Planetary Nebulae in our Galaxy and Beyond
Proceedings IAU Symposium No. 234, 2006
M. J. Barlow & R. H. Méndez, eds.

doi:10.1017/S1743921306004054

High Dispersion Spectroscopy of the PN K 648 in the Globular Cluster M 15

Akito Tajitsu[1], and Masaaki Otsuka[2]

[1]Subaru Telescope, National Astronomical Observatory of Japan,
650 North A'ohoku Place, Hilo, HI 96720, USA
email: tajitsu@subaru.naoj.org

[2]Okayama Astrophysical Observatory, National Astronomical Observatory of Japan,
3037-5 Kamogata Honjo, Asaguchi, Okayama 719-0232, Japan

Abstract. We present our recent results of the high dispersion spectroscopy of a Galactic halo planetary nebula, K 648, in the globular cluster M 15. The position-velocity diagrams of our spectra indicate the existence of collimated outflows in K 648. In the [N II]λ6583 diagram, we found high velocity components with a velocity $\sim$60 km s^{-1} in the central region of K648.

Keywords. planetary nebulae: individual (K 648 = Ps 1), globular clusters: individual (M 15)

1. Introduction

Among over 1000 planetary nebulae (PNe) in the Galaxy, a small number of them are associated with the Galactic halo. They are selected by their Galactic location, kinematics, chemical composition and/or membership in globular clusters. Up to now, four PNe are known in Galactic globular clusters. K 648 (Ps1, PN G 065.0-27.3) is one of such halo PNe, discovered in the crowded field near the center of the Galactic globular cluster M 15 by Küstner in 1921. However, the existence of a PN in M 15 is unexpected. Given the turn-off age of M 15, 12 billion years, the most massive main sequence stars in M 15 should have $M_{initial} < 0.8 M_{\odot}$. Such low mass stars might not ascend the AGB and eject a PN (Rauch *et al.* 2002). A recent *HST* observation by Alves *et al.* (2000) revealed an elongated shell and ripple structures in this nebula. They suggested that the progenitor of K 648 experienced mass augmentation in a close binary merger.

In order to investigate the spatio-kinematics properties of K 648 more precisely, we have carried out the highest dispersion spectroscopy ($R \sim 90,000$) of K 648.

2. Observations and Preliminary Results

High dispersion echelle spectra of K 648 covering the range 3650–7490 Å were obtained with HDS (High Dispersion Spectrograph) of the 8.2 m Subaru telescope in June and July 2005. We set the slit position angle to 153° along the major axis of the nebula and scanned five positions with 0″.36 separations to cover the entire part of the bright nebula. The wavelength resolution was $R \sim 90,000$ with a 0″.4 slit width, equivalent to $\sim$3.3 km s^{-1}. The seeing during the observations was $\sim$0″.55 (in June) and $\sim$0″.8 (in July), respectively.

Figure 1 shows the position-velocity diagrams ("PV diagrams") of [O III]λ5007 and [N II]λ6583 extracted from the echelle spectra for the center slit position. Here, the high spectral and spatial resolutions of our observations can easily show the kinematic difference between the central nebular component and a pair of "FLIERs" arcs. [N II] is clearly enhanced by shock excitation in these arcs. The velocity difference between the bright

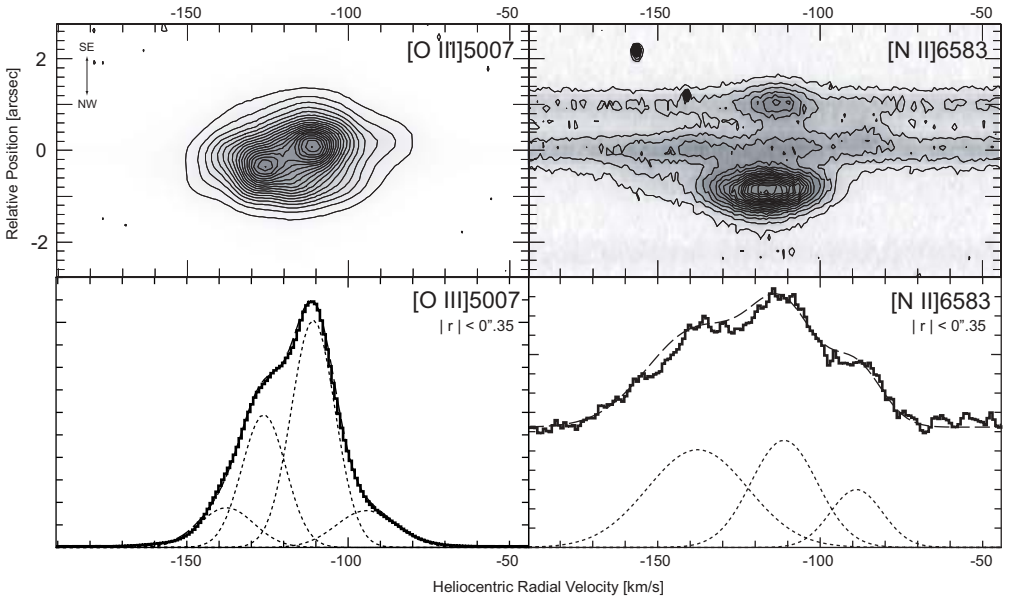

Figure 1. Position-velocity diagrams of [O III]λ5007 and [N II]λ6583 (top). SE is up and NW is down in the diagrams. The spectra binned in the central region (the relative position, $|r| < 0''.35$) are also shown at the bottom with the results of multi-Gaussian fitting analysis.

(northwestern) and the faint (southeastern) arcs is quite small ($\sim$3.2 km s^{-1} in [N II]). But, in the central core region of the nebula, high velocity components (HVCs) toward both red and blue sides can be found. Across the central star, the red- and blue-shifted HVCs are pointing to opposite directions. Their maximum velocity difference is measured as $\sim$60 km s^{-1} by multi-Gaussian fitting analysis.

On the other hand, the [O III] diagram clearly has two peaks with $0''.6$ separation along the slit length. This may have resulted from the existence of a collimated outflow with an expansion velocity of $2V_{exp}$([O III]) $\sim$ 15 km s^{-1} near the center of K 648. Its kinematical age is obtained as 4690yr, using the same estimation method in Alves *et al.*. This is very close to the kinematical age of the whole nebula, 4270yr, estimated by Bianchi *et al.* (2001). Compared with these estimates, the kinematical age of the HVCs is significantly smaller ($\sim$1170yr).

Similar HVCs have also been found in the central core of M 2–9, the "Butterfly Nebula" (Solf 2000). Alhough the velocity of HVCs is much faster in M 2-9 ($2V_{exp} \sim 195$ km s^{-1}), the HVCs in K648 may have resulted from similar mass ejections. This rather younger outflow could imply that the central star of K 648 is still a close binary. Alves *et al.* could not find any signs of a binary after monitoring with *WFPC2* for seven days. However, we strongly suggest that it should be detected by radial velocity monitoring of the central star of K 648.

References

Alves, D.R., Bond, H.E., & Livio, M. 2000, AJ, 120, 2044
Bianchi, L., Bohlin, R., Catanzaro, G., Ford, H., & Manchado, A. 2001, AJ, 122, 1538
Rauch, T., Herber, U., & Werner, K. 2002, A&A, 381, 1007
Solf, J. 2000, A&A, 354, 674

https://doi.org/10.1017/S1743921306004054 Published online by Cambridge University Press