Active OB stars: structure, evolution, mass loss, and critical limits
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Spectroscopic Hα and Hγ survey of field Be stars: 2004–2009

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Abstract. Massive O- and B-type stars are "cosmic engines" in the Universe and can be the dominant source of luminosity in a galaxy. The class of Be stars are rapidly rotating B-type stars that lose mass in an equatorial, circumstellar disk (Porter & Rivinius 2003) and cause Balmer and other line emission. Currently, we are unsure as to why these stars rotate so quickly but three scenarios are possible: they may have been born as rapid rotators, spun up by binary mass transfer, or spun up during the main-sequence evolution of B stars. In order to investigate these scenarios for this population of massive stars, we have been spectroscopically observing a set of 115 field Be stars with the Kitt Peak Coudè Feed telescope in both the Hα and Hγ wavelength regimes since 2004. This time baseline allows for examination of variability properties of the circumstellar disks as well as determine candidates for closer examination for binarity. We find that 90% of the observed stars show some variability with 8% showing significant variability over the 5-year baseline. Such values may be compared with the significant variability seen in some clusters such as NGC 3766 (McSwain 2008). Also, while ∼20% of the sample consists of known binaries, we find that another 15-30% of the sample shows indications of binarity.

Keywords. stars: emission-line, Be, stars: winds, outflows, circumstellar matter, techniques: spectroscopic, surveys

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Since fall 2004, we have spectroscopically investigated 115 field Be stars taken from the Yudin (2001) catalog of bright Be stars - our sample covers magnitudes 2 to 8. We chose the Hα region to investigate disk properties (i.e., size, morphology) and also the Hγ region to investigate stellar properties (i.e., rotation speed, $\log g$) but in some cases we can also examine disk properties. Our spectral resolution $R = \lambda/\Delta\lambda$ for the Hα region was ∼5000 (2004, 2006) and ∼11,500 (2008). For the Hγ region, it was ∼11,000.

For each of the 115 Be stars we studied, we generated a "quadruple plot" such as the example shown in Fig. 1. Also, while examining the Hγ region spectra, we noticed that one can see changes in spectral features (for instance, presence of Fe II emission and absorption features) and the most notable case was Pleione (HD 23862) - a star that has long been known to change between B, Be, and Be-shell states, but many others exhibited this behavior as well (see Fig. 2). The term "shell" star describes a star that has many absorption or emission lines associated with Fe II transitions (which indicates one is looking through or at circumstellar material). We found that fully 50% of our sample shows non-temperature-related Fe II emission or absorption features with a number showing variable Fe II features.

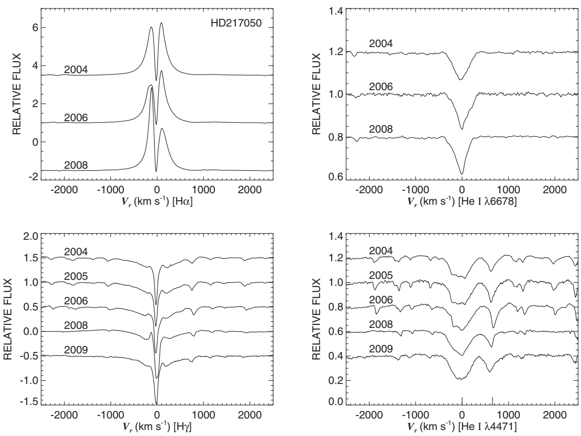

Figure 1. Example of a "quadruple plot" (this of HD 217050). In each quadrant are plots of the normalized fluxes of the seasonal averages of the spectra, offset for clarity, and in radial velocity space. Each is centered on the rest wavelength of a different spectral feature: *top left* - Hα, *top right* - He I λ6678, *bottom left* - Hγ, and *bottom right* - He I λ4471 (with a mark at $\sim$670 km s^{-1} delineating Mg II λ4481).

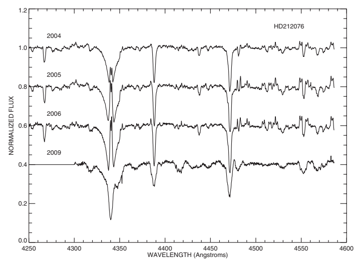

Figure 2. A plot of seasonal averages of the normalized flux versus wavelength for the blue spectrum of 31 Peg (HD 212076) - notice how all emission features diminish greatly in 2009. These spectra are offset for clarity.

Especially from the Hγ region spectra, one can also see radial velocity and line profile variations which can be indicative of binarity and/or nonradial pulsation. Through this survey, we have identified $\sim$40 new nonradial pulsation and/or binarity candidates.

Results from this survey and results concerning particular interesting stars are forthcoming and the reduced spectra will be made public in hopes the astronomical community will utilize them. We will continue to monitor these Be stars whenever possible as well as investigate nonradial pulsation and binary candidates more fully and at higher resolution. Another goal is to compare these field Be stars to Be stars in clusters.

Acknowledgements

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