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The hydrogen-rich envelope mass of a dying massive star is the key factor that determines the type and properties of the resulting supernova. Emulating wind-driven mass loss of single stars with the MESA(Modules for Experiments in Stellar Astrophysics) stellar evolution code, we made a grid of models for a large parameter space of initial mass (12 $M_\odot$ to 30$M_\odot$), metallicity (solar, LMC and SMC), hydrogen envelope mass (0.01$M_\odot$ to 10$M_\odot$) for progenitor stars in their final step of evolution. Our results suggest the final luminosity of the progenitor is largely determined by the initial mass, which means there is luminosity degeneracy for stars with the same initial mass but with different hydrogen-rich envelope masses. Since we can break this degeneracy by correcting luminosity with surface gravity (spectroscopic HR diagram), we can infer the exact mass property of an observed progenitor. The surface temperature drastically varies near the envelope mass of ~0.1M $\odot$ and surface temperature of ~10000 K, where the demarcation between the hydrogen-rich envelope and the helium core lies, which explains the rarity of 'white' supergiants. There also exists a discontinuity in the chemical composition of the progenitor envelope around this critical hydrogen-rich envelope mass of ~0.1 $M_\odot$, which can be tested in future observations of "flash spectroscopy" of supernovae.

[구 IM-07] Circumstellar Clumps in the Cassiopeia A Supernova Remnant: Prepared to be Shocked

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Cassiopeia A (Cas A) is a young supernova remnant (SNR) where we observe the interaction of SNR blast wave with circumstellar medium. From the early optical studies, dense, slowly-moving, N-rich ``quasi-stationary flocculi'' (QSF) have been known. These are probably dense CNO-processed circumstellar knots that have been engulfed by the SNR blast wave. We have carried out near-infrared, high-resolution (R=45,000) spectroscopic observations of ~40 QSF, and here we present the result on a QSF knot (hereafter `Knot 24') near the SNR boundary of Cas A. The average [Fe II] 1.644 um spectrum of Knot 24 has a remarkable shape with a narrow (~8 km/s) line superposed on the broad (~200 km/s) line emitted from shocked gas. The spatial morphology and the line parameters indicate that Knot 24 has been partially destroyed by a shock wave and that the narrow line is emitted from the unshocked material heated/ionized by the shock radiation. This is the first detection of the emission from the pristine circumstellar material of the Cas A supernova progenitor. We also detected H Br gamma and other [Fe II] lines corresponding to the narrow [Fe II] 1.644 um line. For the main clump where we can clearly identify the shock emission associated with the unshocked material, we analyze the observed line ratios using a shock model that includes radiative precursor. The analysis indicates that the majority of Fe in the unshocked material is in the gas phase, not depleted onto dust grains as in the general interstellar medium. We discuss the non-depletion of Fe in QSF and its implications on the immediate progenitor of the Cas A supernova.

[구 IM-08] Kinematic Distances of the Galactic Supernova Remnants in the First Quadrant

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We have carried out high-resolution near-infrared (NIR) spectroscopic observations toward 16 Galactic supernova remnants (SNRs) showing strong H_2 emission features. A dozen bright H_2 emission lines are clearly detected for individual SNRs, and we have measured their central velocities, line widths, and fluxes. For all SNRs except one (G9.9-0.8), the H_2 line ratios are well consistent with that of thermal excitation at T~2000 K and their line widths are broader than ~10 km s^{-1}, indicating that the H_2 emission lines are most likely from shock-excited gas and therefore that they are physically associated with the remnants. The kinematic distances to the 15 SNRs are derived from the central velocities of the H_2 lines using a Galactic rotation model. We derive for the first time the kinematic distances to four SNRs: G13.5-0.2, G16.0-0.5, G32.1-0.9, G33.2-0.6. Among the rest 11 SNRs, the central velocities of the H_2 emission lines for six SNRs are well consistent (±5 km s^{-1}) with those obtained in previous radio observations, while for the other five SNRs (G18.1-0.1, G18.9-1.1, Kes 69, 3C 396, W49B), they are significantly different. We discuss the velocity discrepancies in these five SNRs. In G9.9-0.8, the H_2 emission shows non-thermal line ratios and very narrow line width (~4 km s^{-1}), and we discuss its origin.

태양/태양계

[구 SS-01] Observation of the Rebound Shock Waves and the EUV Brightening of a Light Bridge Jet

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Hα jets of cool chromospheric plasma are protruding into the solar corona 10-100 Mm above the photosphere. The driving mechanisms of Hα jets have been widely studied for decades. However, the detailed process is still elusive. We observed shock signatures moving along a dark jet using 1.6 meter Goode Solar Telescope at Big Bear Solar Observatory. The first shock front of the jet shows sharp --- when it moves upward, while fuzzy and granulated when it moves downward. The jet itself extends upward when the second shock front of the jet reaches the top of the jet. We find abrupt EUV brightenings when the second shock front collides with the edge of the jet. The third front and the fouth front quasi-periodically. These phenomena might be the signs of the rebound shock waves triggered by p-mode wave leakages at the bottom of the jets. Our observation suggests that the jet can be triggered by the rebound shock waves generated by the p-mode waves leaked at the bottom of the jets.

[구 SS-02] Development of a diagnostic coronagraph on the ISS: progress report

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The Korea Astronomy and Space Science Institute (KASI) has been collaborating with the NASA Goddard Space Flight Center (GSFC), to install a diagnostic coronagraph on the International Space Station (ISS). The coronagraph is designed to obtain simultaneous measurements of electron density, temperature, and velocity using multiple filters in the 3-10 Rs range. In 2019, we developed a new coronagraph and launched it on a stratospheric balloon (BITSE) from Fort Sumner, New Mexico in USA. As the next step, the coronagraph will be further developed, installed and operated on the ISS (CODEX) in 2023 to understand the physical conditions in the solar wind acceleration region, and enable and validate the next generation space weather models. In this presentation, we will report recent progress and introduce future plan.

[구 SS-03] Investigation of sunspot substructure using chromospheric bright patches in a merging sunspot

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Sunspot substructure is an important subject to explain their stability and energy transport. Previous studies suggested two substructure models, monolithic and spaghetti model, but no clear evidence has been found supporting a particular model. To obtain the clue of the sunspot substructure the IRIS Mg II 2796Å slit-jaw images (SJI) were examined. The Mg II images formed in the chromosphere show bright patches inside umbrae which are regarded as an observational signature of upward propagating slow magnetohydrodynamic (MHD) waves. The slow MHD waves are expected to be generated by convective motion below the photosphere. By tracking the motion of the bright patches it is possible to estimate the locations of oscillation centers that correspond to the occurrence position of the convections. I investigated the spatial distribution of the oscillation center in a merging sunspot and found it is randomly distributed. It implies that the occurrence rate of the convective motion inside the sunspot is not much different from that of between the two sunspots, and supports the spaghetti model as the sunspot substructure.

[구 SS-04] Inference of Chromospheric Plasma Parameters on the Sun from Strong Absorption Lines

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