Spatially resolved optical spectroscopy of close companions to Herbig Ae/Be and T Tauri stars

Andrés Carmona\textsuperscript{1,2}, M.E van den Acker\textsuperscript{1}, and Th. Henning\textsuperscript{2}

\textsuperscript{(1)} European Southern Observatory, Karl Schwarzschild Strasse 2, 75578 Garching bei München, Germany
\textsuperscript{(2)} Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

Abstract

We present spatially resolved VLT-FORS2 optical (5700 – 9400 Å) spectroscopy of close companions (d < 5\textquoteleft) to four nearby (d < 200 pc) Herbig Ae/Be stars (HD 100546, HD 144432, HD150193, KK Oph, HD 163296) and one T Tauri star (S CrA). We report the detection of Li I (6707 Å) in absorption and emission lines (H\textalpha, Ca II) in several companions. The observations suggest that the companions are physically associated PMS stars. They are most likely surrounded by disks. Localizing primaries and companions in the HR diagram and assuming a contemporaneous formation history, we determined empirical isochrones ranging from 0.2 to about 2.5 M\textsubscript{\odot}.

1. Herbig Ae/Be stars and planet formation

Herbig Ae/Be stars (HaeBes) are intermediate mass pre-main-sequence stars of spectral type B, G, or F. Their spectral energy distributions show near- and mid-infrared excess. Their optical spectra present H\textalpha, H\textbeta, and Ca II in emission. These observational characteristics suggest that HaeBes are young stellar objects surrounded by an accreting circumstellar disk of gas and dust. HaeBes and their low mass counterparts, the T Tauri stars, are important because they are natural laboratories for studying the process of planet formation.

2. Imaging revealed close companions to HAEBe and TTauri stars, the nature of these companions is unknown.

Near and mid-infrared imaging (Pérez et al. 2004, Pirzkal et al. 1997), HST optical coronography (Grady et al. 2000, Augereau et al. 2001) and speckle interferometry (Baier et al. 1985) revealed the presence of nearby companions in the 5\textquoteleft vicinity of nearby HAEBe and TTauri stars. The nature of these companions is poorly constrained.

3. Observations.

In order to determine the nature of the companions optical spectroscopy is needed. Given their close separation to the parent star (r < 5\textquoteleft) and their magnitude (V ~ 16), for obtain good quality spectra a large aperture telescope is required.

In the night of 17\textsuperscript{th} May 2005 we obtained medium resolution (R~3200) VLT-FORS2 optical spectroscopy (5700 – 9400 Å) of the companions to the Herbig Ae/Be stars: KK Oph, HD 100546, HD 150193 and HD 163296, and to the classical T Tauri star S CrA.

To minimize the contamination in companion's spectra, the slit was oriented perpendicular to the line connecting the companion to the central star.

4. Results: The companions are emission line stars

H\textalpha emission was detected in almost all the companions. Li I (6707 Å) in absorption was detected in HD 144432B, HD 150193B and KK Oph B. The sources were classified spectroscopically using the method outlined by Hernandez et al. 2004. The deduced spectral type combined with photometric measurements from the literature allowed us to localize the primaries and the companions in the HR diagram. We assumed that the companion is at the same distance as the primary and has the same extinction.

5. Discussion

- Given that (i) the companions present emission lines (H\textalpha, Ca II) characteristic of classical T Tauri stars, (ii) a number of systems present Li I in absorption, and (iii) several sources have early spectral types (unlikely for field background sources), we conclude that the companions are PMS stars physically associated to the primary.
- Within the errors, according to the theoretical evolutionary tracks (Palla & Stahler 1993), only HD 150193, KK Oph and S CrA A are coeval objects. In the case of HD 144432 there is no isochrone that connects primary and secondary. Theoretical tracks of intermediate-mass and low-mass stars, do not predict the same age for this system.
- The companions of HD 100546 and HD 163296 lie in unphysical positions in the HR diagram. Since photometry and spectral type are robust diagnostics measured observationally, the uncertain factor is the distance and/or the extinction. The primary is nearby, therefore, it is likely that the secondary is in the background. But, since the secondary is a early type emission line star, it is not a field star. If the companion is in the background, it suffers of a high extinction. That could be due to the dense circumstellar material of the primary.

6. References