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HeI λ10830 line: a probe of the accretion/ejection activity in RU Lupi

L. Podio[1], P.J.V. Garcia[2], and F. Bacciotti[1]

[1] INAF – Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[2] Centro de Astrofísica da Universidade do Porto, Rua das Estrelas s/n, P-4150-762 Porto, Portugal

Abstract. Most of the observed lines and continuum emission excesses from Classical T Tauri Stars (CTTSs) take place at the star-disk interface or in the inner disk region. These regions have a complex emission topology still largely unknown. The HeI λ10830 line showed to be a powerful instrument to trace both accreting matter, in emission, and outflowing gas via the frequently detected absorption features. To fully exploit the diagnostic potential of this line we performed a spectro-astrometric analysis of the spectra of the TTS RU Lupi, taken with ISAAC at the VLT. The analysis highlighted a displacement with respect to the source of the region where the absorption feature is generated. This indicates the presence of both an inner stellar wind and a collimated micro-jet in the circumstellar region of RU Lupi.

Key words. Stars: individual: RU Lupi – ISM: jets and outflows – spectro-astrometry

1. Introduction

The study of the circumstellar region of CTTS is fundamental to fully understand the accretion/ejection relationship in young forming stars and to constrain the wind launching region. This region extends at most a few AUs, and thus is not directly reachable with non-interferometric instruments working at subarcseconds resolution ($\sim0\farcs1$, i.e. 14 AU for RU Lupi located at 140 pc). Alternatively to the direct observation, the star-disk inner region can be analysed through the profiles of emission lines and through the use of specialised techniques of data analysis, such as spectro-astrometry, that allows one to obtain positional information down to sub-AU scales (Bailey 1998). In particular, a powerful tracer of both the accreting matter and the wind is the HeI λ10830 line (Edwards et al. 2006). Here we show the results obtained from the spectro-astrometric analysis of the HeI λ10830 line applied to ISAAC spectra of the active TTS RU Lupi.

Send offprint requests to: L. Podio

2. The HeI P-Cygni profile

The HeI line included in our medium resolution ISAAC spectra (panel A of Fig. 1) shows a typical P-Cygni profile with a broad blueshifted absorption penetrating 80% of the continuum emission from RU Lupi, and ranging from -90 km/s to -360 km/s. It is commonly believed that the emission corresponds to accreting gas columns, while the absorption fea-

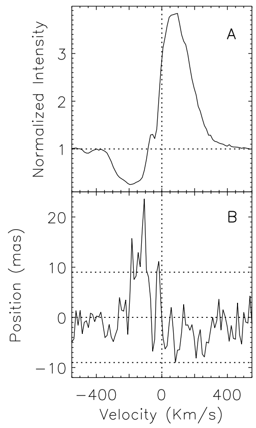

Fig. 1. Spectro-astrometric analysis of the RU Lupi HeI line. The line profile (A) and the position spectrum (B) are shown. The horizontal lines in panel B indicate the position of the star continuum $\pm 3\sigma$. The plot shows the presence of an extended emission in the HeI line.

ture indicates the presence of an inner wind (Edwards et al. 2003). Moreover Edwards et al. (2006) showed that the shape and width of the HeI λ10830 line can constrain the wind launch region. In our case, the broad range of velocities covered by the absorption feature can be explained by a radially emerging wind that absorbs the 1 μm continuum from the stellar surface, thus tracing the full acceleration region of the inner wind. On the contrary, a disk- or x- wind is confined to nearly parallel streamlines emerging at an angle to the disk surface and thus the continuum photons from the star would intercept a narrower range of velocities giving rise to narrower absorption features (Edwards et al. 2006). Further insights on the presence and the geometry of different wind contributions to the HeI λ10830 line can be retrieved from a spectro-astrometric analysis.

3. Insights from spectro-astrometry

Many recent works showed that spectro-astrometry is a powerful technique to investigate the origin of permitted lines, separating the accretion and the wind contributions to the emission (see, e.g., Takami et al. 2001, 2002; Whelan et al. 2004). The technique consists in measuring the spatial position of the centroid of the line and of the source continuum at each λ with accurate Gaussian fits (Bailey 1998). In the obtained so-called 'position spectrum' the outflowing gas reveals to come from an extended region, testified by a detectable positional shift with respect to the star, while accreting gas remains concentrated on the source location.

We applied this analysis to our ISAAC spectra of the HeI line, obtaining the position spectrum showed in panel B of Fig. 1. The biases induced by an elongated PSF in the slit were simulated and carefully subtracted following the procedure explained in Brannigan et al. (2006). The realization that part of the HeI line absorption feature comes from an extended region up to 3 AUs from the source shows that, similarly to what found by Takami et al. (2002), there are three contributes to the profile of the HeI line: (i) accreting gas producing the red-shifted emission; (ii) an almost spherical wind from the vicinity of to the star, producing the broad blue-shifted absorption; (iii) a more collimated wind revealed spectro-astrometrically at ~-100 km/s. We suggest that the latter corresponds to the base of the collimated micro-jet detected at larger distances by Takami et al. (2001) in the forbidden [S II] and [O I] lines and in the Hα line.

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