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ON THE PROFILES AND THE POLARIZATION OF RAMAN SCATTERED O VI LINES IN SYMBIOTIC STARS

H. -W. LEE AND K. W. LEE
Dept. of Astronomy and Atmospheric Sciences, Kyungpook National University, Taegu, Korea

Symbiotic stars are characterized by composite spectra of a cool giant and a hot star, which acts as an ionizing source for an emission nebula. It has been known that about half of symbiotic stars exhibit broad line features around 6827 Å and 7088 Å (e.g. Allen 1980). Schmid (1989, 1992) proposed that these features are Raman scattered O VI doublets $\lambda\lambda$1032, 1038 by atomic hydrogen and showed that these features are polarized.

We calculate the profiles and the polarization of the Raman scattered O VI lines expected in symbiotic stars using a Monte Carlo method. Time dependent perturbation theory is used to calculate the scattering cross sections including the continuum contributions (e.g. Saslow & Mills 1969 , Sakurai 1967), and the numerical result is shown in Table 1.

The scattered line profiles from a point-like isotropic UV radiation source are investigated. We assume that the stellar wind from the cool giant is spherically symmetric with terminal velocity $v_\infty = 20 \mathrm{km\,s^{-1}}$ and that the UV radiation source is governed by a Gaussian of temperature $T = 10^4$ K. A contour map of Doppler factors and scattering optical depths for a mass loss rate $\dot{M} = 10^{-7} \mathrm{M_\odot yr^{-1}}$ is presented in Fig. 1. In Fig. 2, we show the line profiles and the polarization of the scattered feature. The largest contribution to the scattered flux is due to receding atoms from the hot star, which results in asymmetric profiles to the red. The strength of the scattered feature is approximately proportional to the solid angle subtended by the contour of $\tau_s = 1$ from the hot star, which is dependent on the mass loss rate of the cool giant. For small scattering optical depth $\tau_s \lesssim 1$ the polarization behavior can be typified by a high degree of polarization in the blue wing perpendicular to the binary axis, which is represented by a positive polarization in the figure. For large optical depth $\tau_s \gtrsim 5$, the direction of polarization changes around the center and the feature is polarized parallel to the binary axis in the red wing.

We adopt a simple triangular profile for the UV emission lines and show the synthetic profiles of the Raman-scattered feature in Fig. 3. The important parameters affecting the line profiles and the polarization structures include the scattering optical depth, stellar wind velocity and the bulk velocity. When the scattering optical depth is small, the polarization is characterized by a high percentage polarization in the blue wing and a fixed direction perpendicular to the binary axis throughout the feature. For a large scattering optical depth, the scattered feature is polarized parallel to the binary axis around the center and as τ_0 increases the degree of polarization increases. This behavior may provide a clue to the interpretation of the spectropolarimetric data of RR Tel by Espey et al. 1995.

Table 1.

Ions	λ^a (Å)	σ_{Ray}/σ_T	σ_{Ram}/σ_T	σ_{tot}/σ_T
O VI	1031.9261	7.48	34.0	41.5
O VI	1037.6167	2.45	6.77	9.22
N III	989.799	0.64	0.57	1.21
C III	977.020	1.71	4.46	6.17

[a] For wavelengths see Verner, Barthel, & Tytler (1994)

Spectropolarimetry with a detailed analysis of the Raman scattered features and UV emission lines may provide a powerful diagnostic about the kinematics and the ionization structures of symbiotic stars.

ACKNOWLEDGEMENTS

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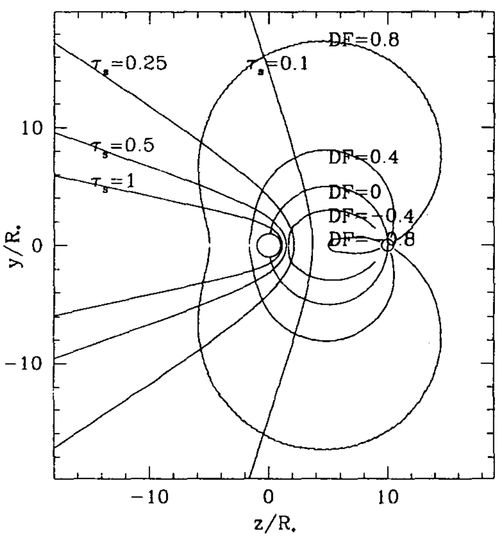

Fig. 1

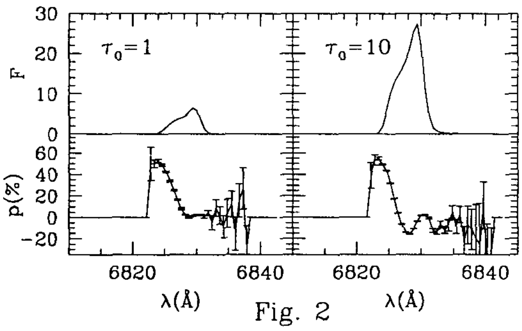

Fig. 2

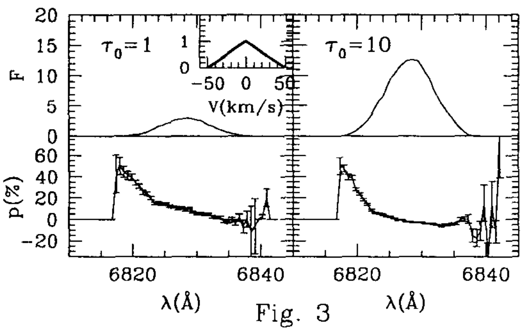

Fig. 3

Fig. 1.— A contour map of Doppler factors and scattering optical depths of incident photons from the hot star. $D.F. \equiv \frac{\hat{k}\cdot v\hat{v}}{c}$ and $\tau_s = \int ds\, n(s)\, (\sigma_{Ray} + \sigma_{Ram})$.

Fig. 2.— Line profiles and polarization of the λ6827 feature for a point-like isotropic source with a Gaussian of $T = 10^4$ K. A typical scattering optical depth is given by $\tau_0 \equiv \sigma_{tot}\dot{M}/4\pi R_* m_p v_\infty$.

Fig. 3.— Synthetic line profiles and polarization of the λ6827 feature for an emission source of a triangular profile with bulk velocity of $v \sim 50 \mathrm{km\,s^{-1}}$.