Very High Spatial Resolution Study of Multiplicity in T Tauri Systems

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Abstract

We present first relevant results from our survey to search multiplicity in T Tauri systems and its relation with disk presence on these stars. This very high resolution survey is being developed with Lucky Imaging techniques using the instruments FastCam and AOLI at the Observatorios de Canarias. Although still in a first phase, we have already obtained some interesting results, such as the system LkHα 262 and LkHα 263. This young system hosts an edge-on disk in combination with close binaries and has longly been discussed to be bounded. We have not only photometrically resolved all components in the visible for the first time but also provided evidences that LkHα263 A-C are gravitationally bounded.

The Survey

We are carrying out an extremely high resolution survey of northern hemisphere T Tauri stars from the Herbig Bell Catalogue, a vast group of early stage stars with the presence of disks. Our goal is to perform the first major study about the existence of multiple companions in T Tauri stars (see Fig. 1). The survey is being done using the Lucky Imaging instrument FastCam, at TCS (OT) and NOT (ORM). Most relevant targets will be followed up with the new state-of-the-art instrument Adaptive Optics Lucky Imager (AOLI).

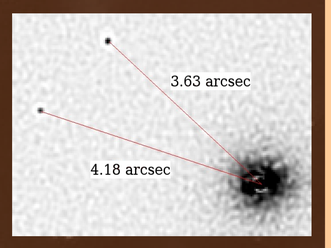

Figure 1.
IS Tau, one of our targets showing multiplicity, taken with FastCam at NOT (ORM).

Method

For each selected target we get 50 thousand images in the *I* band with 30ms of integration time each, meaning 25 minutes on-source with FastCam at TCS (see Fig. 2). Then, a Lucky Imaging process is applied to the best percentage of them. It consists of shift-and-add stacking a bunch of images taken at a very high speed to reach the diffraction limit in the optical bands. We have already completed more than 70 targets up to the 13th magnitude.

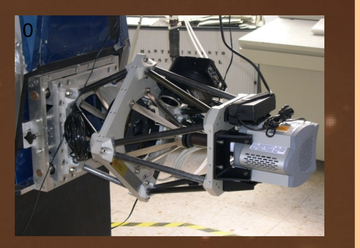

Figure 2.
FastCam installed at TCS (OT) offering a plate scale of 40 mas/pixel and 30ms time resolution.

The Case of LkHα 262-263

LkHα 263 is a triple T Tauri system placed at 275 pc from the Sun. It includes two main bright non-spectroscopically resolved M2-M4 (Meeus et al. (2009), Luhman (2001)) components, A and B, separated by 0.4 arcsec, and a third fainter C component 4 arcsec away. This C component, an optically thick edge-on disk hosting an M0 star, was discovered with adaptive optics in the near-IR band at Keck telescope by Jayawardhana et al. (2002). LkHα 262 is another T Tauri M0 star in the proximity, 15 arcsec away, of LkHα 263.

The possibility of LkHα 263 and 262 being part of a quadruple system was discussed in Chauvin et al. (2002), but it had not been proved yet.

The data presented here, taken at WHT in *I*-band, correspond to the first light observations by AOLI (see talk by Velasco et al.): 4600 images with a PSF of 15.1 mas for which precise astrometry and photometry were performed (see Fig. 3 and 4).

Object	Instrument	Flux I band
LkHα 262	CAMELOT (IAC80)	12.18±0.017
LkHα 263AB	CAMELOT (IAC80)	12.14±0.016
LkHα 263A	AOLI	12.54±0.081
LkHα 263B	AOLI	12.75±0.11
LkHα 263C	AOLI	17.43±0.36

Figure 3. Photometric comparison of the LkHα 262-263 system, AOLI values have been calibrated based on LkHα 262 with CAMELOT (IAC80).

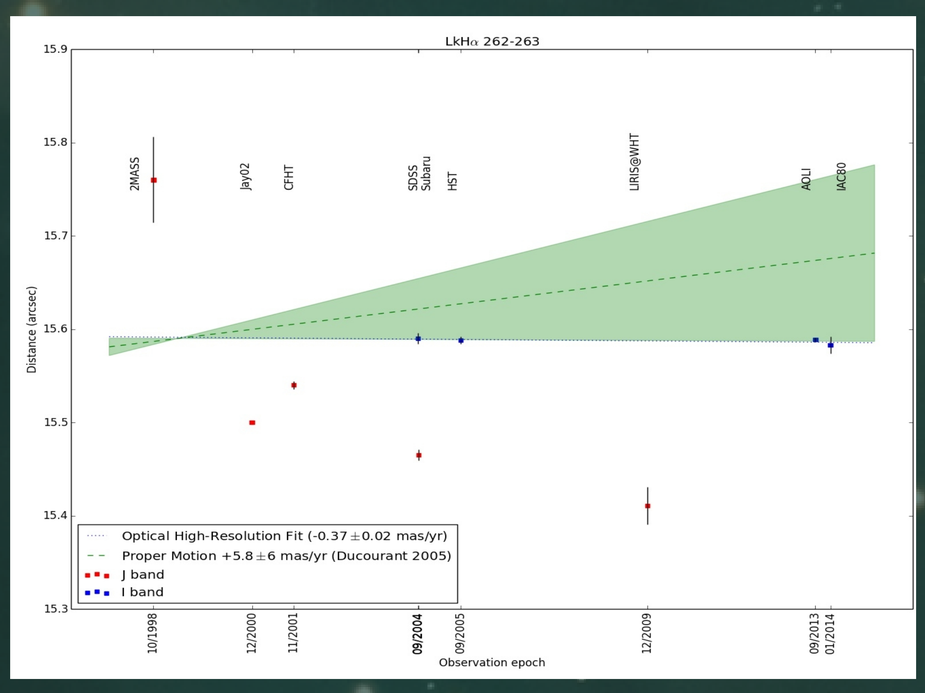

Figure 6. LkHα 262-263 separation measured through time with different instruments. Our (AOLI) given proper motion is -0.4 mas/yr, almost neglectible, clearly differing from that offered by Ducourant et al. (2005) (green boundaries in the figure including its error), with starting point in 1999.3. This states the existence of a boundary between LkHα 262 and 263.

Component	Observation date	Separation [*arcsec*]	Position Angle [*deg*]
B	2000.9	0.415±0.004	51.9±0.1
	2013.75	0.408±0.03	51.1±0.1
C	2000.9	4.115±0.02	58.3±0.2
	2013.75	3.99±0.03	57.3±0.3

Figure 4. (Up) Astrometric values for the LkHα 263 system related to component A position by Jayawardhana et al. (2002), 2000.9 epoch, and AOLI, 2013.75 epoch.

Our high resolution observations of the the first-time optically resolved system LkHα 262 and LkHα 263 (see Fig. 7 and 8) and the proper motion study related to previous data (see Fig. 6) clearly show the existence of orbital movement and a boundary between them, forming a quadruple system. We have also detected an excess in the IR flux (see Fig. 5), compatible with the presence of one or two disks in the 263AB pair.

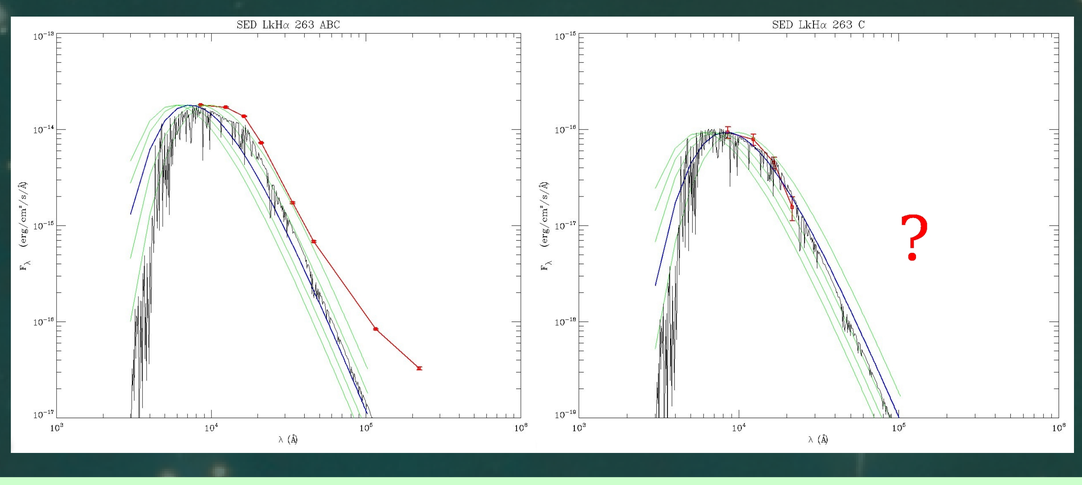

Figure 5 (Right). Integrated SED for LkHα 263 components (left) and for the component C (right) from Jayawardhana et al. (2002), AOLI (2013) and WISE (2010) data. The M0 star blackbody spectrum in the 3000-5000K interval (green) and the M0 type star modelled with MARCS (black) are also shown.

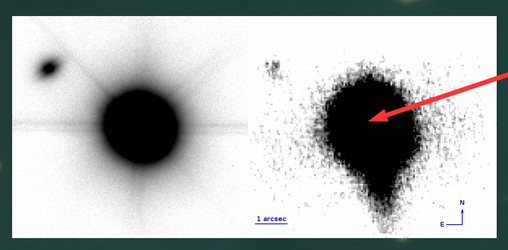

Figure 7 (Up). Comparison between Jayawardhana (2001) and AOLI (2013) images of component C, 4 arcsec away from componentsA and B, saturated here and hence not resolved.

Figure 8 (Right). LkHα 262-263 system as seen by AOLI. The projected separation is 15.55 arcsec. Components A and B, separated 0.4 arcsec, are clearly resolved.

Outlook

We have completed, at TCS, 1/4th of a survey aiming to include all T Tauri stars from the H-B catalogue up to 13th mag in *I* band. Some targets have been selected for further observations with FastCam at NOT and AOLI and WHT. LkHa 262-263 is one of them.

With an expected 20-30% of the population to have companions our goal consists not only in discovering and resolving them but also to describe their orbital motion and main properties.

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