

the direction facing away from the cluster centre. Thanks to the revolutionary wide field-of-view of the MUSE, combined with 8.2-m VLT (UT-4) at Cerro Paranal, we could simultaneously obtain IFU spectra of the blobs, as well as the galaxy. The MUSE spectra clearly confirms that the star-forming blobs are associated with the early-type galaxy. Moreover, MUSE reveals long ionised-gas tails, emanating from the galaxy. The quantity of gas indicates a gas rich progenitor has merged with the early-type galaxy. However the direction of the tails and blobs, and the blob morphology, appears to indicate that strong ram-pressure stripping may have stripped out gas brought in by the merger. We will present kinematic structure of the whole system (the galaxy, star-forming blobs, and gas tails), as well as the star formation history of the system, supporting a scenario where a recent galaxy merger is subjected to cluster environmental mechanisms.

#### [7 GC-16] Photometric Pixel-Analysis of the BCGs in Abell 1139 and Abell 2589

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To understand the coevolution of Brightest Cluster Galaxies (BCGs) and their host clusters, we conduct a case study on the BCGs in dynamically young and old clusters, Abell 1139 (A1139) and Abell 2589 (A2589). We analyze the pixel color-magnitude diagrams (pCMDs) using deep *g*- and *r*-band images, obtained from the CFHT observations. (1) While the overall shapes of the pCMDs are similar to those of typical early-type galaxies, the A2589-BCG tends to have redder mean pixel color and smaller pixel color deviation at given surface brightness than the A1139-BCG. (2) The mean pixel color distribution as a function of pixel surface brightness indicates that the A2589-BCG formed a larger central body by major dry mergers at an early epoch than the A1139-BCG, while they have grown commonly by subsequent minor mergers. (3) The spatial distributions of the pixels with deviated colors reveal that the A1139-BCG experienced considerable tidal events more recently than the A2589-BCG, whereas the A2589-BCG has an asymmetric compact core possibly resulting from

major dry merger at an early epoch. (4) The A2589-BCG shows a very large faint-to-bright pixel number ratio compared to early-type non-BCGs, whereas the ratio for the A1139-BCG is not distinctively large. These results imply that the BCG in the dynamically older cluster (A2589) formed earlier and is relaxed better.

#### [7 GC-17] Lyman alpha emitting blobs at the epoch of cosmic reionization

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Lyman alpha photons emitted from the early generation galaxies are scattered through the intergalactic medium, and can be observed as Lyman alpha emitting sources. We examine the Lyman alpha line transfer mechanism by tracing the random scattering histories of Lyman alpha photons in the intergalactic medium of the early universe. The density and ionization fields are based on the 3D map by N-body + radiation transfer simulations of the epoch of reionization. The calculation is compared with analytical models, too. The emergent line profile and the size of the Lyman alpha blob are strongly tied to the density and ionization environment, likely to give constraints when high-*z* Lyman alpha blobs are observed.

#### [7 GC-18] BCCOMICS: Baryon-Cold dark matter COsmological Initial Condition generator for Small-scale structures

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Density and velocity perturbations in scales most relevant for the first galaxy formation are strongly affected by large-scale density perturbations, velocity-divergence perturbations and the baryon-cold dark matter (CDM) streaming velocities. Even at redshifts as high as  $z \sim 200$ , this mode-mode coupling imprints a significant impact on the small-scale perturbations, at the wavenumber  $k > \sim 100 \text{ Mpc}^{-1}$ , as was calculated in our recent work. This implies that cosmological initial conditions based on the usual linear theory is no longer valid in these scales. We present a new cosmological initial condition generator, BCCOMICS, which generates initial conditions for the cold dark matter (CDM) and baryons in scales most relevant for the first galaxy formation.

BCCOMICS is based on the linear perturbation theory including the mode-mode coupling terms, and generates cosmological initial conditions for the SPH-based code GADGET and the AMR-based code ENZO. We also present our preliminary result on the cosmic variance of the first galaxy formation, studied by using BCCOMICS.

### [구 GC-19] Formation of globular clusters in cosmological radiation hydrodynamic simulation

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This is a presentation of the paper published as Kimm et al. 2016, ApJ, 823, 52. We investigate the formation of metal-poor globular clusters (GCs) at the center of two dark matter halos with  $M_{\text{halo}} \sim 4 \times 10^7 M_{\text{sun}}$  at  $z > 10$  using cosmological radiation-hydrodynamics simulations. We find that very compact ( $\leq 1$  pc) and massive ( $\sim 6 \times 10^5 M_{\text{sun}}$ ) clusters form rapidly when pristine gas collapses isothermally with the aid of efficient Ly $\alpha$  emission during the transition from molecular-cooling halos to atomic-cooling halos. Because the local free-fall time of dense star-forming gas is very short ( $\ll 1$  Myr), a large fraction of the collapsed gas is turned into stars before stellar feedback processes blow out the gas and shut down star formation. Although the early stage of star formation is limited to a small region of the central star-forming disk, we find that the disk quickly fragments due to metal enrichment from supernovae. Sub-clusters formed in the fragmented clouds eventually merge with the main cluster at the center. The simulated clusters closely resemble the local GCs in mass and size but show a metallicity spread that is much wider than found in the local GCs. We discuss a role of pre-enrichment by Pop III and II stars as a potential solution to the latter issue. Although not without shortcomings, it is encouraging that a naive blind (not tuned) cosmological simulation presents a possible channel for the formation of at least some massive GCs.

## 천문우주 관측기술

### [구 AT-01] Evaluation of Phase Calibration Performance with KVN

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In mm-VLBI, the quality of observation data is largely affected by atmospheric effect. The most challenging matter is that the phase of correlator output fluctuates rapidly resulting from a variation of atmospheric propagation delay. Consequently, it is demanding to achieve high Signal-to-Noise ratio by integrating data in time domain before calibrating atmospheric delay. However, Korean VLBI Network (KVN) has a unique system to make a 4-frequency (22/43/86/129 GHz) simultaneous observation in mm-wavelength and Frequency Phase Transfer (FPT) calibration technique has effectively removed atmospheric delay in the simultaneous multi-frequency observation of the KVN.

For astrometric and astrophysical studies, we evaluated the FPT performance of KVN in various observing conditions. Using the total 38 bright AGNs, we have compared atmospheric conditions such as ground-based weather information, system temperature, atmospheric delay with the calibration results of FPT at 22/43/86/129 GHz during the five experiments in 2013, and quantified its performance in terms of coherence function and Allan variance. We present the analysis result of the relation between the FPT performance and observing conditions.

### [구 AT-02] Development of Error Compensation Software, ECS

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ECS(Error Compensation Software)는 알루미늄 자유곡면 반사경의 형상정밀도를 향상시키기 위해 개발된 보정가공 소프트웨어이다. DTM(Diamond Turning Machine)을 이용한 가공공정에서 가공오차의 변화를 쉽게 확인하며 형상을 보정할 수 있도록 설계되었다. 보정가공 공정은 (1) 10차 다항식을 이용하여 표면을 설계한 후 DTM에 입력할 가공경로 계산, (2) DTM에 가공경로를 입력하여 가공, (3) 3차원 초정밀 형상측정 장비로 반사경의 가공오차 분석, (4) 가공오차를 보정하여 새로운 10차 다항식 설계, (5) 보정가공경로 계산 후 재가공으로 이루어진다. 그동안의 공정은 다항식의 설계, 가공경로 계산, 반사경의 가공오차 분석을 위해 다수의 프로그램들을 실행해야만 했다. 본 연구에서는 ECS가 알루미늄 자유곡면 반