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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 ☉ 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