2022년도 봄 한국천문학회 학술대회
발표논문 초록

구두 발표 논문 초록

포스터 발표 논문 초록

구 두 발 표 초 록

초 청 강 연

[초 IT-01-01] UNESCO's Memory of the World

Kyung Joon Lee (이경준)
Seoul National University (명예교수 겸 산림녹화 기록물 UNESCO 등재 추진위원장)

UNESCO 세계기록유산 등재제도는 1992년 처음으로 채택되었다. 현재 124개국 432건의 기록물이 등재되어 있다. 한국은 지금까지 총 16건을 등재하여 세계에서 네 번째로, 그리고 아시아에서 가장 많은 기록유산을 보유하고 있다. 현재 국내에서는 산림녹화와 성변측후단자 등 11개 분야의 기록물이 등재신청을 준비 중이다. 연사는 2016년부터 산림녹화기록물 등재추진위원장을 맡아 이 사업을 진행하고 있으며, 추진위원회 구성과 운영, 기록물의 수집, 분류, 전산화(약 1만여 건)의 경험을 공유하고자 한다.

[초 IT-01-02] SeongByeonCheukHuDanJa: preparing to be listed as the UNESCO's Memory of the World (성변측후단자 UNESCO 세계기록유산 등재를 준비하며)

Hong-Jin Yang (양홍진)
KASI (& 성변측후단자 UNESCO 등재 추진 준비위원회)

星變測候單子는 조선시대 관상감에서 천변을 기록한 관측일지이다. 현재 국내에는 3개의 혜성을 관측한 38장의 관측일지가 남아 전해지고 있는데 1759년(영조 35) 4월의 기록은 핼리혜성을 관측한 것이다. 이들 자료는 혜성의 위치와 형태를 필사한 그림과 함께 관측 시각, 혜성의 위치와 꼬리의 길이, 방향 등을 매일 기록한 것이다. 본 발표에서는 유네스코 세계기록유산 등재 추진을 위해 성변측후단자의 특징과 의미를 간단히 소개하고 그 역사적 가치를 살펴보고자 한다.

[초 IT-02] APEX – An OSIRIS-REx extended mission to asteroid Apophis

Michael C. Nolan
University of Arizona

After the OSIRIS-REx spacecraft returns its sample of asteroid Bennu on September 24 2023, the spacecraft will be available for an extended mission. The instruments are mostly in good working health, and we have sufficient fuel for detailed operations around an asteroid for several years. The team plans to rendezvous with asteroid Apophis in 2029, shortly after the very close encounter of that asteroid with the Earth. We plan 18 months of observations to characterize the asteroid and study any effects of the close Earth approach on its surface. We plan to finish this campaign by using the spacecraft thrusters to excavate a crater, and then study the crater and excavated material in detail. This plan has been submitted to NASA for evaluation, and we expect a decision around the time of the conference.

[초 IT-03] Cassiopeia A: A Prototypical Supernova Remnant for the Study of Core-Collapse Supernova Explosions

Bon-Chul Koo
Department of Physics and Astronomy, Seoul National University

The explosion of core-collapse supernova (SN) is one of the outstanding problems in modern astrophysics. There has been significant progress in both observation and theory during the past decades, but many questions about the nature of the explosion remain unanswered. Cassiopeia A (Cas A) is the youngest (~340 yr) confirmed core-collapse supernova remnant (SNR) in the Milky Way, the SN type of which (SN IIb) has been securely determined from light echo. It is also relatively nearby (3.4 kpc), providing a unique opportunity to see the detailed spatial and kinematic distributions of SN ejecta material as well as the circumstellar material ejected just before the explosion. As such, the remnant has been subject to extensive studies in all wavebands since its discovery in 1943, revealing to us the great details of astrophysical processes in a massive star explosion. In this talk, I will introduce the uniqueness of Cas A in the study of core-collapse SN explosions and present our recent results obtained from near-infrared studies.

[초 IT-04] SPECTR: Spectrophotometer for Transmission Spectroscopy of Exoplanet Systems

Myeong-Gu Park(박명구)[1], Kang-Min Kim(김강민)[2], Yeon-ho Choi(최연호)[2], Chan Park(박찬)[2], Inwoo Han(한인우)[2], Byeong-Cheol Lee(이병철)[2], Ueejeong Jeong(정의정)[2], Be-Ho Jang(장비호)[2], Jeong Gyun Jang(장정균)[2], Sang-Min Lee(이상민)[2], Tae-Yang Bang(방태양)[1], Jae-Rim Koo(구재림)[1]
[1]Kyungpook National University (optionally affiliation in Korea in parenthesis), [2]Korea Astronomy and Space Science Institute

We have developed SPectrophotometer for TRansmission spectroscopy (SPECTR), which is

optimized for observing a transiting exoplanet system simultaneously with the comparison star. SPECTR has a direct-view structure with removable VPHG grism. SPECTR has a wide field of view of 10′ with a spectral resolution R > 400 and 8 slits of width raging from 1.4″ to 25″. SPECTR is easily installed into the CIM of 1.8m BOAO telescope as two cartridges, which facilitates the utilization of CIM lamp and slit viewing camera systems. System control and data acquisition software are also developed. Test observation of TESS transit targets successfully produced planetary radius spectrum for HD 189733 (V = 7.7) and the photometric precision was about 1.2 mmag.

특별포럼

[주제발표] Special Forum: Korea Space Exploration in the 4th Plan for Promotion of Space Development
제4차 우주개발진흥 기본계획 우주탐사 분야 방향성 모색

Ryun Young Kwon, Korea Space Policy Research Center(국가우주정책연구센터)..
Science and Technology Policy Institute, Korea Space Policy Research Center(과학기술정책연구원, 국가우주정책연구센터)

과학기술정책연구원 국가우주정책연구센터에서는 향후 5년간(2023년~2027년)의 구체적 국가 우주개발 계획과 2050년까지의 정책비전을 담는 제4차 우주개발진흥 기본계획 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. 천문학/우주과학 목적 '우주탐사'는 이런 변화를 이끌 수 있는 중요한 주제인 동시에, 또한 국제협력을 통해 선진국의 기술을 흡수할 수 있는 좋은 수단이기도 합니다. 이에 대한민국 천문학과 우주과학을 이끌고 계시는 한국천문학회 회원님들을 모시고 대한민국 우주탐사의 미래 비전, 방향성, 추구할 임무·과학, 이들을 실현할 수 있는 전략 등에 대해 소중한 의견을 듣고자 합니다.

외부은하 / 은하단

[박 GC-01] Parsec-scale jet properties of active galactic nuclei located in a wide range of density environment

Junhyun Baek (백준현), and Aeree Chung (정애리)
Yonsei University (연세대학교)

The feeding and feedback processes associated with the active galactic nucleus (AGN) are believed to play a critical role in a supermassive black hole (SMBH) - galaxy co-evolution. This may imply that the SMBH of the sub-parsec scale is closely connected with the host galaxy of a much larger scale. The primary goal of this thesis is to investigate how the large-scale galactic environment of the host galaxy ultimately affects small-scale AGN activity. For this, we probed newly launched parsec-scale jet properties of AGNs located in a wide range of density environments: from ellipticals/spirals in the local universe (z < 0.05) to brightest cluster galaxies (BCGs) in galaxy clusters (z < 0.3). Throughout the thesis, we used our own data from KVN, KaVA, and VLBA, which was complemented by archival radio and other wavelength data. Our results reveal the parsec-scale jet only in a small fraction of our AGN sample, indicating that recently launched AGN jet is not common. Intriguingly, those AGNs with parsec-scale jets are either showing signs of tidal interactions or located in the environment where the gas accretion is likely effective such as galaxy groups or the center of galaxy clusters with a well-developed cooling gas flow. These imply that mass accretion onto the SMBH indeed plays a key role in triggering the AGN activity. The importance of mass accretion is also supported by our monitoring of the AGNs hosted by BCGs in cool-core clusters in which half of the radio BCGs show year-scale variabilities. Using one BCG case, we discuss how the multi-phase gas can be accreted from the cluster cooling flow of Mpc-scale onto the central SMBH in sub-parsec scale, (re)triggering the central AGN.

[구 GC-02] Spectroscopic reverberation mapping of the intermediate-mass AGN in NGC 4395

Hojin Cho, Jong-Hak Woo, and NGC 4395 Collaborations
Department of Physics & Astronomy, Seoul National University

The active galactic nucleus (AGN) of NGC 4395 is one of few confirmed cases of intermediate-mass black holes (IMBHs). Due to its extremely low luminosity, the size of its broad line region (BLR) is estimated to be only a couple of light-hours. This makes NGC 4395 an extremely challenging target for reverberation mapping study, a traditional method of determining the black hole masses of AGNs. We present the results of our intra-night

optical spectroscopic reverberation mapping on NGC 4395. Using Gemini-N and Keck-I telescopes, we acquired a time series of high signal-to-noise-ratio spectra, accompanied by a number of 1-m class telescopes to provide photometric light curves. Due to the spatially resolved narrow-line region (NLR) of this nearby Seyfert 1 galaxy, its contribution to the slit spectra was variable over the course of observation, rendering the standard procedure of relative flux calibration based on narrow lines impractical. We demonstrate that spatially resolved data from the IFU spectrographs can be effectively used to correct the slit-based spectral light curves. We found the upper limit of the broad-line time lag to be 3 hrs, which is consistent with the photometric broad-line time lag previously reported. By exploiting the high-quality spectra, we measure the second moment of the broad component of the Hα emission line to be 586 ± 19 km s^{-1}. Combining these, we measure the black hole mass to be (1.7 ± 0.3) × 10^4 $M_\odot$. This is far smaller than other measurements on the same AGN. We will discuss the implications.

[구 GC-03] Medium-band Observation of Neutrino Emitting Blazar, TXS 0506+056

Sungyong Hwang[1,2], Myungshin Im[1,2], Yoon Chan Taak[1,2], Insu Paek[1,2], Changsu Choi[1,2], Suhyun Shin[1,2], Sang-Yun Lee[1], Tae-Geun Ji[3], Soojong Pak[3], Hye-In Lee[3], Hojae Ahn[3], Jimin Han[3], Changgon Kim[4], Jennifer Marshall[5], Christopher M. Johns-Krull[6], Coyne A. Gibson[7], Luke Schmidt[5], Travis Prochaska[5]
[1]Astronomy Program, Department of Physics & Astronomy, Seoul National University
[2]SNU Astronomical Research Center, Seoul National University
[3]School of Space Research and Institute of Natural Sciences, Kyung Hee University
[4]Department of Astronomy and Space Science, Kyung Hee University
[5]Mitchell Institute for Fundamental Physics and Astronomy and Department of Physics and Astronomy, Texas A&M University
[6]Department of Physics & Astronomy, Rice University
[7]McDonald Observatory

TXS 0506+056 is a blazar that has been recently identified as the counterpart of the neutrino event IceCube-170922A. Understanding the blazar type of TXS 0506+056 is important to constrain the neutrino emission mechanism, but the blazar nature of TXS 0506+056 is still uncertain. As an attempt to understand the nature of TXS 0506+056, we report the medium-band observation results of TXS 0506+056, covering the wavelength range of 0.575-1.025 μm. The use of the medium-band filters allows us to examine if there were any significant changes in its spectral shapes over the course of one month and give a better constraint on the peak frequency of synchrotron radiation with quasi-simultaneous data sets. The peak frequency is found to be 1014.28 Hz, and our analysis shows that TXS 0506+056 is not an outlier from the blazar sequence. As a way to determine the blazar type, we also analyzed if TXS 0506+056 is bluer-when-brighter (BL Lac type and some flat spectrum radio quasars, FSRQs) or redder-when-brighter (found only in some FSRQs). Even though we detect no significant variability in the spectral shape larger than observational error during our medium-band observation period, the comparison with a data set taken in 2012 shows a possible redder-when-brighter behavior of FSRQs. Our results demonstrate that medium-band observations with small to moderate-sized telescopes can be an effective way to trace the spectral evolution of transients such as TXS 0506+056.

[구 GC-04] The Infrared Medium-deep Survey. IX. Discovery of Two New z ~ 6 Quasars and Space Density down to M_{1450} ~ -23.5 mag

Yongjung Kim[1,2], Myungshin Im[3,4], Yiseul Jeon[5], Minjin Kim[1], Linhua Jiang[2,6], Suhyun Shin[3,4], and IMS team.
[1]Kyungpook National University. [2]Kavli Institute for Astronomy and Astrophysics. [3]SNU Astronomy Research Center. [4]Seoul National University. [5]FEROKA Inc. [6]Peking University

We present the result of the Infrared Medium-deep Survey (IMS) z ~ 6 quasar survey, using the combination ofo the IMS near-infrared images and the Canada-France-Hawaii Telescope Legacy Survey (CFHTLS) optical images over 86 deg^2. In addition to the traditional color-selection method, we introduce the corrected Akaike Information Criterion (AICc) with the high-redshift quasar and late-type star models to prioritize the candidates efficiently. We found seven plausible candidates finally passed AICc selection of which three are known quasars at z ~ 6. The follow-up spectroscopic observations for the remaining four candidates were carried out, and we confirmed that two out of four are z ~ 6 quasars. With this complete sample, we revisited the quasar space density at z ~ 6 down to M_{1450} ~ -23.5 mag. Our result supports the low quasar space density at the luminosity where the quasar's ultraviolet ionizing emissivity peaks, favoring a minor contribution of

quasars to the cosmic reionization.

[구 GC-05] A New Iron Emission Template for Active Galactic Nuclei. I. Optical Template for the Hβ region

Daeseong Park (박대성)[1,2], Aaron J. Barth[3], Luis C. Ho[4], Ari Laor[5]
[1]Kyungpook National University, [2]Korea Astronomy and Space Science Institute, [3]University of California - Irvine, [4]Peking University, [5]Technion - Israel Institute of Technology

We provide a new and improved empirical template covering the 4000-5600Å range for optical iron emission in Active Galactic Nuclei (AGN). The high-quality spectra that have complete and quasi-simultaneous UV-to-optical coverage were obtained consistently with the Hubble Space Telescope (HST) for a new and better iron template basis object, Mrk 493, having preferable properties such as narrower broad-line width and negligible intrinsic reddening than the former I Zw 1 on which most existing empirical templates are based. The improved multicomponent spectral decomposition technique and extensive list of lines were used to the HST data to produce a comprehensive empirical template that consists of all the identified broad and narrow iron lines with additional related metal lines. By performing extensive comparison and application tests on SDSS AGN spectra, we show that our new template outperforms previous empirical templates that have a monolithic structure in terms of statistical performance, recovery of Balmer line profiles, and yielding arguably more accurate spectral measurements, and there is a systematic trend of spectral fitting quality as a function of Hβ broad-line width depending on a template choice. This trend can consequently introduce a systematic bias on black hole mass estimates by ~0.1 dex offset on average and possibly up to ~0.3-0.5 dex for individual objects.

[구 GC-06] BASS DR2: Spectroscopic line measurements and AGN demographics

Kyuseok Oh[1,2],*, Michael J. Koss[3,4], Yoshihiro Ueda[2], Daniel Stern[5], Claudio Ricci[6,7], Benny Trakhtenbrot[8], Meredith C. Powell[9], Jakob S. Den Brok[10,11], Isabella Lamperti[12], Richard Mushotzky[13], Federica Ricci[14,15], Rudolf E. Bar[10], Alejandra F. Rojas[16], Kohei Ichikawa[17,18], Rogerio Riffel[19], Ezequiel Treister[20], Fiona Harrison[21], C. Megan Urry[22], Franz E. Bauer[20,23,4], Kevin Schawinski[24]
*[1]Korea Astronomy and Space Science Institute, [2]Kyoto University, [3]Eureka Scientific, [4]Space Science Institute, [5]Jet Propulsion Laboratory, [6]Universidad Diego Portales, [7]Peking University, [8]Tel Aviv University, [9]Stanford University, [10]ETH Zurich, [11]University of Bonn, [12]Centro de Astrobiologia, [13]University of Maryland, [14]Universita di Bologna, [15]INAF, [16]Universidad de Antofagasta, [17]Max-Planck-Institut for Extraterrestrische Physik, [18]Tohoku University, [19]Universidade Federal do Rio Grande do Sul, [20]Pontificia Universidad Catolica de Chile, [21]California Institute of Technology, [22]Yale University, [23]Millennium Institute of Astrophysics, [24]Modulos AG, *JSPS fellow*

We present the second data release of optical spectral line measurements and AGN demographics of the BAT AGN Spectroscopic Survey, which focuses on the Swift-BAT hard X-ray detected AGNs. We use spectra from dedicated campaigns and publicly available archives to investigate spectral properties of the AGNs listed in the 70-month Swift-BAT all-sky catalog; specifically, 743 of the 746 unbeamed and unlensed AGNs (99.6%). We find a good correspondence between the optical emission line widths and the hydrogen columnn density distributions using the X-ray spectra, with a clear dichotomy of AGN types for NH-10^22 cm^-2. Based on optical emission-line diagnostics, we show that 48%-75% of BAT AGNs are classified as Seyfert, depending on the choice of emission lines used in the diagnostics. Compared to optically-selected narrow-line AGNs in the Sloan Digital Sky Survey, the BAT narrow-line AGNs have a higher rate of reddening/extinction, with Halpha/Hbeta > 5 (~36%), indicating that hard X-ray selection more effectively detects obscured AGNs from the underlying AGN population. Finally, we present a subpopulation of AGNs that feature complex broad-lines (34%, 250/743) or double-peaked narrow emission lines (2%, 17/743).

[구 GC-07] Overdensity of H-alpha Emitters Around an Extremely Massive Quasar at z = 1.47

Hyunsung Jun[1,3], Myungshin Im[1], Minhee Hyun[2], Yongmin Yoon[3], Peter Eisenhardt[4], Jueun Hong[5], Yiseul Jeon[6], Duho Kim[2], Jae-Woo Kim[2], Ji Hoon Kim[7], Changbom Park[3]
[1]Seoul National University, [2]Korea Astronomy and Space Science Institute, [3]Korea Institute for Advanced Study, [4]Jet Propulsion Laboratory, [5]SPHERE, [6]FEROKA, [7]METASPACE

We measure a strong excess in the galaxy number density around PG 1630+377, an extremely massive (M_BH=10^9.7 M_sun) quasar at z = 1.475, using near-infrared narrowband imaging. We

identify 79 narrow H-band excess objects in a 525 arcmin^2 area including the vicinity and surroundings of the quasar. These sources are likely H-alpha line emitting, star-forming galaxies at z=1.47. We detect a delta= 6.6 overdensity of narrow H-band excess objects located at a projected distance 2.1 Mpc northeast of the quasar, which is the densest region in the target area. The overdensity is present in BzK color-selected galaxies, while a previously reported overdensity in the immediate vicinity of PG 1630+377 is not, and yet appears as a group-like structure. These megaparsec-scale environments are estimated to merge into a 10^14.7 M_sun cluster at present. Our results support the view that extremely massive black holes form and grow in group-scale environments and later incorporate into a galaxy cluster, yet further investigation with a larger sample is necessary.

[구 GC-08] The nature of the faint radio source population through stacking

Emmanuel F. Ocran[1,2], J. M. Stil[4], A. R. Taylor[2,3], M. Vaccari[2,3,5], C. H. Ishwara-Chandra[3,6], Jae-Woo Kim[1]
[1]Korea Astronomy and Space Science Institute, [2]University of the Western Cape, [3]University of Cape Town, [4]University of Calgary, [5]INAF, [6]Tata Institute of Fundamental Research

A global understanding of star forming galaxies (SFGs) and Active Galactic Nuclei (AGN), and their host galaxies in radio hinges on completing a census of star formation, and AGN activity without selection biases down to the low sensitivity regime.

We employ radio data from the Giant Metre-wave Radio Telescope, and the Very Large Array, complemented with the first data release of the LOFAR Two-Metre Sky Survey (LoTSS) to map the ELAIS-N1. At 325, 610 and 1400 MHz, we reach median noise levels of ~70, ~19.5, and ~87 μ Jy/beam respectively. At these depths, and with the selection of sources in the deep LoTSS multiwavelength catalogue, we measure the fluxes in the radio maps to obtain reliable detections for the sources below the survey threshold in the EN1 field.

We stack in flux density, and redshift bins in our radio maps for the SFGs, radio-quiet AGN (RQ AGN), high excitation radio (HERGs) and low-excitation radio galaxies (LERGs) in the LoTSS multiwavelength catalogue. We find statistical evidence of a steepening spectral indices with decreasing flux density for the stacked SFGs and RQ AGN. We investigate how the different populations in our sample lie along the SFR – M★ 'main sequence', for the stacked redshift range of $0≤z<4.5$.

[박 GC-09] Detection and Analysis of Low Surface Brightness Systems in the Outskirts of Nearby Galaxies with KMTNet

Woowon Byun[1], Yun-Kyeong Sheen[1], Luis C. Ho[3,4], Kwang-Il Seon[1,2], Joon Hyeop Lee[1], Sang Chul Kim[1,2], Hyunjin Jeong[1], Byeong-Gon Park[1], Yongseok Lee[1,5], Sang-Mok Cha[1,5], Jongwan Ko[1,2], and Minjin Kim[6]
[1]Korea Astronomy and Space Science Institute, Daejeon 34055, Republic of Korea
[2]University of Science and Technology, Korea, Daejeon 34113, Republic of Korea
[3]Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing 100871, People's Republic of China
[4]Department of Astronomy, School of Physics, Peking University, Beijing 100871, People's Republic of China
[5]School of Space Research, Kyung Hee University, Yongin, Kyeonggi 17104, Republic of Korea
[6]Department of Astronomy and Atmospheric Sciences, Kyungpook National University, Daegu 41566, Republic of Korea

In a ΛCDM cosmology, it is expected that massive galaxies are accompanied by numerous dwarf satellite galaxies, which are eventually disrupted and accreted into the host galaxies, thereby developing a stellar halo of hosts. However, this process has not yet been clearly verified because it can only be traced by observations with extremely low surface brightness (LSB) limits. We have conducted a deep imaging survey using Korea Microlensing Telescope Network (KMTNet) to explore the nature of LSB systems. Through dedicated data reduction, we obtain deep and wide-field images in optical (B & R) bands with a surface brightness limit of ~30-31 mag arcsec-2 in 10″×10″ boxes. Using this dataset, we present the photometric properties of the stellar halo and dwarf satellite galaxies in NGC 1291. In addition, we investigate the properties of star formation (SF) in the outer disk of massive spiral galaxies (NGC 1512 & NGC 2090) using BVRI and Hα images obtained with KMTNet, along with the multiwavelength data. We find that there is a deficit of Hα flux relativel to UV in the outskirts of the target galaxies, which may be induced by intensive SF with a short e-folding time that occurred ~10 Myr ago. Our study demonstrates the capabilities of KMTNet for the LSB studies, and that the imaging data from our survey can be useful to investigate the characteristics of the LSB systems.

[구 GC-10] Properties of Fast and Slow Bars Classified by Epicyclic Frequency Curves from Photometry of Barred Galaxies

Yun Hee Lee[1], Myeong-Gu Park[2], Ho Seong Hwang[1,3], Hong Bae Ann[4], Haeun Chung[5], and Taehyun Kim[2]
[1]Korea Astronomy and Space Science Institute (KAS), [2]Kyungpook National University, [3]Seoul National University, [4]Pusan National University, [5]University of Arizona

We test the idea that bar pattern speeds decrease with time owing to angular momentum exchange with a dark matter halo. If this process actually occurs, then the radii of the corotation resonance and other resonances should generally increase with time. We, therefore, derive the angular velocity Ω and epicyclic frequency κ as functions of galactocentric radius for 85 barred galaxies using photometric data. Mass maps are constructed by assuming a dynamical mass-to-light ratio and then solving the Poisson equation for the gravitational potential. The locations of Lindblad resonances and the corotation resonance radius are then derived using the standard precession frequency curves in conjunction with bar pattern speeds recently estimated from the Tremaine-Weinberg method as applied to integral Field Spectroscopy (IFS) data. Correlations between physical properties of bars and their host galaxies indicate that bar length and the corotation radius depend on the disk circular velocity while bar strength and pattern speed do not. As the bar pattern speed decreases, bar strength, length, and corotation radius increase, but when bars are subclassified into fast, medium, and slow domains, no significant change in bar length is found. Only a hint of an increase of bar strength from fast to slow bars is found. These results suggest that bar length in a galaxy undergoes little evolution, and is determined instead mainly by the size of their host galaxies.

[박 GC-11] Study of High Redshift Galaxies at Different Environments with Multi-object Spectroscopic and Submm Observations

Minhee Hyun[1,2], Myungshin Im[2]
[1]Korea Astronomy and Space Science Institute, [2]SNU Astronomy Research Center (SNUARC), Seoul National University

It is well known that galaxy evolution is affected by its environment. Galaxy clusters and superclusters, which are sitting on the top of the hierarchy structure formation in the universe, are valuable objects to witness various types of galaxies and environments and study how the properties of galaxies changed with their surroundings. Despite the advantage and uniqueness of the study, it has not been widely performed at higher redshifts due to the lack of wide and deep multi-wavelength datasets and spectroscopic data. In this thesis, we firstly performed the survey of galaxy clusters and large-scale structures at $z \gtrsim 1$ and confirmed them with Multi-Object Spectroscopic observation (hereafter, MOS). Furthermore, we investigate sub-millimeter galaxies, which are thought to be dusty star-forming populations in the high redshift ($z \gtrsim 3$) with sub-mm data.

[구 GC-12] KS4 Massive Galaxy Cluster Candidates in the Southern Sky

Bomi Park[1], Myungshin Im[1], Joonho Kim[3,1], Minhee Hyun[2], Seong-Kook Lee[1], Jae-Woo Kim[2], Eunhee Ko[1] and KS4 team
[1]SNU Astronomy Research Center, Department of Physics and Astronomy, Seoul National University, Seoul 08826, Korea
[2]Korea Astronomy and Space Science Institute, Daejeon 34055, Korea
[3]Daegu National Science Museum, 20, Techno-daero 6-gil, Yuga-myeon, Dalseong-gun, Daegu 43023, Republic of Korea

Galaxy clusters are the largest structures in the universe located at the top of the cosmological hierarchical model, so the evolution of the universe can be understood by studying clusters of galaxies. Therefore, finding a larger number of galaxy clusters plays an important role in exploring how the universe evolves. A large number of catalogs for galaxy clusters in the northern sky have been published; however, there are few catalogs in the southern sky due to the lack of wide sky survey data. KMTNet Synoptic Survey of Southern Sky(KS4) project, which observes a wide area of the southern sky about 7000 deg2 with KMTNet telescopes for two years, is in progress under the SNU Astronomy Research Center. We use the KS4 multi-wavelength optical data and find massive galaxy clusters at redshift z<1 using the cluster red-sequence method. This will improve the study of galaxy clusters in the southern sky.

[구 GC-13] Testing Web Feeding Model for Star Formation in Galaxy Clusters in the COSMOS Field

Eunhee Ko[1], Myungshin Im[1], Seong-Kook Lee[1], Min hee Hyun[2],and Bomi Park[1]

[1]Astronomy program, Dept of Physics&Astronomy, Seoul National University
[2]Korea Astronomy and Space Science Institute

It is yet to be understood what controls the star formation activity in high-redshift galaxy clusters. One recently proposed mechanism is that the star formation activity in galaxy clusters is fed by cold gas and star-forming galaxies in large-scale structures surrounding them, which we call the "web feeding model". Using galaxies in the COSMOS2020 catalog, with mass completeness at $\log(M/M\odot) \geq 8.78$ and reliable photometric redshift dataσ $\delta z/(1+z)\approx 0.01$, we study the star formation activities of galaxy clusters and their surrounding environment to test the web feeding model. We first identify the 76 overdense regions at $0.1\leq z\leq 1.4$ with number density exceeding the 4 σ-level from photometric redshift data as galaxy clusters. Furthermore, we identify galaxy large-scale structures and present the anti-correlation between quiescent galaxy fraction, an indicator of star-forming activity, and the prevalence of galaxy large-scale structures. We propose that variation of quiescent galaxy fraction at $z \sim 1$ can be explained by the web feeding model.

[구 GC-14] Evidence for Impact of Galaxy Mergers on Properties of Early-type Galaxies

Yongmin Yoon[1], Changbom Park[1], Haeun Chung[2], Gu Lim[3], and Richard R. Lane[4]
[1]School of Physics, Korea Institute for Advanced Study (KIAS), [2]University of Arizona, Steward Observatory, [3]Center for the Exploration of the Origin of the Universe (CEOU), Astronomy Program, Department of Physics and Astronomy, Seoul National University, [4]Centro de Investigacion en Astronomia, Universidad Bernardo O'Higgins

We provide observational evidence that galaxy mergers significantly affect properties of early-type galaxies (ETGs) such as stellar population age, internal structure, and stellar kinematics (e.g., specific angular momentum within the half-light radius λ_R). Our study is based on deep coadded images of the Stripe 82 region and MaNGA integral field unit spectroscopic data of the Sloan Digital Sky Survey. In this study, tidal features around ETGs, which are detected in the deep images, are used as direct evidence for mergers that occurred recently. Our main results show that tidal features are more frequent in younger and more compact ETGs and ETGs with dust lanes, which suggests that those ETGs are involved in recent mergers. We also find that λ_R is lower in ETGs with tidal features than in those without tidal features, in the case of ETGs that do not have dust lanes. This suggests that galaxy mergers can generally lower the angular momentum of ETGs. By contrast, ETGs with dust lanes are fast rotators, and ETGs with both dust lanes and tidal features have the highest λ_R, which indicates that gas-rich mergers can enhance the angular momentum of ETGs.

[석 GC-15] HI gas kinematics of galaxy pairs in cluster environments from ASKAP pilot observations

Shin-Jeong Kim[1], Se-Heon Oh[1,2], Minsu Kim[2], Hye-Jin Park[3], Shinna Kim1, and ASKAP WALLABY Science Group [2] (SWG 2)
*[1]Department of Physics and Astronomy, Sejong University, Seoul, Repulic of Korea
[2]Department of Astronomy and Space Science, Sejong University, Seoul, Republic of Korea
[3]Research School of Astronomy and Astrophysics, The Austrailian National University, Canberra ACT 2600, Austrailia*

We examine the HI gas kinematics and distributions of galaxy pairs in group and cluster environments from the Widefield ASKAP L-band Legacy All-sky Blind surveY (WALLABY) pilot observations undertaken with the Australian Square Kilometer Array Pathfinder (ASKAP). We investigate the well-resolved close galaxy pairs in the two galaxy clusters (Hydra and Norma) and a galaxy group (NGC 4636) which are identified from their visual inspection and spectroscopic information. We perform profile decomposition of HI velocity profiles of the galaxies using a new tool, BAYGAUD which allows us to decompose a line-of-sight velocity profile with an optimal number of Gaussian components based on Bayesian nested sampling techniques. Then, we construct HI superprofiles by co-adding all individual line profiles after aligning the central velocities. We fit a double Gaussian model to the HI superprofiles and classify them as kinematically narrow and broad HI gas components with respect to their velocity dispersions, i.e., narrower or wider σ, respectively. Additionally, we quantify the HI morphological disturbances and gravitational instability of the HI gas disk of the sample galaxies using Toomre Q parameters. We investigate the cluster environmental effects on the HI gas properties of galaxy pairs by comparing the HI superprofiles, HI morphological asymmetries, and Toomre Q parameter values of the sample galaxies in three different environments, 1) cluster, 2) infalling and 3) field which are defined in the phase-space diagram of the galaxy group and clusters. Our results show that the cluster environment seems to impact the HI gas properties

of galaxies in a way of decreasing the kinematically narrow HI gas and increasing the Toomre Q values of the infalling and cluster galaxies. This trend is more obvious for the galaxy pairs being closer to the cluster.

[구 GC-16] Calibration of Simulated Universe with Observed Universe

Yongseok Jo
Seoul National University

Over the decades, simulations and observations have made significant progresses. N-body simulations have successfully simulated the structure formation and large-scale structure of the ΛCDM universe. Moreover, hydrodynamic simulations that include comprehensive physical models such as galactic winds and AGN feedback have been performed in a cosmological context. Numerical simulations, now, have become an indispensable tool for understanding galaxy formation and evolution. In the meanwhile, wide-field and deep surveys have identified samples of more than thousands of nearby and distant galaxies, respectively. Furthermore, high-resolution imaging and spectroscopy have enabled investigations on the structure and kinematics of galaxies. The remarkable progress of simulations and observations has provided considerable insights into physical processes for galaxy formation and evolution and has played a crucial role in constraining theoretical models. However, concerning physical models for galaxy formation and evolution on a cosmological scale, the link between simulations and observations is sundered in the absence of explicit constraints. The reconciliation of simulation and observation has been challenging due to the following: (1) complex and intertwined relations between physical processes and observable and (2) high dimensionality of observable and astrophysical-parameter space. However, the emerging power of machine learning show potential to carry out such studies. To tackle this challenge, We employ the simulation-based inference technique (SBI) to retrieve the posterior distribution over parameters of a cosmological simulation given observable. We find that the SBI works well in our setup so that we can infer a set of parameters that can reproduce the target observation. However, due to resolution effect and limited dimension of parameter space, the physics of the inferred parameters is not clear and it fails to match the stellar mass functions at several different redshifts simultaneously.

[구 GC-17] The Metallicity Distribution Function in Outer Halo Fields of Simulated Elliptical Galaxies Compared to Observations of NGC 5128

Ena Choi (최이나)[1], Jeremiah P. Ostriker[2], Michaela Hirschmann[3], Rachel S. Somerville[4], Thorsten Naab[5]
[1]*Korea Institute for Advanced Study (한국고등과학원),* [2]*Columbia University,* [3]*University of Copenhagen,* [4]*Center for Computational Astrophysics, Flatiron Institute.*
[5]*Max-Planck-Institut für Astrophysik*

Stellar metallicity distribution functions (MDF) have been measured for resolved stellar populations in the outer halos of many galaxies in nearby groups. Among them, the MDF of NGC 5128, the central giant elliptical in the Centaurus group, provides essential constraints for theories of massive galaxy formation and hierarchical assembly. To investigate the formation and chemical evolution history of the outer halo of giant elliptical galaxies, we examine the chemical properties of three zoom-in high resolution cosmological hydrodynamical simulations of an NGC 5128-like giant elliptical galaxy and compare their outer halo MDFs to the observed one of NGC 5128. Even though the simulated galaxies have different merging histories and age distributions, all predicted MDFs are in good qualitative agreement with the observed one. The median metallicity of the simulated galaxies is on average [M/H]=-0.41±0.06 compared to the observed value of [M/H]=-0.38±0.02 for NGC 5128, and the dispersion in metallicity is ~ 0.77 dex for both observed and simulated galaxies. We investigate the origin of the stars ending up in the outer halo field of simulated galaxies and show that most have an `accreted' origin, formed in other small galaxies and later accreted in mergers. Only ~15 percent of the stars are formed `in situ' within the main progenitor of galaxy and radially migrate outwards. We show that the contribution of metal-rich in situ stars is sub-dominant in the outer halos of our simulated galaxies, but can be prominent in the inner regions.

[구 GC-18] Modelling Lyman-alpha emitters (LAEs) and properties of simulated LAEs: an empirical approach

Jaehong Park[1], Changbom Park[1], Jaehyun Lee[1] and Juhan Kim[1]
[1]*Korea Institute for Advanced Study*

Lyman-alpha emitters (LAEs) are known to be young and active star-forming galaxies. LAEs allow us to investigate properties of high redshifts

galaxies(z > 2) due to its strong Lyman-alpha emission line that is redshifted into a visible window. We model LAEs using Horizon Run 5, a cosmological hydrodynamical simulation with a large volume (a Gpc scale) resolving ~ 1kpc. In this modelling, we use a probability distribution function of the rest-frame equivalent width of LAEs obtained from the relation between the equivalent width and the rest-frame UV magnitude. We present the rest-frame UV luminosity functions at z = 2 - 10, and Lyman-alpha luminosity functions (LFs) at z = 2.4, 3.1, and 4.5. Then, we compare the predicted Lyman-alpha LFs with the preliminary result of the ODIN (One-hundred-square-degree Dark energy camera Imaging in Narrowband) survey, a deep narrow-band survey aimed at identifying LAEs at z = 2.4, 3.1, and 4.5 with an unprecedented volume (91 deg^2).

[구 GC-19] Simulated galaxies with an observer's view: from kinematics to photometry

Jaekyoung Jang, Jinsu Rhee, Sukyoung K. Yi
Department of Astronomy and Yonsei University Observatory, Yonsei University, Seoul 03722, Korea

Galaxies are considered complex systems with various sub-structures that are the result of the complex history of galaxy evolution. Bulge and Disk are typically found in most of external galaxies through surface photometric profile fitting. Recent hydrodynamic cosmological simulations with fine resolutions can be used to decompose galaxies based on the kinematics of the stellar particles, and thus are useful to test or confirm the observational finding.

We use the high spatial resolution (35 pc) cosmological hydro simulation, NewHorizon (NH) to perform a kinematical decomposition in the three-dimensional phase space with , , . We search for the clustering of the star particles in thesse spaces using the Gaussian Mixture Model (GMM). We perform photometric decomposition based on the Srsic profile, two-component fitting with the Monte-Carlo Markov-Chain (MCMC) where mock images were generated using the radiative transfer code SKIRT. We also measured the spin parameters of the galaxies in NH for various values of inclinations.

Surprisingly, we only found a weak correlation between the Disk-to-Total ratio, [D/T], between the kinematic and photometric decomposition tries: . We have found that about a half of the NH galaxies show a single component by photometric decomposition, while the same galaxies have both spheroidal and disk components of significant quantities based on kinematic information. The spin parameter and v/sigma naturally show a tighter relation with . We also found diverse subcomponents of the dispersion-dominant component of galaxies. In particular, a "core" component with was often found regardless of galaxy morphology. The core components often show higher metallicity than the other spheroidal subcomponents but interestingly are younger. We present the details of our findings.

[구 GC-20] The star formation quenching and transition epoch of the Horizon-AGN galaxies

Seyoung Jeon, Sukyoung K. Yi, San Han, Ryan A. Jackson, Jinsu Rhee
Department of Astronomy and Yonsei University Observatory, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea

Galaxies in massive clusters do not form stars as much as field galaxies. Which processes affect star formation in galaxies throughout their entire lifetime is not fully understood.

Using a large-scale hydrodynamical cosmological simulation, Horizon-AGN, we examine the quenched fraction and star formation histories (SFHs) of galaxies, and evaluate their quenching timescale whilst considering their environments simultaneously. Finally, we propose quantitative relations between galaxy properties and star formation features.

We find that massive galaxies have higher quenched fractions and shorter quenching timescales regardless of their environments. Whereas, low-mass galaxies show more prominent environmental dependence. In massive host halos, the timescale of low-mass galaxies could be reduced, and it decreases further if they reside in those halos for a longer time.

Furthermore, we define the 'transition epoch' at which cluster galaxies become less star-forming than field galaxies, which implies that environmental effects start to grow stronger than secular effects. The transition epoch is varied by the stellar and host mass of satellite galaxies. While low mass satellites in massive clusters show the oldest transition epochs of ~8 Gyr ago, it decreases down to ~6 Gyr ago in low mass group halos or for massive satellites.

In addition, the halo-to-stellar mass ratio could be a tracer to indicate not only star formation states but also how environmental quenching can influence the entire evolution of satellite galaxies. For example, satellite galaxies with a higher halo-to-stellar mass ratio show quiescent features such as higher quenched fractions and lower

quenching timescales. Conversely, with decreasing mass ratio, satellite galaxies are more star-forming until the ratio is small enough for internal quenching to be the dominant process.

[구 GC-21] Formation and Morphology of the First Galaxies in the Cosmic Morning

Changbom Park[1], Jaehyun Lee[1], Juhan Kim[1], Donghui Jeong[2,1], Christophe Pichon[3,4,1], Brad K. Gibson[5], Owain N. Snaith[6], Jihye Shin[7], Yonghwi Kim[1], Yohan Dubois[3], and C. Gareth Few[5]
[1]Korea Institute for Advanced Study, 85 Hoegi-ro, Dongdaemun-gu, Seoul 02455, Korea, [2]The Pennsylvania State University, University Park, PA, 16802, USA, [3]CNRS and Sorbonne Universit´e, UMR 7095, Institut d'Astrophysique de Paris, 98 bis, Boulevard Arago, F-75014 Paris, France, [4]IPhT, DRF-INP, UMR 3680, CEA, L'Orme des Merisiers, Ba^t 774, 91191 Gif-sur-Yvette, France, [5]E.A. Milne Centre for Astrophysics, University of Hull, Hull, HU6 7RX, United Kingdom, [6]GEPI, Observatoire de Paris, PSL Research University, CNRS, 5Place Jules Janssen, 92190, Meudon, France, [7]Korea Astronomy and Space Science Institute, 776 Daedeokdae-ro, Yuseong-gu, Daejeon 34055, Korea

We investigate the formation and morphology of the first galaxies in the cosmic morning ($10 \gtrsim z \gtrsim 4$), and their morphological evolution using the Horizon Run 5 cosmological simulation with gravity, hydrodynamics and various sub-grid astrophysics. We measure asymmetry and morphology of stellar mass component of the galaxies with stellar mass $M > 2\times10^9$ $M_\odot$ to classify them into disk, spheroid, and irregular types. We find that the initial morphology of the galaxies in the cosmic morning is dominantly disk type with the Sersic index less than 1.5. The fraction of disk-type galaxies is about 2/3 and that of irregular or spheroid type is about 1/6. Irregular or spheroidal morphology is incidental and transient. The fractions are roughly independent of redshift and also of stellar mass up to $10^{10}M_\odot$. Almost all the first galaxies with $M > 2\times10^9$ $M_\odot$ at redshift $z > 6$ form at initial peaks of the matter density field smoothed with 0.35-cMpc Gaussian filter.

Large-scale structures in the universe emerge and grow like cosmic rhizomes as the underlying matter density uctuations grow and form associations of galaxies in rare overdense regions. The growth of the density field further stretches the realm of the galactic world into relatively lower-density regions along evolving laments. The cosmic web of galaxies forms at lower redshifts when most rhizomes globally percolate. The primordial angular momentum produced by the induced tidal torques on protogalactic regions is correlated with the internal kinematics of galaxies and tightly aligned with the angular momentum of the total galaxy mass. However, the primordial angular momentum only very weakly correlates with the instantaneous morphology and orientation of the stellar component below $z = 6$. The large-scale tidal field imprinted in the initial conditions seems responsible for the dominance of disk morphology, and for the tendency of galaxies to re-acquire a disk post-distortion.

[구 GC-22] Simulating jellyfish features with a gas-rich dwarf galaxy

Jaehyun Lee[1], Taysun Kimm[2], Jeremy Blaizot[3], Harley Katz[4], Wonki Lee[2], Yun-Kyeong Sheen[5], Julien Devriendt[4], Adrianne Slyz[4]
[1]Korea Institute of Advanced Study, [2]Yonsei University, [3]Université Claude Bernard Lyon1, [4]University of Oxford, [5]Korea Astronomy and Space Science Institute

We investigate the formation of jellyfish galaxies using radiation-hydrodynamic simulations of gas-rich dwarf galaxies with a multi-phase interstellar medium (ISM). We find that the ram-pressure-stripped (RPS) ISM is the dominant source of molecular clumps in the near wake within 10 kpc from the galactic plane, while in-situ formation is the major channel for dense gas in the distant tail of the gas-rich galaxy. Only 20% of the molecular clumps in the near wake originate from the intracluster medium (ICM); however, the fraction reaches 50% in the clumps located at 80kpc from the galactic center since the ISM-ICM mixing forms a large amount of tail ionized gas with a short cooling time scale (<10 Myr). The tail region exhibits a star formation rate of $0.001\text{-}0.01M_\odot yr^{-1}$, and most of the tail stars are born in the stripped wake within 10 kpc from the galactic plane. These stars induce bright Hα blobs in the tail. We also find that the stripped tails have intermediate X-ray to Hα surface brightness ratios ($FX/FH\alpha \sim 1.5\text{-}20$), compared to the ISM (<1.5) or pure ICM (>>20). Our results suggest that jellyfish features emerge when the ISM from gas-rich galaxies is stripped by strong ram pressure, mixes with the ICM, and enhances the cooling in the tail.

[구 GC-23] Tracking Halo Orbits and Their Mass Evolution around Large-scale Filametns

Hannah Jhee[1], Hyunmi Song[2], Rory Smitn[1,4], Jihye Shin[3], Inkyu Park[1], Clotilde Laigle[5]
[1]Department of Physics, University of Seoul, 163 Seoulsiripdaero, Dongdaemun-gu, Seoul, 02504,

Republic of Korea
[2]Department of Astronomy and Space Science, Chungnam National University, Daejeon 34134, Republic of Korea
[3]Korea Astronomy and Space Science Institute, 776 Daedeok-daero, Yuseong-gu, Daejeon 34055, Republic of Korea
[4]Universidad Technica Frederico de Santa Maria, Avenida Vicuna Mackenna 3939, San Joaquin, Santiago
[5]Institut d'Astrophysique de Paris, UMR 7095, CNRS, and Sorbonne Universite, 98 bis boulevard Arago, 75014 Paris, France

It has been studied that galaxy halos evolve following a typical trajectory on a phase space under the influence of deep gravitational potential of clusters. Similarly, the large-scale filaments could also affect the evolution of halos before falling into the clusters. In this study, using the suite of dark matter only cosmological simulations called *N*-cluster run, we explore the evolution of halos driven by large-scale filaments in phase space. We find that halos around filaments exhibit phase-space trajectories with similarities as galaxies in clusters. We analyze this phase-space trajectory by exploring correlations between halos' initial position, velocity, formation time, and maximum velocity. We also examine the mass evolution of halos as they become filament halos. It turns out that halos tend to grow their mass when they first approach filaments, but the mass growth slows down around the closest approach to filaments. Around denser filaments, halos can undergo mild mass loss while they sink into filaments. Finally we explain the mass segregation around filaments in observations with halo age and dynamical friction.

[구 GC-24] Modeling RPS of the multiphase ISM: a detailed view from TIGRESS simulations

Woorak Choi[1], Chang-Goo Kim[2], Aeree Chung[1]
[1]Department of Astronomy, Yonsei University, Seoul, South Korea [2]Department of Astrophysical Sciences, Princeton University, Princeton, USA

Ram pressure stripping (RPS) is a process that removes the interstellar medium (ISM) quickly, playing a vital role in galaxy evolution. To gain more physical insights into how the multiphase ISM gets affected by RPS, we simulated an inflowing, hot intracluster medium (ICM) with a self-consistently modeled ISM in a local patch of star-forming galactic disks using the TIGRESS framework. Our simulations reveal that the workings of RPS are not only direct acceleration of the ISM by ICM ram pressure but also mixing-driven momentum transfer involving significant phase transition and radiative cooling. The hot ICM passes through the low density channels of the porous, multiphase ISM, while shredding the cool ISM, and creating mixing layers. The ICM momentum is transferred through the mixing layers while populating the intermediate temperature gas. The mixed gas extends beyond galactic disks and forms stripped tails that cool back. The mixing-driven momentum transfer predicts that the more ICM mixes in, the faster the ISM moves, resulting in the anti-correlation of outflow velocity and gas metallicity of the stripped ISM. Star formation can be enhanced up to 50% compared to the model without ICM due to the ISM disk compression by the ICM wind whereas the strong RPS can lead to the quenching of star formation within ~100 Myr. In addition, we discuss the magnetic field properties under the ICM ram pressure based on our JVLA observations, for which the comparison with the TIGRESS simulation is also under plan.

[구 GC-25] Properties of Shocks in Simulated Merging Clusters of Galaxies

Eunyu Lee[1], Dongsu Ryu[1], and Hyesung Kang[2]
[1]Department of Physics, College of Natural Sciences, UNIST
[2]Department of Earth Sciences, Pusan National University

Clusters of galaxies form through successive mergers during the hierarchical formation of the large-scale structure of the universe. Those mergers induce shocks in the intracluster medium (ICM). Such merger shocks are detected in the outskirts of galaxy clusters as radio relics, which are diffuse synchrotron emissions from the cosmic-ray electrons accelerated at the shocks. Using a set of cosmological hydrodynamic simulations, we have sampled twelve merging clusters, and studied merger shocks there. The properties of merger shocks depend on the merger parameters such as the mass ratio and impact parameter of merging clusters. Especially, since the merger shocks have ranges of Mach numbers, rather than a single Mach number, we have obtained the Mach number distributions of simulated merger shocks, and examined how they compared to the Mach numbers observed in X-ray and radio. We here present the results and discuss the implications on the physics of the ICM.

[구 GC-26] Effects of seed magnetic fields on small-scale turbulent dynamo in clusters of

galaxies

Hyeseung Lee, Dongsu Ryu
Ulsan National Institute of Science and Technology (UNIST)

Magnetic field is ubiquitous in the universe. For instance, the magnetic field of μG strength has been observed in clusters of galaxies, while it is expected to be weaker in lower density regions of the universe, such as filaments and voids. While the origin of such cosmic magnetic fields still needs to be understood, it is generally believed that weak seed fields have been amplified up to the observed strength by the turbulence produced during the hierarchical formation of the large-scale structure of the universe.

To explore the nature of the seeds of cosmic magnetic fields, we initiated a simulation study to investigate the effects of initial magnetic field on small-scale turbulent dynamo. Considering either uniform or localized seed fields, which model the primordial or astrophysical origins, we reproduced the magnetic fields amplified in the stratified intracluster medium. In this talk, we present the characteristics of the resulting magnetic fields, and compare them to those of observed magnetic fields. Our work is expected to provide a clue to the seeds of cosmic magnetic fields.

성간물질/별생성/우리은하

[구 IM-01] A study of gas and ice chemistry for protostars in the Perseus molecular cloud using the AKARI near-IR slitless spectra

Jaeyeong Kim[1], Jeong-Eun Lee[2], Chul-Hwan Kim[2], Tien-Hao Hsieh[3], Yao-Lun Yang[4], Nadia Murillo[5], Yuri Aikawa[6] and Woong-Seob Jeong[1]
[1]Korea Astronomy and Space Sicence Institute, Daejeon, Korea, [2]Kyung Hee University School of Space Research, Yongin, Korea, [3]Max-Planck-Institute for extraterrestrial Physics, Garching, Germany, [4]The University of Virginia, Department of Astronomy, Charlottesville, US, [5]RIKEN Wako Institute, Saitama, Japan, [6]University of Tokyo, Institute of Astronomy, Tokyo, Japan

We present near-infrared spectra of nine protostars in the Perseus molecular cloud, acquired using the slitless fields of the Infrared Camera onboard the AKARI space telescope. We detected ice absorption features of H_2O, CO_2, and CO at all spectra in 2.5-5.0 ㎛. The presence of the crystalline H_2O and XCN ice components among our targets suggests that they experienced a hot phase via accretion burst during the past mass accretion process. In addition, the ice abundances obtained from the absorption features therein are used as a clock to measure the timescale after the burst event. We compared the ice abundances of the protostars with the gas emissions of N_2H^+ and HCO^+ in their circumstellar envelopes to trace down the thermal history of accretion burst across the evolutionary stages.

[구 IM-02] Impact of Radiation Feedback on the Formation of Globular Cluster Candidates during Cloud-Cloud collisions

Daniel Han[1], Taysun Kimm[1], Harley Katz[2], Julien Devriendt[2], and Adrianne Slyz[2]
[1]Department of Astronomy, Yonsei University, [2]Astrophysics, University of Oxford

Giant molecular clouds (GMCs) are known to be birthplaces of present-day star clusters. Although the star clusters tend to be less massive and compact than globular clusters (GCs), previous studies based on observations and simulations suggest that cloud collisions likely trigger star formation. To investigate the impact of radiation feedback on the formation process of a massive compact cluster, we simulate a head-on collision of two turbulent GMCs. The idealized radiation-hydrodynamic simulations include photo-ionization, direct radiation pressure, non-thermal pressure due to multiple scattering of infrared and Lyman alpha photons, and Type II SN explosions. We find that a gravitationally bound, compact star cluster of mass $M_{GC} \sim 10^5 M_\odot$ forms when two GMCs with mass $M_{GMC} \sim 3{\cdot}6 \times 10^5 M_\odot$ collide. The GC candidate does not form in a single collapsing event but emerges due to the mergers of local dense gas clumps and gas accretion. The momentum transfer due to the absorption of the ionizing photon is the dominant feedback process that suppresses the gas collapse, and photoionization becomes efficient once a sufficient number of stars form. We also discuss the internal metal enrichment and the compactness of the simulated cluster.

[구 IM-03] Photochemistry and Heating/Cooling of the Multiphase ISM with UV Radiative Transfer

Jeong- Gyu Kim[1,3], Munan Gong[2], Chang-Goo Kim[3], Eve C. Ostriker[3]
[1]KASI, [2]MPE Garching, [3]Princeton University

We present an implementation of an efficient and accurate heating/cooling module coupled to UV radiative transfer. We follow the non-equilibrium abundance of hydrogen species and the equilibrium abundance for carbon- and oxygen-containing species, and include key heating and cooling processes to capture thermodynamics of all ISM phases. UV radiation resulting from discrete point sources and diffuse background is followed through adaptive ray tracing and six-ray approximation, respectively, allowing for H2 self-shielding. We validate our implementation against a variety of tests, including gas in chemical and thermal equilibrium, atomic-to-molecular transition, and expansions of HII regions and supernova remnants. We also compare our static two-phase equilibrium model with those available in the literature. Importantly, we find that the pressure at which cold and warm neutral phases balance vary widely depending on how the grain photoelectric heating effect is modeled. Our cooling module is integrated into the TIGRESS framework and will be used for studying the star-forming, multiphase ISM in a range of environments.

[구 IM-04] Effects of Magnetic Fields on Gas Dynamics and Star Formation in Nuclear Rings

Sanghyuk Moon & Woong-Tae Kim
Seoul National University

Polarimetric observations indicate that magnetic fields in disk galaxies are strong at their centers, especially at star-forming nuclear rings in barred galaxies. We use magnetohydrodynamic simulations of nuclear rings to study the effects of magnetic fields on gas dynamics and star formation. Our models adopt the TIGRESS framework to handle radiative heating and cooling, star formation, and supernova feedback, and treat the bar-driven mass inflows using boundary conditions. We find that magnetic fields grow rapidly due to both small- and large-scale dynamo. The torque due to the magnetic tension causes gas in the ring to inflow toward the center, potentially forming central nuclear disks. Magnetic fields provide strong pressure support for the ring gas, making it more stable to local gravitational collapse compared to the hydrodynamic counterpart. A magnetic contribution to the total midplane pressure reduces the demand for the supernova feedback to maintain the vertical force balance, resulting in smaller star formation rates for more strongly magnetized nuclear rings.

[구 IM-05] A Spiral Magnetic Field in a Hub-Filament Structure, Monoceros R2

Jihye Hwang[1,2], Jongsoo Kim[1,2] and BISTRO team
[1]*Korea Astronomy and Space Science Institute*
[2]*University of Science and Technology*

We present the results of polarization observations obtained from SCUBA-2/POL-2 on the JCMT at 850 μm as a part of the JCMT BISTRO survey towards Monoceros R2 (Mon R2). Mon R2 is one of massive star-forming regions containing a clear hub-filamentary structure. We find filaments using FilFinder algorithm and estimate their physical properties and relative directions of filaments compared to the orientations of polarization vectors. The polarization segments and filaments show a spiral structure. We use a rotating magnetized disk model to estimate an underlying mean magnetic field. We subtract the mean magnetic field directions from the observed magnetic field orientations and estimate the dispersion of their angle differences. We also obtain the distribution of volume density from the Herschel column density map, and the distribution of velocity dispersion from $C^{18}O$ (J = 3-2) observations taken with the HARP on the JCMT. Using the Davis-Chandrasekhar-Fermi method, we make maps of magnetic field strengths and mass-to-flux ratios towards Mon R2. Magnetic field strengths vary from 0.02 to 1.45 mG and their mean value is 0.41 ± 0.20 mG. The mean value of mass-to-flux ratios is 1.06. An eastern filament and central regions are magnetically supercritical, but other regions are magnetically subcritical.

[구 IM-06] Magnetic Fields in the Serpens Main Molecular Cloud

Woojin Kwon (권우진) on behalf of the BISTRO team
Seoul National University (서울대학교)

As part of the B-fields in Star-forming Region Observations (BISTRO) survey, which is a large program using the James Clerk Maxwell Telescope (JCMT) to study the roles of magnetic fields in molecular clouds on intermediate scales (a few thousands au or larger scales), we study the magnetic fields in the Serpens Main molecular cloud composed of two subclusters and six filamentary structures. Using the Histogram of Relative Orientation (HRO) technique, which compares polarization directions with density gradients, we find that magnetic fields are parallel to filaments in less dense regions, $N(H_2) < \sim 10^{22}$ cm^{-2}, but perpendicular to dense filamentary structures. Furthermore, applying the HRO technique to denser core regions we identify the density regimes in which the relative magnetic field orientations change again. These transitions are

understood to happen where core formation occurs ($N(H_2) \approx 4.6 \times 10^{22}$ cm^{-2}) and where magnetic fields are dragged-in by infalling material ($N(H_2) \approx 16 \times 10^{22}$ cm^{-2}). In addition, the magnetic field strengths in filamentary structures are estimated by the Davis-Chandrasekhar-Fermi method and compared with turbulence and gravity.

Note: BISTRO (PI) D. Ward-Thompson, (co-PIs) P. Bastien, T. Hasegawa, W. Kwon, S. Lai, and K. Qiu

우주론/암흑물질/암흑에너지

[구 CD-01] Evidence for strong systematic bias in supernova cosmology

Chul Chung, Young-Wook Lee, Seunghyun Park, Junhyuk Son, Seunghyun An
Department of Astronomy, Yonsei University, Seoul, Korea

Unlike the key assumption of supernova (SN) cosmology, recent robust age datings of stellar populations in SN host galaxies show a significant correlation between progenitor age and Hubble residual (HR). Here we show from the Rose et al. (2019) age dataset that this correlation originates from a strong progenitor age dependence of the width-luminosity relation (WLR) and the color-luminosity relation (CLR) in the type Ia SN luminosity standardization process, in the sense that SNe from younger progenitors are fainter each at given light-curve parameters x1 and c. This result is significant at the 4.6σ level. Other host properties show substantially smaller and insignificant differences in the WLR and CLR for the same dataset, indicating that progenitor age is the root cause of the previously reported correlations between host properties and HR. We further show that the observed dimming of SNe with redshift is most likely an artifact of over-correction in the luminosity standardization caused by the incomplete understanding of the stellar astrophysics effect. When this systematic bias with redshift is properly taken into account, there is little evidence left for an accelerating universe from SNe, posing a serious question to one of the cornerstones of the concordance model.

[구 CD-02] A Negative Cosmological Constant?

Rodrigo Calderon[1], Benjamin L'Huillier[2], Radouane Gannouji[3], David Polarski[4]
[1]*Korea Astronomy and Space Science Institute (한국천문연구원),* [2]*Yonsei University (연세대학교),* [3]*Pontificia Universidad Católica de Valparaíso,* [4]*Université de Montpellier*

Following theoretical (high-energy) considerations, we explore the possibility that our Universe contains a *negative* cosmological constant, dubbed λ, on top of an additional component "X" accounting for the late-time accelerated stage of expansion. In this talk, I will present some of the cosmological implications of introducing λ. In particular, we will assess the viability of such models when considering Baryon Acoustic Oscillations, SNeIa and CMB (geometrical) measurements. We estimate the Bayesian evidence in various cosmological scenarios – characterized by a time-varying equation of state for the X component – through a nested sampling of the parameter space, and compare it to base-ΛCDM for model selection. We will briefly comment on their capability to address the current Hubble tension when a high-$H0$ is taken into account.

[구 CD-03] Bayesian vs frequentist: comparing Bayesian model selection with a frequentist approach using the iterative smoothing method

Hanwool Koo[1,2], Ryan E. Keeley[1,3], Arman Shafieloo[1,2], Benjamin L'Huillier[4]
[1]*Korea Astronomy and Space Science Institute,* [2]*University of Science and Technology,* [3]*University of California Merced,* [4]*Sejong University*

We have developed a frequentist approach for model selection which determines the consistency between any cosmological model and the data using the distribution of likelihoods from the iterative smoothing method. Using this approach, we have shown how confidently we can conclude whether the data support any given model without comparison to a different one. In this current work, we compare our approach with the conventional Bayesian approach based on the estimation of the Bayesian evidence using nested sampling. We use simulated future Roman (formerly WFIRST)-like type Ia supernovae data in our analysis. We discuss the limits of the Bayesian approach for model selection and show how our proposed frequentist approach can perform better in the falsification of individual models. Namely, if the true model is among the candidates being tested in the Bayesian approach, that approach can select the correct model. If all of the options are false, then the Bayesian approach will select merely the least incorrect one. Our approach is designed for such a case and we can conclude that all of the models are false.

[구 CD-04] Mulguisin Clustering Algorithm I. – Comparison of Clustering Algorithms for Study of Cosmic Structure Finding

Young Ju[1,2], Sungwook E. Hong[2,3,4], Inkyu Park[1,2], and Cristiano G. Sabiu[1]
[1]Department of Physics, University of Seoul, Seoul, 02504, Korea,
[2]Natural Science Research Institute, University of Seoul, Seoul, 02504, Korea,
[3]Korea Astronomy and Space Science Institute, Daejeon 34055, Korea,
[4]University of Science and Technology, Daejeon 34113, Korea

We propose a new cluster finding algorithm, MGS(MulGuiSin). This was first introduced in the LHC experiment as a jet finder software and it has evolved into 3d clustering program. The algorithm finds the cluster in the galaxy data like other algorithms used in Astronomy such as FoF, MST. But MGS shows results similar to what the human eye finds and it provides also some characteristic topological informations. In this talk, we describe how the algorithm works in detail and compare the MGS performances with those of other known cluster finder algorithms.

[구 CD-05] Detection of the Integrated Sachs-Wolfe Effect with the Rapid ASKAP Continuum Survey (호주 평방 킬로미터 어레이 패스파인더 신속 연속체 조사를 통한 ISW 효과 관측)

Benedict K. W. Bahr-Kalus[1], Jacobo Asorey[2], Stefano Camera[3], Catherine Hale[4], David Parkinson[1], Fei Qin[1]
[1]Korea Astronomy and Space Science Institute (한국천문연구원), [2]Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas, [3]Dipartimento di Fisica, Università degli Studi di Torino, [4]Institute for Astronomy, University of Edinburgh

The evolution of the gravitational potentials on large scales due to the acceleration of the expansion is an important and independent probe of the dark energy. We measure this Integrated Sachs-Wolfe (ISW) effect through cross-correlation using cosmic microwave background maps from the Planck Surveyor and a radio continuum galaxy distribution map from the recent Rapid ASKAP Continuum Survey (RACS). We detect a positive cross-correlation at ~ 2.8 sigma relative to the null hypothesis of no correlation. We parameterise the strength of the ISW effect through an amplitude, and find the constraints to be $A_{\rm ISW} = 0.90^{+0.47}_{-0.43}$, which is consistent with the prediction of an accelerating universe from ΛCDM. The credible interval on this parameter is independent of the different bias models and redshift distributions that were considered, when marginalising over the nuisance parameters. We also detect a power excess in the galaxy auto-correlation angular power spectrum on large scales ($l < 40$), and investigate possible systematic causes.

[구 CD-06] Challenges of BAO peak measurement using photometric data

Christoph Saulder[1], Yong-Seon Song[1], Minji Oh[2]
[1]Korea Astronomy and Space Science Institute (한국천문연구원), [2]Chosun University (조선대학교)

Most BAO studies are conducted using only the spectroscopic data from large surveys such as DESI or SDSS. However such programmes take several years until they have completed their observations, which is an opportunity to use the photometric data of their target selection to carry out preliminary studies of the BAO peak. However this is not as straight forward as one might think, as the BAO peak obtained using photometric redshifts is plagued by unique systematics that need to be understood. I will present methods how one can still meaningful scientific data from those measurements.

고에너지/이론천문학

[구 HT-01] A Simulation Study of Morphologies of FR-I and FR-II jets

Ayan Bhattacharjee[1], Jeongbhin Seo2, Hyesung Kang[2], Dongsu Ryu[1]
[1]Ulsan National Institute of Science and Technology
[2]Pusan National University

Recently, a high-accurate relativistic hydrodynamic (RHD) code, based on the WENO scheme, has been developed (Seo et al. 2021a). The code has been successfully used to study the energetics and detailed flow structure of FR-II (FR: Fanaroff-Riley) type jets, which are characterized by their ultra-relativistic velocity and high jet power (Seo et al 2021b). Here, we report the results of new 3D RHD simulations on the morphological dichotomy of FR I and II jets, injected into stratified background media, using that code. We

conducted a thorough multi-variate excursion of jet parameters, covering a range of jet powers between 10^{42} erg/s (FR-I) to 10^{46} erg/s (FR-II). In general, with decreasing power, the deceleration of jet due to the external entrainment becomes stronger, resulting in the FR-II to FR-I transition in simulated morphological maps. We find that observational effects, such as viewing angle, time of observation, and observational resolution, are important factors in determining the FR-I/FR-II classes. We also carried out some variations of the background profiles, to capture the effects of source location (that is, in galaxy clusters or in filaments) and the contribution of mass loading from stellar winds along the jet path. Even without any contribution of mass loading, low powered jets form more decelerated and spatially diffused structures, resulting in FR-I morphology. However, the effects of mass loading turn out to be more important, although not large, in low powered cases.

Seo, J, Kang, H., & Ryu, D. 2021b, ApJ, 920, 144
Seo, J, Kang, H., Ryu, D., Ha, S., & Chattopadhyay, I. 2021a, ApJ, 920, 143

[박 HT-02] Acceleration of Ultra-high Energy Cosmic Rays at Relativistic Jets

Jeongbhin Seo[1], Hyesung Kang[1], Dongsu Ryu[2]
[1]Pusan National University, [2]Ulsan National Institute of Science and Technology

Relativistic Jets commonly found in powerful astrophysical objects, such as pulsar wind nebulae, gamma-ray bursts, and radio galaxies, are considered as potential acceleration sites of ultra-high energy cosmic rays (UHECRs). To investigate such a scenario, especially aiming at high-power FR-II jets, we initiated a simulation study of ultra-relativistic jets. First, to correctly reproduce the non-linear flow dynamics, we developed a new relativistic hydrodynamic (RHD) code. It is based on a fifth-order accurate weighted essentially non-oscillatory (WENO) scheme with advanced weigh functions and a fourth-order accurate strong stability preserving Runge-Kutta (SSPRK) scheme, and includes a realistic equation of state (EoS) in the relativistic regime. Second, we performed high-resolution simulations of ultra-relativistic jets with the newly developed code. We then analyzed quantitatively the properties of flow structures, such as shocks, shear, and turbulence. Third, we simulated the acceleration and transport of UHECRs in the jet-induced flows, using a Monte-Carlo technique. We found that the most prominent acceleration occurs around the interface between the jet spine and backflow (cocoon) via the so-called relativistic shear acceleration, while shocks and turbulence in the backflow make subordinate contributions. We demonstrated that UHECRs produced in FR II jets could make up a substantial fraction of the populations observed in Telescope Array and Pierr Auger Observatory. In this talk, we describe the simulations and results of our new study.

[박 HT-03] Cosmic Ray Acceleration at Shocks in Galaxy Clusters

Ji-Hoon Ha[1], Dongsu Ryu[1], Hyesung Kang[2] and Sunjung Kim[1]
[1]Department of Physics, School of Natural Sciences UNIST, Ulsan 44919, Korea
[2]Department of Earth Sciences, Pusan National University, Busan 46241, Korea

Major mergers of sub-clusters drive weak shocks with the sonic Mach number $M_s \sim 2 - 4$ in the hot "intracluster medium" (ICM) with temperature, $T \sim 1 - 10$ keV and plasma $\beta \sim 50 - 100$. Those merger-driven shocks, like most astrophysical shocks, are collisionless, and hence are expected to produce cosmic rays (CRs) through diffusive shock acceleration (DSA; a.k.a 1st-order Fermi acceleration). Mpc-scale diffuse radio synchrotron emissions in the outskirt of galaxy clusters (i.e., the so-called radio relics) indicate the acceleration of CR electrons at such ICM shocks. To investigate the kinetic processes involved, we have performed Particle-in-Cell (PIC) simulations with parameters relevant for ICM plasmas. We found that thermal electrons could be preaccelerated through mechanisms mediated by multi-scale plasma waves in supercritical, quasi-perpendicular shocks with $M_s \gtrsim 2.3$, and hence injected to the DSA process. We have also examined the acceleration of CR protons at quasi-parallel shocks, and estimated the emission of γ-rays through $\pi 0$-decay followed by collisions with thermal protons in the ICM. We have confirmed that the predicted γ-ray emission is below the Fermi-LAT upper limits for observed clusters. Our findings will help to understand high-energy astrophysical processes in galaxy clusters.

[구 HT-04] Evolution of Kinetic and Magnetic Energy in a large magnetic Prandtl number System

Kiwan Park
OMEG Soongsil University

Many regions of the universe are in the state of hot, magnetized, and ionized X-ray emitting

plasmas. We numerically simulated the energy spectrum of this highly viscous and conductive system. Without magnetic field, the fluctuating plasma motion decays in the relatively large viscous scale. However, the magnetic field extends the viscous scale to the magnetic diffusivity one yielding a unique energy spectrum. Numerical simulation shows that kinetic and magnetic energy spectrum are $E_V \sim k^{-3.7}$ and $E_M \sim k^{-0.85}$ in the extended viscous scale regime. To explain this extraordinary power law, we set up two simultaneous differential equations for E_V&E_M and solved them using Eddy Damped Quasi Normal Markovianized approximation. Focusing on the most dominant terms, we analytically derived the spectrum relation $E_M^2 \sim k^2 E_V$ consistent with the simulation data. We also simulated the same system with helical energy. The inversely cascaded magnetic energy makes the spectrum steeper. This inverse energy transfer, in addition to the external magnetic field and instabilities, provides us a clue to the diversified spectra characterized $E_V \sim k^{-3.8} - k^{-3.07}$and $E_V \sim k^{-2.17} - k^{-0.27}$with large magnetic Prandtl number.

고천문학/천문역법/교육홍보

[구 HE-01] Investigation of a stone Angbu-ilgu in the late Joseon Dynasty

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

앙부일구(仰釜日晷, Angbu-ilgu, scaphe sundial)는 천구(天球)의 모양을 본떠 만든 반구 형태의 해시계이다. 세종 때인 1434년 처음 만들어 혜정교와 종묘 앞에 설치하여 한양 도성의 서민들도 볼 수 있도록 공공의 목적으로 설치하였다. 현재 남아 있는 금속 재질의 앙부일구는 조선 후기에 제작된 것이 대부분이다. 그 대표적인 예가 국립고궁박물관에 소장된 2개의 앙부일구인 보물 845호(I, II)이다. 반면 석제(石製) 앙부일구도 남아 있는데, 금속제 앙부일구처럼 북극고도와 각종 선들이 조합된 기본 구성을 가지고 있다. 2021년, 국립기상박물관과 함께 기상청에서 소장하고 있는 앙부일구를 조사했다. 이 앙부일구는 검은 돌에 반구의 홈을 파서 해시계를 만들었다. 석제 앙부일구의 외형은 휴대용인 상아제 앙부일구의 모습을 연상시킨다. 아울러 서울역사박물관에도 석제 앙부일구가 있는데, 이는 기상청의 유물과 매우 유사하다. 앙부일구의 명문, 디자인, 제작기법 등이 모두 동일하지만, 크기가 서로 다르다. 본 연구는 석제 앙부일구의 제원 및 명문 등을 비교하고, 앙부일구의 시간선과 절기선의 특성을 토의하고자 한다.

[구 HE-02] The Model of a Mechanical Armillary Sphere Made by a Neo-Confucian at Late Joseon

Byeong-Hee Mihn[1,4], Yong-Hyun Yun[2], Sang Hyuk Kim[1], Ho Chul Ki[3]
[1]*Korea Astronomy and Space Science Institute,*
[2]*National Science Museum,*
[3]*Ghil Institute of Cultural Heritage,*
[4]*Korea University of Science and Technology*

본 연구는 18세기 중반에 나경적(羅景績, 1690~1762)과 홍대용(洪大容, 1731~1783), 안처인(安處仁, 1710~1787)이 제작한 추동식 혼천시계인 통천의(統天儀) 중 혼의에 대한 것이다. 홍대용의 문집인 『담헌서(湛軒書)』의 「농수각의기지(籠水閣儀器志)」에 실린 통천의에 대한 문헌적 분석과 함께 숭실대학교 한국기독교박물관에 전시되어 있는 홍대용 혼천의 유품을 조사하여 통천의의 혼의에 대한 모델을 제시한다. 이 혼의는 구형의 외층과 내층의 두 부분으로 구성되며 전자는 고정되어 있고, 후자가 회전한다. 추동력에 발현하는 자명종으로부터 회전력을 전달받는 내층에는 황도일규와 백도일규를 갖추어서 내층의 일주운동, 태양의 연주운동, 달의 월주운동을 모사한다. 특히 내층의 구동력을 '격기-직철-유야'의 부품으로 황도일규와 백도일규를 회전시키는 구조는 조선후기 기계식 혼의의 가장 우수한 제작품으로 평가할 수 있다. 본 연구는 통천의의 혼의에 대한 구조와 구동 원리를 소개한다.

[구 HE-03] 《崇禎曆書》의 <月離曆指>에 기록된 달의 운동
Lunar motion described in the Yuè lí lì zhǐ(月離曆指) of the Chongzhen reign treatises on Calendrical Astronomy (Chóngzhēn lìshū 崇禎曆書)

Choe, Seung-Urn[1], Kang, Min-Jeong[2]
[1]*Seoul national University, Sohnam Institute for History of Astronomy*
[2]*Institute for the Translation of Korean Classics*

《숭정역서》는 명말(明末) 역법(歷法)의 개정을 주장한 서광계(徐光啓, 1562~1633)의 기획과 총괄에 의해 편찬되었다. 〈월리역지〉는 이탈리아 선교사 로(Giacomo Rho, 羅雅谷, 1593~1638)가 지었으며, 롱고바르디(Nicolaus Longobardi, 龍華民, 1559~1654), 아담 샬(J. Adam Schall von Bell, 湯若望, 1591~1666)가 검토하였다. 본 연구는 《숭정역서》에서 달 의 이론편인 〈월리역지(月離曆指)〉 3권 후반부에 기록된 달의 운동을 수학적으로, 천문학적으로 검토해 보았다.

<월리역지>에서는 달의 운동을 기술하기 위해 본륜-차륜 모델을 사용하였다. 본륜의 중심은 본천을 반시계 방향으로 하루에 $n_0 = 13$도10분35초01미만큼 이동하며 이를 평행(平行)이라 한다. 차륜의 중심은 시계방향으로 하

루에 $n_1 = 13$도03분53초56미만큼 이동하는 데 이를 자행(自行)이라 한다. 달은 차륜 위를 반시계 방향으로 움직이는데 하루에 달과 태양이 멀어지는 각의 2배인 $n_3 = 2 \times 12$도11분26초41미만큼 이동한다. 이러한 모델을 이용하게 되면 달의 평행에 대한 실행(實行)을 구하기 위한 총가감차(total anomaly of the Moon)값을 구할 수 있다.

본 연구에서는 본륜-차륜모델로 부터 총가감차를 구하는 3가지 방법을 소개하고, 달의 운동을 시뮬레이션 하였다. 본륜-차륜모델에 의한 시뮬레이션은 $t = 0$일 때 달은 원지점에 있고, 합삭일 때를 택하였다. 그리고 $\triangle t = 0.5$일씩 달이 이동하게 하여 30일 동안 달이 지나가는 궤적 위에 달의 운동을 확인할 수 있다. 또한 총가감차를 구하는 식으로부터 어림을 통해 총가감차를 중심차에 의한 가감차(major inequality)와 출차(evection)를 확인 할 수 있었다.

[구 HE-04] A study on the definition of terms related to approach and distance between celestial bodies in Korean historical astronomical records

Hyojun Lee[1,2], Hong-Jin Yang[2], Suk-Jin Yoon[1]
[1]Department of Astronomy, Yonsei University
[2]Korea Astronomy and Space Science Institute

우리나라의 역사 문헌에는 일월오성(日月五星)의 운행을 포함해 천문 현상과 변이에 관한 기록이 다수 포함되어 있다. 이들 기록은 과학적 분석을 통해 현대 연구자료로 활용될 수 있다. 본 연구에서는 『고려사』와 『조선왕조실록』으로부터 천체 간의 접근 및 각거리를 나타내는 기록 4500여 건을 찾아 그 당시 사용된 용어들을 분석하였다. 천체 간 접근을 묘사하는 주요 용어로는 '범(犯)', '입(入)', '엄(掩)', '식(食)' 등이 있는데 이들 용어의 실제 천구상 각거리를 알아보기 위해 천체물리학적 계산으로 관측 당시의 실제 각거리를 계산하였다. 그 결과, 최근접 시의 각거리는 掩≈食, 犯, 入의 순서로 가까움을 확인하였다. 이러한 경향성은 고려시대부터 조선시대까지 유지되었다. 이외에도 각거리를 나타내는 표현인 '척(尺)', '촌(寸)'의 실제 각거리도 함께 조사하였다. 천체 간 접근 관련 용어들의 의미와 관측 오차를 밝힌 본 연구를 통해 고려와 조선시대 근접 천체 기록의 현대천문학적 활용도를 높일 수 있을 것으로 기대한다.

[구 HE-05] Let's go to the Universe, TOGETHER! ('얘들아, 우주로 함께 가자' 활동보고)

Jeong Ae Lee[1], Hojun Lee[2], Sujin Kim[2], Minkyung Woo[3], and on behalf of UNAWE Korea
[1]Korea Astronomy and Space science Institute,
[2]Nowon Cosmos Science Center, [3]SL Lab, INC

Universe Awareness (이하 UNAWE)는 2006년 네널란드 라이든 대학의 George Miley 교수가 동료 천문학자들과 협력하여 만든 NGO 단체로서 전세계 소외받는 어린이들을 위해 천문, 우주과학 교육을 전하고자하는 취지를 가진다. 2009년, 세계 천문의해를 통해 IAU와 유네스코로부터 천문, 우주과학 교육 특성화 단체로 인증을 받았다. 우리나라는 2017년 처음 참여를 시작했으며 국내 천문학자들 및 관련 교육자들이 다양한 활동을 진행하고 있다.

대표적인 활동으로 '얘들아, 우주로 함께 가자' 프로그램이 있으며 UNAWE 한국지부 회원인 ㈜에스엘랩(당시담당자: 이정애, 우민경)의 제안으로 시작되었다. 고등학생 봉사자들을 모집하여 일정 기간 천문, 우주과학 교육을 하고 봉사자들이 제안한 아이디어를 현실화하여 실제 과학나눔 활동에서 실현할 수 있도록 하였다. 이 활동은 노원천문우주과학관(담당자: 이호준)과 한국천문연구원 우주과학본부 태양환경우주환경그룹(담당자: 김수진)이 함께 참여하고 있다. 2019년에는 지역의 저소득층 아이들과 다문화 가정 아이들이 함께 활동하였으며 2021년에는 인공와우와 보청기를 착용하는 청각장애아동들이 함께 참여하였다. 각각의 특성에 맞는 활동을 구성하고 참여자들에게 가장 필요한 것이 무엇인지 고민하고 만들어가는 시간을 통해 모두를 위한 천문, 우주과학 활동의 하나로 만들어 가고 있다.

- 문의 : unawekorea@gmail.com
- 페이스북 : www.facebook.com/unawekorea

[구 HE-06] Pop-up Exhibition of JWST in NSM (과학관에서 JWST 팝업 전시)

Chang Hyun Baek, Cheolhee Kim, Woonhee Min, Jihyuk Lee
National Science Museum (국립중앙과학관)

최신 천문학 이슈와 관련된 팝업 전시는 대국민의 천문학에 대한 관심과 이해 증진에 기여할 수 있다. 국립중앙과학관 전시품개발센터에서는 JWST 발사에 맞춰 NASA, ESA 등의 자료를 활용하여 모형, 인포그래픽, 정보영상 등을 제작하여 팝업(pop-up) 전시회를 개최하였다. JWST 팝업 전시의 기획, 전시품 제작, 운영 등에 대한 정보와 이번 전시를 위해 만들어진 전시품카드를 공유하여 향후 국내에서 추진될 다양한 천문학 및 우주과학 프로젝트의 팝업 전시에 활용될 수 있길 기대한다.

항성,항성계/외계행성

[구 SA-01] Bayesian Estimation of Stellar Ages (BESA)

Jinhee Lee
Pusan National University

Stellar age is one of the most fundamental parameters but is challenging to estimate. While there are various stellar age-dating methods, each approach has weaknesses and these methods have a calibration issue. One of the most popular approach--using theoretical isochrones--appears to systematically deviate from the observation data in the low-mass regime. The goal of this project is

to develop a reliable stellar age-dating tool for low-mass stars based on the Bayesian framework. Empirical color-magnitude diagram models were generated using stellar groups with well-known ages. We here present test results of the Bayesian Estimation of Stellar Ages (BESA) tool.

[구 SA-02] Effects of He and CNO enhanced multiple stellar populations in determining the absolute ages of globular clusters (구상성단의 절대나이 측정에 He과 CNO 함량이 증가한 다중항성종족이 미치는 영향)

Jeongyun Choi[1] (최정윤), Young-Wook Lee[1] (이영욱), Chul Chung[1] (정철), Sohee Jang[2] (장소희), Junhyuk Son[1] (손준혁)
[1]Department of Astronomy & Center for Galaxy Evolution Research, Yonsei University, Seoul 03722, Republic of Korea
[2]Dipartimento di Fisica e Astronomia "Galileo Galilei", Universit`a di Padova, Vicolo dell'Osservatorio 3, I-35122, Padua, Italy

Globular clusters are one of the oldest astrophysical objects in the universe that provide a crucial constraint on the lower limit of the age of the universe. Since most globular clusters are now known to exhibit chemically distinct (He and CNO enhanced) multiple stellar populations (MSPs), it is necessary to consider their effects when determining the ages of globular clusters. However, no such studies have been reported in the literature. For the first time, we will show the effects of He and CNO abundances on the age-dating of GCs with multiple stellar populations. Enriched He and CNO abundances will both decrease the main sequence turn-off luminosity. In contrast, the horizontal branch luminosity will be relatively less affected when He and CNO effects are incorporated. It appears that globular cluster ages are most likely to be about 10 % younger when the effects of MSPs are properly taken into account. This new result would have an impact on the cosmological time scale test.

[구 SA-03] Evidence for Spatially Dependent Magnetic Activity of M dwarfs in the Solar Cylinder

Seo-Won Chang (장서원)[1,2], Christian Wolf[3], Christopher A. Onken[3]
[1]SNU Astronomy Research Center, Seoul National University, [2]Astronomy program, Dept. of Physics & Astronomy, [3]Research School of Astronomy and Astrophysics, Australian National University

Using white-light flare emission as a proxy for magnetic activity, we investigate the spatial distribution of M dwarf activity as a function of Galactic position to assess the link between the observed activity trend and age distribution. With the benefit of near-simultaneous multi-colour observations of the SkyMapper DR3, the number of M dwarf flares ($\Delta m > 0.2$) is increased by factor of 3.5 compared to the previous work. We observe the flaring fraction of M dwarfs to increase from ~ 10 to ~3000 per million stars for spectral types M0 to M8. Based on improved distance measurements from Gaia EDR3, we find a kink in the slope of the flare fraction near 100pc from the Galactic plane ($|Z|$) where a steep decline sets in. In this talk, we will discuss possible explanation of this spatial dependence in the context of age-activity relation.

[구 SA-04] Accretion Disk Model for an S-type Symbiotic Star AG Dra

Hyosun Kim[1](김효선), Young-Min Lee[2,3](이영민), Hee-Won Lee[2](이희원)
[1]KASI, [2]Sejong University, [3]SEP Engineering

적색거성과 백색왜성의 쌍으로 이루어진 S형 공생별 중 하나인 AG Dra의 3차원 유체역학 수치실험 결과를 적색거성의 항성풍 속도에 초점을 두고 분석하였다. 항성풍이 백색왜성을 지나쳐 가는 속도가 느릴수록 백색왜성을 둘러싼 강착원반의 반경과 물질유입률이 증가함을 살펴보았다. 항성풍의 속도가 백색왜성의 공전속도보다 빠른 모형의 경우에는 강착원반의 크기와 물질유입률이 Bondi-Hoyle-Lyttleton 이론과 일치하지만, 상대적으로 느린 항성풍 모형에서는 다른 양상을 보인다. 강착원반 내로 유입된 물질은 두 개의 나선을 따라 주로 분포하는데 이를 추적 분석한 결과, 각각의 나선으로 귀결되는 물질은 원반으로 유입되는 경로가 다르다는 것을 알게 되었다. 이는 원반의 방위각에 따른 평균밀도가 뚜렷한 방향성을 지닌 것과도 연관이 있는 것으로 파악하였다. 원반 물질의 비대칭적 밀도 분포와 케플러속도보다 느린 흐름 등이 라만산란 OVI선 관측 자료 분석에 미치는 효과를 토의하였다.

[구 SA-05] Mass loss enhancement of stripped envelope supernova progenitor and implication for SN 2019yvr

Moo-Keon Jung[1](정무건), Sung-Chul Yoon[1](윤성철), Hyun-Jeong Kim[2](김현정)
[1]Seoul National University(서울대학교)
[2]Korea Astronomy & Space Science Institute (한국천문연구원)

An explosion of a massive star that lost its hydrogen envelope via radiation-driven stellar wind and/or binary interaction can be observed as a type Ib/Ic supernova (SN Ib/Ic). Unlike SN II progenitors, only three SN Ib/Ic progenitors have

been directly identified in the pre-explosion images: iPTF13bvn, SN 2017ein and SN 2019yvr. Pre-explosion images of SN 2019yvr observed with Hubble Space Telescope show that the progenitor candidate has much higher luminosity (log L/Lsun = 5.3) and redder color (Teff = 6800 K) than model predictions. In particular, the surface temperature of a SN Ib progenitor is predicted to be much higher (i.e. Teff > ~10000 K) than the observation. The progenitor mass inferred from the observed progenitor luminosity is also too high compared to what is inferred from the SN light curve. In this talk, we discuss the possibility of late time mass loss enhancement to explain the peculiar observational properties of SN 2019yvr progenitor candidate. We present non-LTE synthetic spectra of SN Ib progenitor models and show that the optical brightness and the colorare highly affected by an optically thick wind because of the lifting-up of the photosphere as well as free-free and line emissions from the wind matter. We conclude that the observed optical magnitudes and color of SN 2019yvr progenitor candidate can be explained by our SN Ib progenitor model with a mass loss rate of Mdot = ~10^(-3) Msun/yr. We also discuss implications of our results for iPTF13bvn and SN 2017ein.

[구 SA-06] The effects of chemical mixing in supernova ejecta on the first peak of type IIb supernovae

Seong Hyun Park and Sung-Chul Yoon
Astronomy Program, Department of Physics and Astronomy, Seoul National University,

A type IIb supernova (SN IIb) is produced by core-collapse in a massive star progenitor that lost most of its hydrogen envelope during its evolution. Diversity in their mass-loss history allows SNe IIb progenitors to have widely varying pre-SN properties. Optical light curves of SNe IIb are dominated by two energy sources: shock-cooling emission (SCE) in early days and radioactive decay of 56Ni in later days. Examples such as SN 1993J and SN 2016gkg show that SNe IIb may have double-peaked light curves with a SCE-produced earlier peak being as bright as the radioactive decay-induced main peak. The first peak properties including the rise time and the brightness have been used to infer the pre-SN structure of the progenitor. Here we show that the early time light curve of a SN IIb can be significantly affected by the chemical mixing in the SN ejecta, which can result from hydrodynamic instabilities induced by the SN explosion, using numerical simulations performed with the hydrodynamic stellar evolution code MESA and the radiation-hydrodynamics code STELLA. A strong chemical mixing makes the outer layers of the SN ejecta more opaque and less affected by the hydrogen recombination compared to the case without mixing, leading to a brighter peak in the optical and faster decline of the light curve during early times. Our result implies that a proper understanding of the chemical mixing in SN ejecta is important for inferring correct information on the progenitor structure from the first peak of a SN IIb.

태양

[구 SS-01] Which Is More Important in Solar Eruption, Magnetic Helicity or Winding Number?

Sibaek Yi[1] and G. S. Choe[1,2]
[1]*School of Space Research, Kyung Hee University, Yongin 17104, Korea*
[2]*Department of Astronomy & Space Science, Kyung Hee University, Yongin 17104, Korea*

Magnetic helicity has intensively been investigated as one of the physical quantities, which seem to provide criteria for the trigger of solar eruptions such as solar flares and coronal mass ejections (CMEs). Magnetic helicity has a dimension of winding (linking) number times magnetic flux squared. Therefore, a value of magnetic flux does not only reflect how much the magnetic field is wound, but also how much magnetic flux is involved. Since magnetohydrodynamics (MHD) is scale-free, a criterion for a critical behavior must be given by a nondimensional quantity. Thus, the winding number has been suspected for a triggering agent of solar eruption. There have been many attempts to measure the magnetic helicity of an active region and estimate the winding number by dividing the former by the total unsigned magnetic flux squared. Such estimates give a winding number of 10-3-10-2 turns, which is far below the apparent winding of observed CMEs or erupting prominences.

In this study, we address this enigma with a numerical simulation of two interacting flux tubes, whose magnetic helicities are of opposite signs. The total magnetic helicity of the system is thus zero. When the two flux tubes gain twist by footpoint motions, they interact and generate new flux ropes, which are barely tied to the boundary. The magnetic flux of the flux ropes at the boundary is tiny, but their winding number is

huge. Our result suggests that only a small part of the boundary magnetic flux may participate in solar eruption with a large winding number. Therefore, the number obtained by dividing the magnetic helicity by the total magnetic flux squared is rather irrelevant to the trigger of solar eruption.

[구 SS-02] On the Poloidal-Toroidal Representation of Magnetic Field

Gwangson Choe[1,2], Sibaek Yi[1] and Minseon Lee[2]
[1]School of Space Research, Kyung Hee University, Yongin 17104, Korea
[2]Department of Astronomy & Space Science, Kyung Hee University, Yongin 17104, Korea

Magnetic field is a vector field with three components. Due to its divergence-freeness, the three components of magnetic field are not independent of each other. There are descriptions of magnetic field by two scalar fields. Among them, the most well-known one is the Euler potential description. However, Euler potentials may be multi-valued in complex field geometry and are often incapable of describing a global field. On the other hand, the poloidal-toroidal representation of magnetic field can be applied for arbitrary magnetic fields and has proven its usefulness in the dynamo theory community. In this description, each field line of the toroidal field lies in a surface called toroidal field surface while the poloidal field has both normal and tangential components to the surface. In this paper, we briefly review the PT representation of magnetic field and report our recent research addressing the question why only planes or spheres are qualified for toroidal field surfaces. Application of the PT representation to coronal magnetic field will also be touched on.

[구 SS-03] Numerical study of low-velocity dust ejection from Phaethon and its connection to the Geminid meteoroid stream

Hangbin Jo and Masateru Ishiguro
Seoul National University (서울대학교)

Interplanetary dust particles (IDPs) are important to our understanding of the composition and dynamics of the Solar System and are useful reference points for exoplanetary research. Meteoroid streams, such as the Geminid, transport IDPs to Earth (Love and Brownlee 1993), making them relevant to the formation of terrestrial life. The Geminid stream is thought to have originated from asteroid (3200) Phaethon and is part of the Phaethon-Geminid stream complex (Whipple 1983; Gustafson 1989). By studying the Geminids, we get a closer look into the properties and evolution of IDPs and small bodies in the near-Earth space. The DESTINY⁺* mission by JAXA/ISAS will perform in-situ observation in the late 2020s and further advance our knowledge on near-Earth IDPs, and provide insight as to how dust is ejected on Phaethon and even other active asteroids (Arai et al. 2018).

The dust ejection mechanism of Phaethon remains mysterious. There have been many dynamical studies trying to recreate the Geminid stream by numerical simulation, but with varying degrees of success. However, none have given satisfactory answers to how mm- and cm-sized dust particles can be ejected from the asteroid and be observed at the present day on Earth in the form of Geminid meteoroids. In this work, we performed a numerical study of large (> 1 mm) particles from Phaethon ejected with low velocity by using the N-body integrator MERCURY6 (Chambers 1999). We will present our results and discuss what this may mean in terms of the dust ejection mechanism.

We also plan to describe the perspective of Apophis science based on this research.

* Demonstration and Experiment of Space Technology for Interplanetary voYage Phaethon fLyby and dUst Science

1. Arai, T., Kobayashi, M., Ishibashi, K., & Yoshida, F. 2018, LPI, 49, 2570
2. Chambers, J. E. 1999, MNRAS, 304, 793
3. Gustafson, B. A. S. 1989, A&A, 225, 533
4. Love, S.G. & Brownlee, D. E. 1993, Science, 262, 550
5. Whipple, F. 1983, International Astronomical Union Circular, 3881

천문우주관측기술

[구 AT-01] Aspera: The UV Small-Satellite mission for mapping warm-hot gas in nearby galaxy halos

Haeun Chung, Carlos Vargas, Erika Hamden, Aspera Team
Steward Observatory, Univesity of Arizona, USA

Aspera is a new UV Small-Satellite mission to detect and map the warm-hot phase halo gas (10^5-10^6 K) around the nearby galaxy, led by the University of Arizona (PI: Carlos Vargas). The warm-hot phase gas occupies a considerable fraction of the galaxy baryonic mass budget. However, its amount and distribution are poorly

unknown observationally. Aspera is specifically designed to observe those gas via UV spectroscopic observation of O VI line emission at 103.4 nm, a proxy of hot phase gas. High-sensitivity of Aspera down to 5E-19 ergs/s/cm^2/arcsec^2 as well as a large field of view of 30 arcsec x 1 degrees allow detecting the faint O VI line emission efficiently.

Aspera has been selected as one of the inaugural NASA Astrophysics Pioneers missions in early 2021. It has passed its conceptual design review and is now in the preliminary design phase, with a launch date of mid-2025. Here we introduce the payload design and the status of the Aspera mission.

[구 AT-02] Optical design and analysis of Linear Astigmatism Free-Three Mirror System (LAF-TMS) for MESSIER satellite

Changgon Kim[1], Dohoon Kim[2], Jimin Han[1], Sunwoo Lee[3], Seunghyuk Chang[4], Daewook Kim[5], David Valls-Gabaud[6], Rémi Cabanac[7], Soojong Pak[1]
[1]School of Space Research and Institute of Natural Science, Kyung Hee University
[2]Department of Astronomy and Space Science, Kyung Hee University
[3]Division of Scientific Instrumentation and Management, Korea Basic Science Institute
[4]Center for Integrated Smart Sensors,
[5]James C. Wyant College of Optical Sciences, University of Arizona
[6]Observatoire de Paris
[7]IRAP, University of Toulouse, CNRS, CNES, UPS, (Toulouse), France

Theoretical and numerical simulations of galaxy mergers and tidal actions based on ΛCDM model have a profound impact on our view of the Universe. The rare detection rate of the Low Surface Brightness (LSB) galaxies is due to current telescope designs. Progress in this observational domain requires more statistically meaningful observational investigations. In order to overcome this observational limit of these LSB targets, the proposed MESSIER satellite project adopts an off-axis reflective telescope which enables a survey of satellite galaxies and tidal remnants with sensitivities down to 37 mag arcsec^2 . The Linear Astigmatism Free-Three Mirror System (LAF-TMS) of the MESSIER satellite can mitigate the diffraction and scattering issues of common on-axis telescope systems. Also, a wide field of view telescope is possible as the linear astigmatism aberration is eliminated using the confocal off-axis reflective theory, so called Chang's theory. We present the MESSIER telescope's optical layout with its imaging performance simulated by photon Monte Carlo simulator PhoSim.

[구 AT-03] CNN-TDA Net: Enhancing Convolutional Neural Networks for Classification of Transient and Bogus Using Topological Data Analysis (CNN-TDA Net: 위상적 데이터 분석을 이용한 돌발천체 및 가짜신호 분류 합성곱 인공 신경망 고도화)

Seong-Heon Lee[1](이성헌), Dongjin Lee[1](이동진), Jae-Hun Jung[1,2](정재훈)
[1]Graducate School of Artificial Intelligence, POSTECH (포항공과대학교 인공지능대학원),
[2]Department of Mathematics, POSTECH (포항공과대학교 수학과).

초신성 발생, 감마선 폭발 등과 같이 우주적 규모에서 돌발적으로 발생하는 현상이나 천체 (transient)를 감지하고 이를 가짜신호 (bogus)와 분류하는 것은 천체 물리학계에서 중요한 문제 중 하나이다. 최근에는 관측 기술의 발달로 대량의 천체 관측 데이터가 수집되면서 이 작업을 효율적으로 수행하는 기술이 필요하게 되었다. 이로 인해 내량으로 주어시는 네이터를 분류, 분석하기에 적합한 딥러닝을 활용하여 돌발천체를 신속하게 탐지하는 연구가 활발하게 이뤄지고 있다. 특히 합성곱 인공 신경망 (Convolutional Neural Networks, CNN)을 활용하여 천체의 이미지를 돌발천체와 가짜신호로 분류하는 문제 (Real/Bogus classification)가 연구되고 있다. 기존의 CNN 모델은 천체 이미지의 점광원이 아닌, 배경잡음을 특징으로 분류하는 현상을 보여왔다. 본 연구에서는 CNN에 위상적 데이터 분석(Topological Data Analysis, TDA)을 결합하여 기존 CNN 모델이 점광원에 초점을 맞출 수 있도록 교정할 뿐만 아니라, 수치적인 성능까지 향상시킨 CNN-TDA Net을 제안한다. 본 연구는 레몬산 천문대 (LOAO)의 관측 자료에 O'TRAIN과 CNN-TDA Net을 적용하여 성능을 정량적으로 평가 및 비교하고, Grad-CAM 분석을 통해 위상적 데이터 분석이 어떻게 기존 모델의 성능을 향상시킬 수 있는지 설명하는 정성적 평가를 포함한다.

[구 AT-04] CNN-TDA Net : Construction of Training Image Sets for Real/bogus Object Classification with Artificial Intelligence

Gregory S.H. Paek[1,2], Myungshin Im[1,2], Seo-won Chang[1,2], Seong-Heon Lee[3], Dongjin Lee[3], Jae-Hun Jung[3], and IMSNG team[1,2]
[1]Astronomy Program, Department of Physics & Astronomy, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Korea
[2]SNU Astronomical Research Center, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Korea
[3]Graduate School of Artificial Intelligence, Pohang University of Science and Technology, 77, Cheongam-ro, Nam-gu, Pohang-si, Gyeongsangbuk-do, Republic of Korea

Transients, fast decaying astrophysical events, such as supernovae (SNe), kilonovae, and gamma-ray bursts, have become important astrophysical objects since the advent of time-domain astronomy. Transients are commonly found in an image which shows the difference between the observed image and a reference image through image subtraction (difference image). However, image subtraction is not always perfect, and the difference image almost always contains not only true transients, but also a number of image subtraction artifacts that could be confused as astrophysical sources. Exclusion of artifacts is critical, but it involves a time-consuming process of visual inspection of many (thousands and more) transient candidates, which delays the transient search process. For fast and reliable real (transient) and bogus (artifact) classification of signals in difference images, we have been constructing CNN-TDANet, a deep learning architecture which combines the convolutional neural network (CNN) and the topological data analysis (TDA) methods. Here, we present the image datasets that have been used for training CNN-TDANet. To make the dataset we used images taken almost every night for two months as a part of the Intensive Monitoring Survey of Nearby Galaxies with the LOAO 1-m telescope. Postage stamp images of real/bogus objects were generated by gpPy (automatic image process pipeline), and labeling was conducted by matching detected sources in difference images with reported transient objects and visual inspection. As a result, the postage stamp image dataset for an initial test of CNN-TDANet is constructed, containing 351 transient images and 3365 bogus images (real:bogus=1:9.6). The real transient sample consists of three SNe at dim and bright phases, and two variable objects. Finally, we will also show future works for improving the AI test dataset.

[구 AT-05] Photometric Calibration and Source Catalog Construction of KMTNet Synoptic Survey of Southern Sky (KS4)

Mankeun Jeong[1,2], Myunshin Im[1,2], Joonho Kim[2,3], Seo-Won Chang[1,2], Sunho Jung[1] and Suhyun Shin[1,2]
[1]Astronomy Program, Department of Physics & Astronomy, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Korea
[2]SNU Astronomical Research Center, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Korea
[3]Daegu National Science Museum, 20, Techno-daero 6-gil, Yuga-myeon, Dalseong-gun, Daegu 43023, Republic of Korea

KMTNet Synoptic Survey of Southern Sky (KS4) is a wide-field imaging survey of the southern hemisphere sky. Using the three 1.6m KMTNet telescopes, the observation is currently in progress covering about 7000deg2 area where deep and complete optical data have been deficient.

In this presentation, we will introduce the photometry and catalog construction process for KS4 images obtained until now. It includes data quality assurance, geometric correction for mosaic images, image stacking and magnitude conversion using reference catalogs such as APASS and SkyMapper. Consequently, we can achieve photometric results with roughly 23ABmag 5σ depth and 0.05mag rms errors in BVRI bands. We anticipate the KS4 catalog will open up the possibilities of various science projects in the southern sky and collaborate with other future surveys.

[구 AT-06] Performance analysis of Automatic Observing Software for Wide-field Imaging Telescope

Tae-Geun Ji[1], Sungyong Hwang[2], Hye-In Lee[3], Changsu Choi[2], Myungshin Im[2], Soojong Pak[1]
[1]School of Space Research, Kyung Hee University, [2]SNU Astronomy Research Center, Department of Physics and Astronomy, Seoul National University, 3Korea Astronomy and Space Science Institute

Since 2017 August, we have operated the automatic observing software for the Wide-field Imaging Telescope (WIT) at McDonald Observatory in Texas, United States. The software is composed of TCS communication, data taking, auto-focusing, and command-line scripting for automation. It is easy to apply this software to other wide-field telescope platforms because one can manage each package based on a modular structure. It employs libraries from the vendor's software development kit (SDK) and the ASCOM platform for an extension to diverse hardware, based on the universal serial bus (USB) and the transmission control protocol/internet protocol (TCP/IP) communication standards. In this study, we show the software performance such as auto-focusing and scheduling observation as well as some of the scientific achievements using this operating system.

[구 AT-07] First Spectra from a GPU Spectrometer for the ALMA Total Power Array

Jongsoo Kim
Korea Astronomy and Space Science Institute (한국천문연구원)

During the ALMA (Atacama Large Millimeter/submillimeter Array) maintenance period, February, 2022, a GPU (Graphic Processing Unit) spectrometer was installed in the ACA Correlator room at the Array Operation Site (AOS) by its developers from the KASI (Korea Astronomy and Space Science Institute) and the NAOJ (National Astronomy Observatory of Japan). The GPU spectrometer was mainly designed for signal processing from the ALMA total power array and became the first in-kind contribution of the KASI to the ALMA collaboration. Right after the installation, SiO (J=2-1; v=1) 86 GHz maser spectral lines from the Orion KL region were successfully detected using the spectrometer. After commission and science verification observations, the spectrometer will be used from the Cycle 10 (September 2023). In my talk, I will tell a successful story of the spectrometer installation during the COVID-19 pandemic, and briefly introduce its capabilities.

[구 AT-08] SDSS-V LVM-I Observation Control Software: SCP, ECP and NPS

Mingyeong Yang[1], Changgon Kim[1], José Sánchez-Gallego[2], Florian Briegel[3], Felipe Besser[4], Pavan Bilgi[3], Hojae Ahn[1], Tae-Geun Ji[1], Nicholas P. Konidaris[5], Guillermo A. Blanc[5], Taeeun Kim[1], Mingyu Jeon[1], Hyun Chul Park[6], Hye-In Lee[7], Erika Cook[8], Cynthia S. Froning[5], Solange Ramirez[5], Niv Drory[9], Juna A. Kollmeier[5], and Soojong Pak[1],
[1]Kyung Hee University, [2]University of Washington, [3]Max Planck Institut Fur ¨ Astronome, [4]Las Campanas Observatory, [5]Carnegie Institution for Science, [6]Konkuk University, [7]Korea Astronomy & Space Science Institute, [8]Texas A&M University, [9]University of Texas at Austin

The SDSS-V Local Volume Mapper (LVM) provides a contiguous 2,500 square degrees integral-field spectroscopic survey to understand the physical conditions of the ionized interstellar medium of various local-volume galaxies. The subsystems composing the LVM Instrument (LVM-I) are largely composed of a telescope, spectrograph, and enclosure system. We developed the Spectrograph Control Package (LVMSCP), the Enclosure Control Package (LVMECP), and Network Power Switch (LVMNPS) for the operation of spectrograph and enclosure subsystems. These packages are implemented by Python 3.9 following the SDSS software framework, which uses the SDSS-CLU as a message-passing protocol based on RabbitMQ and the Advanced Message Queuing Protocol (AMQP). We also used asynchronous programming to process numerous requests simultaneously in our system. The LVMSCP provides several functions that allow the observer to control science CCD for conducting spectroscopic observations. The enclosure system consists of four main systems by manipulating the LVMECP: 1) a roll-off dome, 2) building lights, 3) a Heating, Ventilation, and Air Conditioning (HVAC) system, and 4) a safety system. The LVMNPS remotely controls the power of devices linked to the instrument system. In this talk, we present the overview and the design for these control softwares

[구 AT-09] Development of siderostat control system for SDSS-V Local Volume Mapper

Hojae Ahn[1], Florian Briegel2, Mingyu Jeon[1], Tom Herbst[2], Sumin Lee[1], Inhwan Jung[1], Changgon Kim[1], Jimin Han[1], Geon Hee Kim[3], Wolfgang Gaessler[2], Markus Kuhlberg[2], Tae-Geun Ji[1], Hyun Chul Park[4], Soojong Pak[1], Nicholas P. Konidaris[5], Niv Drory[6], José Sanchez-Gallego[7], Dmitry Bizyaev[8], Cynthia S. Froning[6], Solange Ramirez[5], Juna A. Kollmeier[5]
[1]Kyung Hee University, [2]Max Planck Institute for Astronomy, [3]Hanbat University, [4]Konkuk University, [5]Carnegie Institution for Science, [6]University of Texas at Austin, [7]University of Washington, [8]Apache Point Observatory

Sloan Digital Sky Survey fifth-generation (SDSS-V) Local Volume Mapper (LVM) is an all-sky IFU survey that uses an array of four 160 mm telescopes. It provides IFU spectra over the optical range with R ~ 4,000 to reveal the inner components of galaxies and the evolution of the universe. Each telescope observes the science field or the calibration field independently, but all of them should be simultaneously synchronized with the science exposure. To minimize the moving parts, the LVM adopted the siderostat design with a field derotator. We designed the optimized control software for our LVM observation focusing on autofocus, field acquisition, and autoguide. Also, we designed and fabricated the protomodel siderostat for the software test. The real sky test was made with protomodel siderostat, and our system showed arcsecond-level field acquisition accuracy.

[구 AT-10] 7-Dimensional Sky Survey

Myungshin Im
SNU Astronomy Research Center, Astronomy Program, Dept. of Physics & Astronomy, Seoul National University

Recent time-domain surveys have found that the universe is full of interesting time-varying sources and transients, revealing the diverse nature of the

death of stars and a variety of phenomena occurring near objects with strong gravitational field. At the same time, large area spectroscopic surveys have allowed us to understand statistical properties of galaxies and quasars, advancing our knowledge on the galaxy evolution and cosmology. However, spectra of the majority of astronomical objects are left unexplored, and even more, the time evolution of spectral properties of various sources are very poorly known. To open the new field of time series, spectral mapping of the sky, we plan to conduct the 7-dimensional sky survey (7DS). 7DS will map thousands square degrees of the sky at about two week cadence, and will monitor spectral variability of ~100,000 AGNs. The deepest stacked time-series data will reach the depth of the PS1 survey, providing us with spectral information of every object in the 7DS survey area. With 7DS, one can obtain new views on many subjects of observational astronomy, such as AGN, cosmology, galaxy evolution, solar system objects, galactic objects, transients, and multi-messenger astronomy. This talk introduces 7DS and its prospects.

특별세션 아포피스/ 태양계

[구 AS-01] Rendezvous Mission to Apophis: I. 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 Univ, [4]Chungbuk National Univ, [5]Yonsei Univ, [6]Auburn Univ, USA, [7]Technical Univ 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, and briefly introduce the updates of the Apophis mission.

[구 AS-02] Rendezvous Mission to Apophis: II. Changes of the spin state and the orbital parameters of Apophis during the 2029 Earth encounter

Youngmin JeongAhn[1], Myung-Jin Kim[1], Hee-Jae Lee[1], Hong-Kyu Moon[1], Young-Jun Choi[1,2]
[1]Korea Astronomy and Space Science Institute
[2]University of Science and Technology

On April 13, 2029, Apophis will experience a close encounter with Earth. The flyby of Apophis will modify the Apophis' orbit from an Aten-class orbit to an Apollo-class orbit while shifting the semimajor axis from 0.92 AU to 1.1 AU. The gravitational torque during the encounter will also change the spin-state of Apophis. As the current spin angular momentum of Apophis is relatively small, the influence of the gravitational torque is expected to be significant. In order to predict the detailed outcome of the encounter, however, we need a precise body axis orientation of Apophis at the time of flyby. With the currently known information, we will predict the variation of spin state by integrating gravitational torque during the encounter. We will also discuss the implication of these changes in orbit and spin state of Apophis.

[구 AS-03] Rendezvous Mission to Apophis: III. Physical properties of (99942) Apophis revealed from the observations in 2021

Hee-Jae Lee[1], Myung-Jin Kim[1], Dong-Heun Kim[1,2], Hong-Kyu Moon[1], and Young-Jun Choi[1,3] on behalf of the Apophis Observation Team
[1]Korea Astronomy and Space Science Institute,
[2]Chungbuk National University, 3University of Science and Technology

Extensive observations of a space mission target provide unparalleled dataset not only to establish scientific goals but also to design efficient operation scenarios for the mission. Then, we study the physical nature of the target with the dataset for optimal mission planning. For this purpose, we conducted an extensive time-series photometric and spectroscopic observation campaign aimed at (99942) Apophis during the 2021 apparition. We refined the spin state and convex shape model of Apophis with its different taxonomic signatures at different rotational phases.

In this talk, we present the details of the physical model with its time-dependent reflectance spectra to briefly discuss the cause of such variation.

[구 AS-04] 아포피스 프로젝트의 과학문화 콘텐츠 활용(Utilizing Scientific Culture Contents in Apophis Project)

Chang Hyun Baek[1], Young-Jun Choi[2]
[1]National Science Museum
[2]Korea Astronomy & Space Science Institute

대형 연구 프로젝트 수행을 위해서는 국민들의 프로젝트에 대한 관심과 이해, 그리고 지지가 가장 선행되어야 한다. NASA, ESA, JAXA 등 해외 연구기관들의 대형 연구 프로젝트의 대국민 홍보, 콘텐츠 및 교육자료 제공은 국민들의 관심이나 이해 증진에 중요한 역할을 하고 있다. 일본에서 수행된 '하야부사2 프로젝트' 사례와 앞으로 추진 될 아포피스 프로젝트의 대국민 홍보와 교육적 활용뿐 아니라 과학문화 콘텐츠로서의 활용 방안과 기대효과에 대해 살펴보고자 한다.

[구 AS-05] Polarimetric Observation of (3200) Phaethon, in Preparation for the Upcoming DESTINY+ Space Mission

Jooyeon Geem[1](김주연), Masateru Ishiguro[1], Jun Takahashi[2], Hiroshi Akitaya[3], Koji S. Kawabata[4], Tatsuya Nakaoka[4], Ryo Imazawa[4], Fumiki Mori[4], Daisuke Kuroda[5], Sunao Hasegawa[6], Fumi Yoshida[3], Ko Ishibashi[3], Tomoko Arai[3], Tomohiko Sekiguchi[7], Yuji Ikeda[8], Yoshiharu Shinnaka[8], Yoonsoo P. Bach (박윤수)[1], Sunho Jin(진선호)[1], Hangbin Jo(조항빈)[1], Myungjin Kim(김명진)[9]
[1]Seoul National University, South Korea (서울대학교), [2]University of Hyogo, Japan, [3]Chiba Institute of Technology, Japan, [4]Hiroshima University, Japan, [5]Kyoto University, Japan, [6]Japan Aerospace Exploration Agency, Japan, [7]Hokkaido University of Education, Japan, [8]Kyoto Sangyo University, [9]Korea Astronomy and Space Science Institute (한국천문연구원)

The ground-based observations of target objects have led space projects to successful results. For example, some physical properties such as albedo and size (i.e., the total mass) are crucial for designing the camera sensitivity and considering the total fuel mass. Such ground-based supports via observations have been conducted for any space programs, including Hayabusa, Hayabusa2, and OSIRIS-REx.

Here, we introduce our observational research of the asteroid (3200) Phaethon. It is the target asteroid of JAXA's DESTINY+ mission (will be launched in 2024). It is worth noting that there is a large discrepancy in the estimated geometric albedo (pV = 0.031~0.221, [1, 2, 3]). This large discrepancy makes it difficult to design the flyby observation with the onboard cameras. Under the framework of the DESTINY+ Science Working Group, we conducted the polarimetric observation of Phaethon in 2021 Oct 27 - Dec 23 when the asteroid was at a small phase angle (Sun-Target-Observer angle, alpha = 8.8 to 23 degrees). We made use of the 2-m Nayuta telescope and the 1.5-m Kanata telescope with polarimetric devices. As a result, we determined pV = 0.081~0.131 to an accuracy, nearly a factor of 4 better than the previous estimates.

At the end of our presentation, we will talk about the polarimetric properties of (99942) Apophis [4] and consider a possible in-situ remote-sensing observation and outcome.

[1] Ishiguro M., et al., 2022, MNRAS, 509, 3, [2] Kareta T., et al., 2021, AAS/Division for Planetary Sciences Meeting Abstracts, p.110.02D, [3] McAdam M., et al. 2018, AAS/Division for Planetary Sciences Meeting Abstracts #50, p. 312.01, [4] Delbo M., et al., 2007, Icarus, 188, 1

[구 AS-06] Laboratory experiment for light scattering near opposition with 3D printed regolith models

Mingyeong Lee[1,2], Minsup Jeong[2], Young-Jun Choi[1,2]
[1]University of Science and Technology, [2]Korea Astronomy and Space Science Institute

Light scattering on the airless bodies, such as the Moon, is important for information like surface structure, grain size, and porosity. This kind of surface shows a sharp surge of its brightness at a small phase angle (i.e., the angle between the Sun-object-detector). This phenomenon, called the opposition effect, has been studied with laboratory experiments and observations. However, the relationship between the effect and the fine structure of the lunar surface is not known well so far. In order to obtain the clue to reveal the relationship between the fine structure of regolith and light scattering near the opposition, we set an experiment to measure the reflectance of a regolith model printed by a 3D printer in various angle conditions. We use printed surface models with various fine structures and porosity and measured their reflectance near the opposition (phase angle about 1 degree to 10 degrees). In this talk, we introduce an experiment investigating the reflectance of the 3D regolith model near the opposition and present the initial result. In addition, we suggest a way to use it in future lunar exploration.

특별세션 중력파 관측기술

[구 GWDT-01] aLIGO Gravitational Wave Detector: Quad Suspension and Optical Mirrors

Kyung-ha Lee
Sungkyunkwan University

In 2015, the very first direct detection of gravitational waves opened a new horizon of multi-messenger astronomy research. Behind this success, there was continuous world-wide collaborations to improve LIGO detector's sensitivity. Considering that GW signals are in the order of 10^{-21}, the main limiting factor for this field is the noise coming from various sources. In today's talk, I would like to introduce key components of the detector science, covering two main parts of the aLIGO detector: quadruple monolithic suspensions and mirror coatings. This suspension was one of the key upgrades implemented in the Advanced LIGO detector that significantly reduced suspension thermal noise and seismic noise. This suspension system improved the low frequency sensitivity greatly that the very first signal, GW150914, indeed passed that newly obtained detection band. As we further improved other noise sources via suspension upgrade and quantum noise improvement, the top priority moved on to the mirror coating research. The most sensitive frequency band is limited by coating Brownian noise, thus the new coating material research is essential for the A+LIGO upgrade plan.

[구 GWDT-02] Experimental Demonstration of Squeezing the Vacuum

Chang-Hee Kim (김창희), Sungho Lee (이성호), June Gyu Park (박준규), Yunjong Kim (김윤종), Ueejeong Jeong (정의정), Hyeon Cheol Seong (성현철)
Korea Astronomy and Space Science Institute (한국천문연구원)

Quantum shot noise dominates the total noise for existing gravitational-wave (GW) detectors based on the Fabry-Perot Michelson interferometer. By squeezing the vacuum fluctuations entering a interferometer's readout port, sensitivity of the GW detector can be significantly improved. Recently at KASI experimental works have been carried out to demonstrate generation of squeezed vacuum.

In this talk we present the progress of squeezing experiment at 1064 nm and upgrade plans for it.

[구 GWDT-03] Frequency dependent squeezing using filter cavity and vacuum compatible faraday isolator for KAGRA

June Gyu Park (박준규), Sungho Lee (이성호), Chang-Hee Kim (김창희), Yunjong Kim (김윤종), Ueejeong Jeong (정의정), Hyeon Cheol Seong (성현철)
Korea Astronomy and Space Science Institute (한국천문연구원)

Frequency dependent squeezing(FDS) is technique that controls noise by radiation pressure and shot noise according to frequency in gravitational wave(GW) detector. Filter cavity is a useful FDS technique that has been experimentally proven and is being installed in GW-detector. Currently, the KASI GW experimental group is participating in the KAGRA filter cavity project to develop FDS technology, and is responsible for the development of Faraday isolators that can be used in vacuum.

In this talk we present the FDS technique using filter cavity and development status of vacuum compatible faraday being developed in KASI.

[구 GWDT-04] Mode matching telescope design and simulation for the EPR-SIPS experiment

Sumin Lee[1](이수민), Chang Hee Kim[2](김창희), Jimin Han[1](한지민), Sibilla Di Pace[3], V Sequino[4], Yunjong Kim[2](김윤종), Changgon Kim[1](김창곤), Hojae Ahn[1](안호재), Soojong Pak[1](박수종), Sungho Lee[2](이성호), Jaewan Kim[5](김새완), M Bawaj[6], M Barsuglia[7], M Bazzan[8], E Calloni[9], G Ciani[8], L Conti[8], B D'Angelo[1011], M De Laurentis[9], R De Rosa[9], V Fafone[1314], B Garaventa[1011], G Gemme[11], A Gennai[15], L Giacoppo[1314], J Harms [1617], I Khan[1614], E Majorana[1218], L Naticchioni[18], C Nguyen[7], D Passuello[15], G Prodi[19], F Ricci[1218], A Rocch[13], F Sorrentino[11], M Vardaro[8], JP Zendri[8]
[1]Kyung Hee University (경희대학교), [2]Korea Astronomy and Space Science Institute (한국천문연구원), [3]University of Roma "La Sapienza", [4]INFN Sezione di Genova, [5]Myongji University (명지대학교), [6]INFN, Sezione di Perugia, [7]APC, Universit´e Paris Diderot, CNRS/IN2P3, CEA/Irfu, Observatoire de Paris, [8]Universit`a di Padova, [9]Universit`a di Napoli "Federico II", [10]Universit`a degli Studi di Genova, [11]INFN Sezione di Genova, [12]Universit`a di Roma "La Sapienza", [13]Universit`a di Roma "Tor Vergata", [14]INFN Sezione di Roma Tor Vergata, [15]INFN Sezione di Pisa, [16]Gran Sasso Science Institute, [17]INFN Laboratori Nazionali del Gran Sasso, [18]INFN Sezione di Roma, [19]Universit`a di Trento

중력파 검출기는 양자 잡음을 줄이기 위해 양자 조임 기술을 사용한다. EPR- Small scale Suspended Interferometer for Ponderomotive Squeezing (EPR-SIPS) 실험은 EPR(Einstein-Podolsky-Rosen) 효과를 이용하여 주파수 의존 양자 조임 기술을 구현하는 연구이다. 이 실험에서는 대형 중력파 검출기에 적용하기에 앞서 소형 레이저 간섭계인 SIPS를 활용하여 EPR 기술을 구현하고자 하며, Virgo 중력파 검출기의 양자조임기술 연구그룹 주도로 한국천문연구원과 경희대학교 연구팀이 참여하고 있다. 양자 조임광에 공간 모드 불일치가 발생하면 양자 조임으로 얻을 수 있는 잡음 감소 효과가 줄어든다. 따라서 공간 모드 불일치를 조정하는 장치인 모드 맞춤 망원경이 필요하다. 이 연구에서는 EPR-SIPS 실험을 위한 모드 맞춤 망원경의 광 설계 과정을 소개한다. 모드 맞춤 망원경을 통과하면서 발생하는 광 손실 목표를 5% 미만으로 정해 설계를 진행한다. 수차를 최소화하면서 목표를 달성할 수 있으며 제작이 가능한 광 설계를 판단한다. 공차 해석을 통해 광 설계의 타당성을 검토하고, 이를 바탕으로 광 기계 설계 시 기기의 자유도를 결정한다.

[구 GWDT-05] Gravitational-wave detector characterization and machine learning application

Young-Min Kim[1], Kihyun Jung[1], Kyujin Kwak[1], Sang Hoon Oh[2], Whasun Kim[2], Edwin J. Son[2], and John J. Oh[2]
[1]Ulsan National Institute of Science and Technology, [2]National Institute for Mathematical Sciences

Ground-based Gravitational-wave (GW) detectors, LIGO and Virgo, have been successfully operated during three observing runs (O1, O2, O3), and 90 events of compact binary coalescences (CBCs) were identified with $p_{astro} > 0.5$. The successful observation was conducted based upon the upgrade of subsystems in large-scale (4-km / 3-km) laser interferometers as well as the characterization of the detectors. Main purpose of the detector characterization is to investigate any instrumental anomaly and disturbances from environmental sources, to figure them out, and to finally mitigate them. In this presentation, I review the methods of the detector characterization and how it works with examples of LIGO and KAGRA detectors. In addition, I summarize the recent progress of machine learning applications used in the noise identification and the investigation of noise sources.

포스터 발 표 초 록

고에너지/이론천문학

[포 HT-01] The novel signal detection for gravitational waves via auto-regressive approach

Sangin Kim[1], C. Y. Hui[2], Kwangmin Oh[1]
[1]Department of Space Science and Geology, Chungnam National University (CNU), Daejeon 34134, Korea, [2]Department of Astronomy and Space Science, Chungnam National University (CNU), Daejeon 34134, Korea

For detecting signal on gravitational wave (GW) data, we have employed stochastic autoregressive (AR) model. This novel framework is focusing on improving noise reduction, event candidate detections, and template-free parameter estimation. For the preliminary result, we have tested our framework on black hole-black hole merger data, GW150914. To compare the performance, we adopted 'matched filtering' which has been used in GW detection to calculate signal-to-noise ratio (SNR) as a performance metric, then the SNR of our method could be as higher as ~5 times than simple whitening method which is used to reduce the noise.

The final goal of our study is to establish simplest and robust methodology automated by AR and anomaly detection to search GW signal and clean as clear as possible, so as to detect neutron star-neutron star merger (e.g. GW170817) which have longer observation time and weaker strain than black hole-black hole merger.

Currently, we are examining all detected GW signals in GWTC-1 catalog.

[포 HT-02] Development of a fully explicit, energy conservative, electromagnetic hybrid simulation code

Sunjung Kim and Dongsu Ryu
Department of Physics, School of Natural Sciences UNIST, Ulsan 44919, Korea

Space and astrophysical plasmas have been studied by magnetohydrodynamic (MHD) fluid and kinetic particle models. Many of the observed physical phenomena, however, cannot be described by the MHD model because kinetic effects, such as nonthermal velocity distributions and finite gyro radius effects, are not included. The full particle model with kinetic ions and electrons can be applied for describing phenomena involving the kinetic effects. For the study of large-scale problems, it is also difficult to resolve the electron spatial and temporal scales because full particle simulations are computationally expensive. The quasi-neutral hybrid simulation, in which the ions are treated kinetically and the electrons are assumed to be an inertialess charge neutralizing fluid, is a powerful method bridging MHD and full particle in cell (PIC) simulations.

We have developed a 2.5-dimensional, fully explicit, energy conservative, electromagnetic hybrid simulation code to investigate phenomena that occur in space and astrophysical plasmas. Here we present the mathematical and numerical details. The relativistic Buneman-Boris scheme and the predictor-corrector method are used for solving ion equation of motion and electromagnetic fields. To reduce discrete particle noise, the 2nd-order shape function for the particle-mesh interpolations and the binomial smoothing is allowed. Instead of the staggered grid commonly used in PIC, we applied a cell centered algorithm. Using the developed code, we also performed a number of test problems (quiet plasmas, ion temperature anisotropy and ion beam instabilities). The test simulation results are identical with those of the previous studies and show very good energy conservation.

[포 HT-03] A deep analysis of the compact binaries in globular cluster

Kwangmin Oh (K. Oh)
Chungnam National University (충남대학교)

구상성단은 중력으로 묶여진 별의 집합체로, 현재 약 160여개가 우리 은하 내에 존재하는 것으로 알려졌다. 구상성단은 우주에서 가장 높은 공간 밀도를 가지고 있는 천체로, 질량 분리가 잘 이루어져 있는 천체이며 다양한 쌍성 연구에 가장 적합한 천체로 여겨진다. 구상성단에서 관측 가능한 고에너지 천체들로는 블랙홀 쌍성 (Black Hole), 펄서 (Pulsar), 격변 변광성 (Cataclysmic Variable) 또는 저/고질량 엑스선 쌍성 (Low/High mass X-ray binary) 등이 있는데, 이러한 쌍성 형성은 천체들의 높은 밀도로 인한 조우 및 병합 현상일 것으로 여겨진다.

한편, 쌍성의 배경을 조금 더 가까이 엿볼 수 있는 천체로 관측이 비교적 많이 이루어진 전체인 '격변 변광성'을 예로 들 수 있지만, 원시 생성 (primordial formation)과 역학적 생성(dynamical formation) 사이에서 의견이 상충하고 있다. 연구에 사용될 MOCCA (Monte-Carlo globular cluster simulation data)는 N-body 시뮬레이션을 기반으로 만들어진 기술로 성단의 완화시간 (relaxation time)을 고려하여 제작되었으며 이에 따라 구면 대칭성을 가진 성단 내의 진화를 장기적으로 관찰하고

연구하는 데 유용하다. 현재 해당 시뮬레이션을 통한 격변변광성 연구의 데이터의 사전 정리 작업은 완료되었으며, 임의의 초기 조건을 가진 성단들을 통해 만들어진 주요한 결과를 소개하고자 한다.

고천문학/천문역법

[포 HA-01] Statistical Analysis for Astronomical records of Hyeonjong-Donggung-Ilgi

Uhn Mee Bahk[1,2], Byeong-Hee Mihn[2,4], Ki-Won Lee[3], Sang Hyuk Kim[2], Jaeyeon Hyun[2,4], Yonggi Kim[1]
[1]*Chungbuk National University*
[2]*Korea Astronomy and Space Science Institute*
[3]*Daegu Catholic University*
[4]*University of Science and Technology*

본 연구는 『현종동궁일기』에 실린 10년간의 천문기록을 활용하여 천문현상을 통계적으로 분석하고자 한다. 『현종동궁일기』는 조선의 18대 임금인 현종이 세자(1649~1659)였을 때 시강원에서 작성한 매일의 정사(正史) 기록이다. 이 일기에는 총 3,625일의 기록이 남아있으며, 이 중 천문현상기록은 2,004일에 해당된다. 이번 연구에서는 『서운관지』의 현상분류방법을 참고하여 5가지 범주 및 16개 항목으로 구분하였다. '대기' 범주에는 해, 달, 구름에 관한 분류가 있고, '주현' 범주에는 태백주현과 세성주현이 있으며, '출현·발현' 범주에는 유성, 혜성, 화광, 객성, 흑점이 나타나는 기록이며, '접근' 범주에는 천체간 범/합, 엄/식, 입/출, 수 현상을 말하며, '(교)식' 범주에는 일식, 월식이 포함된다. 각 그룹은 57.9%, 17.3%, 20.9%, 3.3%, 0.6%의 비율을 보이는 것으로 나타났다. 천문기록 중 절반 이상의 기록이 대기에 관한 내용이며, 그 중에서도 해에 관련된 항목이 전체 기록의 33.5%에 해당한다. 연도별 분석에 의하면, 1657년과 1655년에 최대와 최소로 나타났으며, 연간 평균 304건으로 확인되었다. 1657년에 태백주현이 배 이상 관측되어서 그 해 기록건수가 최대로 나타났다. 월간 평균 기록은 254건인데, 월별로 3월이 가장 많았고, 7월이 가장 적었다. 한편 천문기록 일수가 청정일수와 상관관계가 있는 것으로 나타났다. 추가적으로 월령별 분석에 의하면, 달무리기록과 달과 관련된 접근현상은 주로 보름을 기준으로 대칭되는 모습을 보였다. 화광은 보름보다 삭과 그믐 무렵에 발생빈도가 높은 것으로 확인되었다.

교육홍보

[포 AE-01] 2022 Daegu National Science Museum Observatory Status

Joonho Kim, Hyeonwoo Moon, Yeejeong Lee
Daegu National Science Museum, 20, Techno-daero 6-gil, Yuga-myeon, Dalseong-gun, Daegu 43023, Republic of Korea

We report current status of Daegu National Science Museum (DNSM) Observatory. DNSM have 1m telescope with 4K by 4K CCD which shows depth of ~18 magnitude at 5-sigma with 180s exposure time. Using the telescope, we will study variable sources like supernovae, gravitational wave sources, and active galactic nuclei. Also, we have some educational programs for citizen (mainly for students). Some events with astronomical phenomena such as lunar eclipse are planned. We are open to use 1m telescope for other purpose of education or research.

[포 AE-02] Research using a remote observation for the Radio Telescope of Gwacheon National Science Museum(국립과천과학관 전파망원경 원격관측을 통한 연구)

Jaeil Cho(조재일)[1], Bong Won Shon(손봉원)[2], Tae Hyun Kim(김태현)[3], Hyo Ri Jeon(전효리)[3], Jae Seong Noh(노재승)[3], Ye Som Jung(정예솜)[3], Chae Rin Kim(김채린)[3], Jung Si Woo(정시우)[4], Son Young Jin(손영진)[4], YoungPyo Hong(홍영표)[5], Haerang Park(박해랑)[6], Sungmin Lim(임성민)[6], Yuna Hahn(한윤아)[6], Taehyun Jung(정태현)[2], Jung-Hoon Kim(김정훈)[7]
[1]*Gwacheon National Science Museum(국립과천과학관),* [2]*Korea Astronomy and Space Science Institute(한국천문연구원),* [3]*Chunbuk National University(충북대학교),* [4]*Kyung Hee University(경희대학교),* [5]*Yonsei University(연세대학교),* [6]*Ewoo High School(이우고등학교),* [7]*SET SYSTEM(에스이티시스템)*

Gwacheon National Science Museum(GNSM) has a 7.2m radio telescope which is only one possessed by a science museum in Korea. It was fully remodified in 2020 to produce better performance than before. Remote accessibility makes any allowed people to observe anywhere in Korea. So we received remote observation proposals and selected six proposals, two from high schools and four from universities, after examination. six teams propose various research purposes : measuring radial velocity of the Milky Way, producing radio map of Supernova Remnant, Observing 21cm line in the Galactic Plane, possibility of detecting radio signal in quasars, and comparing observation between GNSM and own made radio telescope. In this poster, we present some provisional results from students.

[포 AE-03] Telescope Relay System Design for the Disabled(장애인을 위한 릴레이 접안부 설계)

Daeyoung Park(박대영)
Gwacheon National Science of Museum

국립과천과학관의 1미터 망원경은 초점거리 7,498mm, 유효구경 995mm, 구경비 7.5의 리치-크레티앙 반사망원경으로 포크식 적도의 마운트에 장착되어 있다. 망원경의 구조적인 특성으로 관측대상의 고도에 따라 접안부의 높이가 지면으로부터 172.5cm에서 217.5cm 사이에서 변한다. 이 때문에 안정적인 관측을 위해서 분리식 3단 계단을 사용하고 있다. 그러나 계단을 사용할 경우 휠체어를 탄 지체장애인이나 키가 작은 유아는 관측할 수 없는 구조적인 문제가 있다.

만일 접안부의 길이를 관측자의 눈 가까운 곳까지 충분히 연장할 수 있다면 계단이나 사다리를 사용하지 않고도 관측이 가능하다. 그러나 이 경우 망원경의 초점면에 접안렌즈의 초점면을 일치시킬 수 없어 결상이 되지 않는다. 릴레이 광학계는 망원경의 초점면과 접안렌즈 사이에 릴레이 렌즈를 배치함으로써 초점거리의 변화 없이 초점면의 위치를 뒤로 이동시켜 결상이 가능하고, 전체 접안부의 길이를 늘일 수 있다.

릴레이 광학계는 상면만곡을 억제하고 비네팅을 최소화하기 위해 매우 복잡하고 많은 렌즈 구성으로 설계해야 한다. 그러나 사진 촬영이나 정밀 관측이 아닌 교육적 용도로 사용할 경우라면 상면 전체를 보정할 필요는 없으므로 렌즈를 직접 설계, 가공하지 않고 시판 중인 제품군에서 렌즈를 선택한 후 설계하여 적정성을 판단하였다.

설계에 사용된 렌즈는 현재 국립과천과학에서 사용 중인 접안렌즈의 종류, 망원경의 구경비 및 비네팅, 렌즈를 조합했을 때의 색수차 정도 등을 고려하여 선정하였다. 또한 렌즈의 구경비와 초점거리, 직경 등을 달리해 설계함으로써 각각의 설계조합이 어떤 광학적 특성을 보이는지를 분석하였고 릴레이 광학계를 사용한 접안부 제작을 위한 제언을 하였다.

성간물질/별생성/우리은하

[포 IM-01] Methanol Ice Absorption toward Red Point-like Objects in the Central Molecular Zone

[1]Dayoung Pyo, [1]Deokkeun An, [2]Kris Sellgren, [3]Solange V. Ramirez,
[1]Ewha Womans University. [2]Ohio State University. [3]Carnegie observatory

Methanol ices form in dense environment, and therefore can be used to trace regions with active star formation. Here, we study mid-infrared spectra of red point-like objects in the Central Molecular Zone to detect an absorption band at 9.7 μm from C-O stretching mode of solid CH_3OH. We find positive detections in a dozen of objects in An et al. (2011), which support their status as a young stellar object. Our analysis further suggests that strong CO_2 ice absorption at 15.4 μm observed in these objects are caused by CO_2 ice mixed with CH_3OH.

[포 IM-02] YSO Variabilities in Various Timescales

Sieun Lee[1], Jeong-Eun Lee[1], Carlos Contreras Peña[2], Gregory Herczeg[3], Doug Johnstone[4,5]
[1]School of Space Research, Kyung Hee University, Republic of Korea.
[2]Department of Physics and Astronomy, Seoul National University, Republic of Korea.
[3]Kavli Institute for Astronomy and Astrophysics, Peking University, 5 Yiheyuan Road, Haidian District, Beijing 100871, People's Republic of China
[4]NRC Herzberg Astronomy and Astrophysics Centre, 5071 West Saanich Road, Vitorai, BC V9E 2E7, Canada
[5]Department of Physice and Astronomy, University of Victoria, Victoria, BC V8P 5C2, Canada

Variability in Young Stellar Objects (YSOs) can be caused by variation of accretion rates, geometric changes in the circumstellar disks, the stochastic hydromagnetic interactions between stellar surfaces and inner disk edges, reconnections within the stellar magnetosphere, and hot/cold spots on stellar surfaces. To trace the variability, many observational studies have been done at optical wavelengths, but the embedded protostars are obscured at the short wavelengths. On the other hand, monitoring protostars at mid-Infrared (mid-IR) is powerful for tracing the variability over a wide range of evolutionary stages from the embedded protostars to the pre-main sequence stars. We investigate the long-term and short-term variabilities using the two mid-IR survey data, Near-Earth Object WISE (NEOWISE) and Young Stellar Object Variability (YSOVAR). The extension of the Wide-field Infrared Survey Explorer (WISE) mission, NEOWISE provides ~7 years all-sky photometric monitoring at mid-IR (3-5μm) up to now, with 6 months cadence. YSOVAR is a mid-IR survey observation monitoring the variability of YSOs for 40 days (short-term) with the Spitzer Space Telescope. To those two datasets, we apply the method developed by Park et al. (2021) to classify variabilities into six types based on their light curves (Linear, Curved, Periodic, Burst, Drop, Irregular). We present the results of the classification and discuss the differences between long-term (over ~7 years) and short-term (within 40 days) variabilities.

[포 IM-03] Gemini High-resolution Infrared Spectroscopy of Red Point-like Objects in the Central Molecular Zone

[1]Jiwon Han, [1]Deokkeun An, [2]Kris Sellgren, [3]Solange V. Ramirez, [4]A. C. Adwin Boogert,
[1]Ewha Womans University, [2]Ohio State University, [3]Carnegie observatory, [4]University of Hawaii

We present preliminary results obtained from high-resolution near-infrared spectroscopic observations of red point-like objects in the Central Molecular Zone (CMZ). Our sample is composed of 5 objects with distinctly redder infrared colors than those of the majority of sources in the CMZ, implying extra dust layers in each line of sight toward these objects, and includes two candidates of young stellar objects previously identified from *Spitzer* mid-infrared spectroscopy. We identify key molecular absorption bands in our *K*- and *L*-band spectra, such as from 2.3 μm CO, 3.0 μm H_2O ice, 3.54 μm CH_3OH ice, and discuss possible origins of such absorption features and the nature of our targets.

[포 IM-04] The CO outflow ejected by a recent accretion burst in B335

Chul-Hwan Kim[1], Jeong-Eun Lee[1], Carlos Contreras Peña[2], Doug Johnstone[3,4], Gregory J. Herezeg[5]
[1]School of Space Research, Kyung Hee University, Republic of Korea.
[2]Department of Physics and Astronomy, Seoul National University, Republic of Korea.
[3]NRC Herzberg Astronomy and Astrophysics Centre, 5071 West Saanich Road, Vitorai, BC V9E 2E7, Canada
[4]Department of Physice and Astronomy, University of Victoria, Victoria, BC V8P 5C2, Canada
[5]Kavli Institute for Astronomy and Astrophysics, Peking University, 5 Yiheyuan Road, Haidian District, Beijing 100871, People's Republic of China

The discrete outflow knots are an evidence of discontinuous accretion process in the growth of stellar mass. In order to understand the direct relation between mass accretion and ejection, we analyse the contemporary accretion activity and outflow in B335. The brightness of B335 in mid-IR has increased since 2010, indicative of an enhanced accretion event. Using the ^{12}CO emission known as an outflow tracer, we found the high-velocity outflow component associated with this recent accretion burst in the position-velocity diagram. The high-velocity outflow component is estimated to have been ejected around 2014. The epoch in which the high-velocity outflow component was ejected is consistent with the epoch of the increase in brightness. This result can be interpreted that the high-velocity outflow component is linked to the recent outburst caused by the recent accretion activity. We also estimate the outflow mass, mass ejection rate, and mass accretion rate for the recent events. Finally, the mass ratio between ejection and accretion for the recent accretion activity is about 0.01, which is lower than the known average value by an order of magnitude.

[포 IM-05] The JCMT BISTRO Survey: an 850/450μm polarization study of NGC 2071IR in Orion B

A-Ran Lyo[1], Jongsoo Kim[1,2], Sarah Sadavoy[3], Doug Johnstone[4,5], David Berry[6] and the BISTRO team
[1]Korea Astronomy and Space Science Institute, [2]University of Science and Technology, [3]Queen's University, [4]NRC Herzberg Astronomy and Astrophysics, [5]University of Victoria, [6]East Asian Observatory

We present the results of simultaneous 450/850μm polarization observations toward the massive star forming region NGC2071IR, a target of the BISTRO (B-fields in Star-Forming Region Observations) Survey, using the POL-2 polarimeter and SCUBA-2 camera mounted on the James Clerk Maxwell Telescope. We find a pinched magnetic field morphology in the central dense core region, which could be due to a rotating toroidal disk-like structure and a bipolar outflow originating from the central young stellar object, IRS 3. Using the modified Davis-Chandrasekhar-Fermi method, we obtain a plane-of-sky magnetic field strength of 563±421μG in the central ~0.12 pc region from 850μm polarization data. The corresponding magnetic energy density of 2.04×10-8erg cm-3 is comparable to the turbulent and gravitational energy densities in the region. We find that the magnetic field direction is very well aligned with the whole of the IRS 3 bipolar outflow structure. We find that the median value of polarization fractions, 3.0%, at 450μm in the central 3 arcminute region, which is larger than the median value of 1.2% at 850μm. The trend could be due to the better alignment of warmer dust in the strong radiation environment. We also find that polarization fractions decrease with intensity at both wavelengths, with slopes, determined by fitting a Rician noise model, of 0.59± 0.03 at 450μm and 0.36±0.04 at 850μm, respectively. We think that the shallow slope at 850μm is due to grain alignment at the center being assisted by strong radiation from the central young stellar objects.

우주론/암흑물질,암흑에너지

[포 CD-01] Clustering of Critical Points in Massive Neutrino Cosmologies

Jeongin Moon, Graziano Rossi, Hogyun Yu
Sejong University

Critical points are a subset of special points tracing cosmological structures, with remarkable topological properties. They thus offer a higher-level description of the multiscale cosmic web, being more robust to systematic effects. For the first time, we characterize here their clustering statistics in massive neutrino cosmologies, including cross-correlations, and quantify their simultaneous effects on the main web constituents - i.e., halos, sheets, filaments, and voids. In particular, we show that the presence of massive neutrinos do affect the BAO-like peak amplitudes and inflection scale positions of their corresponding two-point statistics, and this in turn can be used as a novel technique to set upper limits on the summed neutrino mass and type of hierarchy. Our study is relevant - with direct applications - to ongoing and future large-volume redshift surveys such as DESI and LSST, that will provide unique datasets for neutrino mass constraints.

[포 CD-02] Comparing Cosmological Information from Deep Learning and Higher Order Statistics

Seyeon Hwang, Sumi Kim, Cristiano G. Sabiu, Inkyu C. Park
Department of Physics, University of Seoul, Seoul 02504, KOREA

In this work we consider analysing the large scale structure within astronomical data with Machine Learning techniques. We use 3-dimension Convolutional Neural Networks (CNN) to estimating cosmological parameters, specifically Ω_m and σ_8, from the morphology of the large scale structure. Training and test data are generated by the simulation code PINOCCHIO, which is based on a Lagrangian Perturbation Theory approach. We generate the dark matter halos catalogues with position, mass and velocity. We then use these properties (number density, mass density, velocity), in various combinations to extract cosmological information.

We also analyse the same simulation data using the higher order correlation functions. Using the GRAMSCI (GRAph Made Statistics for Cosmological Information) code we compute the 3-point correlation function and train a simple ML model to estimate cosmological parameters. We then compare higher order statistics and CNN deep learning from an information perspective.

[포 CD-03] Head-on Collision of Fuzzy/Cold Dark Matter Halos

Hyeonmo Koo(구현모), Dongsu Bak(박동수), Sangnam Park(박상남)
University of Seoul (서울시립대학교)

We compare the cold dark matter (CDM) halo model with the fuzzy dark matter (FDM) one by performing simulation of head-on collisions.

We show that the FDM halo dynamics is more dissipative than the CDM counterpart by measuring the velocity decrease of halos after the collision.

For this comparison, we prepare two equal-mass halos and head-on collide them with various initial velocities. In this simulation, we take the mass and half mass radius of FDM halo to be identical to the CDM counterparts.

천문우주관측기술

[포 AT-01] Development of Mirror Manufacturing with 3D Printing Method

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

Telescope mirrors are made of various materials such as glass, metal, ceramic, etc. Most highly qualified mirrors are made of ceramics with very low coefficient of temperature expansion. They are Zerodur®, ULE®, Astrosital, and ClearCeram®-Z. The ceramic materials are formed to a mirror by melting it in a vessel prepared to the mirror-size and by cooling it down. The process needs long time for slow cooling and large space.

A 3D printing method by using ceramic material has been devised, so the method is being tried to make a ceramic mirror. Starting from a disc of 50 mm in diameter, a flat mirror is being made. Alumina was 3D printed for a mirror, which was proved to be suitable for 3D printing. In this paper, the process of ceramic 3D printing is explained and current status of manufacturing a 3D alumina mirror is presented.

Keywords: mirror, 3D printing, ceramic, alumina

[포 AT-02] Formation Flying SNIPE Mission

Data

Jaejin Lee, and SNIPE Team
Korea Astronomy and Space Science Institute,

The formation flying CubeSat constellation, SNIPE mission will be launched by Soyuz-2 at Baikonur Cosmodrome in December 2022. The SNIPE's scientific goal is to observe spatial and temporal variations of the micro-scale plasma structures on the topside ionosphere. The four 6U CubeSats (~ 10 kg) will be launched into a polar orbit at an altitude of ~500 km. The distances of each satellite will be controlled from 10 km to more than ~ 100 km by the formation flying algorithm. The SNIPE mission is equipped with identical scientific instruments, solid-state telescopes, magnetometers, and Langmuir probes. All the payloads have a high temporal resolution (sampling rates of about 10 Hz). Iridium communication modules provide an opportunity to upload emergency commands to change operational modes when geomagnetic storms occur. SNIPE's observations of the dimensions, occurrence rates, amplitudes, and spatiotemporal evolution of polar cap patches, field-aligned currents (FAC), radiation belt microbursts, and equatorial and mid-latitude plasma blobs and bubbles will determine their significance to the solar wind-magnetosphere-ionosphere interaction and quantify their impact on space weather. The data will be released after validation.

[포 AT-03] Design for new structure of IGRINS-2 control software as a facility instrument of the Gemini observatory.

Hye-In Lee[1], Francisco Ramos[2], Hwihyun Kim[2], Heeyoung Oh[1], Jae-Joon Lee[1], Chan Park[1], Pablo Prado[2], Ignacio Arriagada[2], Ueejeong Jeong[1], Moo-Young Chun[1], Young Sam Yu[2], Sungho Lee[1], and In-Soo Yuk[1]
[1]*Korea Astronomy and Space Science Institute,*
[2]*Gemini Observatory*

We propose a new design of the control software that will be used to operate the second Immersion GRating INfrared Spectrometer (IGRINS-2), currently being built by KASI in collaboration with the Gemini Observatory. The software design is based on requirement analysis, architecture development, and existing matured IGRINS software. The design also follows the Gemini approach to developing new instruments software using the Gemini Instrument Application Programmer Interface (GIAPI) to connect the instrument with the Gemini environment such as the Gemini Master Process (GMP). The GMP aligns the relationship between subsystems of the Gemini Observatory (e.g. the Telescope Control System) and the IGRINS-2 software packages. The IGRINS-2 users will observe using the Sequence Executor (SeqExec), Observing Tools (OT), and the other auxiliary software. In this poster, we particularly focus on the considerations for communication method and GUI structure of the new design.

[포 AT-04] Status and Plan of KMTNet Operation

Chung-Uk Lee, Dong-Joo Lee, Yongseok Lee, Hyunwoo Kang, Dong-Jin Kim, Sang-Mok Cha, Seung-Lee Kim, Eon-Chang Sung, Seung-Cheol Bang, Sungwook E. Hong, Jae-Woo Kim
Korea Astronomy and Space Science Institute

외계행성 탐색시스템 2021년 운영현황과 2022년 계획을 보고한다. 2021년 관측장비 가동율은 99.3% 이었으며, 천문박명시간 기준으로 10806.9 시간이 할당되었고, 이 중 8197.7 시간 동안 관측이 이루어져 관측율은 75.2%에 이른다. 이 발표에서는 2021년 날씨 및 관측통계 결과와 함께 최근 진행되고 있는 외계행성 탐색시스템의 원격관측 환경 구축 계획과 진행 상황을 소개한다.

외부은하/은하단

[포 GC-01] HI superprofile analysis of nearby galaxies

Minsu Kim[1], Se-Heon Oh[1,2]
[1]*Department of Astronomy and Space Science, Sejong University, Seoul, Korea*
[2]*Department of Physics and Astronomy, Sejong University, Seoul, Korea*

We study the global HI properties of nearby galaxies in the local Universe by stacking their individual spectral line profiles obtained from HI observations. The so-called HI superprofile is derived by co-adding velocity profiles of an HI data cube after aligning their central velocities. This high S/N HI superprofile is useful for examining global HI properties of a galaxy in a way of being correlated with other galaxy properties like star formation rate, HI mass to stellar mass ratio, gas metallicity, dynamical mass, etc. In this work, we present our new method for constructing an HI superprofile of a galaxy which is based on Bayesian profile decomposition techniques. This is compared to the previous approach where no prior profile decomposition is made for the velocity profiles being stacked. As a practical test, we apply

our new method to a number of high-resolution HI data cubes of nearby galaxies in the local Universe which are taken from THINGS and LITTLE THINGS. Particularly, we construct two different types of HI superprofiles for each galaxy: the one derived using the HI gas velocity profiles which are consistent with the global kinematics of the galaxy (named as 'bulk'), and another one for those deviating from the global kinematics ('non-bulk'). We quantify the shapes of the HI superprofiles by fitting a double Gaussian model from which kinematically cold and warm HI gas components are extracted with respect to their velocity dispersions. These global HI gas properties of the galaxies are then compared to their other physical properties to see if any correlations between them are present. From this, we find that the shape parameters (e.g., velocity dispersions, mass ratios of the kinematically cold and warm HI gas components) of the HI superprofiles of the galaxies constructed using their bulk HI gas components are better correlated with other physical properties like star formation rate and gas metallicity than those constructed using non-bulk HI gas components. The weak correlations shown for the HI superprofiles of the non-bulk gas motions can be associated with stellar feedback in the galaxies, giving rise to turbulent random gas motions.

[포 GC-02] Correlations of the multiwavelength emission in the blazar CTA 102 during 2016-2018

Sang-Hyun Kim[1,2] and Sang-Sung Lee[1,2]
[1]Korea Astronomy and Space Science Institute, Daejeon, Korea
[2]University of Science and Technology, Daejeon, Korea

Blazars are among the most powerful objects in the universe. Their relativistic jets pointing towards Earth characterize them by relativistically boosted emission, variable emissions extending from radio to gamma-ray energies, and superluminal jet motions. The Fermi-Large Area Telescope observed the active gamma-ray states from 2016 to 2018 in the blazar CTA 102. During this period, we find two prominent gamma-ray outbursts, known as flares. The multiwavelength light curves covering radio to X-ray energies show flares that seem to be associated with the gamma-ray flares. In this study, we explore correlations of the multiwavelength emission to figure out the nature of the gamma-ray flares. We find a > 2σ correlation between the radio and gamma-ray energies. The optical/X-ray emissions show > 3σ correlations with the gamma-ray emission. We discuss the possible origins of the gamma-ray flares.

[포 GC-03] Velocity dispersions of globular cluster systems in ultra-diffuse galaxies in the Virgo cluster.

Sungsoon Lim[1], Elisa Toloba[2], Eric Peng[3] and the NGVS team
[1]Department of Astronomy, Yonsei University, [2]Department of Physics, University of Pacific, [3]Department of Astronomy and KIAA, Peking University

Ultra-diffuse galaxies (UDGs) are interesting objects having luminosities comparable to classical dwarf galaxies but effective radii much larger. Its formation mechanism is still in debate, and their dynamical masses are one of the key aspects to understand the formation mechanism of UDGs.

We present Keck/DEIMOS spectroscopy of globular clusters (GCs) around nine UDGs in the Virgo cluster. We find that all nine UDGs have systemic velocities consistent with being in the Virgo cluster. We also estimate their velocity dispersions and compare them with those of other galaxies, and find a large range of velocity dispersions of GCs systems in UDGs. Half of Virgo UDGs have much larger velocity dispersions than normal galaxies, but another half have similar or even smaller velocity dispersions. We will discuss the implications of these results.

[포 GC-04] Double Synchrotron Self Absorption Spectrum of the Blazar 3C454.3 and Its Magnetic Field Strength

Hyeon-woo Jeong[1,2], Sang-Sung Lee[1,2]
[1]University of Science and Technology, [2]Korea Astronomy and Space Science Institute

The blazar 3C454.3 is one of the most famous and bright source in the sky from radio to gamma-ray. For radio regime, it is believed that radio emission is the result of synchrotron radiation by magnetic field. Thus, studying magnetic field of relativistic jet from blazar is important to figure out what is the cause of launching, collimating, and powering the jet. In order to estimate magnetic field strength of relativistic jet, we perform spectral analysis with using multi wavelength light curves from single-dish and short baseline interferometry when the source was flaring. In this step, we suggest double synchrotron-self absorption(SSA) spectrum, the one SSA has low turnover frequency range(3~25GHz), while the other SSA region has relatively high turnover frequency

range(60~120GHz). In order to identify the location for both SSA regions, we use VLBI observations. And then we estimate the magnetic field strength for both SSA regions.

[포 GC-05] A Hyperwide Study of the Intracluster Globular Cluster Population in Hydra

Brian S. Cho[1](조브라이언), Myung Gyoon Lee[1], In Sung Jang[2]
[1]Department of Physics and Astronomy, Seoul National University; [2]Department of Astronomy & Astrophysics, University of Chicago

Intracluster globular clusters (IGCs) are the expected result of galaxy interactions stripping globular clusters (GCs) from galaxies in a galaxy cluster. They are a population of GCs bound to a galaxy cluster rather than to individual galaxies. IGCs are an important population to understand because they provide valuable insights into the hierarchical assembly history of galaxy clusters. Abell 1060, or the Hydra I cluster, is one of the largest and nearest rich cluster of galaxies, and it hosts a massive globular cluster system. Therefore, we use Hyper Suprime-Cam (HSC) archival images to study a "hyper-wide" view of the Hydra cluster, covering up to 1.8 degrees from the cluster center. From this, we obtain the largest survey of the globular clusters in Abell 1060. We choose IGC candidates as those with colors similar to the colors of globular clusters belonging to galaxies, but at distances outside of regions dominated by galaxy potential. We find that there exists a large population of intracluster globular clusters that is not associated with any individual galaxy and outside of the region dominated by the central cD galaxy NGC3311. We investigate this IGC population and study its distribution, extent, and relation with the different galaxy populations in Hydra. We discuss the origin of the IGC population in Hydra and provide comparison with those found in other massive clusters. Thus, we present the most comprehensive study of the intracluster globular cluster population in Hydra.

[포 GC-06] Construction of GALEX UV catalog of low redshift galaxies

Jeeun Hwang, Myungshin Im, Gregory S.H. Paek, and IMSNG team
SNU Astronomy Research Center

Detection of transients such as supernovae (SNe) and kilonvae (KNe) in early phase has recently become important for understanding the progenitor properties and multi-messenger astronomy. Predicting which galaxy has the higher probability of hosting the transient events would help detect the early phase of the events and get information on their progenitors. The SN and KN rates are known to be the function of star formation rate (SFR) of the host galaxy. The SFR of the galaxy can be estimated from ultraviolet (UV) luminosity. However, the UV magnitudes have been derived for a limited number of nearby galaxies. In this work, we introduce GALEX galaxy catalog to offer all-sky UV brightness of low redshift galaxies. As a first step of this research, we select nearby galaxies from the GLADE catalog. We derive the UV photometry of the galaxies from the GALEX AIS images, supplemented by NGS and MIS data observed from GALEX. From the near-UV (NUV) and far-UV (FUV) magnitudes, we calculate the SFRs of the galaxies, which will further be useful for estimating the SN and KN rate. The results are compared with previous GALEX UV catalog of galaxies. There will be an updated catalog based on this catalog for calculating KN rate of the galaxies in the future work.

[포 GC-07] Star Formation Histories of nearby Dwarf Spheroidal and Dwarf Elliptical Galaxies

Mira Seo, Hong Bae Ann
Pusan National University

We present the star formation histories (SFHs) of early-type dwarf galaxies, 200 dSphs and 234 dEs, in the local universe within redshift $z<0.01$. SFHs of the early-type dwarf galaxies are characterized by pre-enrichment and early quenching of star formation which result in the prevalence of metal-poor old stellar populations and absence of moderately old stars that have ages of a few Gyr. There is a clear difference between dSphs and dEs. The effects of reionization and feedback from supernova explosions are thought to be strong enough to remove the gas left in dSph galaxies. In contrast, the ejected gas are not completely removed from dE galaxies and fall back to ignite burst of star formation at a few Gyr after the first period of violent burst of star formation.

[포 GC-08] A systematic study of ionized gas-radio emission connection in active galactic nuclei

Ashraf Ayubinia[1,2,3], Jong-Hak Woo[1]
[1]Department of Physics & Astronomy, Seoul National University, [2]CAS Key Laboratory for Research in Galaxies and Cosmology, Department

of Astronomy, University of Science and Technology of China, [3]School of Astronomy and Space Science, University of Science and Technology of China

Using a large sample of ~ 6000 targets, we study the relationship between the ionized gas kinematics and radio emission in active galactic nuclei (AGNs). Particularly, we compare ionized outflows and radio connection in different types of AGNs such as Type 1 vs Type 2, HERGs vs LERGs and compact vs extended radio galaxies. While we find no strong correlation between ionized outflows and radio emission in the first and the second, we find evidence that ionized outflow velocity trends to increase with radio luminosity in compact radio galaxies. By selecting a subsample of ~700 significantly jet-dominated sources, we find that small scale jets with $L_{1.4\mathrm{GHz}} = 10^{38} - 10^{40}\mathrm{erg\,s^{-1}}$ substantially contribute in accelerating ionized gas. However, as radio luminosity exceeds $L_{1.4\mathrm{GHz}} \geq 10^{40}\mathrm{erg\,s^{-1}}$, the velocity of ionized gas trends to be smaller. One interpretation is that high-power jets are very collimated that pierce the ISM without disturbing gas significantly. Therefore, Eddington ratio and properties of the ISM are more important parameters in dictating ionized gas kinematics in these radio powerful AGNs.

[포 GC-09] Star-formation of Galaxies in an Ancient Megalopolis

Seong-Kook Lee[1], Myungshin Im[1], Insu Paek[1], Minhee Hyun[2], Yongjung Kim[3], and Jae-Woo Kim[2]
[1]Seoul National University, [2]Korea Astronomy and Space Science Institute, [3]Kyungpook National University

A super-cluster is the most massive, large-scale structure in the Universe. And, at high redshift, there is only a handful of them which have been observationally found. Super-clusters generally consist of several galaxy clusters, galaxy groups, and filaments connecting these clusters and groups. Therefore, it provide a very interesting laboratory in studying the evolution of galaxies as well as galaxy clusters and groups. Here, we analyze the star-formation properties of galaxies which belong to the super-cluster at z~0.65 (when the age of the Universe is ~7.5 billion years) observed in the UDS field.

천문화학/천문생물학

[포 AB-01] Complex organic molecules detected in twelve high-mass star-forming regions with Atacama Large Millimeter/submillimeter Array (ALMA)

Giseon Baek[1], Jeong-Eun Lee[1], Tomoya Hirota[2], Kee-Tae Kim[3], KaVA Star-Formation Science Working Group
[1]School of Space Research, Kyung Hee University, 1732, Deogyeong-daero, Giheung-gu, Yongin-si, Gyeonggi-do 17104, Republic of Korea, [2]Department of Astronomical Sciences, SOKENDAI (The Graduate University for Advanced Studies), Osawa 2-21-1, Mitaka-shi, Tokyo 181-8588, Japan, [3]Korea Astronomy and Space Science Institute, 776 Daedeok-daero, Yuseong, Daejeon 34055, Korea

Recent astrochemical models and experiments have explained that complex organic molecules (COMs; molecules composed of six or more atoms) are produced on the dust grain mantles in cold and dense gas in prestellar cores. However, the detailed chemical processes and the roles of physical conditions on chemistry are still far from understood. To address these questions, we investigated twelve high-mass star-forming regions using the ALMA band 6 observations. They are associated with 44/95GHz class I and 6.7 GHz class II CH3OH masers, indicative of undergoing active accretion. We found 28 cores with COMs emission among 66 detected components and specified 10 cores associated with 6.7 GHz Class II CH3OH masers. Up to 19 COMs are identified including oxygen- and nitrogen-bearing molecules and their isotopologues in the cores. The derived abundances show a good agreement with those from other low- and high-mass star-forming regions, implying that the COMs chemistry is predominantly set by the ice chemistry in the prestellar core stage. One clear trend is that the COMs detection rate steeply grows with the gas column density, which can be attributed to the efficient formation of COMs in dense cores. In addition, cores associated with a 6.7 GHz class II CH3OH maser tend to emit a larger number of COMs. Finally, our results suggest that the enhanced abundances of several molecules in our hot cores could be originated by the active accretion of each source as well as different physical conditions of cores.

태양/태양계

[포 SS-01] 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, Korea*
[2]*University of Science and Technology, Korea*
[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.

[포 SS-02] Effect of collisional thermalization process in a steady-state solar wind model

Hwanhee Lee[1], Jungjoon Seough[1], Bo Li[2], Yeon-Han Kim[1], Kyung-Suk Cho[1]
[1]*Korea Astronomy and Space Science Institute*
[2]*Institute of Space Sciences, Shandong University*

The Coulomb collisions play an important role in regulating the thermodynamic evolution of the solar wind. The low proton temperature and high particle density of the slow solar wind mean that the collisional process works more efficiently than fast solar wind. Recently, a newly defined collisional frequency considering cross-field particle collisions through the gyro-motions has been reported. By incorporating the new formula into the steady-state solar wind model with the Alfven-wave turbulence, we investigate how the Coulomb collisions affect the radial evolution of proton temperatures and discuss the importance of thermalization process in the solar wind model.

[포 SS-03] A New Method for Quantitatively Classifying Solar Active Regions

Yeon Woo Jang[1], Sibaek Yi[1] and Tetsuya Magara[1,2]
[1]*School of Space Research, Kyung Hee University, 1732, Deogyeong-daero, Giheung-gu, Yongin-si, Gyeonggi-do 17104, Korea,* [2]*Department of Astronomy and Space Science, Kyung Hee University, 1732, Deogyeong-daero, Giheung-gu, Yongin-si, Gyeonggi-do 17104, Korea*

Classification of solar active regions (ARs) has followed a conventional method based on their morphological characteristics. Although it provides a simple way to classify ARs, the method cannot provide quantitative comparison between ARs, thereby limiting the quantitative discussion of ARs. On the other hand, the so-called relative magnetic helicity may be a quantity representing the magnetic field configuration of an AR, and it provides information on the activity of the AR to some extent, although the quantity is derived from the integral operation that removes all characteristics of spatial distributions in the AR. Furthermore, since the relative magnetic helicity depends on not only the field-line twist representing stored free magnetic energy but also total magnetic flux in an AR, taking a large positive or negative value of it does not necessarily indicate that the AR is "really active".

Here we propose a new method for quantitatively classifying ARs, which is based on characteristics of the spatial distribution of the field-line twist. As the spatial distribution of gas density provides information on the gravity of a system, we considered that the spatial distribution of the field-line twist gives information on the activity of an AR. From the spatial distribution of the field-line twist we calculated its gradient vector field and then derived the divergence (or convergence) of that vector field. We applied this method for ARs obtained from flux-emergence simulation and nonlinear force-free field reconstruction. In both cases we found a common negative correlation between the field-line twist and divergence of its gradient vector field. We show a physical interpretation of this correlation and also discuss how our method can be used to quantitatively classify ARs.

[포 SS-04] CODEX Data Processing

Su-Chan Bong[1], Jae-Ok Lee[1], Ji-Hye Baek[1], Jongyeob Park[1], Nelson L. Reginald[2], Jeffrey S. Newmark[2]
[1]*Korea Astronomy and Space Science Institute, Korea,* [2]*NASA Goddard Space Flight Center, USA*

Coronal Diagnostic Experiment (CODEX) is a diagnostic coronagraph developed by the Korea Astronomy and Space Science Institute and the NASA Goddard Space Flight Center (GSFC) to be deployed in 2023 on the International Space Station (ISS). It is designed to obtain simultaneous measurements of electron density, temperature, and velocity in the 2.5 - 10 solar radius range using multiple filters. The observed data is processed from Level 0 to the higher levels. Level 0 is the data packets or compressed image files replicating what was on board before being packetized. Onboard processing may have been applied. Level 1 is FITS files with uncompressed images with header information from the image header and available ancillary data. Values are in raw counts. Level 2 is FITS files with calibrations applied. Calibration includes corrections on dark, exposure duration, calibration factor, pointing, extinction ratio. Values are in physical units. Level 3 is the result of combining two or more images or derived quantities. Images are integrated in space and time, polarization properties are derived, and then temperature and speed are derived.

[포 SS-05] The light field camera ray-tracing simulation for CLPS/GrainCams

Minabe Kim[1], Minsup Jeong[1], Young-Jun Choi[1], Sungsoo S. Kim[2]
[1]*Korea Astronomy and Space Science Institute*
[2]*Kyung Hee University*

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

항성,항성계/외계행성

[포 SA-01] NIR high spectral resolution observations of AG Car

Jae-Joon Lee[1] and Hyun-Jeong Kim[1]
[1]*Korean Astronomy and Space science Institute*

AG Car is a member of small group of massive stars classifies as Luminous Blue Variables (LBVs). The ring nebula around AG CAR can provide detailed nature of mass loss during the late stage evolution of very massive stars. We present NIR high spectral resolution spectroscopic observations of the ring nebular around AG Car with IGRINS and PHOENIX on Gemini south. We also present observation with IRIS2 on AAT 3.9m telescope, together with archival data of VLT MUSE and HST WFC3. The kinematics of AG Car ring is presented and we discuss its mass loss history.

[포 SA-02] Very early light curve of Type Ia Supernova SN 2021aefx

Hyeonho Choi[1,2](최현호), Myungshin Im[1,2](임명신), Gu Lim[1,2](임구), Gregory S.H. Paek[1,2](백승학), Sophia Kim[1,2](김소피아), Mankeun Jeong[1,2](정만근), Changsu Choi[1,3](최창수), Seo-Won Chang[1,2](장서원) and IMSNG Team
[1]*SNU Astronomy Research Center, Seoul National University, Seoul, Republic of Korea*
[2]*Astronomy Program, Department of Physics & Astronomy, Seoul National University, Seoul, Republic of Korea*
[3]*Korea Astronomy and Space Science Institute, Daejeon, Republic of Korea*

Despite significant efforts to identify a progenitor and explosion mechanism of Type Ia supernovae, their origin is still controversial, leading to several models to explain observational features. Since these models expect diversity in a very early phase, the early phase observation plays a key role in constraining the model. However, the lack of early phase observation of Type Ia Supernova put constraints on testing various models.

In this poster, we present early phase observations and preliminary results of SN 2021aefx as a part of IMSNG(Intensive Monitoring Survey of Nearby Universe) project which aims to find transient by high-cadence monitoring of the nearby galaxies. To estimate the explosion date, we fit early flux to single power law and derive exponent n of 2.35 with explosion time of MJD 59528.07±0.1 which is 1.2 days before the discovery date. Using SALT2 model, we find that SN 2021aefx is close to normal type Ia supernova $m_{B,15} = 0.96 \pm 0.01, M_{B,\max} = -19.42 \pm 0.05$ and the distance is consistent with the host galaxy within the error. The early color information indicates that the supernova is early-red type, suggesting that SN 2021aefx is possibly originated

from "double detonation model" or "Ni mixing model". The possibility of these models will be discussed in a later study.