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Spectro astrometry of the Hα emission of T Cha

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Abstract. For this project we present a spectro-astrometric study of the Hα emission from T Cha, a young stellar object with a transitional disk. The aim is to explore the possibility of detecting a substellar companion using spectro-astrometry. While no spectro-astrometric signal was found in the Hα line it is planned that the next step will be to combine the spectro-astrometric results with estimates of the mass accretion rate for T Cha to put an upper limit on the mass accretion rate onto any companion.

1. Motivation

The mechanics and timescale of the formation of planetary bodies around Young Stellar Objects (YSO's) remains obscure. When the dust and gas around the YSO settles into the midplane, it forms a circumstellar disk (Espaillat et al. 2014). Transitional disk objects have evolved to a point where gaps have formed in the disk. There are several different theories on the formation of these gaps, such as clearance via planetary body or substellar companion (Artymowicz & Lubow 1994), photoevaporation (Alexander R. D. et al. 2006b) and grain growth (Dullemond and Dominik 2005). Transitional Disks represent one of the earliest evolutionary stages of planetary formation, and topics such as grain growth and the clearance of gaps in the disk are vital to the understanding of planetary formation. Here we report on VLT-UVES observations of T Cha. The goal of this project was to investigate the possibility of detecting a planetary companion using spectro-astrometry (SA) and thus to test if SA can be generally used to detect recently formed planets. The motivation to use this technique is that planets are formed very close to the central star and it is difficult to detect and spatially resolve them at optical wavelengths. This is a follow-on study from the X-Shooter study of LkCa 15 (Whelan et al. 2015).

2. Observations, data reduction and analysis

Spectra were obtained with UVES in February and March of 2014. UVES provides a wavelength range of approximately 500 – 700 nm and a spectral resolution R $\approx$ 40000. Three epochs of data were obtained and in each epoch spectra were taken at orthogonal slit position angles (PAs). For each PA observations consisted of 6 spectra of exposure time 600s. Therefore, in total we had 36 spectra. The first reason for this observational set up was to factor in the strong variability of the source in the Hα line. Obtaining several epochs of data increased our chances of detecting a signal from T Cha b. Secondly, the orthogonal slit PAs would allow us to recover the

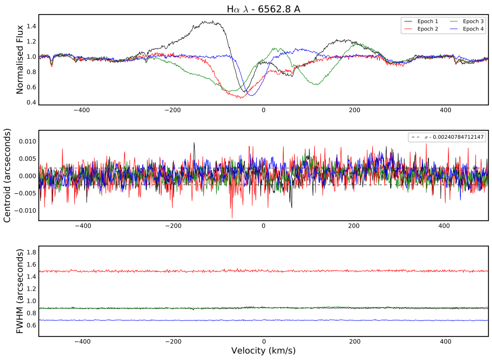

Fig. 1. Spectro-astrometric analysis of the Hα emission from T Cha. It can be seen that the Hα line region is very variable with emission and absorption components. There was no signal found in the data. What is shown here is the median of the 12 spectra for each of our three epochs. The spectra were checked individually and no signal was found. Epoch 4 is made up of the UVES spectra downloaded from the archive. The accuracy we achieved in our measurements was ?? = 2.5 mas or 0.3 au at a distance of 108 pc to T Cha.

direction on the sky of any detected signal. Archived UVES observations of T Cha [089.C-0299 (A)] allowed us to include a fourth epoch in our study. These spectra were taken with anti-parallel slits PAs which gives a direct way of checking for spectro-astrometric artefacts (Brannigan et al. 2006). The datasets were reduced using the ESO pipeline for UVES. The spectro-astrometric analysis was carried out in the usual way but in this case using specially designed python routines (Whelan & Garcia 2008). For this dataset, an artefact was discovered in one of the observations when the telescope lost tracking of the object. This introduced a false signal which had to be removed, as was found in Whelan et al. (2015).

3. Results and future work

The spectrum of T Cha is lacking in emission lines compared to other TD objects (Whelan et al. 2015). By comparing all spectra the Hα and Na D lines were found to be highly variable but the [O I] lines were not. Each of the 48 spectra from our programme and the archived data were analysed using spectro-astrometry and no signal was found for any spectrum (Figure 2). The overall accuracy achieved in our analysis was σ = 2.5 mas or 0.3 au at a distance of 108 pc to T Cha. The next step in this work is to use the mass accretion rate estimates for this object in combination with the uncertainty in our anaylsis of the Hα line to put an upper limit on the mass accretion rate onto any possible planet as was done in Whelan et al. (2015). This will then be compared to predictions of planet formation models. We will also further investigate the emission line variability of the source.

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