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The Role of Electron Scattering in Probing the Wind from the Hot Star in Symbiotic Binaries

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Abstract. We modeled the broad wings of the OVI 1032,1038Å resonance lines and HeII 1640Å line in the spectra of some symbiotic stars by the electron-scattering process. We determined an empirical relationship between the emission measure of the symbiotic nebula and the electron optical depth. This allowed us to determine a contribution from the electron-scattering also to emission lines, which originate in a more extended, low density part of the nebula. For example, subtracting the electron-scattering contribution from the Hα line profile makes it possible to determine more precisely the mass loss rate via the wind from the hot star in symbiotic binaries.

Keywords. binaries: symbiotic, scattering, line: profiles

1. Introduction

Symbiotic stars are interacting binaries with the longest known orbital period on the order of years to decades, consisting of a cool giant and a hot compact star. As a result, in their spectra we observe contributions from the red giant, the hot star, and the nebula, which represents ionized winds from the binary components. During quiescent phases, the hot star releases its energy at a constant rate and temperature, while during active phases, the energy in the spectrum is redistributed and the brightness of the star increases by about 2 - 3 mag in the optical. Active phases are also connected with an increase of the nebular component of radiation. In this work, we investigated the effect of the electron-scattering on the strongest emission lines in the spectra of symbiotic stars.

2. The contribution of the electron-scattering to the Hα wings

We assumed, that the observed broad wings of the OVI 1032, 1038Å resonance line and HeII 1640Å emission line are created only by the electron-scattering process. According to Castor, Smith & van Blerkom (1970), we applied the model in which the photons are transferred throughout the layer of free electrons (the symbiotic nebula) in the direction of the observer, characterized by the electron optical depth, τ_e and electron temperature T_e. An example of the observed and modeled wings is shown in Fig. 1.

By modeling the spectral energy distribution of the symbiotic star AG Dra, Skopal *et al.* (2009) showed that the stellar wind of the hot star is enhanced during the active phases, with an increase in the particle density (and thus free electrons) at the vicinity of the hot star and consequent increases in the electron optical depth of the symbiotic nebula. Concentration of the free electrons and the volume of the nebula determine the so-called emission measure (EM), that changes with the star's activity. According to the definition of τ_e and EM, $EM \propto {\tau_e}^2$. To demonstrate this relationship, we used τ_e from the models of the line profiles observed at different stages of activity for different objects

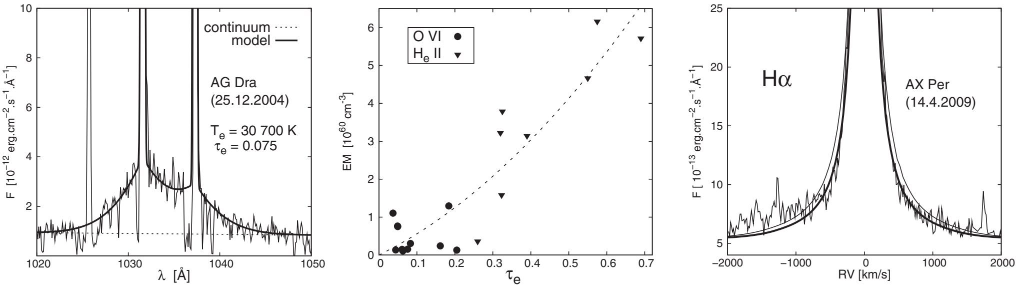

Figure 1. Left: Modeled (heavy line) profile of the OVI 1032, 1038Å lines. In the middle: The relation between τ_e and EM for different levels of symbiotic star's activity. Right: The models of Hα wings before (thin line) and after (heavy line) extracting the electron-scattering contribution.

and corresponding EM, determined from the continuum flux in the near-UV region. In this way, we determined this relationship as $EM = 6.6\,{\tau_e}^2 + 4.9\,\tau_e$ (Fig.1).We didn't take into account the dependence of EM and τ_e on the orbital phase and also neglected the contribution of the enhanced stellar wind of the hot star in the line wings during the active phase, which leads to uncertainties in determination of the $EM(\tau_e)$ relationship.

According to Skopal (2006), the broad wings of the Hα line profile originate in the ionized wind from the hot star. According to the $EM(\tau_e)$ relationship, there is also a contribution due to the electron scattering in the Hα wings. To determine more precisely the mass loss rate, we have to subtract its contribution to the wings. We demonstrate this approach on the spectrum of the symbiotic star AX Per, observed during its last activity increase in 2007-2010 (Skopal *et al.* 2011). We determined EM from the luminosity of the Hα line using the total volume emission coefficient in Hα line for T_e = 20 000 K. We estimated $\tau_e = 0.059$ from the $EM(\tau_e)$ relationship, which allowed us to subtract the contribution of the electron-scattering from the Hα wings. The corresponding mass loss rate decreased by about 12% from the value of $\dot{M}_{\rm h}$=3.25×10^{-6}M$_\odot$yr^{-1} to $\dot{M}_{\rm h}$=2.88×10^{-6}M$_\odot$yr^{-1} (Fig.1).

3. Conclusion

Electron-scattering can explain the very broad wings of the strongest emission lines of highly ionized elements, which are created in densest parts of the nebula at a vicinity of the hot star. The increase of τ_e and EM indicate the increase in the number of free electrons in the line of sight, which is in major part due to the enhanced stellar wind from the hot star during active phases. Despite the illustrative character of the $EM(\tau_e)$ relationship, the estimated reduction in the mass loss rate of the hot star suggests that electron-scattering is not the dominant contributor to the broad Hα wings.

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