

simultaneously recorded with a single detector in a spectrograph. The instrument TIP (Tenerife Infrared Polarimeter) has been continuously operating since 1999 at the 70-cm German VTT of the Observatorio del Teide and has been recently moved to the 1.5-m German GREGOR. During all this time, results have been obtained concerning the nature of the weak photospheric magnetic field of the quiet sun, magneto-acoustic wave propagation, evolution with the cycle of sunspot magnetic fields, photospheric and chromospheric magnetic field in emerging regions, magnetic field in chromospheric structures such as filaments, prominences, flares, and spicules, etc. In this talk, I will review the main results obtained after all these observations and mention the main challenges for the future. With its novel polarization-free design and a complete suite of instruments aimed at simultaneous (imaging and spectroscopic) observations of the solar photosphere and chromosphere, the EST (European Solar Telescope) will represent a major world-wide infrastructure to understand the physical nature of all these phenomena.

[초 IT-05] 20 years of Bohyunsan Optical Astronomy Observatory (보현산천문대 20년)

Hyun-Il Sung
Korea Astronomy and Space Science Institute

1996년, 보현산천문대는 1.8m 반사망원경과 1K CCD 카메라, 그리고 태양망원경을 갖추고 한국 천문학의 본격적인 광학관측시대를 열었다. 준공 직후인 1997년에는 측광관측기기를 2K CCD로 교체 하였으며, 1998년에는 망원경 제어시스템(TCS)을 국내 연구진이 자체 개발하였고 망원경의 전자부도 교체하였다. 1999년의 중분산분광기 제작 이후 2003년에는 고분산에셀분광기 BOES를 개발하여 세계적인 경쟁력을 갖춘 분광관측이 가능하게 되었다. BOES는 현재 보현산천문대의 주 관측기기로 활용 중이다. 2008년에는 적외선이미징카메라 KASINICS를 개발하여 관측 파장대를 적외선까지 넓혔으며, 2010년에는 가시광 측광관측기기를 4K CCD로 업그레이드 하였다. 2015년에는 망원경 구동시스템을 다시 한 번 개선하여 보다 안정적이고 정밀한 관측시스템을 갖추게 되었다. 또한, 2014년과 2015년에는 2년에 걸쳐 관측실과 숙소, 그리고 각종 연구시설의 전면 리모델링을 실시하여 관측자를 위한 환경도 개선하였다. 이러한 다양한 관측지원을 바탕으로 보현산천문대 연구장비를 활용한 논문은 매년 꾸준히 생산되고 있으며 관측과 연구결과들은 한국 광학천문학의 밑거름이 되고 있다. 2016년에는 1m 망원경 설치를 완료할 예정이며 장기관측 과제에 집중함으로써 연구의 새로운 지평을 열게 될 것이다. 연구장비의 안정적인 구동과 성능 향상을 위해 중장기발전계획 아래 노후화된 기기의 교체와 개발을 진행 중이다. 2016년 4월, 제2의 도약기를 준비 중인 보현산천문대의 준공 20주년을 맞이하여, 그

동안의 발자취를 돌아보고 앞으로 나아갈 길을 제시하고자 한다.

외부은하 / 은하단

[구 GC-01] Ten Years of Debate on the Origin of Globular Cluster Color Bimodality

Hak-Sub Kim and Suk-Jin Yoon
Department of Astronomy & Center for Galaxy Evolution Research, Yonsei University

The globular cluster (GC) systems in most elliptical galaxies show bimodal color distributions. This phenomenon has been generally regarded as a bimodal metallicity distribution, indicating the presence of two sub-populations in a GC system. However, since a new explanation on the bimodality was introduced where the nonlinear metallicity-to-color conversion can cause bimodal color distributions, the origin of this phenomenon has been under hot debate. In this presentation, we briefly review the ten-year debate on the origin of GC color bimodality, and present our recent pieces of evidence on the nonlinear nature of GC color-metallicity relations.

[구 GC-02] Multiple stellar populations in the classical bulge

Young-Wook Lee¹, Sohee Jang¹, Jaeyeon Kim¹, Seok-Joo Joo², Chul Chung¹
¹*Center for Galaxy Evolution Research and Department of Astronomy, Yonsei University, Seoul 03722, Korea*
²*Korea Astronomy and Space Science Institute, Daejeon 34055, Korea*

The presence of multiple stellar populations is now well established in most globular clusters in the Milky Way. Here we show that two populations of RR Lyrae stars and the double red clump observed in the Milky Way bulge are another manifestations of the same multiple population phenomenon observed in halo globular clusters. We will discuss the implications of this result on the stellar populations and formation of early-type galaxies.

[구 GC-03] The Effect of Local-Global Environmental Bias on the Type Ia Supernova Host Galaxy Studies

Young-Lo Kim¹, Mark Sullivan², Mathew Smith²,
and Young-Wook Lee¹

¹*Center for Galaxy Evolution Research &
Department of Astronomy,
Yonsei University, Seoul 03722, Korea,*

²*School of Physics and Astronomy, University of
Southampton, Southampton SO17 1BJ, UK*

Recent studies suggest that the difference between global and local properties of galaxies (the local-global environmental (LoG) bias) might be important in the Type Ia supernova (SN Ia) host galaxy studies. Obtaining local spectroscopic properties of hosts at high redshift, however, is challenging. Here we will introduce a more efficient way to conduct this study by only using photometric data. We find that when we restrict a sample to the hosts whose stellar mass is less than $10^{10} M_{\odot}$, a sample without LoG bias is efficiently selected. From the sample without LoG bias, we confirm that SNe Ia in locally star-forming environment are 0.103 ± 0.010 mag and 0.085 ± 0.012 mag fainter than those in locally passive region, for MLCS2k2 and SALT2, respectively. Because of ~ 6 times larger sample that covers much wider redshift range, our results are far more significant statistically, 10.3σ for MLCS2k2 and 7.1σ for SALT2, than previous results.

[7 GC-05] Internal kinematics of dwarf early-type galaxies with blue-center in the Virgo Cluster from Gemini GMOS long-slit spectroscopy

Jiwon Chung¹, Soo-Chang Rey¹, Eon-Chang Sung²,
Youngdae Lee¹, Suk Kim², Woong Lee¹

¹*Chungnam National University,*

²*Korea Astronomy and Space Science Institute*

Dwarf elliptical galaxies (dEs), the most abundant galaxy type in clusters, were recently shown to exhibit a wide variety in their properties. Particularly, the presence of blue cores in some dEs, what we call dE(bc), supports the scenario of late-type galaxy infall and subsequent transformation into red, quiescent dEs. While several transformation mechanisms for these dE(bc)s within cluster environment have been proposed, all these processes are able to explain only some of the observational properties of dEs. In this context, internal kinematic properties of dE(bc)s provide the most crucial evidence to discriminate different processes for the formation of these galaxies. We present Gemini Multi Object Spectrograph (GMOS) long-slit spectroscopy of two

dE(bc)s in the Virgo cluster. We obtained radial profiles of velocity and velocity dispersion out to ~ 1.3 effective radius. We found that two dE(bc)s exhibit kinematically decoupled components as well as distinct peculiar features in velocity profiles, supporting the scenario of mergers. We also found that these galaxies are structurally compatible with low surface brightness component of blue compact dwarf galaxies. We suggest that a part of dE(bc)s in the Virgo Cluster were formed through galaxy merger in low density environment such as galaxy group or outskirts of the cluster, and then were quenched by subsequent effects within cluster environment.

[7 GC-06] Optical properties of dwarf galaxies in Leo I galaxy group

Myo Jin Kim¹, Aeree Chung¹, Jong Chul Lee²,
Sungsoon Lim³, Minjin Kim^{2,6}, Jongwan Ko^{2,6},
Soung-Chul Yang^{2,5}, Joon Hyeop Lee^{2,6}, Narea
Hwang², Byeong-Gon Park^{2,6}, Hye-Ran Lee^{2,6}

¹*Department of Astronomy, Yonsei University,*

²*Korea Astronomy and Space Science Institute,*

³*Department of Astronomy, Peking University,
China*

⁴*Kavli Institute for Astronomy and Astrophysics,
Peking University, China*

⁵*The Observatories of the Carnegie Institution of
Washington,*

⁶*Korea University of Science and Technology*

Since the serendipitous discovery of a large-scale atomic hydrogen (H_I) ring discovered in the Leo I galaxy group, its origin has been under debate till today, whether it is the leftover after group formation or stripped gas structure during the galaxy-galaxy interaction. Intriguingly a number of H_I clumps have been identified along the gas ring, some of which turn out to be associated with optically catalogued dwarf galaxies. The formation history based on detailed optical and H_I gas properties of those dwarf galaxies will enable us to verify the origin of the Leo ring. In this work, we first probe the redshift and multi-color properties of those dwarf galaxies, using deep photometric and spectroscopic data from CFHT, Gemini and Magellan telescope.

[7 GC-07] Recent galaxy mergers and star formation history of red sequence galaxies in rich Abell clusters at $z \leq 0.1$

Yun-Kyeong Sheen¹, Sukyoung K. Yi², Chang H.
Ree¹, Yara Jeffé³, Ricardo Demarco⁴, and Ezequiel