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H_α orbital variations of the symbiotic star EG And from optical spectroscopy

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Abstract. In this contribution, we explore the orbital variability of the Hα-line emission and absorption components of the symbiotic system EG And.

We have found that the equivalent width of the core emission is the largest at the orbital phase $\varphi \approx 0.4$ and the smallest at $\varphi \approx 0.2$. This probably reflects an asymmetric distribution of the cool giant wind at the orbital-plane area. Furthermore, the core emission equivalent width has a secondary maximum at $\varphi \approx 0.1$. The strongest absorption in the profile is measured around the inferior conjunction of the white dwarf, $\varphi \approx 0.4$. This suggests that the ionized region is partially optically thick in the Hα line.

Key words: symbiotic binary stars – stellar spectral lines – stellar mass loss

1. Introduction

EG And is an eclipsing symbiotic star with no recorded outbursts (Stencel, 1984; Crowley et al., 2008). The binary system consists of a white dwarf accretor that ionizes a fraction of the neutral wind from a red giant donor. The presence of the ionized and neutral region in the binary star and its high orbital inclination of $\approx 80°$ (Vogel et al., 1992) causes the observed orbitally-related variations in the Hα line profile (e.g. Smith, 1980). To identify the physical properties of the ionized region, we used the advantage of the long-term monitoring of this source with the orbital period of 483 days (Kenyon & Garcia, 2016) by small optical telescopes.

2. H_α orbital variability

We use 90 optical spectra obtained during years 2015 - 2018 by 60 cm and 1.3 m telescopes at the Stará Lesná (G1 in the figures) and Skalnaté Pleso (SP) observatories, complemented with those available at the Astronomical Ring for Access to Spectroscopy Data Base (*www.astrosurf.com/aras/Aras_DataBase/Symbiotics.htm*) to fit the Hα line profile by three Gaussian functions corresponding to the core emission, broad wings emission and the central absorption. The resulting fits do not perfectly match the observed Hα line profile (Fig. 1). The most important source of errors of equivalent widths are the errors of the heights of the Gaussian components that are typically higher than 10%. This is caused mainly by the fact that we did not allow the height of the core emission component to vary freely, otherwise the fitting procedure would converge to unrealistically high values. Therefore, our equivalent widths' values can be considered as lower estimates.

The resulting equivalent widths of the core emission and absorption are plotted in Fig. 2. Both quantities are strongest at $\varphi \approx 0.4$ and weakest at $\varphi \approx 0.2$, reflecting the asymmetry of the circumstellar matter density distribution with respect to the binary star axis. Another interesting feature is the secondary maximum of the core emission equivalent width at $\varphi \approx 0.1$. Its existence probably reflect a complex wind flow, as suggested by hydrodynamical simulations of symbiotic stars (e.g. Walder & Folini, 2000). Moreover, solely the fact that we see an emission in the Hα line at orbital phases near the eclipse of the white dwarf by the red giant means that the size of the ionized region exceeds the size of the giant star, as was also found in the study of Kondratyeva et al. (2018).

The maximum of both emission and absorption component at $\varphi \approx 0.4$ reflects a higher density region on the line of sight. This causes a higher emissivity and also absorbing ability, because of shortening the recombination time in the ionized medium. In other words, the fraction of the H^0 atoms in the H^+ zone increases, which makes this part of the nebula partially optically thick in the Hα transition. A similar interpretation was given by Blanco & Mammano (1995) to explain the HeI 587.6 nm orbital variability of EG And. From the presence of the emission component during the inferior conjuction of the giant, they infer that the nebula has to be larger than the obscuring region. At the same time, the absorption component becomes invisible, indicating that the densest part of the nebula, where the absorption occurs, is occulted by the red giant.

Our dataset covers almost two orbital cycles of the system. However, measured equivalent widths from the two different orbital cycles overlap only between the orbital phase 0.6 and 0.8. Outside this range, the data from different cycles are rather complementary. The agreement between the comparable parts of the dataset supports the orbitally-related properties of the Hα line profile.

3. Conclusion

By quantifying the orbital variability of the emission and absorption components of the Hα line separately, we identified several properties of the nebula in EG And. The changes of the absorption component revealed that the ionized

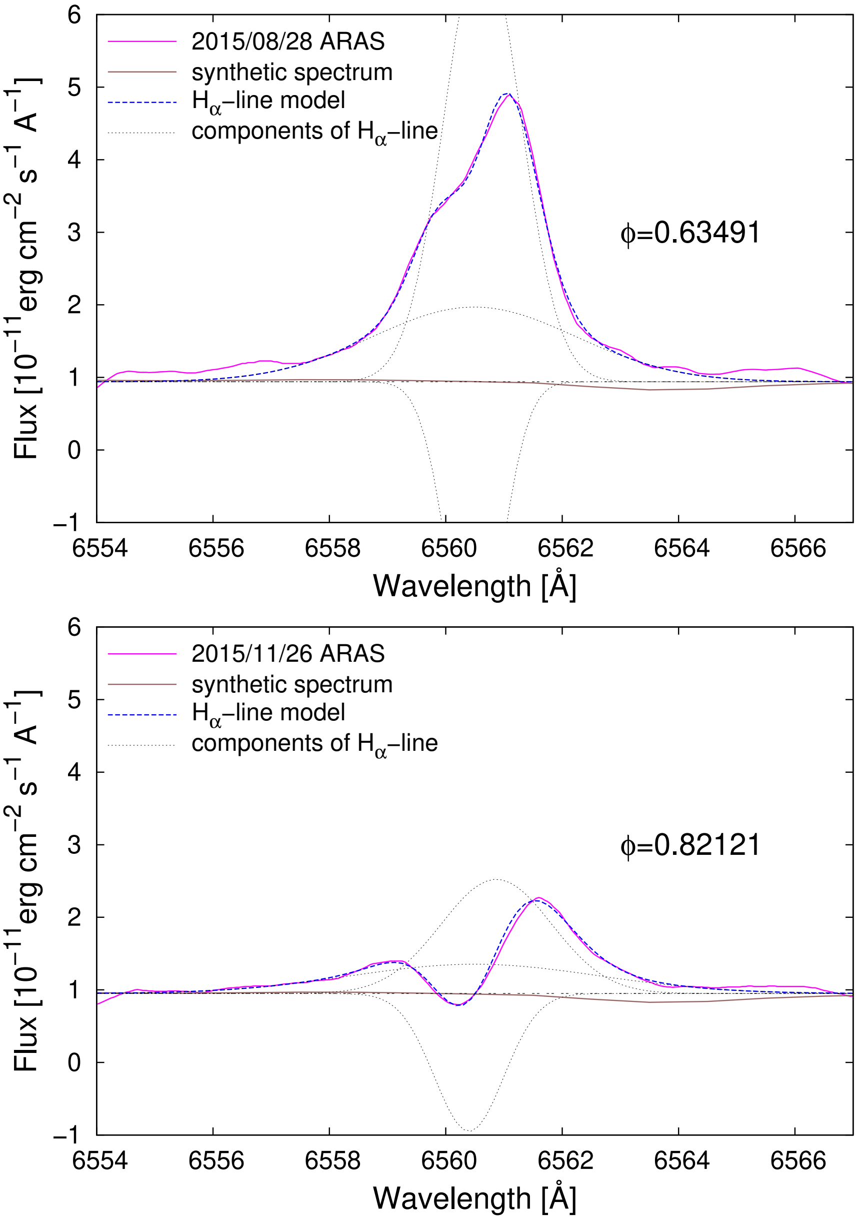

Figure 1. An example of the fit of the Hα line profile by three Gaussian components relatively far from the eclipse (top) and near the eclipse (bottom) of the white dwarf.

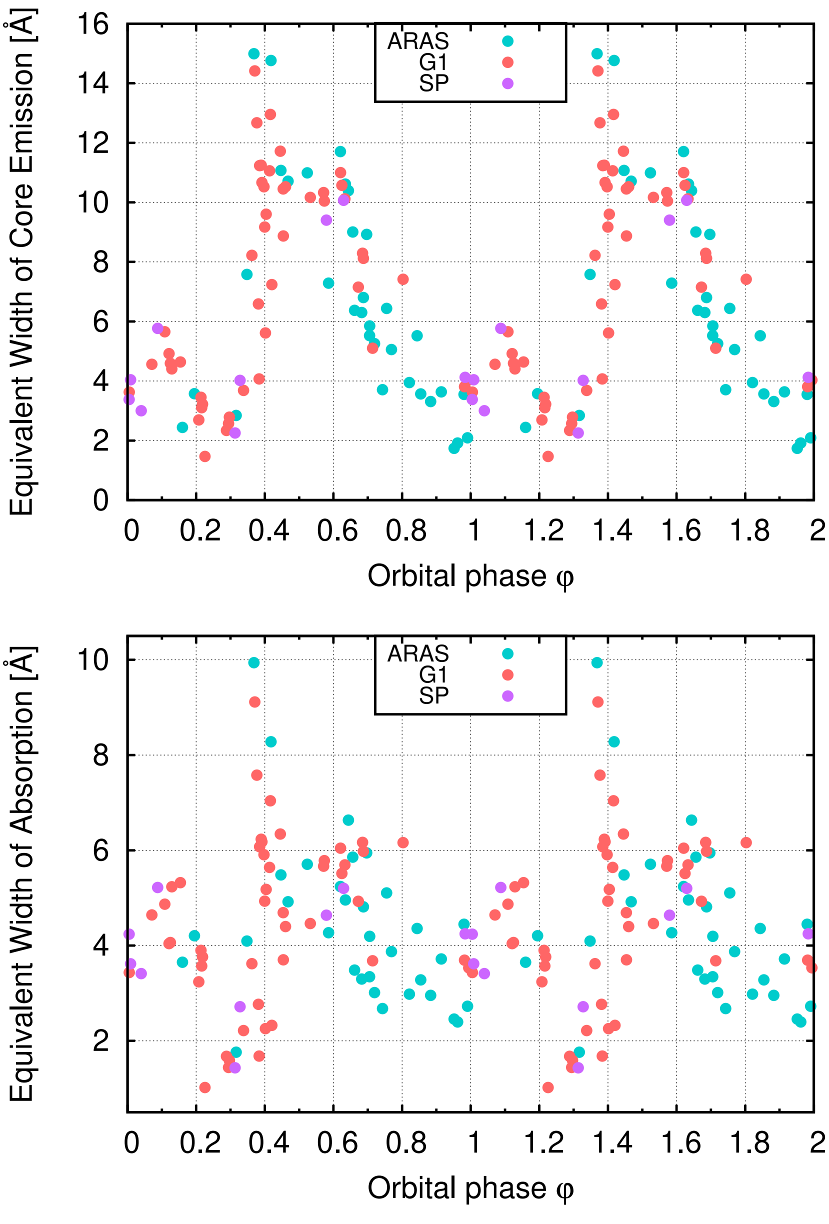

Figure 2. The orbital variabity of equivalent widths of the core emission (top) and absorption (bottom) components of the Hα line profile. We used the time of inferior conjunction of the red giant $MJD = 50683.2$ ($\varphi = 0$) according to Fekel et al. (2000).

region is partially optically thick in the Hα line, while the emission component presence during eclipse shows that the nebula is larger in size than the red giant.

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