Park[1], Ho Lee[2], Hyunjong Kim[2], Soojong Pak[1]
*[1]School of Space Research, Kyung Hee Univsersity, [2]Gyeonggi Science High School for the Gifted*

Gyeonggi science high school for the gifted (GSHS) installed 60cm telescope, which is waiting for student observers. It is essential to understand the characteristics of the photometric system, consisting of telescope, filter, and CCD, to get reliable data. CCD images of SA98 Landolt standard field and M67 were obtained on 19th March 2020. The images of each field were combined by filters, i.e., we ignored the monochromatic atmospheric extinction since the photometric objects themselves are standard stars. 24 standard stars in SA98 field and 12 standard stars in M67 were used to derive the tentative transformation equation between our bv photometric system and Johnson BV photometric system. In this poster, we present the preliminary standardization result for Johnson BV photometric system in GSHS 60cm telescope. The reproductivity is discussed by comparing color coefficients of two fields. We plan to extend this process to Johnsons-Cousins BVRI photometric system and narrow-band filters for flux calibration.

## [포 AT-05] Development of adaptive optics system for SNUO 1m telescope

Hyungjoon Ryu, Yong-Sun Park, Jin-guk, Seo
*Astronomy Program, Dept of Physics and Astronomy, Seoul National University*

Adaptive Optics (AO) is the technology for ground-based telescopes to overcome the interference caused by atmospheric turbulence. We are developing an AO system for the 1-m telescope at Seoul National University Observatory (SNUO). The seeing size of the SNUO is 2 arcseconds on average, and 0.85 arcseconds at best condition. Our system is based on MEMS deformable mirror and Shack-Hartmann wavefront sensor. We developed the wavefront sensor using a cheap CMOS camera, and measured phase disturbance at SNUO. To verify the performance of the AO system, we designed an artificial phase disturber that produces similar scale phase error, measured at SNUO. We carried out laboratory tests in which the AO system measures and corrects the wavefront using the phase disturber and an F/6 light source, the same as that of SNUO telescope. The control system was developed in C++. The system performs closed-loop PI correction up to 100 Hz at a consumer-grade PC.

## [포 AT-06] Surface Error Generation of Freeform Mirror Based on Zernike Polynomial for Optical Performance Prediction

Sunwoo Lee[1], Woojin Park[1], Jimin Han[1], Hojae Ahn[1], Yunjong Kim[2], Dae-Hee Lee[2], Geon Hee Kim[3], Soojong Pak[1]
*[1]School of Space Research and Institute of Natural Science, Kyung Hee University, [2]Korea Astronomy and Space Science Institute, [3]Korea Basic Science Institute*

Not only the magnitude of the mirror surface error, the pattern matters as it produces certain aberrations. In particular, the surface error of the freeform mirrors, which are optimized to eliminate specific aberrations, might show much higher sensitivity in optical performance. Therefore, we analyze the mirror surface error with Zernike polynomials with the goal of generating a realistic error surface. We investigate the surface error of the freeform mirror fabricated by diamond turning machine to analyze the realistic tendency of the error. The surface error with 0.22 μm root-mean-square value is fitted to the Zernike terms using the incremental fitting method, which increases the number of the fitting coefficients through steps. Furthermore, optical performance via surface error pattern based on Zernike terms is studied to see the influences of each term. With this study, realistic error surface generation may allow higher accuracy not only for the feasibility test but also for all tests and predictions using optical simulations.

## [포 AT-07] Design of the Filter Exchange Mechanism for Schmidt Telescope

Tae-Geun Ji[1], Woojin Park[1], Jimin Han[1], Dohoon Kim[3], Gu Lim[2], Mankeun Jeong[2], Myungshin Im[2], Soojong Pak[1]
*[1]School of Space Research, Kyung Hee University, [2]Astronomy Program, Department of Physics & Astronomy, Seoul National University, [3]Department of Astronomy & Space Science, Kyung Hee University*

A prime focus telescope, e.g., Schmidt telescope, has advantages especially for a wide field of view survey in astronomy. In this optical configuration, the camera is placed in front of the primary mirror. Since the installation of a typical filter wheel to the prime focus telescope causes serious obscuration of the incoming light, a customized filter device is required for high sensitivity images. In this poster, we present a new filter exchange mechanism, which can host four filters moving along quadrant directions. We plan to install this on the Celestron 36 cm Rowe-Ackermann Schmidt

Astrograph (RASA 36) located at El Sause Observatory in Chile.

### [포 AT-08] Design and Analysis of Collimator in Spectrophotometer for Transmission Spectroscopy of Exoplanets

Yeonho Choi[1], Kang-Min Kim[2], Chan Park[2], Jeong-Gyun Jang[2], Inwoo Han[2], Byeong-Cheol Lee[2], Bi-Ho Jang[2], Jong-Ung Lee[3], Eui-Jeong Jeong[2], Myeong-Gu Park[1]
*[1]Department of Astronomy and Atmospheric Sciences, Kyungpook National University, 80 Daehakro, Bukgu, Daegu 41566, Korea; apollo.choe@gmail.com, mgp@knu.ac.kr*
*[2]Korea Astronomy and Space Science Institute, 776 Daedukdae-ro, Yuseong-gu, Daejeon 34055, Korea; kmkim@kasi.re.kr, chanpark@kasi.re.kr, iwhan@kasi.re.kr, bclee@kasi.re.kr*
*[3]Department of Laser and Optical Information Engineering, Cheongju University, Cheongju 28371, Korea*

외계행성 대기 연구를 위한 투과스펙트럼 관측에 적합한 측분광기를 개발하고 있다. 이 측분광기의 광학적 특성은 380~685nm의 파장범위, FOV 10', R>~400이며, 슬릿부, collimator, VPH grism, imaging lens와 CCD로 구성되어 있는데, 보현산천문대 1.8m 망원경의 CIM (Cassegrain Interface Module)에 카트리지 방식으로 장착되어 사용한다.

그 중 doublet 렌즈 2개를 대칭으로 배치하여 초점거리 280mm가 되도록 만든 collimator는 슬릿을 통과한 f/8 입사광에서 지름 35 mm의 pupil을 만드는데, 이곳에 VPH grism을 설치하였다. collimator 렌즈는 axial spring과 radial spring으로 알루미늄 barrel에 고정하였다. 이 collimator barrel은 CIM에 쉽게 장탈착 할 수 있도록 모듈화 하였다. Collimator Barrel에 대한 구조 해석 결과, 망원경 이동에 따른 중력에 의한 변형은 충분히 작았다. Grism은 슬라이딩 형태로 장착되어 영상 확인도 가능하도록 설계하였다.

### [포 AT-09] Optical Design and Tolerance Analysis for UVO-Multiband Polarizing Imager System

Jimin Han[1], Seunghyuk Chang[2], Woojin Park[1], Sunwoo Lee[1], Hojae Ahn[1], Geon Hee Kim[3], Dae-Hee Lee[4,5], Soojong Pak[1]
*[1]Kyung Hee University, [2]Center for Integrated Smart Sensors, Korea Advanced Institute of Science and Technology (KAIST), [3]Korea Basic Science Institute, [4]Korea Astronomy and Space Science Institute, [5]Department of Aerospace Engineering, Korea Advanced Institute of Science and Technology (KAIST)*

UVO-Multiband Polarizing Imager System (UVOMPIS) is an ultraviolet to visible light multi-wavelength polarization/imaging system for Compact Advanced Satellite. We developed Linear Astigmatism Free-Three Mirror System (LAF-TMS) D200F2 as an optical system of UVOMPIS which has an entrance pupil diameter of 200 mm, a focal ratio of 2, a field of view of 2° × 4°. LAF-TMS is a confocal off-axis reflecting telescope system that removes linear astigmatism, and its all mirrors (M1, M2, M3) are optimized with the freeform surface to reduce high-order aberrations. Through the sensitivity analysis and Monte-Carlo simulation as the tolerance analysis, we can confirm the feasibility of the system, relatively sensitive parameters (tilt, decenter, despace, surface RMS error), and considerations for optomechanical design. From the sensitivity analysis, we can discover the relatively sensitive optical alignment parameters to a single perturbation. Further more, in the monte-carlo simulation, we investigate the minimum tolerance budget satisfying the required optical performance and whether the tolerance range is satisfied within manufacturing error.

## 우주론

### [포 CD-01] `Mind the Mocking and don't Keep on Walking': Galaxy Mock Challenges for the Completed SDSS-IV Extended Baryon Oscillation Spectroscopic Survey

Jeongin Moon, Peter D. Choi, Graziano Rossi + eBOSS Team
*Department of Physics and Astronomy, Sejong University, Seoul, Korea*

We develop a series of N-body data challenges, functional to the final analysis of the extended Baryon Oscillation Spectroscopic Survey (eBOSS) Data Release 16 (DR16) galaxy sample, primarily based on high-fidelity catalogs constructed from the Outer Rim simulation. We generate synthetic galaxy mocks by populating Outer Rim halos with a variety of halo occupation distribution (HOD) schemes of increasing complexity, spanning different redshift intervals. We then assess the performance of three complementary redshift space distortion (RSD) models in configuration and Fourier space, adopted for the analysis of the complete DR16 eBOSS sample of Luminous Red Galaxies (LRGs). We find that all the methods are mutually consistent, with comparable systematic errors on the Alcock-Paczynski parameters and the growth of structure, and robust to different HOD prescriptions - thus validating the robustness