Jin Jeong[1]

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

In this study, we develop a deep learning model to make a time-series forecasting of global Total Electron Content (TEC) maps using an image-to-image translation method based on conditional generative adversarial networks. For training our deep learning model, we use the International GNSS Service (IGS) TEC maps from 2003 to 2012. Our model uses two input data (t−12 and t+0 IGS TEC map) and generate 6 TEC maps with a cadence of 12 hours (t+12, t+24, t+36, t+48, t+60 and t+72). And sequentially shifting two hours back input data to generate the output data. Then combine all the outputs. Finally, our model provides a time-series forecasting up to 72 hours with 2-hour time cadence. Our models are tested for solar maximum period (2013−2014) and minimum period (2017−2018) data. For evaluation we compare our model results and IGS TEC maps using Pearson correlation coefficient (CC), root mean square error (RMSE), bias, and standard deviation (STD). The results of one-day forecasting predicted by our models are 0.98, 2.57 TECU, −0.13 TECU and 2.45 TECU for mean CC, RMSE, bias and STD, respectively, which are better than the previous models. Our study shows that a set of deep learning models successfully generate a time-series forecasting of TEC maps.

[P-82] Analysis of the Intensity Variation of the Equatorial Electrojet (EEJ) According to Altitude

Eunjin Jang[1], Kwangsun Ryu[1], Junchan Lee[1], Seunguk Lee[1,2], Changho Woo[1], Jaemin Hwang[1]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

The equatorial electrojet (EEJ) is the eastward current flow along the dip equator in the E-region ionosphere, and also can significantly impact the performance of communication and navigation systems. According to previous studies (e.g., Benaissa et al., 2017; Yamazaki & Maute, 2017), the seasonal and longitudinal variation of the EEJ was examined with the magnetic field data obtained from LEO (Low Earth Orbit) satellites and ground stations equipped with high-precision (nominally < ∼1 nT) magnetometers. However, few studies have discussed the detailed analysis of the altitude variation of the EEJ intensity. To estimate the measured value of the EEJ and determine the magnetometer specification of IAMMAP (Ionospheric Anomaly Monitoring by Magnetometer And Plasma-Probe), which is one of the scientific instruments for the Compact Advanced Satellite 500-3 (CAS500-3), we focus on the variation of EEJ intensity according to the altitude of LEO satellite. So, we have analyzed the altitude variation of EEJ by using the previous satellite data and EEJM2 (EEJ model; Alken & Maus, 2007) for the candidate orbits of CAS500-3.

[P-83] Dayside Aurora Observed by All-Sky Camera at Jang Bogo Station, Antarctica

Yoonseung Choi[1], Geonhwa Jee[1,2], Hyuckjin Kwon[1]

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

The majority of auroral study has been concentrated on the nightside aurora in the northern hemisphere due to the regional limitation of the ground observations in the southern polar region. It results in less attention paid to the auroral study in the southern hemisphere. Korea Polar Research Institute (KOPRI) has operated All-Sky Camera (ASC) at the Jang Bogo Station (JBS, geographic: 74.62°S, 164.22°E / geomagnetic: 79.87°S, 53.56°W), Antarctica since 2018. In this study, we investigate the representative features of the dayside aurora over the JBS station, as well as the comparison between dayside and nightside aurora according to the locational characteristics of the station by using ASC observations from 2018 to 2020. We

present the initial results of the analysis of the ASC auroral images during daytime in comparison with the nighttime auroral images. It is found that the dayside aurora exhibits its distinct features in morphology and colour.

[P-84] Statistical Investigation of the Effect of Coulomb Collisions on Thermodynamic Evolution of the Alfvenic Slow Wind

Jimin Hong[1], Jungjoon Seough[2], Kyungguk Min[1]

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

Coulomb collisions are believed to be an important mechanism leading to thermal equilibrium of solar wind plasma. In this study, we investigate the effect of Coulomb collisions on thermodynamic evolution of protons in the Alfvenic slow wind by analyzing in situ measurements made by Helios spacecraft during the solar minimum of solar cycle 21 (1975–1977). Based on the value of proton specific entropy, we group the Alfvenic slow wind into three, called a "stream". For each stream we analyze the radial evolution of physical quantities responsible for thermodynamic equilibrium of Alfvenic slow wind protons. We find that Coulomb collisions can affect the thermodynamic evolution of Alfvenic slow wind and cause its temperature isotropy (equilibrium). Finally, we suggest that the three different Alfvenic slow wind streams examined in this study are related to different source regions in the Sun.

[P-85] Structural/Thermal Analysis of AIPIM (Advanced Impedance Probe for Ionospheric Monitoring) for CAS500-3 Payload

Jaemin Hwang[1], Wonho Cha[1], Kwangsun Ryu[1], Junchan Lee[1], Changho Woo[1], Eunjin Jang[1], Seunguk Lee[1,2], Dooyoung Choi[2], Jeongrim Choi[2]

[1]*Satellite Technology Research Center (SaTRec), Korea Advanced Institute of Science and Technology*
[2]*Chungbuk National University*

The AIPIM is one of scientific payloads of CAS500-3 (Compact Advanced Satellite 500-3), which consists of Impedance Probe (IP) and Langmuir Probe (LP). IP and LP measure plasma density and temperature, independently and on-board cross-calibration to complement each other in terms of reliability of the measured data. We have been attempted to integrate them as a compact structure, called as S-Box (sensor box), for reducing mass and mounting space. The S-Box will be mounted on top of the satellite and is exposed directly to launch and orbit environment. Each environment acts as a load on the structure. In launch environment, the quasi-static, sine, random, and shock load are applied by the launch vehicle and in orbit environment, thermal load is applied because of the difference in the thermal expansion coefficient of material according to temperature change in orbit. Therefore, it is necessary to perform the structural/thermal analysis of the integration model to evaluate its structural safety. In this paper, the structural/thermal analysis of the integrated model is performed at the qualification level of the CAS500-3 and the result such as stress field and margin of safety (MoS) is calculated. The EQM of AIPIM will be designed by using the analysis results.

[P-86] A Comparison of the Propagating Characteristics of Mesospheric Gravity Waves over King Sejong Station, Antarctica (62.2°S, 58.8°W) and Mt. Bohyeon Observatory (36.2°N, 128.9°E)

Jun-Yeong Hwang[1], Young-Sook Lee[1], Yong Ha Kim[1], Hosik Kam[2], Young-Sil Kwak[2,3], Tae-Yong Yang[2]

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

We have analyzed O I 557.7 nm airglow images observed by all-sky camera Mt. Bohyeon Observatory (36.2°N, 128.9°E) for the period of 2017–2019. By applying the same analyzing method to the O I 557.7 nm images obtained at King Sejong Station, Antarctica (62.2°S, 58.8°W) for the similar period, we will compare the characteristics of mesospheric gravity waves over the completely different two locations; one at mid-latitude in the east Asia, the other at southern high latitude near the tip of Antarctic peninsula. Expecially, we will focus on the propagating characteristics that may be sensitively different due to source locations and middle atmospheric wind environments.

한국우주과학회보
제31권 1호 2022년 4월
전화 042-865-3391 (FAX: 042-865-3392)
학회 홈페이지 http://ksss.or.kr

발행인 이 유
편집인 정종균 · 고미희
발 행 사단법인 한국우주과학회
인 쇄 ㈜거목문화사/거목인포(02-2277-3324)

학회 소재지 대전시 유성구 대덕대로 776 한국천문연구원 내
전화: 042-865-3391 / 팩스: 042-865-3392
학회대표메일: ksss@ksss.or.kr