Workshop Report

CLJ2010+0628:
from massive galaxy formation to dark energy

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In the current paradigm of cosmic structure formation, the cold dark matter model with a dominant dark energy component (hereafter LCDM), gravitational collapse of dark matter leads to the formation of halos, which then grow in mass by merging and accreting with other halos. Given a cosmological model, the abundance and spatial distribution of massive halos (e.g., $>10^{13}$ M_{sun}) can be estimated to high precision through analytical calculations and numerical simulations. The number density of massive halos can therefore be used to constrain cosmological parameters, such as the matter density, amplitude of the matter power spectrum, and the degree of the primordial non-gaussianity.

Now enter the reality. Clusters of galaxies are the real-world counterparts of the massive dark matter halos. And they are more fun/difficult to deal with, considering the large amount of gas (called intracluster medium, ICM) that has been shock heated to 10^7 K during infall to the cluster gravitational potential, as well as the hundreds of galaxies of various masses and formation history swarming inside. For a galaxy, clusters is a hectic place to live: interactions with the dark matter potential well, the ICM, and other galaxies will distort its shape, strip off its stars, induce new star formation and maybe awaken the super massive black hole at its center; dynamical friction will drag it to the bottom of the potential -- a kind of galactic graveyard -- and merge with the giant galaxies there. Gradually, the cluster galaxies are transformed into a population quite distinct from their cousins living in much smaller halos. Meanwhile, the ICM radiates prodigiously via bremsstrahlung, making clusters among the brightest X-ray sources in the Universe; occasionally the electrons inverse-Compton scatter off the photons from the cosmic microwave background, modifying the energy spectrum of the latter (known as the Sunyaev-Zel'dovich effect, SZE).

The above broadbrush picture shows our understanding of clusters to the first order. At a distance, clusters appear to be simple objects: dark matter halos behave as suggested by the LCDM, ICM often in hydrostatic equilibrium with the cluster potential, properties of cluster galaxy populations correlate well with the host clusters. When we try to ask more detailed questions such as "how well can we measure the cluster mass?" "what is the density and pressure distribution of ICM?" "what mechanism is

the primary cause of galaxy transformation?" we start to realize there is still a long way to go, before we can really use clusters as a precision cosmology probe.

"CLJ2010+0628*: from massive galaxy formation to dark energy" was planned in preparation for the era of precision cluster cosmology. The idea was simple: bringing together experts working in different areas of cluster study to discuss how we can use multi-wavelength data to identify the critical theoretical and observational issues that may limit our ability to fully exploit the upcoming large cluster data sets.

The preparation for the conference officially started in summer 2009. The invited speaker list was largely finalized by the end of that year. The cluster community was enthusiastic, and we had a hard time selecting contributed talks out of many excellent submissions. Due to the space limit, we also had to turn down registration from many people.

The conference took place on 6/28-7/2, 2010, at the Media Hall in the Kashiwa Library, although we also had "lunch sessions" at IPMU and the General Research Building. There were 160 participants, including 20 invited speakers. We had 39 contributed talks and 80 posters. Slides and video recording of all the talks are online at the conference website. This was a truly international conference, as people from Europe and North America accounted for 2/3 of the participants, and the rest were from Japan, Taiwan, and Korea.

Gus Evrard (Michigan) gave the opening review, linking the dark and bright sides of cluster study. Eiichiro Komatsu (Texas/IPMU) provocatively discussed "Gem vs Junk cluster cosmology". Anthony Gonzalez (Florida) impressed the audience with a beautiful image of the intracluster light in the Bullet cluster. Bill Holzapfel (Berkeley) discussed a mismatch between the theoretical and observed SZE power spectrum, while Daisuke Nagai (Yale) offered an explanation based on the gas motion at outskirts of clusters. Jim Gunn (Princeton) summarized the conference, emphasizing the need to first understand the stars, galaxies, ICM, before we can confidently constrain cosmology.

The success of the conference owed a large part to the hard work of other local organizing committee members, Tsz Yan Lam, Masamune Oguri, and Naoki Yoshida. The conference wouldn't materialize without the dedicated efforts of Ujita-san of IPMU administrative office. We are also in debt to other staff members, especially those in the international relationship and IT sections. Finally, we gracefully acknowledge financial supports from IPMU and from the DENET grant of Prof. Yasushi Suto (University of Tokyo).

* Naming of a cluster usually follows the format of (prefix)-J-HHMMsDDMM, where prefix may be the project that discovers the cluster, J stands for the equinox of the observation, HHMM and sDDMM denote the longitude and latitude in celestial coordinates, respectively. CLJ2010+0628 follows this scheme, but uses the start date of the conference as the coordinates; in addition, "J" stands for Japan.