N45a Seimei KOOLS-IFU mapping of the gas and dust distributions in Galactic PNe: Unveiling the origin and evolution of the metal-deficient Galactic halo PN H4-1

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H4-1 is a planetary nebula (PN) located in the Galactic halo, and is notably carbon-rich and the most metal-deficient PN in the Milky Way ($\sim$0.01 $Z_{\odot}$). Despite the general consensus that H4-1 formed in the early phase of the Milky Way Galaxy evolution, its origin and evolution is still under debate. To unveil its progenitor evolution through the accurate measurement of the gas mass, we conducted a comprehensive investigation of H4-1, using the newly secured Seimei/KOOLS-IFU spectra and multiwavelength spectro-photometry data. The emission line images generated through the PSF deconvolved KOOLS-IFU datacube successfully resolve the ellipsoidal nebula and the flattened central equatorial disk frequently seen in bipolar PNe evolved from massive progenitors. By using only the PSF-matched optical spectra, we derive the seven elemental abundances, the gas-to-dust mass ratio, and the gas and dust masses based on our own distance scale. By verifying the observed quantities by both the photoionization model and the binary nucleosynthesis model, we conclude that H4-1 is found to be currently in the white dwarf cooling phase and originated from a binary system experienced a coalescence during the course of its evolution. Our findings are not only crucial for understanding the evolution of low-mass stars but also provide potential insights into the evolution of carbon-enhanced metal-poor stars found in the Galactic halo.