investigate the topological structures of five different multiverses produced by cosmological n-body simulations with various cosmological initial conditions: (1) one standard universe, (2) two different dark energy states, and (3) two different dark matter densities.

For the Big Data calculations, we use a custom build of stand-alone Spark cluster at KIAS and Dataproc Compute Engine in Google Cloud Platform with the sample sizes ranging from 7 millions to 200 millions.

Among many graph statistics, we find that three simple graph measurements, denoted by (1) $n_\k$, (2) $\tau_\Delta$, and (3) $n_{S\ge5}$, can efficiently discern different topology in discrete point distributions. We denote this set of three graph diagnostics by kT5+.

These kT5+ statistics provide a quick look of various orders of n-points correlation functions in a computationally cheap way: (1) $n = 2$ by $n_k$, (2) $n = 3$ by $\tau_\Delta$, and (3) $n \ge 5$ by $n_{S\ge5}$.

## [구 GC-18] Making the Invisible Visible: Dark Matter Mapping of the Merging Galaxy Cluster ZwCl 1447.2+2619 via Weak Lensing

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ZwCL 1447.2+2619 is a merging galaxy cluster at z=0.37 with clear substructures in X-ray emission and galaxy distribution. In addition, the system possesses distinct radio relics. In order to constrain the merger scenario, it is necessary to measure both the distribution and mass of the cluster dark matter. We perform a weak lensing analysis of ZwCL 1447.2+2619 using Subaru imaging data. After carefully addressing instrumental systematics, we detect significant lensing signals. In this talk, our methodology, weak lensing results, and possible merging scenarios will be presented.

## [구 GC-19] A redshift survey of the nearby galaxy cluster Abell 2107: Global rotation of the cluster and its connection to large-scale structures in the universe

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We present the results from a spectroscopic survey of the nearby galaxy cluster Abell 2107 at z=0.04 that has been known as a rotating cluster. By combining 978 new redshifts from the MMT/Hectospec observations with the data in the literature, we construct a large sample of 1968 galaxies with measured redshifts at R<60', which results in high (80%) and spatially uniform completeness at $m_{r,Petro,0}$<19.1. We use this sample to study the global rotation of the cluster and its connection to the large-scale structures in the universe. We first apply the caustic method to the sample and identify 285 member galaxies in Abell 2107 at R<60'. We then measure the rotation amplitude and the position angle of rotation axis. The member galaxies show strong global rotation at R<20' (V/σ~0.60-0.70) with a significance of >3.8 σ, which is confirmed by two independent methods. The rotation becomes weaker in outer regions. We find at least four filamentary structures at R<30$h^{-1}$Mpc smoothly connected to the cluster galaxies, which can suggest that the global rotation of the cluster is induced by the inflow of galaxies from the surrounding large-scale structures in the universe.

## [구 GC-20] Environmental Dependence of Galaxy Properties in the Framework of the Cosmic Web

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There is growing observational evidence from several galaxy surveys that the cosmic web plays an important role in shaping galaxy properties in addition to the effects of isotropic environment including local density. To study the distinctive effects of anisotropic and isotropic environments on galaxy properties, we simultaneously examine the galaxy properties as functions of anisotropic and isotropic environments using the SDSS data.

We focus on galaxy morphology and star formation/nuclear activity, and find the importance of both anisotropic and isotropic environments in determining galaxy properties.

### [구 GC-21] A Hydrodynamical Simulation of the Off-Axis Cluster Merger Abell 115

Wonki Lee, Mincheol Kim and Myungkook James Jee
*Yonsei University*

A merging galaxy cluster is a useful laboratory to study many interesting astrophysical processes such as intracluster medium heating, particle acceleration, and possibly dark matter self-interaction. However, without understanding the merger scenario of the system, interpretation of the observational data is severely limited. In this work, we focus on the off-axis binary cluster merger Abell 115, which possesses many remarkable features. The cluster has two cool cores in X-ray with disturbed morphologies and a single giant radio relic just north of the northern X-ray peak. In addition, there is a large discrepancy (almost a factor of 10) in mass estimate between weak lensing and dynamical analyses. To constrain the merger scenario, we perform a hydrodynamical simulation with the adaptive mesh refinement code RAMSES. We use the multi-wavelength observational data including X-ray, weak-lensing, radio, and optical spectroscopy to constrain the merger scenario. We present detailed comparisons between the simulation results and these multi-wavelength observations.

### [구 GC-22] Preprocessing and mass evolution of dark halos in the hydrodynamic zoom-in simulation

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To understand the assembly of the galaxy population in clusters today, it is important to first understand preprocessing, the impact of environments prior to cluster infall. We use 15 cluster samples from YZiCS, a hydrodynamic cluster zoom-in simulation to determine the significance of preprocessing, and focus on the tidal mass loss of dark matter halos. We find ~48% of the cluster member halos were once satellites of another host. The preprocessed fraction depends on each cluster's recent mass growth history. Also, we find that the total mass loss is a clear function of the time spent in a host. However, two factors can increase the mass loss rate considerably. First, if the satellite mass is approaching the mass of its host. Second, when the halo suffers tidal mass loss at a higher redshift. Being in hosts before cluster infall enables halos to experience tidal mass loss for an extended period of time.

## 성간물질/별탄생/항성

### [구 IM-01] 3-D Shock Structure of Orion KL Outflow with IGRINS

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We present the results of high-resolution near-IR spectral mapping toward the Orion KL outflow. In this study, we used the Immersion Grating Infrared Spectrometer (IGRINS) on the 2.7 m Harlan J. Smith Telescope at McDonald Observatory. IGRINS's large wavelength coverage over the H & K bands and high spectral resolving power (R ~ 45,000) allowed us to detect over 35 shock-excited ro-vibrational H2 transitions and to measure directly the gas temperature and velocity of the dense outflows. In our previous study toward the H2 peak 1 region in the Orion KL outflow, we identified 31 outflow fingers from a datacube of the H2 1-0 S(1) 2.122 μm line and constructed a three-dimensional map of the fingers. The internal extinction (ΔAV > 10 mag) and overall angular spread of the flow argue for an ambient medium with a high density (105 cm-3). In this presentation, we show preliminary results of additional mapping toward a remarkable chain of bows (HH 205 - HH 207) farther from the ejection center, and obtain a more clear view of the shock physics of a single isolated bullet that improves on the knowledge gained from observations of the more complex peak 1 region in our earlier study.