Physical Properties of the Be Star Disks in *h* and *χ* Persei

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Abstract

Classical Be stars are best known for their circumstellar disks, which are composed of material ejected off of the stellar surface during outburst events. The double open clusters *h* and *χ* Persei present an optimal location for studying the physical properties and variability of these disk structures, as they are rich in massive B-type and Be stars. Here we continue our study of the cluster Be stars by examining the disk spectral energy distributions (SEDs) via observations from WEBDA, 2MASS, *Spitzer*, *AKARI*, and *WISE*. We also present multiple observations of Hα taken between 2009-2012 with the KPNO Coudé Feed, KPNO 2.1m, and WIRO. We will use the Hα equivalent width model of Grundstrom & Gies and the infrared flux model of Touhami et al. to constrain the disk masses, radii, and densities for our Be star sample.

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Be Star Variability

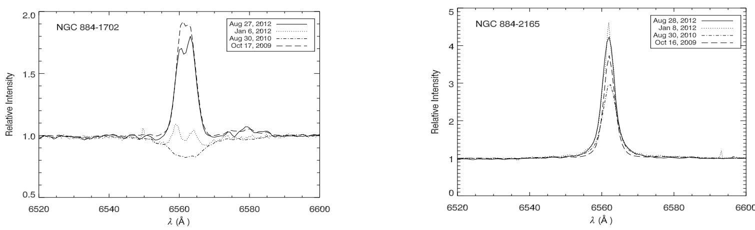

Figure 1: Hα spectra of NGC 884-1702 (left) and NGC 884-1926 (right). Both Be stars exhibit highly variable disks.

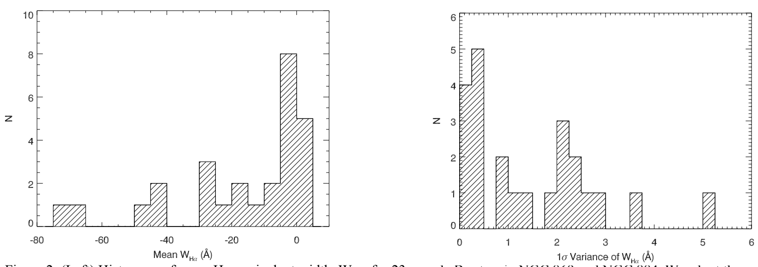

Figure 2: (Left) Histogram of mean Hα equivalent width, $W_{H\alpha}$, for 23 sample Be stars in NGC 869 and NGC 884. We adopt the convention that the $W_{H\alpha}$ of emission lines are negative. (Right) Histogram of 1σ variance of $W_{H\alpha}$ for 23 sample Be stars in NGC 869 and NGC 884. Most of our sample Be stars show little variance in their disks; however a few are highly variable.

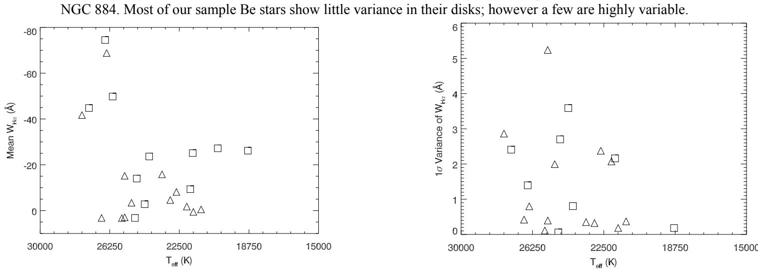

Figure 3: (Left) Plot of mean $W_{H\alpha}$ vs. T_{eff}. (Right) Plot of 1σ variance of $W_{H\alpha}$ vs. T_{eff}. Hotter Be stars tend to have larger disks, but are not necessarily more variable than cooler Be stars.

Be Disk Parameters

We use the models of Grundstrom & Gies (2006) with our measurements of $W_{H\alpha}$ to determine the radius of half light, R_{disk}, and disk base density, ρ_0, for our sample Be stars. The following plots show results obtained for an average inclination angle of $i = 60°$ and include 20 of our sample stars for which we have multiple Ha observations.

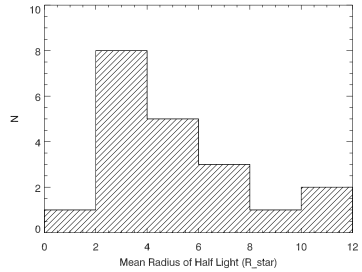

Figure 4 : Histogram of mean radius of half light, R_{disk}. Most stars in our sample have small to moderate sized disks, while those of a few are very extensive.

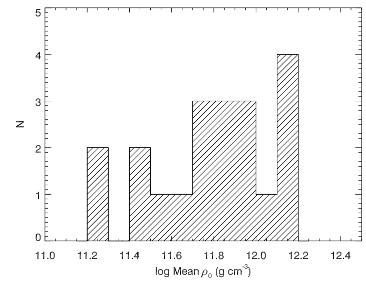

Figure 5: Histogram of the log of mean ρ_0. We do not find a large spread in disk density among our sample of Be stars.

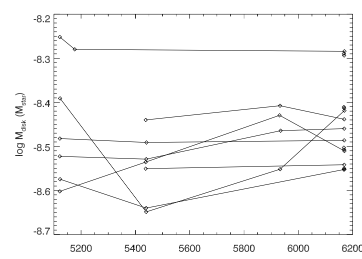

Figure 6: Plot of log disk mass over time. The plot shown is zoomed into a limited region to highlight the changing masses of a few systems.

Infrared Flux Excess

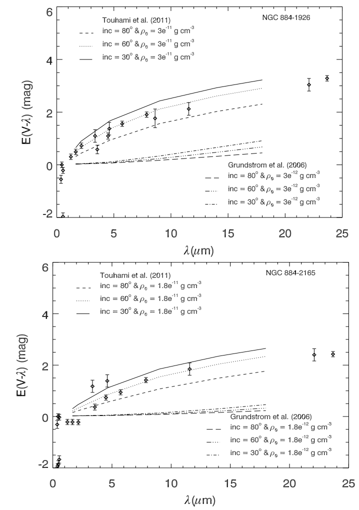

Figure 7: Plots of the observed infrared excesses compared to flux excesses predicted by the radiative transfer models of Touhami et al. (2011). When we apply the predicted disk densities of Grundstrom & Gies (2006), the resulting excesses are too low. The observed flux excesses suggest an order of magnitude higher disk density. The data points from WEBDA, 2MASS, *Spitzer*, *WISE*, and *AKARI* have all been obtained at different epochs and reflect the substantial variability of Be disk sizes.

Continuing and Future Work

Estimating Be Star Disk Temperature and Mass

- Implement the ATLAS9 SED models from Castelli & Kurucz (2002) to produce SED models and determine flux excesses for sample stars with $T_{eff} < 15000$ K.
- Further investigate the discrepancy of disk base density between that predicted by Grundstrom & Gies (2006) and the models of Touhami et al. (2011).
- Investigate means for constraining *i* in order to break the current degeneracy of *i* and ρ_0 in our use of the Touhami et al. models.
- Compute simple blackbody models for the equatorial disks to preliminarily investigate disk structures and temperature profiles.

Balmer Decrement

- Examine the decrement of Balmer line emission and its relationships to disk physical parameters and temperature profiles of our sample Be stars.

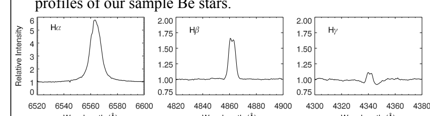

Figure 8: Higher order Balmer lines probe different temperature and density regions of the Be star disk.