한국천문연구원은 GMT (Giant Magellan Telescope) 관측기기로 제안한 GMTNIRS (GMT Near Infrared Spectrograph)의 선행 관측기기인 IGRINS (Immersion Grating Infrared Spectrograph)를 텍사스 오스틴대학과 공동개발하고 있다. IGRINS는 맥도날드천문대 2.7미터 망원경에 장착하여 시험관측을 수행할 예정이며 4미터급 망원경 장착을 목표로 하고 있다. IGRINS는 한 번의 노출로 H-밴드와 K-밴드 전체를 분광분해능 40,000으로 분광관측할 수 있다. 4미터 망원경으로 1시간 정도 노출하였을 때 H-밴드에서는 14.8등급을 K-밴드에서는 14.3등급을 S/N=10으로 관측 가능하다. IGRINS는 에셀 격자로 실리콘 담금격자 (Silicon immersion grating)를 사용하고, 교차분산 격자는 VPH (Volume Phase Holographic) 격자를 사용하여 효율을 높인다. White pupil 디자인의 광학설계를 채택하여 분광기 제작비를 낮추고 크기를 소형화한다. IGRINS 광학계는 망원경을 연결하고 열잡음을 제거하는 릴레이 렌즈시스템과 검교정을 위한 검교정 광학부, 가이드 카메라부, 분광 카메라부 그리고 분광 광학계로 구성된다. 현재 IGRINS는 광학계의 최적화를 진행 중이며, 곧이어 공차해석과 기계부 설계가 진행될 예정이다.

[KG-05] 대형광학망원경 개발사업(K-GMT) : Science Plan

천무영, 여아란, 김상철, 김영수, 김호일, 박귀종, 박병곤, 박찬, 육인수, 이성호
한국천문연구원

앞으로 10년간 진행될 대형광학망원경 개발사업은 거대 마젤란 망원경 개발 사업의 참여를 주요 축으로 천문 연구 역량 강화와 망원경/관측기기 관련 기술능력 배양을 목표로 하고 있다. 한국 천문학계가 가진 연구 역량에 비해 현재 보유하고 있는 망원경 등 기본 연구시설은 많이 부족한 형편이며 이 사업의 성과를 통해 일정부분 확충될 것이다. 이 사업의 성공과 광학/가시광 관측 분야의 연구 역량 강화를 위해서는 원할한 소통, 젊은 천문학자를 위한 지원, 현재 쓸 수 있는 관측 시설 확보등이 필요하다. 이 발표에서는 광학 관측 연구분야의 역량 강화를 위하여 대형 광학망원경 개발사업을 통해 수행하고자 하는 계획에 대해 발표한다.

[KG-06] Sciences We Can Do in the GMT era

Myung Gyoon Lee
Astronomy Program, Department of Physics and Astronomy, Seoul National University

2009 is not only the year of Astronomy for the entire world, but also the year we, Korean astronomers, prepared a stepping stone for joining the fore-front optical astronomy with the Giant Magellan Telescope (GMT). In this talk I present and discuss what sciences we can do in the GMT era.

■ Session : 은하/우주론 I (GC)
4월 29일(수) 11:00 - 13:00 제1발표장

[초GC-01] Outstanding Problems in Cosmic Ray Astrophysics

Hyesung Kang
Department of Earth Sciences, Pusan National University

The observed energy spectrum of cosmic rays (CRs) can be approximated over more than 12 orders of magnitude in energy by a broken power law, whose slope changes at several features such as the first knee, second knee, ankle and GZK cutoff. Moreover, the composition of CRs becomes heavier beyond the first knee toward the second knee, and it seems to get lighter again toward the ankle and then become proton-dominated above the ankle. Recent observational evidence indicates there seems to be positional correlation of arrival directions of ultrahigh energy cosmic rays above 1019.5eV with the large scale structure of the universe All these observational facts provide crucial clues to the search for the origin of high energy CRs, which is one of key unresolved astrophysical problems. In this review, we will examine some of currently debated issues in cosmic ray astrophysics.

[GC-02] A study of the astrophysical sources of ultra high energy cosmic rays

Santabrata Das[1], Dongsu Ryu[2], and Hyesung Kang[3]
[1]*International Center for Astrophysics, Korea Astronomy and Space Science Institute*
[2]*Department of Astronomy and Space science, Chungnam National University*
[3]*Department of Earth Sciences, Pusan National University*

In the course of propagation, the trajectories of ultra high energy cosmic rays (UHECRs) from the cosmologically distant sources deviate from the photon propagation paths due to the presence of ubiquitous magnetic fields in the intergalactic space (IGMF) that are believed to follow the large scale structure (LSS) of the universe. Accordingly, finding the UHECR sources from the directional analysis of observed events is not very straightforward. Performing the simulation of the propagation of UHE protons (Das et al 2008) through the magnetized LSS of the universe (Ryu et al 2008), we compute the statistics of the angular distance using the positional correlations between the arrival directions of UHECR events in our simulation and the possible nearby astrophysical candidates. In the simulation, UHECR sources are placed at the cluster regions and observers are selected inside groups of galaxies that have similar properties as the Local Group. With this, we quantify

the probabilty of identifying the true UHECR sources in terms of the angular distance. We also calculate the cross correlation between the simulated UHECR events and the sources and estimate the angular correlation length. Due to the absence of any satisfactory observational description of magnetic fields within the Local Group, we study the above statistics of angular distance in terms of the strength of the magnetic fields at the observer location as well. To compare our simulation result, we study the similar statistic with Auger detected events and a good agreement is observed. Implications of this study on the nature of UHECRs sources are discussed.

[GC-03] Energy Dissipation of Cosmological Shock Waves in the Large Scale Structure

Renyi Ma[1], Dongsu Ryu[1], and Hyesung Kang[2]

[1]*Department of Astronomy and Space Science, Chungnam National University* [2]*Department of Earth Sciences, Pusan National University*

To investigate the complex cosmological shocks, we explore the statistic properties of cosmological shock waves in terms of preshock density and temperature. It is shown that the most frequent shocks are the external shocks that formed around shee-like structures, and for the WHIM and intercluster medium (ICM), internal shocks dominate over external shocks both in frequency and shock kinetic energy flux at present epoch. The mean properties of weak internal shocks depend mainly on the pre- or post-shock temperature. More importantly, as previous paper we calculate the acceleration effency of the shocks by adopting a DSA model for quasi-parallel shocks, but more complete set of parameters are considered. The efficiencies for different parameters are fitted with algebric formula. We further calculate the time integrated energy fluxes that pass through the shocks. It is found that the energy density of the accumulated cosmic ray (CR) protons can be consistent with the upper limits constrained by observations.

[GC-04] Galactic Spiral Shocks with Thermal Instability in Self-Gravitating, Vertically-Stratified Disks

Kim, Chang-Goo[1], Kim, Woong-Tae[1], and Ostriker, Eve C.[2]

[1]*Department of Physics and Astronomy, Seoul National University,* [2]*Department of Astronomy, University of Maryland*

Galactic spiral shocks are dominant morphological features and believed to be responsible for substructure formation of sprial arms in disk galaxies. They can also provide a large amount of kinetic energy for the interstellar gas by tapping the rotational energy. In this work, we use numerical hydrodynamic simulations to investigate the turbulence driving and clump formation by two-dimensional galactic spiral shocks in self-gravitating, vertically-stratified disks subject to radiative cooling and heating. We initially consider an isothermal disk in vertical hydrostatic equilibrium. Due to cooling and heating, the disk rapidly evolves to a dense slab near the midplane surrounded by rarefied, hot gas at high-altitude regions. The imposed stellar spiral potential forms a vertically curved shock that exhibits strong flapping motions along the direction perpendicular to the arm. The flows across the spiral shock are characterized by transitions from rarefied to dense phases at the shock and from dense to rarefied phases at the postshock expansion zone. The shock flapping motions stirs the disk, supplying the gas with random kinetic energy. The flows achieve a quasi-steady state after a few orbits. The density-weighted velocity dispersions in the vertical directions are measured to be $\sigma z \sim 1.5-3$ km/s for the rarefied gas and $\sigma z \sim 0.5-1.5$ km/s for the dense gas. Despite clumpy structure of spiral shocks with thermal instability, time-averaged profiles of surface density are similar to those of viscous isothermal spiral shocks. When self-gravity is included, spiral shocks form large dense condensations by collecting high-altitude gas that falls toward the midplane right after the shock compression. Internal motions of these condensations gradually change from supersonic to subsonic values as they move downstream from the shock front.

[GC-05] Nonlinear Effects of Dynamical Friction in a Gaseous Medium

Hyosun Kim and Woong-Tae Kim

Department of Physics and Astronomy, Seoul National University

Dynamical friction of orbiting objects is of great importance in various astronomical systems ranging from protoplanetary disks to galaxy clusters. In analytic studies of dynamical friction, it has been usually assumed that the density wake produced by a moving perturber has low amplitude and is thus in the linear regime. However, there are many astronomical situations such as in a merger of black holes near a galaxy center, where a perturber is so massive that the induced wakes are well in the nonlinear regime. In this work, we consider a perturber in a wide mass range, and study the nonlinear effects of dynamical friction by running high-resolution numerical simulations using the FLASH code. Unlike in the linear cases where Mach waves are attached to a perturber, a very massive perturber quickly develops nonlinear flows that produce a detached bow shock in front