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# Wind-embedded shocks in FASTWIND: X-ray emission and K-shell absorption

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**Abstract.** EUV and X-ray radiation emitted from wind-embedded shocks can affect the ionization balance in the outer atmospheres of massive stars, and can also be the mechanism responsible for producing highly ionized atoms detected in the wind UV spectra. To investigate these processes, we implemented the emission from wind-embedded shocks and related physics into our atmosphere/spectrum synthesis code FASTWIND. We also account for the high energy absorption of the cool wind, by adding important K-shell opacities. Various tests justfying our approach have been described by Carneiro+(2016, A&A 590, A88).

In particular, we studied the impact of X-ray emission on the ionization balance of important elements. In almost all the cases, the lower ionization stages (O IV, N IV, P V) are depleted and the higher stages (N V, O V, O VI) become enhanced. Moreover, also He lines (in particular He II 1640 and He II 4686) can be affected as well.

Finally, we carried out an extensive discussion of the high-energy mass absorption coefficient, $\kappa_\nu$, regarding its spatial variation and dependence on $T_{\rm eff}$. We found that (i) the approximation of a radially constant $\kappa_\nu$ can be justified for $r \geqslant 1.2 R_*$ and $\lambda \leqslant 18$ Å, and also for many models at longer wavelengths. (ii) In order to estimate the actual value of this quantity, however, the He II background needs to be considered from detailed modeling.

**Keywords.** methods: numerical, stars: atmospheres, stars: early-type, stars: mass loss

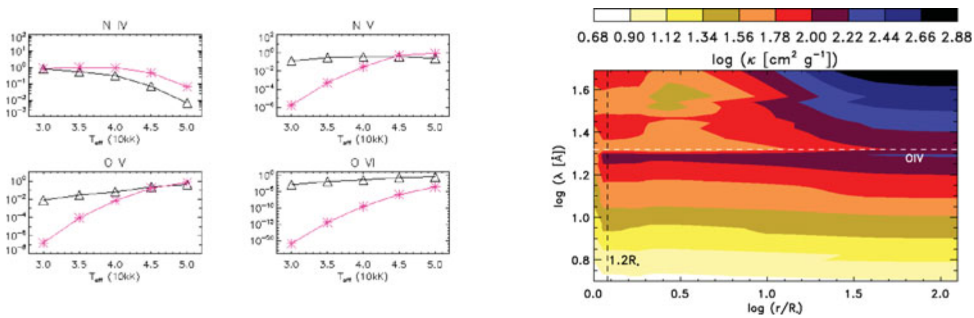


**Figure 1. Left:** Ionization fractions of important ions at $v(r) = 0.5\ v_\infty$, as a function of $T_{\rm eff}$, for supergiant models with typical X-ray emission (black triangles), and without X-rays (pink asterisks). The figure demonstrates the importance of including the shock emition to obtain a proper description of ions like N V, O V, O VI, particularly in 'cooler' objects.
**Right:** Contour plot of the radial dependence of the mass absorption coefficient in a supergiant model at $T_{\rm eff}$=40kK, as a function of wavelength. We note that $\kappa_\nu$(r) becomes constant when r $\geqslant 1.2 R_*$ and $\lambda \leqslant 20$Å (log $\lambda \leqslant 1.3$ ∼O IV edge), to be on the safe side. In most cases, the quoted radial limit, arising from fluctuations in the background opacity, is even lower. *L.P.C. gratefully acknowledges a grant by the International Astronomical Union. This work has been supported by the Brazilian Coordination for the improvement of Higher Education Personnel* (CAPES).