Space Missions for Astronomy and Astrophysics in Korea: Past, Present, and Future

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우주기반 기초과학 워크샵

Background

- Year 2020 is the 25th anniversary of Astrophysics Division of Korean Physical Society (KPS)
- A special issue of Journal of Korean Physical Society (JKPS) to celebrate the 25th anniversary of AD of KPS, which has 15 articles, will be published early next year
- This presentation is based upon one article in the special issue
- The paper is now available at the arXiv archive (http://arxiv.org/abs/2012.01120)

Missions with Contributing Authors

- Kwang-il Seon (KASI): FIMS/SPEAR
- Wonyong Han (KASI): MIRIS
- Young-Wook Lee (Yonsei Univ.): GALEX
- Hyung Mok Lee (KASI): AKARI
- Min Bin Kim & I. H. Park (SKKU): UFFO
- Woong-Seob Jeong (KASI): NISS and SPHEREx
- Kyung-Suk Cho (KASI): NGC
- Jae Jin Lee (KASI): SNIPE
- Dae Hee Lee (KASI & KAIST): UVOMPIS

대한민국 인공위성 목록

- 위키피디아: https://ko.wikipedia.org/wiki/대한민국의_인공위성_목록 (업데이트 필요)
- 함께 보기: https://ko.wikipedia.org/wiki/대한민국의_우주_개발

위성명	발사일 (UTC)	개발 기관	발사체	발사 장소	궤도	임무	운용기관	비고
우리별 1호	1992년 8월 11일	SaTReC	아리안 4 (아리안스페이스)	기아나 우주 센터	저궤도	위성제작기술습득	SaTReC	임무 종료
우리별 2호 (KITSAT-2)	1993년 9월 26일	SaTReC	아리안 4 (아리안스페이스)	기아나 우주 센터	저궤도	소형위성기술습득	SaTReC	임무 종료
무궁화 1호 (KOREASAT-1)	1995년 8월 5일	록히드 마틴	델타 II (맥도넬 더글라스)	케이프커내버럴 공군 기지	정지궤도	통신, 방송	KT	임무 종료
무궁화 2호 (KOREASAT-2)	1996년 1월 14일	록히드 마틴	델타 II (맥도넬 더글라스)	케이프커내버럴 공군 기지	정지궤도	통신, 방송	KT	임무 종료
우리별 3호 (KITSAT-3)	1999년 5월 26일	SaTReC	PSLV-C2 (인도)	사티시 다완 우주 센터	저궤도	지상 및 과학 관측	SaTReC	임무 종료
무궁화 3호 (KOREASAT-3)	1999년 9월 4일	록히드 마틴	아리안 4 (아리안스페이스)	기아나 우주 센터	정지궤도	통신, 방송	KT	운용 중(ABS-7)
아리랑 1호 (KOMPSAT-1)	1999년 12월 21일	KARI	타우루스 (오비탈 사이언스)	반덴버그 공군 기지	태양동기궤도	지상, 해양, 과학 관측	KARI	임무 종료
과학기술위성 1호 (STSAT-1)	2003년 9월 27일	SaTReC	코스모스 3M (팔료트)	플레세츠크 우주 기지	태양동기궤도	우주환경 측정	SaTReC	임무 종료
한별 (MBSat)	2004년 3월 13일	에스에스로랄	아틀라스 III-A (록히드 마틴)	케이프커내버럴 공군 기지	정지 궤도	모바일 방송	SK텔링크, MBCO	한국 SK텔링크와 일본 MBCO 공동 운용
아리랑 2호 (KOMPSAT-2)	2006년 7월 28일	KARI	로콧 (유로콧)	플레세츠크 우주 기지	태양동기궤도	지상 관측	KARI	임무 종료
무궁화 5호 (KOREASAT-5)	2006년 8월 22일	알카텔	제니트 3SL (씨런치)	오디세이호(해상발사)	정지궤도	통신, 방송	KT, 국방과학연구소	운용 중
천리안 (COMS-1)	2010년 6월 27일	KARI	아리안 5 (아리안스페이스)	기아나 우주 센터	정지궤도	통신, 해양, 기상	KARI	운용 중
올레 1호 (KOREASAT-6)	2010년 12월 28일	TAS, 오비탈 사이언스	아리안 5 ECA (아리안스페이스)	기아나 우주 센터	정지궤도	통신, 방송	KT	운용 중
아리랑 3호 (KOMPSAT-3)	2012년 5월 18일	KARI	H-IIA (미쓰비시 중공업)	다네가시마 우주 센터	태양동기궤도	지상 관측	KARI	운용 중
나로과학위성 (STSAT-2C)	2013년 1월 30일	SaTReC	나로호 (KARI)	나로 우주 센터	태양동기궤도	저궤도 인공위성 궤도진입기술 습득	SaTReC	임무 종료
아리랑 5호 (KOMPSAT-5)	2013년 8월 22일	KARI	드네프르 (유즈노예)	야스니 발사장	태양동기궤도	지상 관측	KARI	운용 중
과학기술위성 3호 (STSAT-3)	2013년 11월 21일	KARI	드네프르 (유즈노예)	야스니 발사장	태양동기궤도	우주/지구 과학관측	KARI	운용 중
아리랑 3A호 (KOMPSAT-3A)	2015년 3월 26일	KARI	드네프르 (유즈노예)	야스니 발사장	태양동기궤도	지상 관측	KARI	운용 중

FIMS/SPEAR

MIRIS

FIMS/SPEAR

- FIMS = Far-ultraviolet Imaging Spectrogram
- SPEAR = Spectroscopy of Plasma Evolution from Astrophysical Radiation

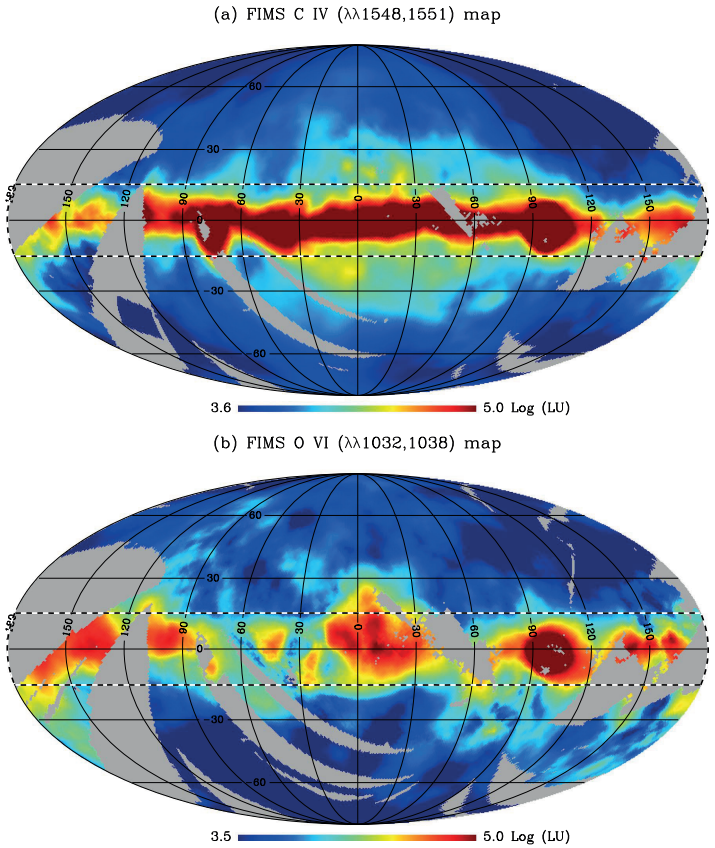

FIG. 2: (a) C IV all-sky map and (b) O VI map after correcting for dust extinction. The strong extinction region of $|b| < 15^\circ$ around the Galactic disk is indicated with a dashed rectangular box. Here, LU denotes line unit (photons cm^{-2} s^{-1} sr^{-1}). Adopted from [7].

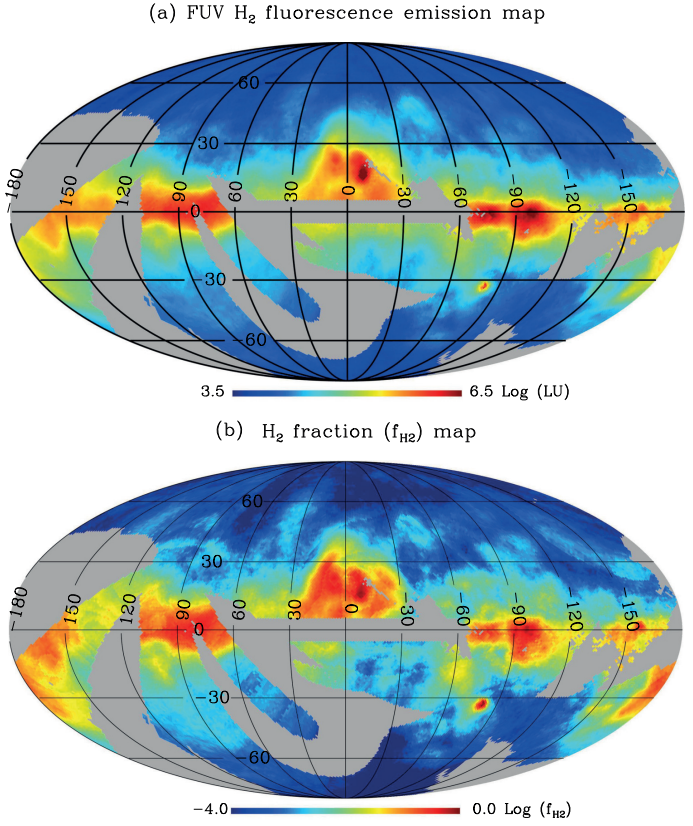

FIG. 3: (a) FUV fluorescent H_2 emission line map after correcting for dust extinction and (b) all-sky map of the H_2 fraction f_{H_2}. The strongly extinguished region of $|\ell| < 60^\circ$ and $|b| < 5^\circ$ is excluded in the figure. Adopted from [8].

MIRIS (Multi-purpose InfraRed Imaging System)

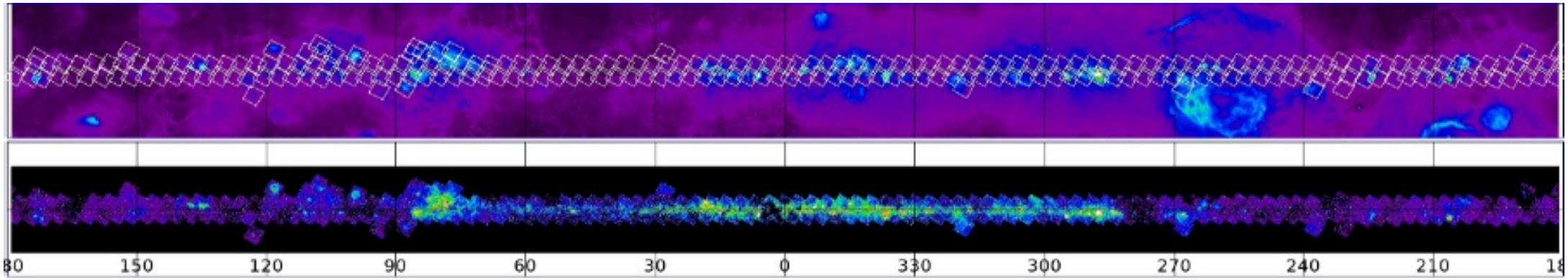

FIG. 7: The upper image is the full-sky Hα Map by Finkbeiner [51], and the below image is the MIRIS Paα survey image (continuum-subtracted) along the entire Galactic Plane (Milky Way) in Kim et al. [49] where the rectangles are the 235 fields observed by MIRIS and the numbers below are the galactic longitudes.

GALEX (Galaxy Evolution Explorer)

- NASA-led UV imaging and spectroscopic survey mission
- First official case of Korea-NASA cooperation on major space science program
- Korean contribution was lead by Yonsei University.

https://en.wikipedia.org/wiki/Explorers_Program

List of SMEX missions[20][28]

Name	SMEX number	Explorer number	Launch (UTC)	End of mission	Status
SAMPEX	SMEX-1	Explorer-68	3 July 1992	30 June 2004	Reentered on 13 November 2012
FAST	SMEX-2	Explorer-70	21 August 1996	4 May 2009	
SWAS	SMEX-3	Explorer-74	6 December 1998	21 July 2004	
TRACE	SMEX-4	Explorer-73	2 April 1998	21 June 2010	
WIRE	SMEX-5	Explorer-75	5 March 1999	N/A	Spacecraft equipment failure; reentered on 10 May 2011
RHESSI	SMEX-6	Explorer-81	5 February 2002	April 2018	Decommissioned on 16 August 2018
GALEX	SMEX-7	Explorer-83	28 April 2003	May 2012	Decommissioned on 28 June 2013
SPIDR	SMEX-8	—	*Scheduled for 2005*	N/A	Cancelled in 2003 due to poor instrument sensitivity[29]
AIM	SMEX-9	Explorer-90	25 April 2007		**Operational**
IBEX	SMEX-10	Explorer-91	19 October 2008		**Operational**
NuSTAR	SMEX-11	Explorer-93	13 June 2012		**Operational**
IRIS	SMEX-12	Explorer-94	28 June 2013		**Operational**
GEMS	SMEX-13	—	*Scheduled for 2014*	N/A	Cancelled in 2012 due to expected cost overruns[30]
IXPE	SMEX-14		2021[31]		In development[32]
PUNCH			2023[33]		In development
TRACERS			2023[33]		In development

Small Explorers (SMEX) Program of NASA

AKARI

- AKARI means warm light in Japanese
- Significant contribution from Korean participants of Seoul National University
- Heritages of the AKARI Project to Korean Community
  - The Korean members of AKARI started community-wide workshops by forming an Infrared Astronomy Working Group (IRWG) in 2001
  - The experience in the AKARI collaboration led to KASI Near Infrared Camera System (KASINICS), MIRIS, NISS, and SPHEREx

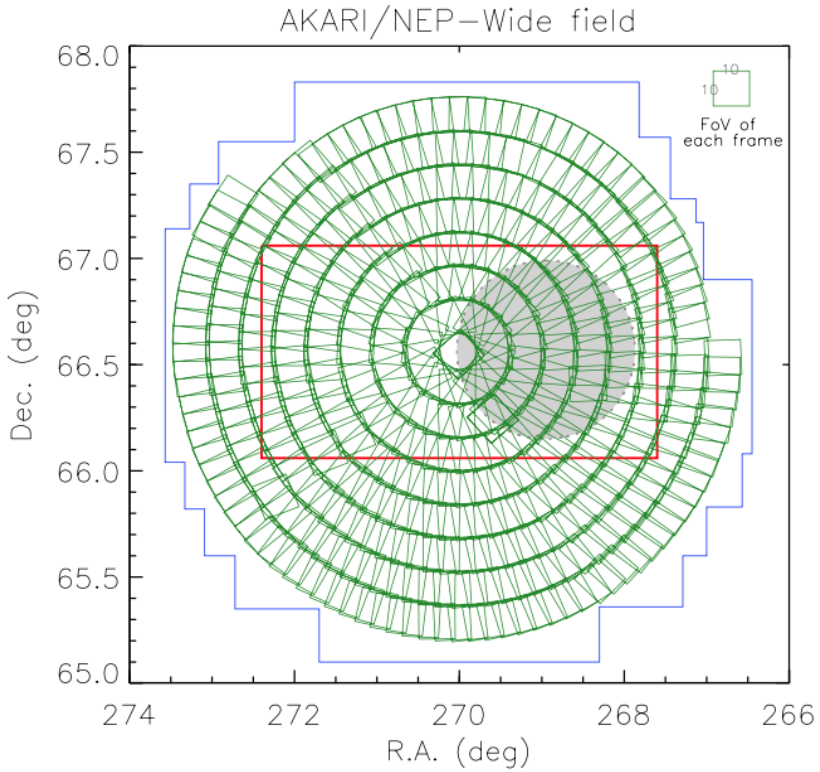

FIG. 12: Survey areas of NEP-Wide (large circle) and Deep (small shadowed circle on the right). Survey areas of preflight optical survey with CFHT (red box) [78] and optical survey with Maidanak Observatory (blue line) [79] are also shown. Each green box represents the IRC pointing field.

UFFO (Ultra-Fast Flash Observatory) - Pathfinder

- Proposed by Il H. Park in 2009 for precise observation and identification of early UV/optical photons from Gamma-Ray Bursts (GRBs)
- UFFO-100 (planned): a large GRB observation payload with a total mass of 100 kg

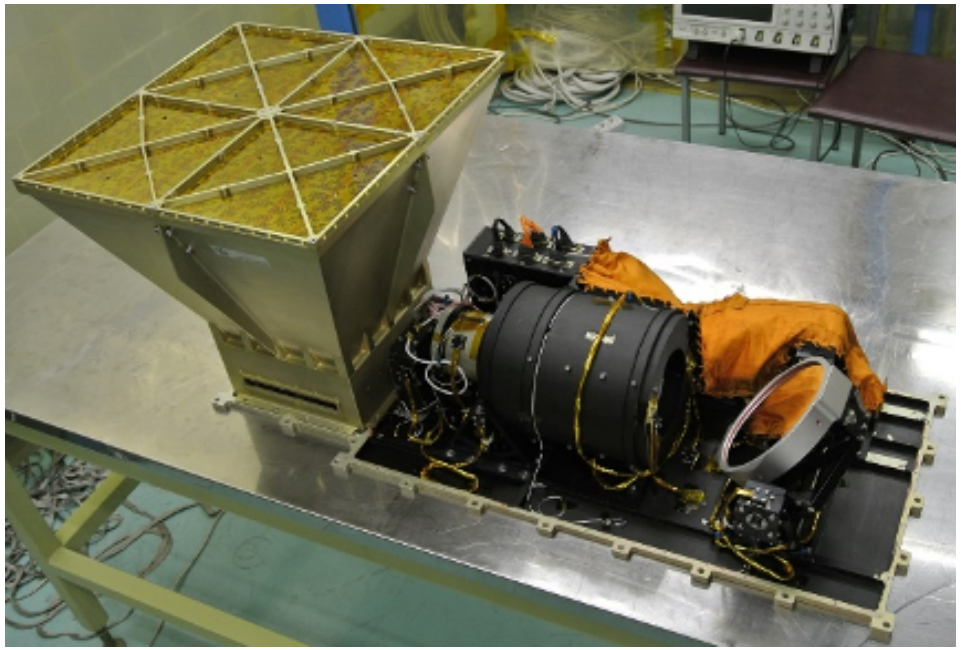

FIG. 13: Fabricated UFFO-pathfinder flight model. The left gold color structure is UBAT and right is SMT without housing.

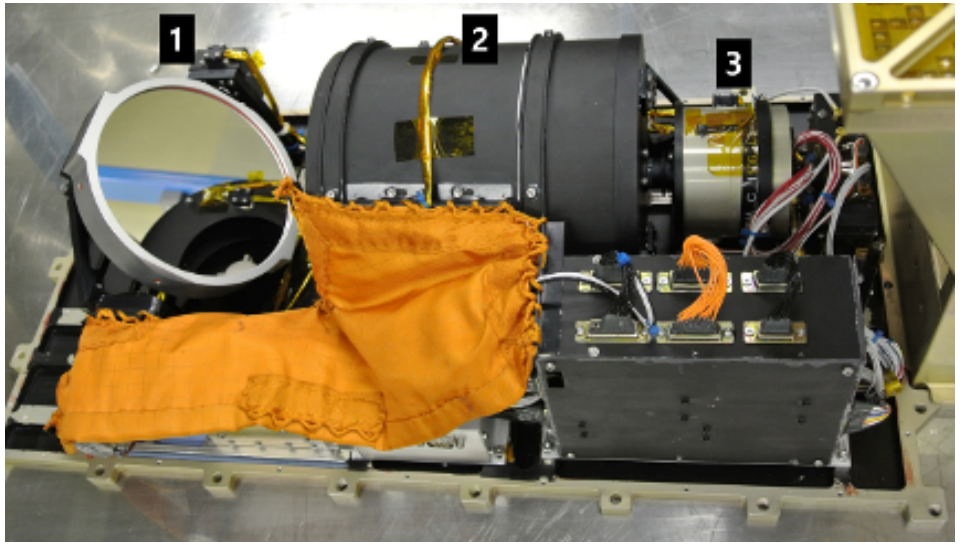

FIG. 14: Integrated SMT. (1) Slewing mirror system consisting of 2-axis gimbal mirror; (2) 10 cm aperture Ritchey-Chrétien telescope; (3) ICCD

NISS and SPHEREx

- NISS (Near-infrared Imaging Spectrometer for Star formation history): NEXTSAT-1 (차세대 소형 위성 1호)
- SPHEREx (Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer): Medium-Class Explorer (MIDEX) of NASA

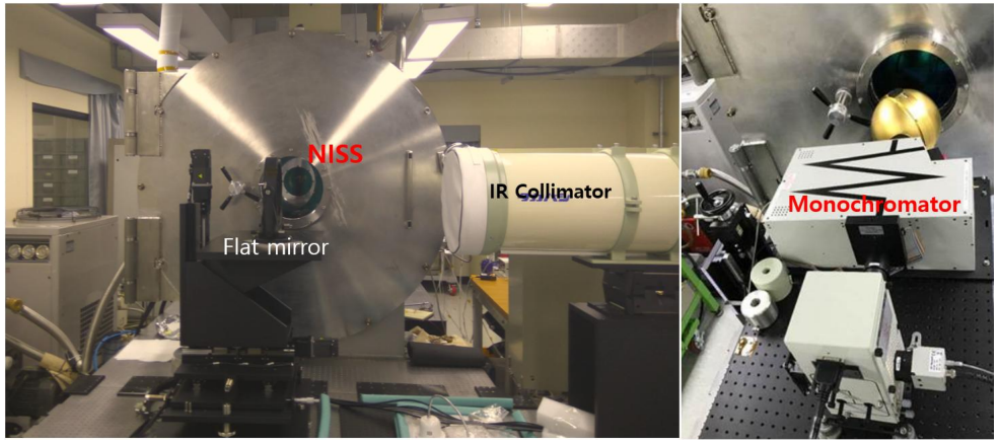

FIG. 20: The calibration facility for NISS. The collimator system (left) and the monochromator system (right) are for the purpose of the focus adjustment and wavelength calibration, respectively.

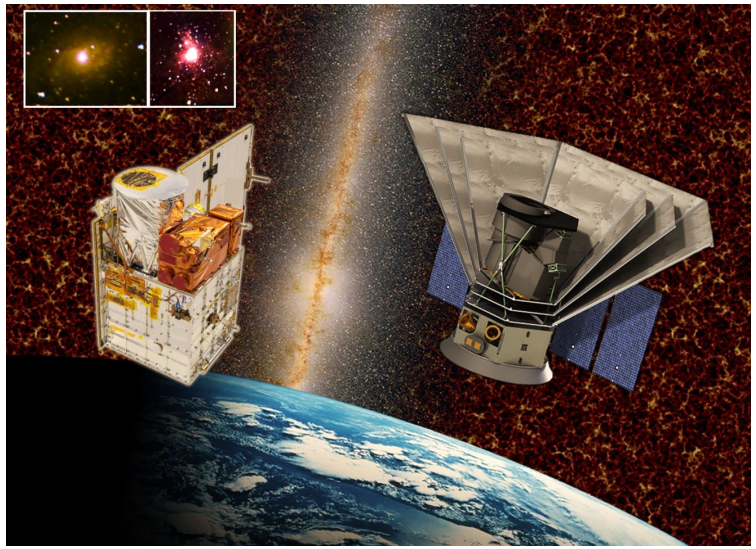

FIG. 21: Illustrated image expected from SPHEREx together with NISS onboard NEXTSAT-1 and SPHEREx (modified from the original image from NASA press release on February 14, 2019, https://www.nasa.gov/press-release/nasa-selects-new-mission-to-explore-origins-of-universe). The images of Triangulum Galaxy and Large Magellanic Cloud in the top-left are taken from NISS in the spectro-photometric observation.

List of MIDEX missions[19][20][21]

Name	MIDEX number	Explorer number	Launch (UTC)	Status
RXTE		Explorer-69	December 30, 1995	Ended in 2012
ACE		Explorer-71	August 25, 1997	**Operational**
FUSE	MIDEX-0	Explorer-77	June 23, 1999	Ended in 2007
IMAGE	MIDEX-1	Explorer-78	March 25, 2000	Lost contact in 2005. Partial contact reestablished in January 2018
WMAP	MIDEX-2	Explorer-80	June 30, 2001	Ended in 2010
Swift	MIDEX-3	Explorer-84	November 20, 2004	**Operational**
FAME	MIDEX-4	—	*Scheduled for 2004*	Cancelled in 2002 (cost)
THEMIS A	MIDEX-5A	Explorer-85	February 17, 2007	**Operational**
THEMIS B	MIDEX-5B	Explorer-86	February 17, 2007	**Operational**
THEMIS C	MIDEX-5C	Explorer-87	February 17, 2007	**Operational**
THEMIS D	MIDEX-5D	Explorer-88	February 17, 2007	**Operational**
THEMIS E	MIDEX-5E	Explorer-89	February 17, 2007	**Operational**
WISE / NEOWISE	MIDEX-6	Explorer-92	December 14, 2009	**Operational**[22]
TESS	MIDEX-7	Explorer-95	April 18, 2018	**Operational**
ICON	MIDEX-8	Explorer-96	11 October 2019	**Operational**
SPHEREx	MIDEX-9		2024	In development[23]

CODEX (COronal Diagnostic EXperiment)

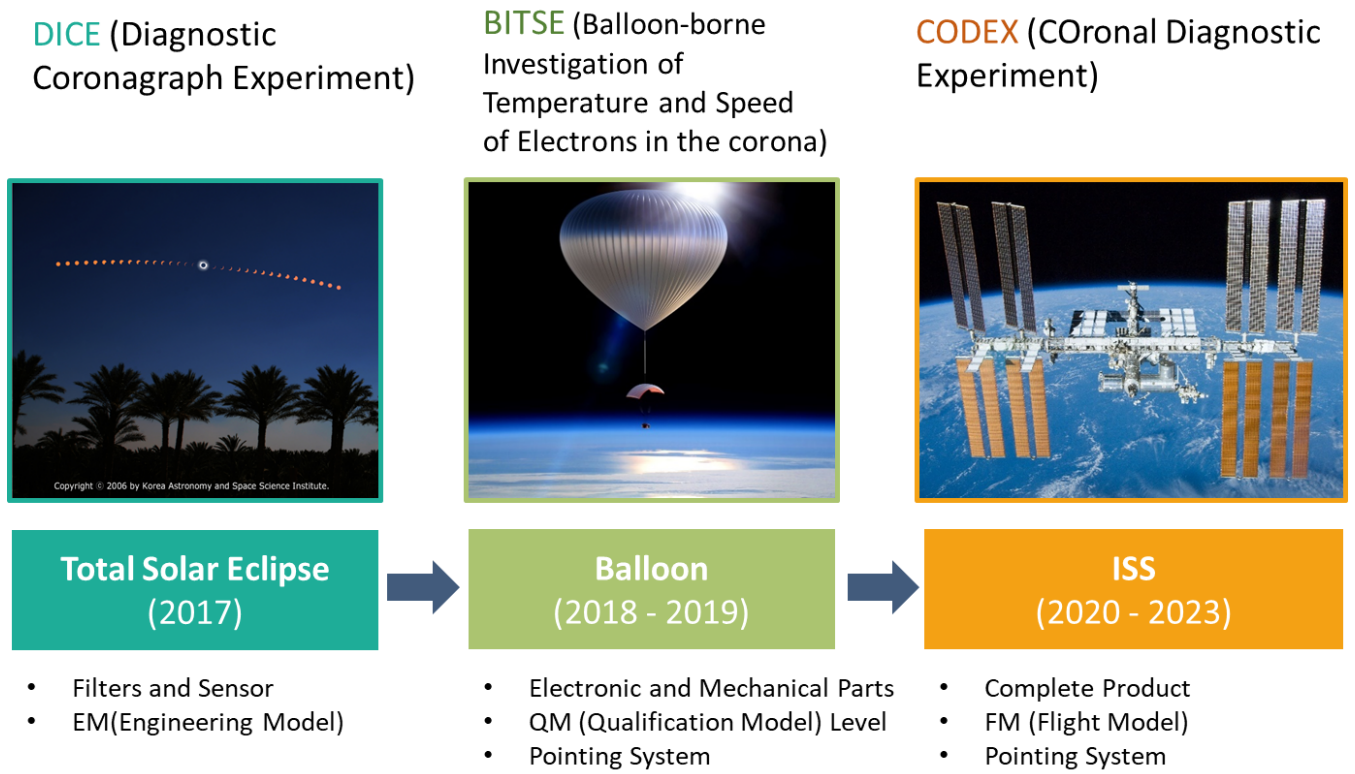

FIG. 22: (Color online) Timeline toward the next generation white-light coronagraph. Observations of total solar eclipse (DICE) and balloon experiments (BITSE) were preformed for the demonstration and validation of the coronagraph technology before launch of the ISS coronagraph (CODEX).

SNIPE (Small scale magNetospheric and Ionospheric Plasma Experiment)

TABLE IV: SNIPE Science Payload

Instruments	Range	Cadence	Heritage
Langmuir Probe	$2 \times 10^3 - 2 \times 10^6 cm^{-3}$	0.1s for Ne 1 s for Te	STSAT-1[125]
Magnetometer	±60,000 nT sensitivity: 30 pT/$\sqrt{Hz}$ at 1Hz	0.1 s	STSAT-1[125]
Solid State Telescope	100 - 400 keV (Variable) electron 16 energy channels	0.01s for Burst 0.1 s for Survey	STSAT-1[125]

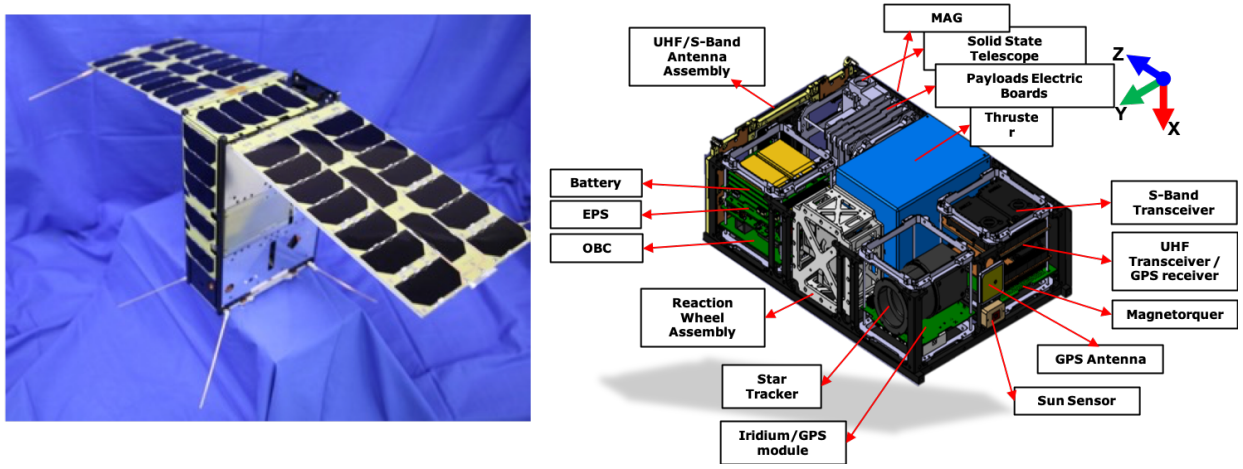

FIG. 27: The photo of the SNIPE EQM (left), and the configuration of spacecraft subsystems (right).

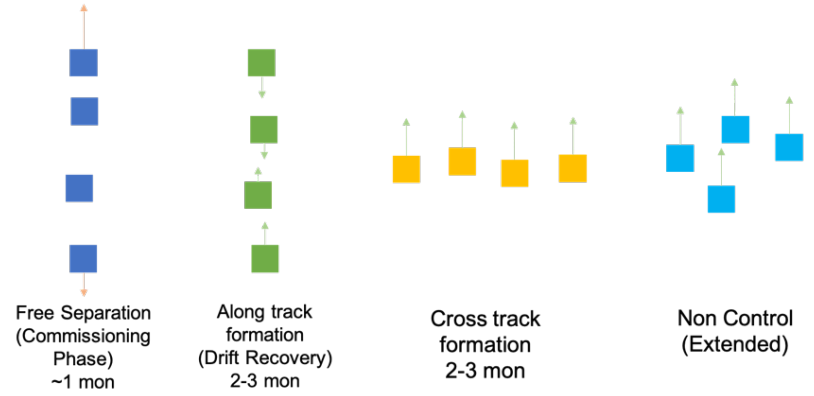

FIG. 29: The configuration of SNIPE mission formation flying

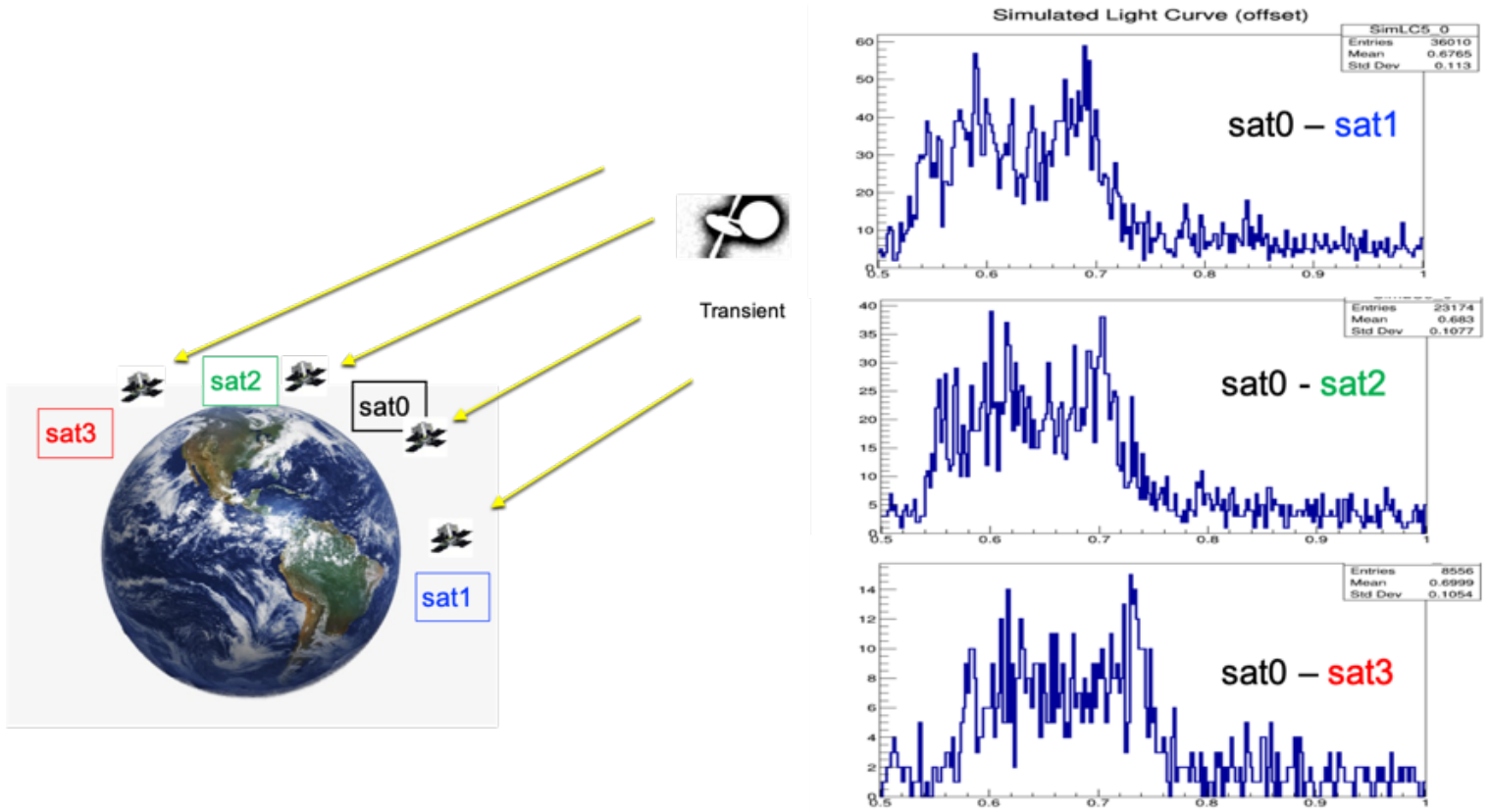

FIG. 30: Conceptual diagram for localization of gamma-ray bursts. Four CubeSats detect delayed gamma-ray count rate and identify the direction of the gamma-ray burst position.

UVOMPIS (UV-Optical Multiband Polarizing Imager System)

- Planned payload for the CAS (Compact Advanced Satellite) 500- 3 (차세대 중형 위성 3호: 500 kg 급)
- Unique instrument to cover the band from ultraviolet to optical with polarizing capability

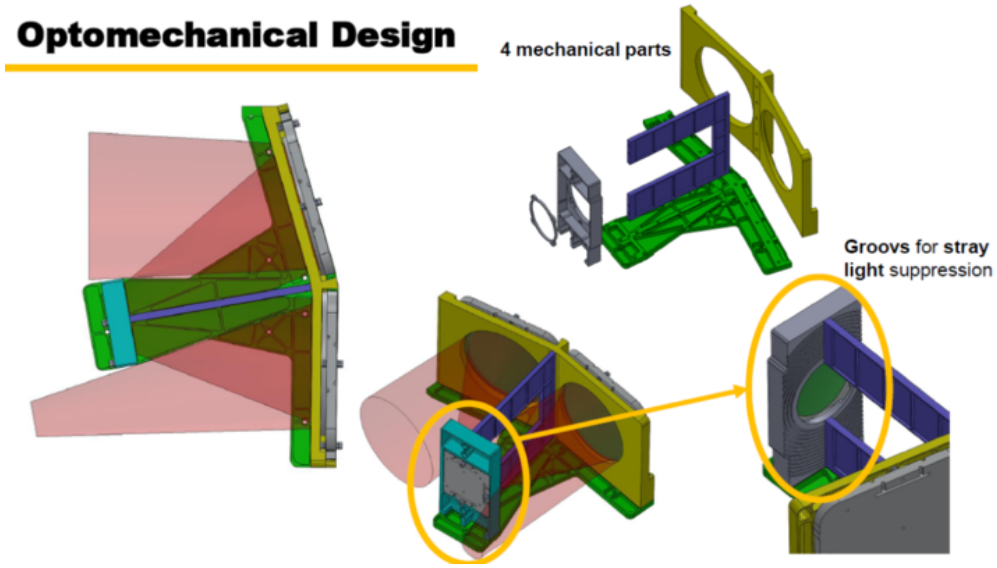

FIG. 31: The conceptual design of the UVOMPIS optomechanical part

Conclusion and Prospects

- Necessity to pursue our own big (?) space program
- Possibility to join the Large UV/Optical/IR Surveyor (LUVOIR)
- More opportunities to use International Space Station (ISS) and small (cube) satellites
- Discussions for future missions for high energy astronomy and astrophysics (X-ray & gamma-ray)
- Other possibilities ….