

predominantly determined by tenuous but energetic electrons, and that denser and less energetic background electrons do not contribute much to the peak intensity. This finding shows that upper-hybrid fluctuations detected during quiet time are useful not only for the determination of the electron density, but also they contain information on the ambient energetic electron population as well.

## 항성

### [구 ST-01] The Formation Timescale of the Young Open Cluster NGC 2264: Implication on the Lithium Abundance Distribution of Pre-Main Sequence Stars

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The duration of star formation activity is a key to understanding the formation process of star clusters. Although a number of astronomers have attempted to derive the underlying age spread in photometric diagrams with a variety of stellar evolutionary models, the resultant findings are subject to uncertainties due to intrinsic variability of pre-main sequence (PMS) stars, observational errors, difficulties in reddening correction, and systematic differences in adopted stellar evolutionary models. The distribution of Li abundance for PMS stars in a cluster could, on the other hand, provide an alternative way to estimate the age spread. In this study, a total of 134 PMS stars in NGC 2264 are observed with the high resolution multi-object spectrograph Hectochelle attached to the 6.5m Multi Mirror Telescope. We have successfully detected Li  $\lambda$ 6708 resonance doublet for 86 low-mass PMS stars. The Li abundance of the stars is derived from their equivalent width using a curves of growth method. After correction for non-LTE effects, the underlying age spread of 3 – 4 Myr is inferred from the Li abundance distribution of low-mass PMS stars. We suggest that NGC 2264 formed on a timescale shorter than 5 Myr given the presence of embedded populations.

### [구 ST-02] New Photometric System for CN and CH

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During the last decade, there has been a dramatic paradigm shift on the definition of the globular cluster (GC) systems. The decades-long lighter elemental variation issue in GC stars is now considered to be a generic feature of normal GCs in our Galaxy, most likely engraved during the multiple-phase normal GC formation. In this talk, we will introduce the new photometric system, so-called the JWL System, to measure CN and CH abundances in multiple stellar populations in GCs. The utility and the future application of the JWL System will be discussed.

### [구 ST-03] IGRINS Spectral Library

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We present a library of high-resolution (R~45,000) and high signal-to-noise ratio (S/N  $\geq$  200) near-infrared spectra of 147 standard stars. High quality spectra were obtained with Immersion GRating INfrared Spectrograph (IGRINS) covering the full range of H (1.496-1.795  $\mu$ m) and K (2.080-2.460  $\mu$ m) bands. The targets are mainly selected as MK standard stars which have well-defined spectral types and luminosity classes, and cover a wide range of effective temperatures and surface gravities. The spectra were corrected for telluric absorption lines and absolute flux calibrated using Two Micron All Sky Survey (2MASS) photometry. We find new spectral indices in H and K bands and provide their EWs. We describe empirical relations between the measured EWs and stellar atmosphere parameters such as effective temperature and surface gravity.

### [구 ST-04] Low-Resolution Spectroscopy for the Intriguing Globular Cluster NGC 2808 : Chemical abundance patterns among

## subpopulations

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The presence of multiple stellar populations is now well established in most globular clusters (GCs) in the Milky Way. The origin of this phenomenon, however, is yet to be understood. In this respect, the study of NGC 2808, an intriguing GC which hosts subpopulations with extreme helium abundances, would help to resolve this problem. In order to investigate chemical abundance patterns among different subpopulations in this GC, we have performed low-resolution spectroscopy for the red-giant-branch (RGB) stars and measured CN & CH bands, and Ca line strength. We have identified at least three subpopulations from the CN abundance distribution. This GC shows CN-CH anti-correlation following the general trend among “normal” GCs. In addition, we have cross-matched our results with the high-resolution data in literature, and found a tight correlation between CN strength and sodium abundance. However, CN is anticorrelated with oxygen abundance, as expected from the well known N(&Na)-O anticorrelation. In this talk, we will discuss the implication of these results.

### [박 ST-05] A Deep Optical Photometric Study of the Massive Young Open Clusters in the Sagittarius-Carina Spiral Arm

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The Sagittarius-Carina spiral arm in the Galaxy contains several massive young open clusters. We present a deep optical photometric study on the massive young open clusters in the Sagittarius-Carina arm, Westerlund 2 and the young open clusters in the  $\eta$  Carina nebula. Westerlund 2 is a less studied starburst-type cluster in the Galaxy. An abnormal reddening law for the intracluster medium of the young starburst-type cluster Westerlund 2 is determined to be  $R_{V,cl}=4.14\pm 0.08$ . The distance modulus is determined from zero-age main-sequence fitting to the reddening-corrected color-magnitude diagrams

of the early-type members to be  $V_0-M_V=13.9\pm 0.14$  mag. The pre-main sequence (PMS) members of Westerlund 2 are selected by identifying the optical counterparts of X-ray emission sources from the Chandra X-ray observation and mid-infrared emission sources from the Spitzer/IRAC (the Infrared Array Camera) observation. The initial mass function (IMF) shows a slightly flat slope of  $\Gamma = -1.1\pm 0.1$  down to  $5 M_{\odot}$ . The age of Westerlund 2 is estimated to be  $\sim 1.5$  Myr from the main-sequence turn-on luminosity and the age distribution of PMS stars. The  $\eta$  Carina nebula is the best laboratory for the investigation of the Galactic massive stars and low-mass star formation under the influence of numerous massive stars. We have performed deep wide-field CCD photometry of stars in the  $\eta$  Carina nebula to determine the reddening law, distance, and the IMF of the clusters in the nebula. We present VRI and H $\alpha$  photometry of 130,571 stars from the images obtained with the 4m telescope at Cerro Tololo Inter-American Observatory (CTIO).  $R_{V,cl}$  in the  $\eta$  Carina nebula gradually decreases from the southern part ( $\sim 4.5$ , around Trumpler 14 and Trumpler 16) to the northern part around Trumpler 15 ( $\sim 3.5$ ). Distance to the young open clusters in the  $\eta$  Carina nebula is partly revised based on the zero-age main-sequence fitting to the reddening-corrected color-magnitude diagrams (CMDs) and the (semi-) reddening-independent CMDs. We select the PMS members and candidates by identifying the optical counterparts of X-ray sources from the Chandra Carina Complex Survey and mid-infrared excess emission stars from the Spitzer Vela-Carina survey. From the evolutionary stage of massive stars and PMS stars, we obtain that the northern young open cluster Trumpler 15 is distinctively older than the southern young open clusters, Trumpler 14 ( $\leq 2.5$  Myr) and Trumpler 16 (2.5–3.5 Myr). The slopes of the IMF of Trumpler 14, Trumpler 15, and Trumpler 16 are determined to be  $-1.2\pm 0.1$ ,  $-1.5\pm 0.3$ , and  $-1.1\pm 0.1$ , respectively. Based on the  $R_{V,cl}$  of several young open clusters determined in this work and the previous studies of our group, We suggest that higher  $R_{V,cl}$  values are commonly found for very young open clusters with the age of  $< 4$  Myr. We also confirm the correlation between the slope of the IMF and the surface mass density of massive stars.

### [구 ST-06] Red supergiant stars in NGC 4449, NGC 5055, and NGC 5457

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