The Fundamental Parameters of Massive Stars

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Abstract. We analyzed far-UV (FUSE), UV (HST,IUE) and optical spectra of hot massive stars in the Milky Way with non-LTE, line-blanketed models with sphericity and expanding winds. We were able to reconcile previously discrepant diagnostics from Hα to highly ionized transitions (e.g. OVI and NV) with a revised treatement of soft X-rays from shocks and clumping in the stellar wind. These effects could be constrained uniquely by combining lines in the FUSE range and at longer wavelenghs. We derived T$_{eff}$ and luminosity values lower than canonical values, and refined measurements of mass-loss rate. The T$_{eff}$ recalibration of O-type stars has relevant implications for our understanding of massive star evolution and energy balance of HII regions. Mass loss is a major source of uncertainty in our current knowledge of massive stars evolution, and a consistent derivation of mass-loss rate from optical and far-UV lines is an important step forward.

Keywords: Mass loss and stellar winds - Main-sequence: early-type stars (O and B) - Stellar atmospheres - Ultraviolet (10-300 nm)
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SAMPLE AND DATA

The sample includes 17 Milky Way stars of early- to mid-O spectral type, for which high resolution spectra could be obtained with the FUSE satellite [9], in the far-UV range 905-1187Å (Bianchi's GI programs H023, E805, and archival data), and spectra at longer wavelengths (1150-3000Å) are available from IUE of HST spectrographs. For many targets we also have ground-based optical spectra providing H and He lines. The diagnostic transitions in the far-UV and UV ranges and their variation as a function of spectral type and luminosity class were discussed by [2, 5] for the initial samples. Figure 1 shows the lines in the FUSE range for the supergiants in our final sample, from spectral type O4 to O7, as an example.

ANALYSIS AND RESULTS

We modeled consistently the stellar lines from the far-UV to Hα, using synthetic stellar atmospheres computed with two non-LTE codes: WM-basic [10] which includes sphericity and hydrodynamics, and CMFGEN ([7, 6] and references therein) which includes sphericity and mass loss. A vast grid of WM-basic models was initially computed to analyze the far-UV and UV spectra [2, 5, 3, 1]. Soft X-rays from shocks in the wind contribute to the ionization and were taken into account, to reconcile higher and lower energy transitions observed in the UV. A further analysis with CMFGEN confirmed and refined the values of T$_{eff}$ derived from the WM-basic modeling, and moreover allowed us to reconcile the remaining discrepancies among some UV lines (SIV, PV, NV), and

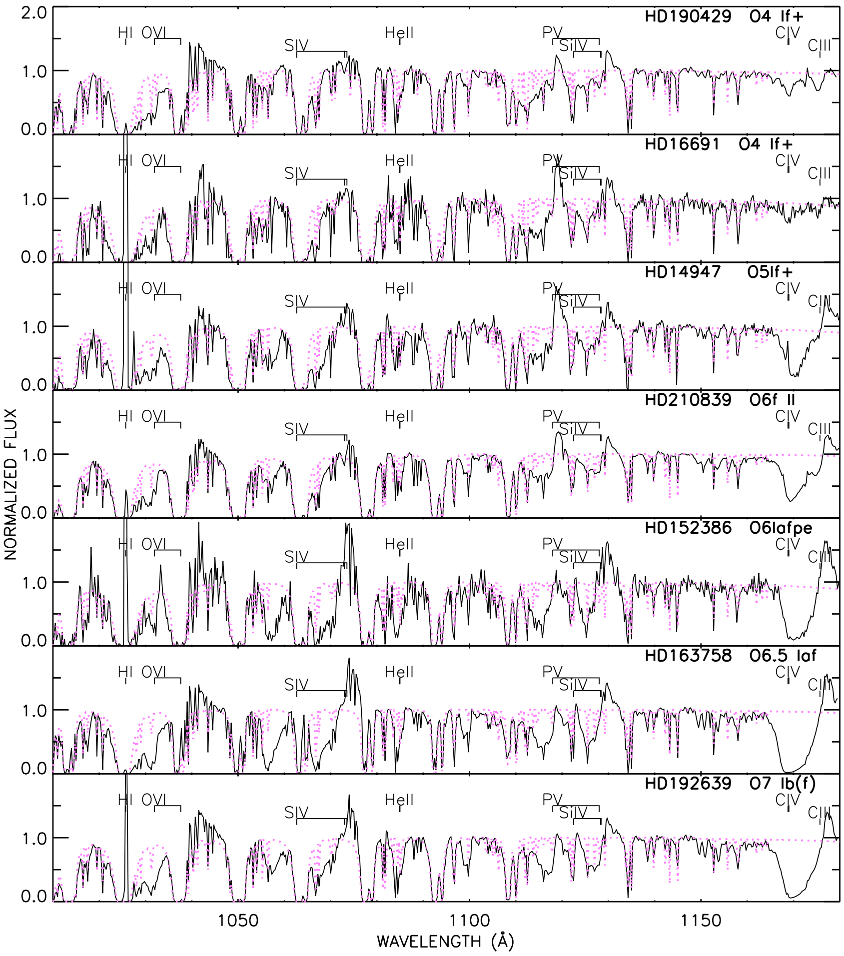

FIGURE 1. Stellar wind lines in the FUSE range for O-type supergiants. The observed spectra (black) are normalized to their continuum flux. Pink dotted lines are models of interstellar HI+H_2, shown to help discern stellar features from interstellar absorption.

to extend a consistent analysis to the optical range, by including effects of clumping and a revised distribution of the X-ray flux throughout the expanding wind. An example of model analysis is shown in Figure 2. We derived lower effective temperatures than those assigned to our sample's spectral types in older calibrations (Figure 3), and consequently lower luminosities.

ACKNOWLEDGMENTS

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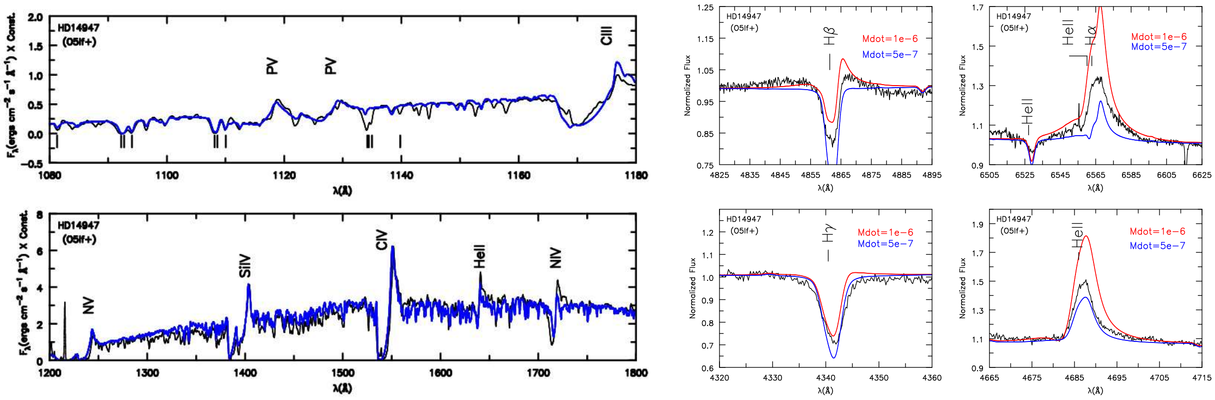

FIGURE 2. Modeling of an O5If star with CMFGEN. The best-fit model (blue, shown on the left) has T_{eff}=35,000 K. Interstellar extinction has been applied to the model spectrum. The right-side panels illustrate the sensitivity of the H Balmer lines (progressively increasing from Hγ to Hα) and HeIIλ4686 to mass-loss rate (CMFGEN models with clumping, spanning a factor of two around the best-fit solution).

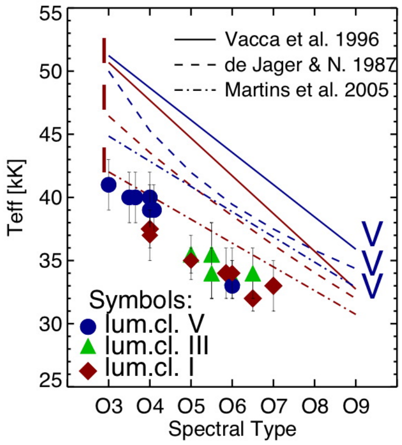

FIGURE 3. O-type stars' T_{eff} from our analysis (symbols) compared to calibrations by [4, 11, 8].

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