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TITLE: 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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ABSTRACT:
H4-1 is well known planetary nebula (PN) located in the Galactic halo; it is notably carbon- and molecular hydrogen rich and also the most metal-deficient PN in the Milky Way. 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 Kyoto-U Seimei 3.8-m telescope/KOOLS-IFU spectra and multiwavelength spectro-photometry data. The emission line images generated from the KOOLS-IFU datacube successfully resolve the ellipsoidal nebula and the flattened central equatorial disk frequently seen in bipolar PNe evolved from more massive progenitors. By using the PSF-matched spectra, we can directly measure seven elemental abundances, gas-to-dust mass ratio, and each gas and dust mass based on our own distance scale (heliocentric distance of 9.2 kpc). We construct a detailed photoionization model to be consistent with all the observed quantities and post-AGB evolution, and then we derive the total gas mass of ~0.4 Msun, indicating that H4-1 is not evolved from a typical halo single mass star (~0.9 Msun). We verify the observed quantities by binary nucleosynthesis simulation. We conclude that H4-1 is currently in the white dwarf cooling phase and originated from a binary system experienced a coalescence during the course of its evolution.