Dust and Chemical Abundances of the Sagittarius Dwarf Galaxy Planetary Nebula Hen2-436

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We have estimated elemental abundances and dust mass of the planetary nebula (PN) Hen2-436 in the Sagittarius (Sgr) spheroidal dwarf galaxy using ESO/VLT FORS2, Magellan/MMIRS, and *Spitzer*/IRS spectra.

We have detected candidates of fluorine [F II]λ4790, krypton [Kr III]λ6826, and phosphorus [P II]λ7875 lines and successfully estimated the abundances of these elements for the first time. These elements are known to be synthesized by neutron capture process in the He-rich intershell during the thermally pulsing AGB phase. We present a relation between C, F, P, and Kr abundances among PNe and C-rich stars. The detections of F and Kr in Hen2-436 support the idea that F and Kr together with C are synthesized in the same layer and brought to the surface by the third dredge-up (Fig. 1).

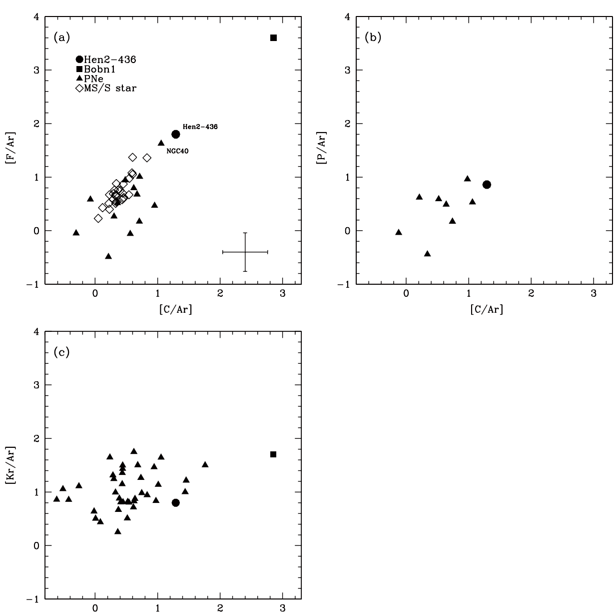

Figure 1: (*a*): The [F/Ar]–[C/Ar] diagram. The typical error is indicated by the cross (the same for the other diagrams). BoBn1 is a Sgr PN. (*b*): The [P/Ar]–[C/Ar] diagram. (*c*): The [Kr/Ar]–[C/Ar] diagram.

To investigate the status of the central star of the PN, nebula condition, and dust properties, we construct a theoretical spectral energy distribution (SED) model to match the observed SED with Cloudy. By comparing the derived luminosity and temperature of the central star with theoretical evolutionary tracks, we conclude that the initial mass of the progenitor is likely to be ~1.5–2.0 $M_\odot$ and the age is ~3000 yr after the AGB phase. The observed elemental abundances of Hen2-436 can be explained by a theoretical nucleosynthesis model with a star of initial mass 2.25 $M_\odot$, $Z = 0.008$ and LMC compositions. We have estimated the dust mass to be $2.9 \times 10^{-4} M_\odot$ (amorphous carbon only, Fig. 2a) or $4.0 \times 10^{-4} M_\odot$ (amorphous carbon and PAH, Fig. 2b). Based on the assumption that most of the observed dust is formed during the last two thermal pulses and the dust-to-gas mass ratio is 5.58×10^{-3}, the dust mass-loss rate and the total mass-loss rate are $< 3.1 \times 10.8\, M_\odot\, \mathrm{yr}^{-1}$ and $< 5.5 \times 10.6\, M_\odot\, \mathrm{yr}^{-1}$, respectively. Our estimated dust mass-loss rate is comparable to a Sgr dwarf galaxy AGB star with similar metallicity and luminosity[1].

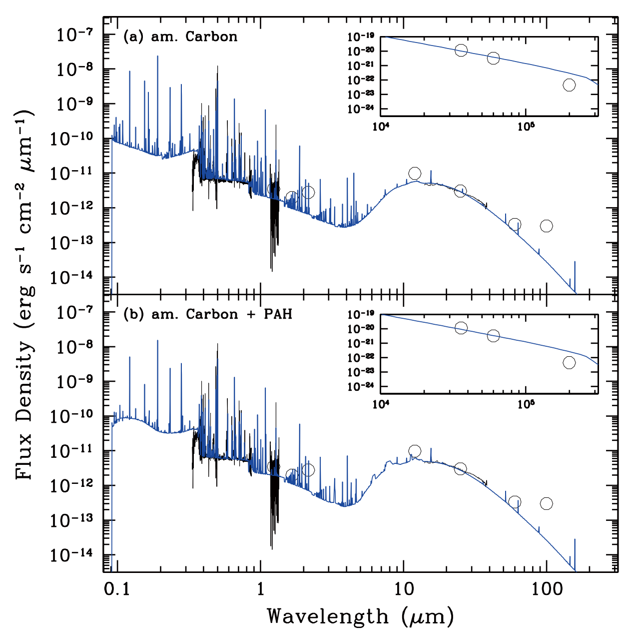

Figure 2: The predicted SED from Cloudy modelings (blue lines). The observed data are indicated by the black lines or circles. In the inner small boxes we plot the radio data and the predicted SED. (*a*) The predicted SED by Cloudy considering amorphous carbon only. (*b*) The predicted SED considering amorphous carbon and PAH grains.

Reference

[1] Otsuka, M., et al.: 2011, *ApJ*, **729**, 39.