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New insights on weak winds in massive stars from hydrodynamical simulations

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We show an overview of the results from de Almeida et al. (2019) about the weak wind phenomenon in massive stars (O-type stars). We present our ongoing study on weak winds based on hydrodynamical simulations and our perspectives to draw a multi-wavelength picture about this phenomenon.

One of the main open questions in the literature about massive stars is the so-called weak wind phenomenon. Weak winds were originally found in late O dwarfs (O8-9V stars), which have luminosity values lower than $\log(L_\star/L_\odot) = 5.2$ (e.g., Marcolino et al. 2009). Quantitative modeling (using radiative transfer models) of the ultraviolet (UV) spectra of these stars indicate $\dot{M}$ of up to 2 orders of magnitude lower than theoretical predictions from Vink et al. (2000).

We present here an overview of the results from de Almeida et al. (2019). This study derived the fundamental stellar and wind parameters of nine late O giants (O8-9III) from modeling their UV and visible spectra using the non-LTE radiative transfer code CMFGEN (Hillier & Miller, 1998). de Almeida et al. (2019) showed for the first time that more evolved massive stars, late O giants, present the weak wind phenomenon, where the derived $\dot{M}$ are much lower (by up to 10^2) than the values predicted using the Vink mass-loss recipe (Vink et al., 2000). This work shows that the luminosity value of $\log(L_\star/L_\odot) = 5.2$ is indeed critical for the onset of weak winds in O-type stars.

We also present our ongoing study of weak winds from coupling radiative transfer models with hydrodynamical simulations using the code HYDWIND (Curé & Rial, 2007). Fig. 1 shows our very preliminary results based on Hα spectroscopy for the weak wind O9V star HD 46202, with synthetic profiles calculated using CMFGEN and FASTWIND (Puls et al., 2005). The Hα line is well reproduced using both codes with the solved hydrodynamics by HYDWIND. For this star, we derived $\dot{M} = 1.3 \times 10^{-9}\ M_\odot\ \mathrm{yr}^{-1}$, that is, in the weak wind regime ($\dot{M} < 10^{-9} - 10^{-8}\ M_\odot\ \mathrm{yr}^{-1}$).

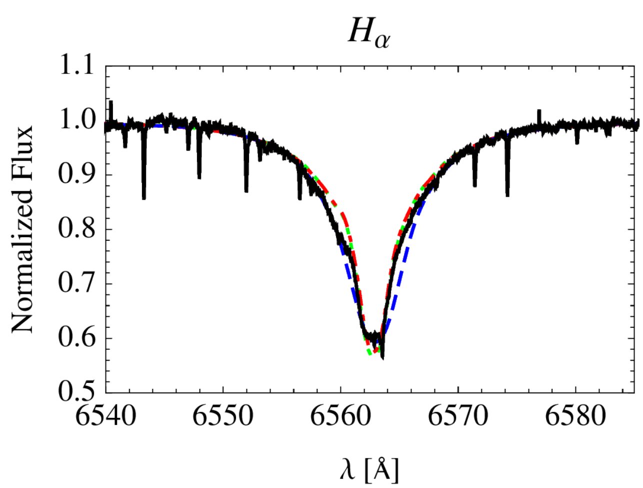

Figure 1. Observed Hα line profile of the weak wind O9V star HD 46202 (black line). Synthetic spectra are shown in red (FASTWIND using solved hydrodynamics from HYDWIND) and blue (CMFGEN using solved hydrodynamics from HYDWIND.

This means that weak winds could be explained in terms of first principles, deserving additional observational constraints. We aim to draw a multi-wavelength picture of weak wind stars by modeling their observed UV, visible and infrared spectra. For this purpose, we have already observed both late O dwarfs and giants in the L-band (enclosing Brα) with the Gemini/GNIRS instrument (λ Ori A, HD

24431, HD 216898; Gemini period 2023B) and with the ESO/CRIRES instrument (λ Ori A, μ Col, and HD 115455; ESO period P112). We also had allocated time to observe 10 Lac, 68 Cyg, ζ Oph, and HD 193443 with GNIRS (Gemini period 2024A), and ζ Oph, HD 135591, and HD 156292 with CRIRES (ESO period P113).

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