Searching for close companions in young stellar systems

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VLT/CRIRES RV survey of resolved tight (≤ 1") binaries and triple systems in Cha I

- Follow-up of the VLT/NACO imaging survey (Lafreniere et al. 2008) that lead to the discovery of 30 binaries and 6 triples.
- Focused on the tightest binaries, where the gravitational interaction from a new found companion might be of importance

Stellar Sample

17 tight binary systems (sub-arcsecond, with projected separation < 150 AU)
3 triple systems

Observing Strategy

✗ **Long slit mode**, with the slit placed over both the components of each binary: provides simultaneous RV (control systematic effects e.g. variable line spread function)

✗ **Telluric lines** used as simultaneous **wavelength reference**: allows a precision of about 300-100 m/s (Blake et al. 2007)

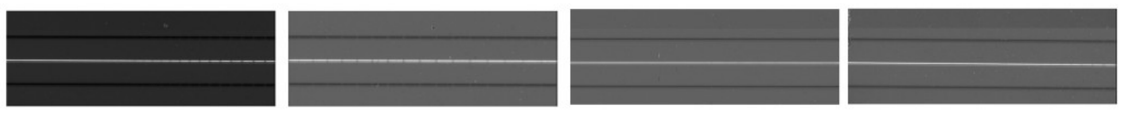
GOALS:

✔ Search for tight binaries to refine the estimate of the multiplicity fraction
✔ Investigate the long-term stability of multiples at a young age

CRIRES (Criogenic InfraRed Echelle Spectrograph)

- Mounted on the Unit Telescope 1 (UT1, Antu) of the ESO VLT (Kaeufl et al. 2004).
- The main optical elements consist of a prism acting as a pre-disperser and a 31.6 lines/ mm echelle grating.
- Resolution of up to 100 000 when used with a 0.2" slit.
- It operates in the range 960-5200 nm with an instantaneous wavelength coverage of = 50.

The spectra is imaged on a detector mosaic, composed of four Aladdin III detectors (4096x512 pixel) with a gap of 250 pixels between the chips.



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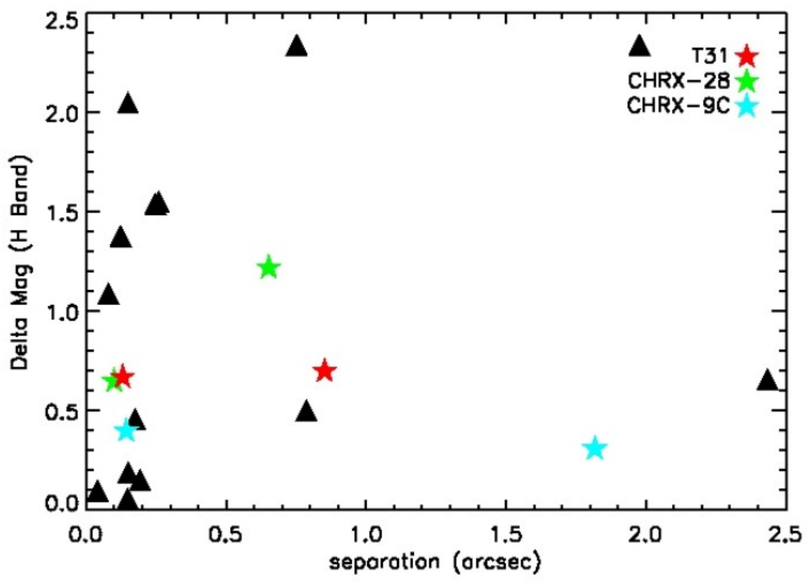


Fig. 1 Magnitude difference (H Band) vs separation (arcsecs) of the binaries in the observed sample (from Lafreniere et al. 2008). The three triple systems (star symbols) are showed twice to take into account both the value of the tight and wide pair.

Spectral Extraction

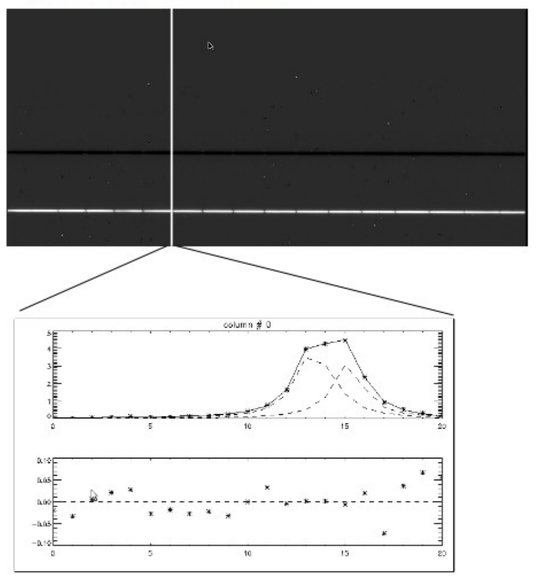


Fig. 2
Example of spectral extraction, in the case of a single line binary. The upper panel shows the best fit (solid line) resulting from the sum of the two Moffat functions (dashed lines). The residuals from the fit are showed in the lower panel.

At every wavelength, the peak(s) are fitted with a sum of two Moffat functions, using the values of the separation and flux ratio from the NACO data as first guesses.

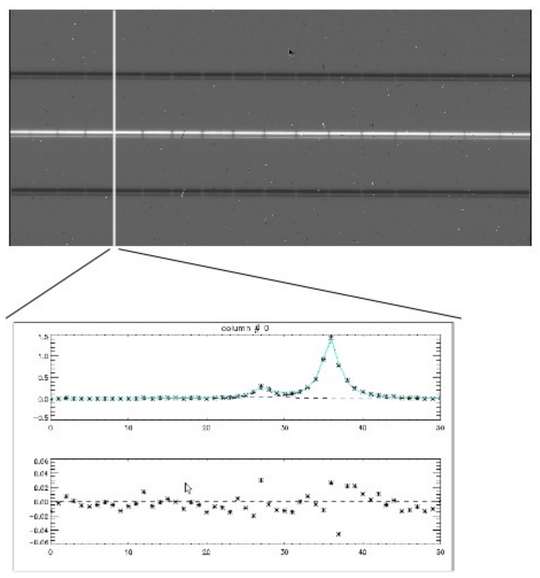
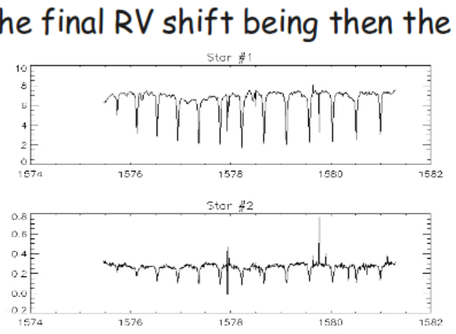


Fig. 3
Example of spectral extraction, in the case of a single line binary. The upper panel shows the best fit (solid line) and the two Moffat functions used for it. The residuals from the fit are showed in the lower panel.

Results

At every epoch each system is observed at four nodding position.
For each one of them, and for each chip, the spectra of the two components are extracted and the RV shift is evaluated, using the first epoch as reference.
The final RV shift being then the average over the nodding positions and the chips.



Relative (EP02/03 to EP01) RV shift estimate with an error of about 100-300 m/s

Fig. 4 Example of extracted spectra for the two components of one of the stars in the sample.

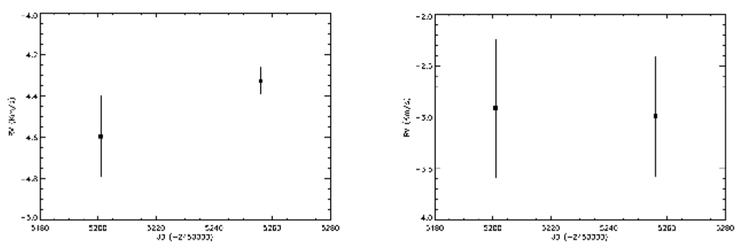


Fig. 5 Relative RV shift for the same star showed in Fig. 4

Conclusions:

We carried out a RV survey for additional close companions in binary systems in the Cha I region, using VLT/CRIRES.
No additional companions have been found.
Given their precision our observations are suited to detect companions down to the brown dwarf limit and in some cases planetary size.
Further analysis is ongoing.

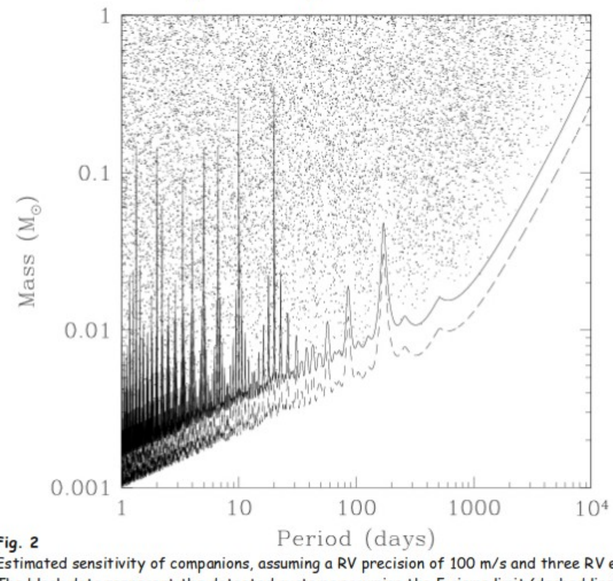


Fig. 2
Estimated sensitivity of companions, assuming a RV precision of 100 m/s and three RV epochs. The black dots represent the detected systems assuming the 5 sigma limit (dashed line). The solid line is the 3 sigma limit.

References:
Lafreniere D., Jayawardhana R., Brandeker A. et al., 2008, ApJ, 683, 844: "A Multiplicity Census of Young Stars in Chamaeleon I"
Nguyen D. C., Jayawardhana R. et al., 2009, ApJ, 695, 1648: Disk Braking in young Stars: Probing Rotation in Chamaeleon i and Taurus-Auriga"