The properties and impact of stars stripped in binaries

Götberg, Y.L.L.

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Appendices to Chapter 2
A.1 Connection between the atmosphere and structure models for varying metallicity

In Sect. 2.2.3 we describe how we construct CMFGEN atmosphere models for the stellar structure models computed with MESA. Here, we provide additional plots analogous to Fig. 2.1 to show the connection for the temperature and density structure. The top, middle, and bottom panels of Fig. A.1, show our $Z = 0.0047$, $Z = 0.0021$, and $Z = 0.0002$ models, respectively. Within each panel, we show the connection for the standard mass loss rate together with a mass loss rate that is three times enhanced and three times reduced. The differences in the estimated stellar radii from the MESA and CMFGEN models translate into temperature differences. The largest difference is $\sim 200$ K for the $Z = 0.0002$ model, which is negligible compared to the surface temperature ($\sim 50\,000$ K). This is accurate enough to reliably predict the spectral properties.

A.2 Impact of parameter variations

A.2.1 Wind speed and clumping variations

For the atmosphere models presented in this work we adopted a terminal wind velocity $v_\infty = 357$ km s$^{-1}$ motivated by the measurements for the stripped star in the HD 45166 system. This value is small in comparison with the typical values measured for the higher mass counterparts, WR stars, which commonly have $v_\infty = 1300$ km s$^{-1}$ (see Groh et al. 2008, for a discussion). We investigated the impact of changes in this assumption by computing an atmosphere model equivalent to our standard model, but instead assuming $v_\infty = 1300$ km s$^{-1}$ and an increased effect of wind clumping by setting the wind clumping volume filling factor to 0.1.

The spectral energy distribution is not affected by the changes in these assumptions. However, the spectral features broaden and stand out less strongly above the continuum, as can be seen in Fig. A.2. This would make it harder to identify the features of stripped stars when they are accompanied by an optically bright main sequence companion. However, the prominent HeII $\lambda 4686$ feature shown in panel e) is still about seven times stronger than the continuum, despite spanning over about 30 Å.

The example shown considers a more WR-like set of parameters compared to the standard model. It is also interesting to consider spectral models with low wind speed and increased clumping or high wind speed and less clumping. In the case of low wind speed and increased clumping we expect the spectral features to be stronger compared to the standard model as the increased wind clumping makes the atmosphere seem more optically thick. The lines would however remain narrow. For a model with instead high wind speed but less clumping we expect broad features, but potentially more P Cygni profiles compared to the model with
A.2 Impact of parameter variations

Figure A.1: Connection between the MESA and CMFGEN models similar to Fig. 2.1, but here for metallicities $Z = 0.0047$ (top left panel), $Z = 0.0021$ (top right panel) and $Z = 0.0002$ (bottom panel).

high wind speed and more clumping presented in this subsection. This because less clumping makes the wind seem optically thinner.

A.2.2 Other uncertain parameters

Here we list several other uncertain parameters, which have not been investigated in detail in this work. We explain how these could potentially impact the appearance of the spectra.

- Composition not scaled according to solar. The relative metal mass ratios may vary with metallicity, in particular over cosmic time. A larger amount of CNO for a specific
iron abundance would increase the spectral features of CNO, but not affect the emitted ionizing flux significantly.

- Initial helium mass fraction. The initial helium mass fraction might vary between environments of the same metallicity. Such a change would affect the compactness of the stars throughout the evolution and also affect the size of the helium core after the main sequence. This has direct implications for the luminosity and thus ionizing flux of the stripped stars.
A.2 Impact of parameter variations

- Including other Fe-group elements in spectral modeling. To include more elements from the Fe-group could increase the line blanketing in the extreme UV and in such a way reduce the flux of ionizing photons.