High Velocity Collimated Flow in a Halo Planetary Nebula, H 4-1

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H 4-1, PN G 049.3+88.1 ($\alpha = 12^h59^m27.6^s$, $\delta = +27°38'14''$, 2000), was one of well known halo Planetary Nebulae (PNe). During our program to study the expanding characteristics of PNe, the long-slit spectroscopic observations were made by the cassegrain spectrograph of the 74 inch telescope at the Okayama Astrophysical Observatory in March 1995.

In the resultant contour map of Hα & [N II] region at PA = 180°, Hα line shows broad profile (FWZI $\sim$ 350 km s^{-1}) and Hα and [N II] line show a spiky feature at both sides of its profile that escaping from the central star. In the [O III] position-velocity map, we can also see the broad emission structure of FWZI $\geq$ 350 km s^{-1} at PA= 180°. Similar emission (more weaker and narrower) is also seen in the spectra at PA= 45° and 135°. These collimated flow showing a high velocity field is generally explained as a bipolar flow.

From the obtained spectra, we could consider that the low ionization asymmetrical structure as a polar cap of the bipolar nebula. If we adopted the distance of this object as 17.8 kpc, we can estimate that the linear size of the displacement as $\sim$ 1.1 pc. Using these derived value and adopting the inclination angle as 45°, we can calculate the kinematical age of this feature as 2×10^4 year.

The central collimated high velocity field could be explained by the interaction between the collimated stellar wind and the surrounding nebular materials. By this IUE spectrum of H 4-1 (swp20599), we can estimate an edge velocity of the strong stellar wind in the central region as about 3000 km s^{-1}.

From observational and/or theoretical investigations, bipolar PNe were thought that they evoluved from massive progenitor. On the other hand, halo PNe show low metal abundance and are consisted type IV (Peimbert 1978). Therefore, their progenitors are regarded as less massive stars.

It is not strange to say that H 4-1 has a bipolar structure, since a bipolar structure of K 648, one of the most studied halo PNe, was revealed by HST (Bianchi et al. 1995). Not only in massive type but also in less massive type PNe, we could find a bipolar structure. Based on these observational evidence, we could consider that these asymmetrical mass loss is a general process of low- and intermediate-mass star evolution of the last stage.

REFERENCES

Bianchi, L., et al., 1995, A&A, 301, 537.

Peimbert, M., 1978, in IAU Symp. No.76 "Planetary Nebulae", ed. Terzian, Y., (Dordrecht Reidel), p.215.