Physical Properties of the Be Star Disks in \( h \) and \( \chi \) 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 \( \chi \) 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 Be taken between 2009-2012 with the KPNO Coudé Feed, KPNO 2.1m, and WIRO. We will use the H\( \alpha \) equivalent width model of Grundstrom \& Gies (2006) 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: H\( \alpha \) spectra of NGC 884-1702 (left) and NGC 884-1926 (right). Both Be stars exhibit highly variable disks.
- Figure 2: (Left) Histogram of mean H\( \alpha \) equivalent width, \( W_{\text{H}\alpha} \), 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 \( W_{\text{H}\alpha} \) vs. \( T_{\text{eff}} \). (Right) Plot of \( T_{\text{eff}} \) vs. \( R_{\text{half, light}} \).  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 \( W_{\text{H}\alpha} \) to determine the radius of half light, \( R_{\text{half, light}} \), and disk base density, \( \rho_0 \), for our sample Be stars. The following plots show results obtained for an average inclination angle of \( i = 60^\circ \) and include 20 of our sample stars for which we have multiple H\( \alpha \) observations.

- Figure 4: Histogram of mean radius of half light, \( R_{\text{half, light}} \). 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 \( \rho_0 \). 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, AKARI, and WIRO have all been obtained at different epochs and reflect the substantial variability of the 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 \( T_{\text{eff}} < 15000 \) 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 \( \rho_0 \) 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.

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