Journal of Physics: Conference Series **728** (2016) 072014 doi:10.1088/1742-6596/728/7/072014

Raman-scattered O VI λ1032 and He II λ1025 and Bipolar Outflow in the Symbiotic Star V455 Sco

Jeong-Eun Heo[1], Rodolfo Angeloni[2], Francesco Di Mille[3], Tali Palma[4], Seok-Jun Chang[1], Chae-Lin Hong[1] and Hee-Won Lee[1]

[1] Department of Physics and Astronomy, Sejong University, Korea
[2] AURA-GEMINI Observatory, Chile
[3] Las Campanas Observatory, Chile
[4] Pontificia Universidad Católica de Chile, Chile

E-mail: jeung6145@gmail.com

Abstract. Raman-scattering by atomic hydrogen is a unique spectroscopic process that may probe the mass transfer and mass loss phenomena in symbiotic stars(SSs). In the optical high-resolution spectra of the S-type SS V455 Sco, we note the presence of two Raman-scattered features, one at around 6825 Å with a triple-peak profile formed from Raman-scattering of O VI λ1032 and the other Raman-scattered He II λ1025 at around 6545 Å. Adopting an accretion flow model with additional contribution from a collimated bipolar outflow, we propose that the blue and central peaks are contributed from the accretion flow and the bipolar flow is responsible for the remaining red peak. With the absence of [N II] λ6548, the Raman-scattered He II λ1025 at around 6545 Å is immersed in the broad Hα wings that appear to be formed by Raman-scattering of far-UV continuum near Lyman series.

1. Raman O VI and Bipolar Outflow

A number of symbiotic stars(SSs) exhibit broad emission features at around 6825 Å and 7082 Å which are formed through Raman-scattering of O VI $\lambda\lambda$1032, 1038 by atomic hydrogen.[1] Raman O VI features in SSs are known to exhibit complicated profiles including double-peak profiles and triple-peak profiles and strong polarization.[2] They are unique and useful tools to probe the wind accretion process as some fraction of material from the giant is captured by the white dwarf. [3-5]

In Fig. 1 we present the optical high-resolution spectrum of the S-type SS V455 Scorpii taken with the Echelle spectrograph on the Magellan telescope in March 2015, in which we find that the Raman-scattered O VI λ1032 feature exhibits a triple-peak profile. We transform the Raman O VI feature to the rest frame determined by the optical emission line He I λ7065 to find that the line center of the Raman O VI at 6825 Å feature falls on the dip dividing the blue peak and the central peak. In the Doppler factor(ΔV) space (upper x-axis of Fig.1), which is measured by an imaginary observer that is at rest with respect to the giant, the first dip is found to correspond to 0 km s^{-1} and the two main peaks are ~ -30 km s^{-1} and $+40$ km s^{-1}.

Based on the accretion flow model [3], the accretion flow is divided into the 'Blue Emission Region(BER)' and the 'Red Emission Region(RER)', where the BER approaches and the RER recedes from the imaginary observer located at the giant. In this picture, we propose that the blue peak and central peak are contributed from the accretion flow around the white dwarf.

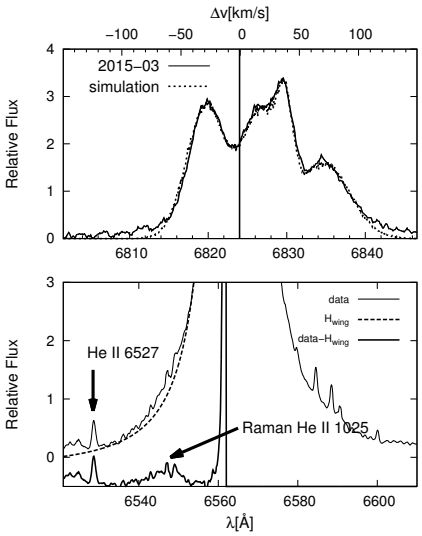

Figure 1. MIKE spectrum around the Raman-scattered O VI λ1032 at 6825 Å (upper panel) and He II λ 1025 at 6545 Å (lower panel)

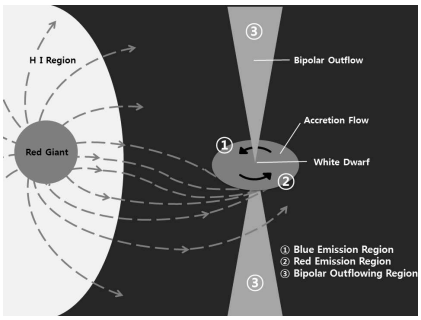

Figure 2. A schematic illustration of the accretion and bipolar outflow in V455 Sco

Based on the separation of two peaks, we suggest that the O VI emission region lies within 1AU from the white dwarf. We also propose that the remaining red peak is formed from O VI coming from the bipolar outflowing region which moves away with a velocity $\sim +80$ km s^{-1}.(e.g., [6])

Assuming the O VI emission region including the accretion flow and bipolar outflow as shown in Fig. 2, we show the profile of Raman O VI 6825 feature produced by our Monte-Carlo code as shown by dotted line in Fig. 1.

2. Raman He II λ1025

Raman He II features are useful as a spectroscopic diagnostic to estimate the mass loss rate of the scattering region. However, all the Raman He II λ1025 at 6545 Å features discovered so far suffer from heavy blending with the forbidden line [N II] λ6548 rendering it very difficult to obtain the line profile with sufficient quality.

He II λ4686 and He II λ6527 emission lines in V455 Sco spectrum provide strong hints pointing out the existence of the Raman He II features. We find the Raman-scattered He II 6545 feature by subtracting Hα wings which are excellently fitted by a $\Delta\lambda^{-2}$ profile as shown in the lower panel of Fig. 1. It is quite noticeable that the Raman He II feature is free of blending with [N II] λ6548 which is absent in the spectrum.

Acknowledgments

This research was supported by the Basic Science Research Program of the National Research Foundation (NRF-2014R1A1A2054887) and the Korea Astronomy and Space Science Institute under the R&D program (Project No. 2015-1-320-18).

References

[1] Schmid H M 1989 *Astron. Astrophys.* **211** L31
[2] Harries T J and Howarth I D 1997 *Astron. Astrophys. Suppl. Series* **121** 15
[3] Lee H-W and Park M-G 1999 *Astrophys. J.* **515** L89
[4] Kang E-H and Lee H-W 2008 *J. Korean Astron. Soc.* **41** 49
[5] Heo J-E and Lee H-W 2015 *J. Korean Astron. Soc.* **48** 105
[6] Angeloni R, Di Mille F, Bland-Hawthorn J and Osip D J 2011 *Astrophys. J. Lett.* **743** L8