system consists of three freeform mirrors. Due to its well-corrected aberrations and obstruction-free clear aperture, the LAF-TMS provides a wide field of view with very low scattered lights.

[구 KDC-03] Fabrication, Assembly and Alignment of the Off-axis Freeform K-DRIFT Pathfinder

K-DRIFT Collaboration: Yunjong Kim[1] ,Dohoon Kim[2] et al.
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표준우주모형이 예측하는 천체의 성장 역사를 추적하기 위해서는 보통의 밤하늘 밝기보다 약 1000배 어두운 낮은 표면밝기(Low Surface Brightness, LSB) 우주 탐사가 필요하지만, 관측기술의 한계로 아직 LSB 우주는 거의 미지의 세계에 있다고 할 수 있다. 한국천문연구원에서는 LSB 천체 관측에 최적화된 직경 300 mm K-DRIFT Pathfinder 망원경을 개발하였다. LSB 천체는 ~28 mag/arcsec2 보다 어두운 천체로 표면밝기가 매우 낮기 때문에 망원경 내부의 미광(stray light)을 최소화하는 것이 중요하다. 이를 구현하기 위해 K-DRIFT Pathfinder 망원경에는 선형 비점수차가 제거된 비축 자유곡면 삼 반사경 형태를 적용하였다. 본 연구를 통해 가시광 영역에서 선형 비점수차가 제거된 비축 자유곡면 삼 반사 망원경의 설계, 제작 및 측정 가능성을 검증하였다. 본 발표에서는 K-DRIFT Pathfinder 망원경에 적용된 비축 자유곡면 광학면의 가공, 삼 반사 망원경의 조립 및 정렬 결과를 소개한다.

[구 KDC-04] A Simulation Study for Mid-spatial Frequency Errors: Scattering Effects from Residual Optical Fabrication Errors

K-DRIFT Collaboration: Gayoung Lee[1] Yunjong Kim[2], Kwang-Il Seon[2,3] et al.
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[2]*Korea Astronomy and Space Science Institute,*
[3]*University of Science and Technology*

한국천문연구원에서는 LSB 천체 관측에 최적화된 유효 직경 300 mm의 비축 자유곡면 K-DRIFT pathfinder 망원경을 개발하였다. 밝은 별로 시험관측을 한 결과 설계에서 예상된 점퍼짐함수(point spread function)보다 약 5배 정도 (또는 목표로 한 점퍼짐함수보다 약 1.5배 정도) 큰 점퍼짐함수를 얻었다. 이에 대한 원인 분석 결과 비축 자유곡면을 가공하면서 발생한 툴 마크에 의한 MSF (Mid-Spatial Frequency) 효과가 점퍼짐함수 증가에 주도적인 영향을 주는 것으로 판단되었다. 본 발표에서는 반사경면의 MSF를 다양한 조건에 따라 시뮬레이션한 결과를 소개하고 이를 토대로 실제 반사경 제작에서 MSF 효과를 최소화 하는 방안에 대해 논의하고자 한다.

[구 KDC-05] First Results from the K-DRIFT pathfinder: A Single Curved Stellar Stream in the Nearby Galaxy NGC 5907

K-DRIFT collaboration: Woowon Byun[1,2] et al.
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[2]*University of Science and Technology, Korea*

In a ΛCDM universe, most galaxies are believed to evolve by mergers and accretions. The debris resulting from such processes remains faint and/or diffuse structures, such as tidal streams and stellar halos. Although these structures are a good indicator of the recent mass assembly history of galaxies, they have the disadvantage of being difficult to observe due to their low surface brightness (LSB). To recover these LSB features by reducing the photometric uncertainties introduced by the optics system, we attempt to develop an optimized telescope, called a linear astigmatism free-three mirror system, that minimizes the loss and scattering of light within the telescope. With that prototype, we observe NGC 5907, known as a nearby galaxy with a fabulous loop structure(s), to inspect its performance. After a dedicated data reduction process, including flat-fielding with dark sky flat and sky subtraction, our observation reaches a 1σ surface brightness limit of μlim,r ≃ 28.3 mag arcsec-2 in 10×10 arcsec boxes. We finally identify a single tidal stream that is likely the remnant of a nearly disrupted galaxy. This finding emphasizes that the capability of LSB detection with our telescope is comparable to that of much larger telescopes.

[구 KDC-06] Studies of LSB Features with K-DRIFT: Galactic Cirrus Clouds and Extragalactic Objects

K-DRIFT Collaboration: Kwang-Il Seon[1,2] et al.
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The low surface brightness (LSB) universe has been largely unexplored. The LSB structures are extremely difficult to image due to systematic errors of sky subtraction and scattered light in he atmosphere and in the telescope. Among the systematic errors of sky subtraction, the widespread presence of Galactic cirrus clouds is one of the major obstacles in studying the LSB features of extragalactic sources. Interstellar dust clouds are also fundamental to understand many issues in the Milky Way. Therefore, understanding the Galactic cirri is a crucial topic in the LSB studies. We present the ubiquitousness and current understanding of the Galactic cirri. We also discuss what is necessary to study the LSB features with

K-DRIFT and what we can learn from the K-DRIFT observations.

[구 KDC-07] A novel simulation technique invented for studying low-surface brightness features in and around galaxies: Galaxy Replacement Technique (GRT)

Jihye Shin[1], Kyungwon Chun[1], Rory Smith[1,2], Jongwan Ko[1,2]
[1]*Korea Astronomy and Space Science Institute (KASI)*
[2]*University of Science Technology (UST)*

K-SIM (KASI-Simulation) research project is dedicated to develop new numerical techniques in order to theoretically study galaxy formation and evolution. As the first step of the K-SIM, to model tidal stripping of galaxies with a very high resolution in a fully cosmological context, we invented the Galaxy Replacement Technique (GRT) that is very efficient and fast. The high resolution allows us to accurately resolve the tidal stripping process and well describe the formation of ultra-low surface brightness features in the galaxy cluster (μV < 32 mag/arcsec^2), such as the intra-cluster light, shells and tidal streams. I'll introduce how the GRT is designed and which science topics in low-surface brightness regime can be visited using the GRT.

[특별세션] Rendezvous Mission to Apophis

[구 RMA-01] Rendezvous Mission to Apophis: I. Mission Overview

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

[구 RMA-02] Rendezvous Mission to Apophis: II. Science Goals

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99942 Apophis is an Sq-type Potentially Hazardous Asteroid (PHA) with an estimated diameter of 370 m. It 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. The science goal of the Apophis mission is to global-map the asteroid before and after the Earth's approach. In this talk, we will present scientific objectives, and briefly introduce instruments and operation scenarios of the mission.

[구 RMA-03] Rendezvous Mission to Apophis: III. Polarimetry of S-type: For A Better Understanding of Surficial Evolution

Jooyeon Geem[1](김주연), Minsup Jeong[2](정민섭), Sunho Jin[1](진선호), Chae Kyung Sim[2](심채경), Yoonsoo P. Bach[1](박윤수), Masateru Ishiguro[1], Yuna G. Kwon[3](권유나), Hong-Kyu Moon[2](문홍규), Young-Jun Choi[2](최영준), Myung-Jin Kim[2](김명진)
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