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Spectroscopic observations of BD +31°643, BH Cep, LkHα 234 and LkHα 262

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Abstract. We present spectroscopy of BD +31°643, BH Cep, LkHα 234 and LkHα 262 obtained as a part of the 1998 La Palma international time program on extrasolar planetary systems. We analyse line profiles (mainly Hα, NaI and HeI), equivalent widths, presence of different velocity components and the spectroscopic variability.

1. Introduction

La Palma International Time Proposal 1998 has been devoted to the study of planetary systems through the project *Planetary Systems: their formation and properties*. EXPORT (EXo-Planetary Observational Research Team) has observed a large number of objects including T Tauri stars, HAeBe, Vega–like stars and stars in which planets have been identified. In the case of pre-main sequence stars (PMS) and some main sequence stars (MS) many observations have demonstrated the existence of circumstellar gas and dust disks (e.g. Beckwith & Sargent 1996; Aumann et al. 1984). In some cases, the presence of solid bodies/planetesimals in both PMS and MS stars has been inferred through transient blueshifted and redshifted absorption components (BACs and RACS) in some metallic lines (Grinin et al. 1994; Crawford et al. 1998; Beust et al. 1998). It is thought that planetary systems originate from these disks. Therefore, PMS and MS stars may reveal key information about the properties, formation and evolution of protoplanetary disks.

Four stars observed by EXPORT have been selected to be analyzed in this contribution: BD +31°643, BH Cep, LkHα 234 and LkHα 262. BD +31°643 is a B5 Vega–type star, which is surrounded by a dust disk similar to that of β Pic

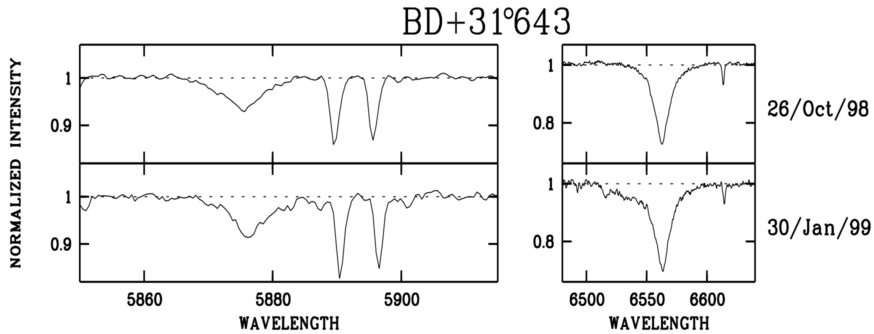

Figure 1. INT spectra of BD +31°643 around the HeI, NaI and Hα lines as observed on 26/Oct/98 and 30/Jan/99.

(Kalas & Jewitt 1997). BH Cep is an F5IV T Tauri star known by its rapid variations. LkHα 234 is a Herbig Ae/Be star classified as B5–B7 and associated with the NGC 7129 reflection nebula. LkHα 262 is a classical T Tauri star of spectral type around K. These four stars cover a range of spectral types, masses and different evolutionary status. Thus, it is interesting to analyze them in order to compare the observed phenomenology.

2. Observations

For BD +31°643 the following data have been obtained: INT spectra (24–28 October 1998, 29–31 January 1999), a WHT–UES spectrum (26 October 1998). For BH Cep we obtained: INT spectra (15–17 May, 28–31 July, 24–28 October 1998, 30 January 1999), WHT–UES spectra (17 May, 31 July, 25–26 October 1998). In the case of LkHα 234 the data are: INT spectra (28–31 July, 24–28 October 1998). For LkHα 262 we have INT spectra (24,25,28 October, 31 July 1998). A description of the instrumental setup and relevant information on the data can be found in the EXPORT contribution by Mora et al.in this volume.

3. BD +31°643

Figure 1 shows the INT spectra around the HeI, NaI and Hα lines obtained in 26/Oct/98 and 30/Jan/99. Some variability of the He I profile and equivalent width are observed during October and January. The Hα does not present variations except on 30/Jan/99 where an extended blue wing is observed. In NaI, the October WHT spectrum indicates that the strong NaI absorptions are interestellar. Nevertheless, weak absorption features could be present around the NaI lines but only on 30/Jan/99, coinciding with the presence of the blue Hα wing. New observations are necessary to investigate in more detail these weak features. Strong diffuse interstellar bands are observed at 5780, 5797, 5850,6196, 6270, 6284, 6369 and 6614 Å.

4. BH Cep

Figure 2 shows the HeI, NaI and Hα profiles as observed in the INT spectra. Dramatic changes in time scales of hours, days and months are observed. However, the changes follow a well defined sequence during each month. In May and July, the profile is double-peaked, with the blue peak stronger than the red one. The intensity of the peaks changes, being more noticeable the changes in the red peak. The heliocentric radial velocity of the blue peak decreases systematically from 15/May/98 to 29/Jul/98 with daily values of -220, -198, -160, -150 and -130 km s^{-1}. In October, the Hα profile is completely different from that observed in the previous months. Even though strong changes in intensity are observed, the same absorption and emission components are present during this month. In Jan/99, the profile is similar to that observed on 15/May/98. The relative intensity of the blue and red emission peaks changes through the four months. In May, July and January, the blue peak is stronger than the red one while in October, the red peak is the strongest one.

The NaI lines present both blue and red absorption components (BACs and RACs) as well as central emissions, which can be better recognized in the high-resolution WHT spectra (not shown here). The velocities are relatively low with values between $+25$ and $+50$ km s^{-1} for the RACs and -20 and -75 for the BACs. Between 15/May/98 and 28/Jul/98 the INT spectra also show a faint blue emission component. Its radial velocity coincides each day with that of the blue peak of the Hα emission (see above), suggesting a relationship between both emissions. A faint blueshifted NaI emission component is also observed during October. The HeI line also presents blue emission components and RACs which appears related to the presence of the same components in the NaI line.

5. LkHα 234

The spectra around the HeI, NaI and Hα lines are shown in Figure 3. We note that HeI lines are not always observed towards this star (de Winter et al. 2000, in preparation). From previous and present data, a spectral type B8–A3 is deduced for LkHα 234 with preference for the later given the absence of HeI lines in some spectra. In our spectra the [OI]6300,6363 and [SII]6716,6731 are also exceptionally observed. The Hα profile show two emission peaks, the red one stronger than the blue one, separated by an absorption reversal. This is the kind of profile always observed in this star. The relative intensity of the peaks changes in time scales of days. However, the radial velocities are rather constant. The red emission peak is observed at a heliocentric radial velocity of $\simeq +50$ km s^{-1} whereas the absorption reversal appears at $\simeq -45$ km s^{-1}. The only velocity variations are observed in the blue emission peak which is observed at -145 km s^{-1} in July and -125-100 km s^{-1} in October.

The NaI lines exhibit complex and highly variable profiles with absorption and emission components. RACs are clearly seen on 28/Jul/98 and, probably, on 31/Jul/98 at a heliocentric velocity of $\simeq +160$ km s^{-1}. NaI emission components are observed in almost all spectra, except in that on 30/Jul/98. The NaI absorptions are probably interstellar and their variablity may be related to variability of the emission components. Although the intensity of these emis-

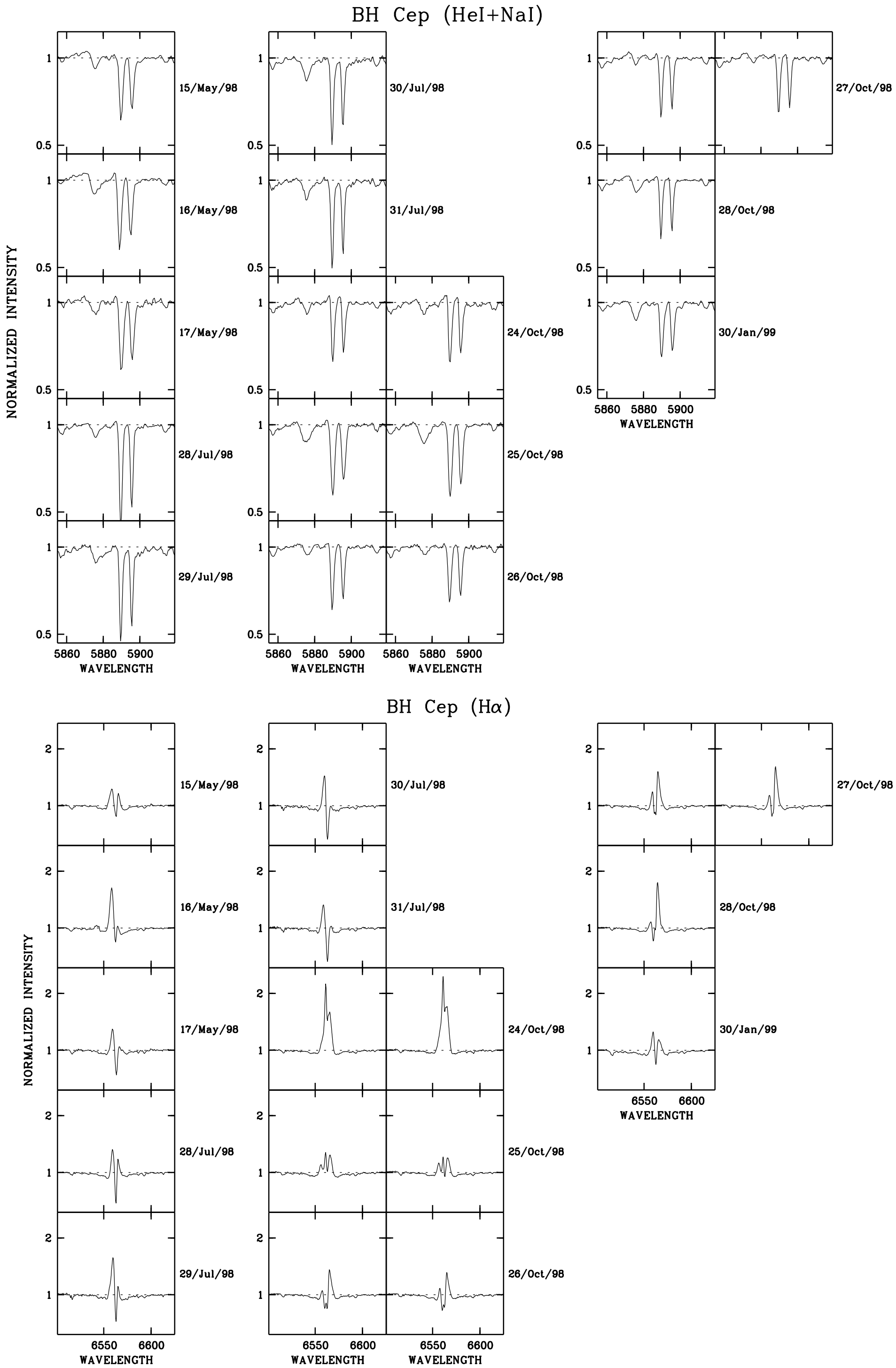

Figure 2. INT spectra of BH Cep around the HeI and NaI (top) and Hα lines (bottom).

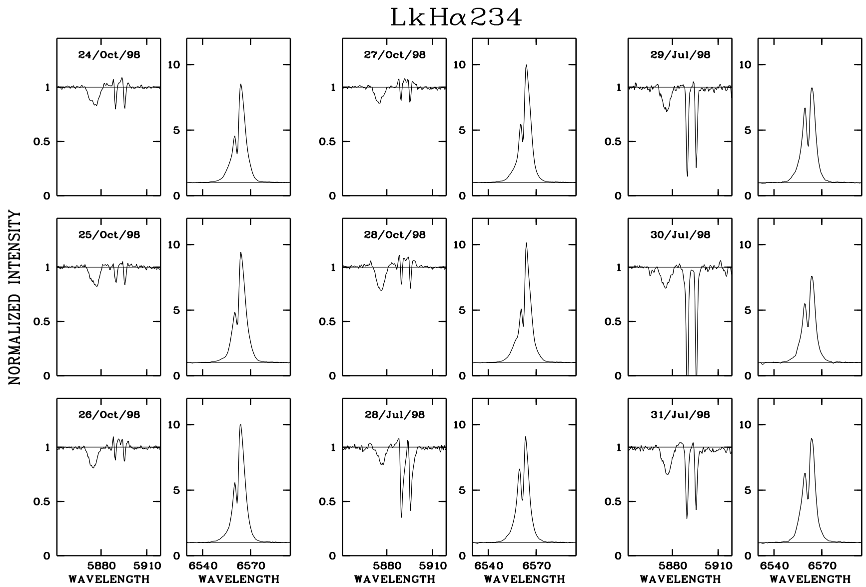

Figure 3. INT spectra of LkHα 234 around the HeI, NaII and Hα lines.

sions varies, their velocity appears approximately constant with velocities of $\simeq -70$ and $+95$ km s^{-1}. A correlation between the variations in NaI and Hα is not observed. Variability of the HeI line profile and equivalent width is also observed as well as the possible presence of BACs and RACs. However, the variations do not appear to be correlated with those observed in the NaI and Hα lines.

6. LkHα 262

Figure 4 shows the spectra of LkHα 262. The spectral type changes from about K5 on 24/Oct/98 to early M on 25 and 28/Oct/98. Hα, HeI 5785 and [OI] 6300,6363 are in emission as well as the HeI 6678 line observed on 24/Oct/98. The Hα emission is double–peaked and the equivalent width and radial velocity of the emission peaks and absorption reversal vary. The blue peak is stronger than the red one on 24 and 28/Oct/98 whereas the contrary is observed on 25/Oct/98. In the NaI lines, RACs could be present on 24–25/Oct/98, although the absorption bands prevent definitive conclusions to be drawn.

7. Conclusions

The phenomenology observed in these four stars is varied. Evidence for blue- and/or red-shifted transient absorption components is found in BH Cep, LkHα 234 and, perhaps, in LkHα 262. Similar events in UX Ori and β Pic have been interpreted in terms of solid bodies, although they could also reflect disk inhomogeneities. In our spectra, BD $+31°643$ does not show clear evidence for blue and red absorption components as those observed in β Pic, which could indicate the presence of solid bodies in its disk. In BH Cep, the relationships between some emission components in NaI and Hα suggest that the Hα line may be composed

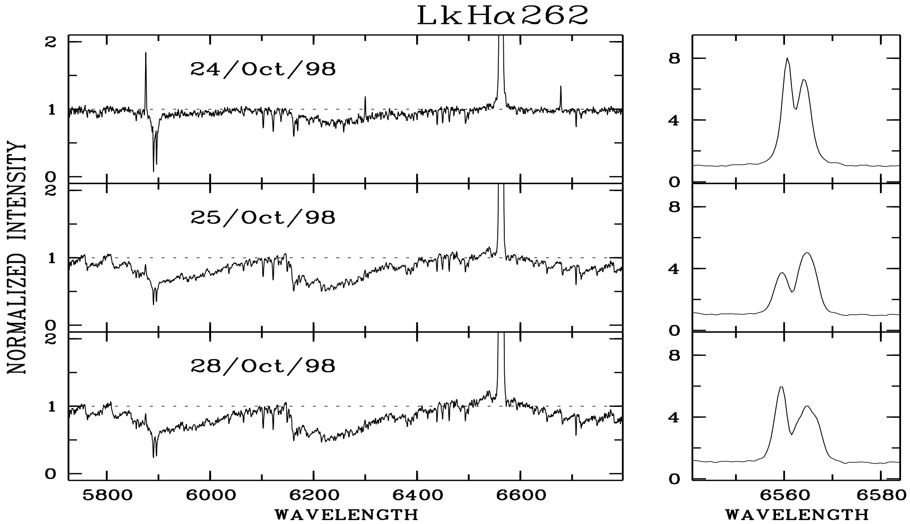

Figure 4. INT spectra of LkHα 262 and detail around the Hα line.

of "circumstellar" and "stellar" contributions. At the contrary, in the Herbig Ae/Be star LkHα 234, Hα and NaI apparently trace different regions with Hα probably related to a stellar wind and NaI to the circumstellar environment.

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