A sparse population of young stars in Cepheus

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Once mixed in the ambient galactic plane stellar population, young stars are virtually indiscernible because neither their global photometric properties nor the presence of nearby gas can help to disentangle them from older ones. Nevertheless, in the RasTyc sample, we discovered 4 lithium-rich field stars displaying the same space motion, which are located within a few degrees from each other on the celestial sphere near the *Cepheus-Cassiopeia complex* and at a similar distance from the Sun. Both physical and kinematical indicators show that all these stars are young, with ages in the range 10 − 30 Myr. Using multivariate analysis methods, we selected optical counterparts of XMM-Newton / ROSAT All-Sky Survey X-ray sources cross-identified with late-type stars around these 4 young stars. Recent intermediate- and high-resolution spectroscopic observations of this sample allowed us to discover additional lithium-rich sources. Our preliminary results show that some of them share the same space motion as our 4 original stars. They have properties rather similar to the members of the TW Hydrae association, although they are slightly older and located in the northern hemisphere. Young nearby stars in the field are of great importance to understand the recent local history of star formation, as well as to give new insight into the process of star formation outside standard star-forming regions and to study the evolution of circumstellar discs.

I) Stellar X-ray sources in the solar neighborhood

- ✓ Most stars detected by the ROSAT mission **are younger than 1 Gyr** (Motch et al. *1997*).
- ✓ Guillout et al. (*1999*) cross-correlated the ROSAT All-Sky Survey (RASS) with the Tycho catalogue for creating the largest (≈14 000 active stars) and most comprehensive set of late-type stellar X-ray sources constructed so far, the so-called ***RasTyc* sample**.
- ✓ This stellar population can be used as **a tracer of young local structures** and displays a **significant asymmetry** in the all-sky *RasTyc* distribution **with respect to the galactic plane** (Guillout et al. *1998*), i.e. more than one order of magnitude between:
  - ➥ *Southern hemisphere*: Identification of 9 nearby (30 − 150 pc) young (5 − 70 Myr) associations (see the reviews of Zuckerman & Song *2004* and Torres et al. *2008*; Torres et al. *2006*): e.g. the **TW Hydrae association** (TWA) around TW Hya (Gregorio-Hetem et al. *1992*; Kastner et al. *1997*).
  - ➥ *Northern hemisphere*: Discovery of **five young stars**, in the *optically bright sample* (Guillout et al. *2009*), which are located in various over-densities of *RasTyc* sources (red contours on Fig. 1), but none is near the largest one. The sky density of the youngest stars is fairly uniform (Klutsch *2008*).

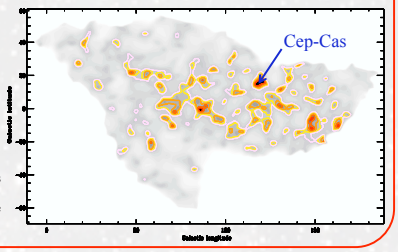


Fig.1. Density map of about 1100 *RasTyc* sources selected for our spectroscopic survey (Guillout et al. *2009*) in galactic coordinates. We also superposed the iso-contours.

II) Discovery of four "isolated" comoving T Tauri stars (TTS)

- ✓ In the *optically faint sample*, we discovered **an unusual group** (Klutsch *2008*) **of four lithium-rich stars** (green squares on Fig. 7) in the largest over-density on Fig. 1, towards the Cepheus-Cassiopeia complex, i.e. a sky area rich in CO molecular regions (Dame et al. *2001*) and dark clouds (Dobashi et al. *2005*). However these stars are projected several degrees off-clouds **in front of a region devoid of interstellar matter** (Fig. 7).
- ✓ The 4 stars have **typical spectral signatures of young stars** (Guillout et al *2010*a) as *i)* a Hα emission or a filled-in profile (Fig. 2, left panel), *ii)* a strong lithium line (Fig. 2, right panel) and *iii)* a X-ray luminosity (L_X) of ~$10^{30.4}$ erg s^{-1} (within 0.2 dex) similar to weak-line T Tauri stars (WTTS) in Taurus-Auriga-Perseus star-forming regions (SFR).

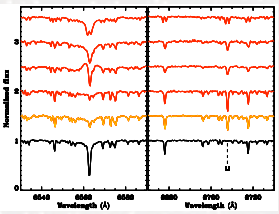


Fig.2. Spectra centered in a 60 Å-wide region around Hα (left panel) and lithium (right panel) lines of 4 comoving TTS (red) and V368 Cep (orange) spectra. We also displayed the spectrum of a "non-active" standard star (black).

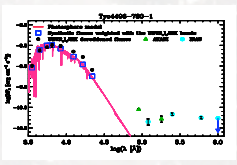


Fig.3. SED of the source showing a near- and far-infrared excess, a typical signature of an accretion disc (Guillout et al. *2010a,b*).

- ✓ Only the star with a strong Hα emission displays a near- and far-infrared (IR) excess (Fig. 3), which is typical of **TTS still surrounded by an accretion disc** (Guillout et al *2010*b). Because of the lack of IR excess, 3 other sources are likely **WTTS or post-TTS** (age ~ 10 − 70 Myr) **with a disc already dissipated**.
- ✓ Unfortunately, their Tycho parallaxes are useless and one must rely on photometric distance estimations. To cover a wide range of possibilities, for each star we estimated two distances: *i)* a *lower limit* of 80 − 100 pc if the star is on the zero-age main sequence (ZAMS), *ii)* an *upper limit* of 130 − 180 pc assuming a stellar age of 15 Myr. A lower age would be in contradiction to our photometric observations showing that no stars suffer major interstellar extinction (Guillout et al *2010*a).
- ✓ Fig.4 shows that, whatever the distance is, 4 TTS share the same kinematics (within a few km s^{-1}) proving that they form a **homogeneous group with a common origin** and they are **unrelated with the naked TTS V368 Cep and its comoving companion** (pentagons on Fig. 7) discovered in the same sky area.

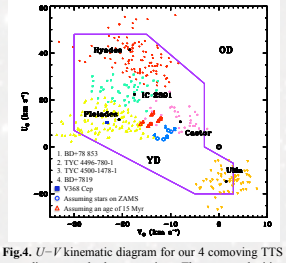


Fig.4. *U−V* kinematic diagram for our 4 comoving TTS according to our both assumptions. The space velocities of late-type stellar components of SKGs' members are also plotted. The loci of the young-disc (YD) and old-disc (OD) populations are also marked.

III) New young stars in the CO Cepheus void

- ✓ We searched for **optical counterparts of XMM / RASS X-ray sources** cross-identified with late-type stars using **multivariate analysis methods** (Pineau *2009*) allowing to disentangle the stellar population from the extragalactic component (galaxies and quasars) also emitting in X-ray (see Fig. 5). All candidates are in a region 30° wide around 4 original TTS and compile according to the following selection criteria: *i)* faint – V > 10 mag, *ii)* late-type stars – B-V > 0.6, *iii)* X-ray luminous – $L_X > 10^{30}$ erg s^{-1} and *iv)* within 170 pc of the Sun.

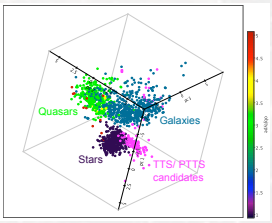


Fig.5. Result of the multivariate analysis, applied on both XMM X-ray sources, that maximizes the separation of the different classes of X-ray emitters and allows to select a priori, with a high probability, young star candidates.

- ✓ During our ongoing project [semester 2009B on T193/Sophie (OHP), 2.2m/FOCES (CAHA) and INT/IDS (La Palma)], we found **25 stars displaying a strong lithium line** similar to that of original TTS. Out of 8 discovered with IDS (Fig. 6), 4 are good young comoving candidates, but 3 turn out to be spectroscopic binaries. Moreover three of them are in the CO Cepheus void. Spectra of the remaining 17 are in the reduction/analysis phase.

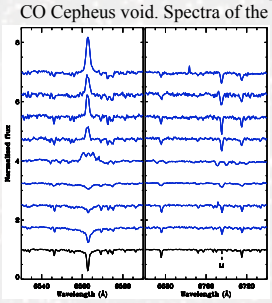
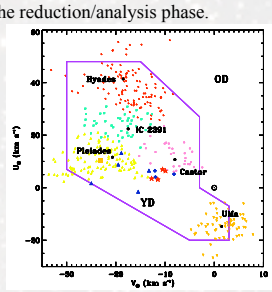


Fig.6. *Left*: IDS spectra centered in a 60 Å-wide region around Hα (left panel) and lithium (right panel) lines of 8 new lithium-rich stars. We also displayed the spectrum of a "non-active" standard star (black). *Right*: As Fig.4, but for these 8 comoving candidates seen as single stars (triangles) and spectroscopic systems (diamonds) with the cross-correlation technique. We also plotted the space velocities of our original TTS (star symbols).



- ✓ On Fig 7, we show the spatial distribution of all new lithium-rich stars (hexagon symbols). Some of them (including one of original TTS) were already identified as WTTS (orange circles) by Tachihara et al. (*2005*). Presently, a total of **15 stellar X-ray sources**, **located in the CO Cepheus void**, **are rich in lithium**.
- ✓ We decided to include all stars of Tachihara et al. (*2005*) in our sample for determining their kinematics and **their possible connection with our TTS**. Our preliminary results seem to confirm the existence of **such a link between them**. Therefore, the more plausible explanation of **their formation** will be the ***in-situ* star-formation scenario**.

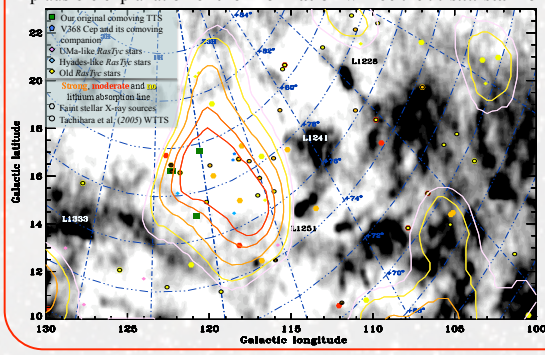


Fig.7. Spatial distribution of stellar X-ray sources located around our 4 comoving TTS, which we over-plotted on the extinction map (Av) published by Dobashi et al. (*2005*). For our selected stellar X-ray (hexagons) and Tachihara et al. (*2005*) single stars (circles) and visual binaries (double circles), each symbol is filled in orange, red or yellow if the star displays a strong, moderate or no lithium, respectively. The main clouds near the CO void region are labeled. We also indicated the density contours (already displayed in Fig.1).

IV) Conclusions and perspectives

- ✓ Discovery of a **new TTS still surrounded by an accretion disc outside of SFR's cores**.
- ✓ Discovery of a **homogeneous comoving TTS group with a common origin** (similar to TWA, although slightly older) where the *runaway* hypothesis is unlikely because of their kinematics and the **discovery of new (comoving?) T Tauri candidates near them**.
  - ➥ Raise the question of the ***in-situ*** star-formation scenario in low-mass cloud regions
  - ➥ The Gaia mission, with its unprecedented astrometry precision, will certainly shed light on this issue and on the origin of this group (related to the Cep-Cas complex?).

First young loose association in the northern hemisphere?

References : Dame, et al. 2001, ApJ, 547, 792; Dobashi, et al. 2005, PASJ, 57, 1; Gregorio-Hetem, et al. 1992, AJ, 103, 549; Guillout, et al. 1998, A&A, 334, 540; Guillout, et al. 1999, A&A, 351, 1003; Guillout, et al. 2009, A&A, 504, 829; Guillout, et al. 2010a, A&A, accepted; Guillout, et al. 2010b, in prep.; Kastner, et al. 1997, Science, 277, 67; Klutsch, 2008, PhD Thesis, ULP and Strasbourg Observatory; Motch, et al. 1997, A&AS, 122, 201; Pineau, 2009, PhD Thesis, ULP and Strasbourg Observatory; Tachihara, et al. 2005, A&A, 437, 919; Torres, et al. 2006, A&A, 460, 695; Torres, et al. 2008, Handbook of Star Forming Regions, Volume II, The Southern Sky; Zuckerman & Song, 2004, ARA&A, 42, 685

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