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CHARACTERIZATION OF YOUNG FIELD STARS IN THE VICINITY OF THE CO CEPHEUS VOID

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Abstract. After mixing in the Galactic plane, young stars are barely discernible from old ones. Nonetheless, the characterization of stars in the *RasTyc* sample has led to the discovery of several sources whose lithium content is higher than that of the Pleiades cluster members. In the locus of the CO Cepheus void, we identified four comoving T Tauri stars within a few degrees. They likely form a new young association. Looking for the presence of further members, we performed selections through multivariate analysis. We focused on the late-type stars in the field, which are identified as the optical and infrared counterparts of ROSAT All-Sky Survey/XMM-Newton X-ray sources and are in a 30°-wide region encompassing this new moving group. Based on our spectroscopic observations of this dataset, we identified two distinct populations of lithium-rich stars that are spatially and kinematically separated. While the sources having the same lithium content as the members of the Pleiades cluster are mostly projected in front of the Galactic plane, the youngest stars are mainly located towards the sky area surrounding the CO Cepheus void. The latter stars have an age of about $5 - 15$ Myr, which is rather similar to that derived for the four comoving T Tauri stars previously found in this region. The discovery and characterization of all the young stars in the field are of great importance to have new insights into the process of stellar formation outside the typical star-forming regions. The Gaia mission will certainly shed light on this issue and on the origin of this group that could be related to the Cepheus-Cassiopeia complex.

Keywords: stars: fundamental parameters, stars: pre-main sequence, stars: formation, stars: kinematics and dynamics, stars: late-type, X-rays: stars

1 Introduction

In the optically bright sample of ROSAT All-Sky Survey/Tycho (*RasTyc*) sources, Guillout et al. (2009) identified 5 pre-main-sequence stars that appear to be unrelated to any known star-forming region. Analysing our first observations of the optically faint sources (Klutsch 2008), we discovered a group of four lithium-rich stars near the Cepheus-Cassiopeia complex, which is rich in CO molecular regions (Dame et al. 2001) and dark clouds (Dobashi et al. 2005; Kiss et al. 2006). Although this sky area is known as an active star-forming region (Kun 2008; Kun et al. 2008, 2009; Kirk et al. 2009), this concentration of young stars is projected in front of one of the sky areas devoid of interstellar matter listed by Kiss et al. (2006). Guillout et al. (2010) showed that they form a homogeneous group of T Tauri stars with a common origin. From all the observations of the faintest targets, Frasca et al. (2012) found more than 10 new sources displaying a lithium content larger than that of the Pleiades cluster members. Two of them (crosses in Fig. 1) are located in the same sky area as the four comoving T Tauri stars (asterisks in Fig. 1).

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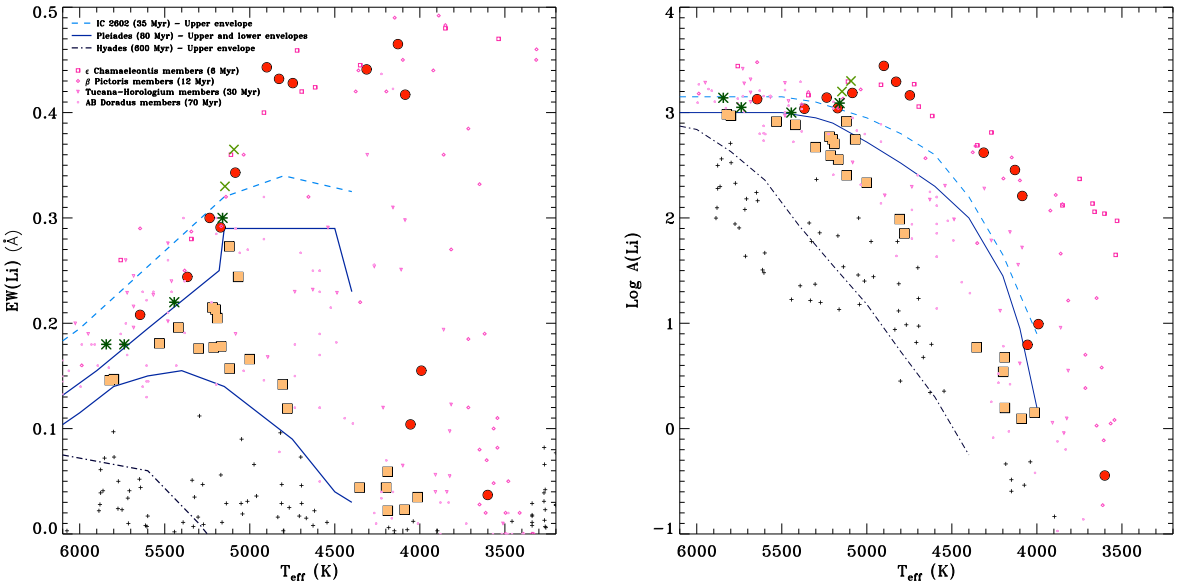

Fig. 1. Left: Li I λ6707.8 line equivalent width versus the effective temperature of our young star candidates. **Right:** Lithium abundance versus the effective temperature of targets. On both panels, we highlight the stars whose lithium content is larger than the Pleiades cluster members (circles), and the Pleiades-like ones (squares). We use plus symbols for the other candidates. We show the locus of the four comoving T Tauri stars (asterisks), and the two lithium-rich stars (crosses) discovered by Frasca et al. (2012). We also overplot the envelopes of three young clusters (various lines) and the distribution of members for 4 young associations (various small pink symbols) taken from da Silva et al. (2009).

2 Young star candidates: Selection, observations and analysis

Looking for new members of this association, we adopted the innovative analysis methods of Pineau et al. (2011) for building a sample of 162 young star candidates (see Klutsch et al. 2011, for details on our selection criteria). Tachihara et al. (2005) also discovered several T Tauri stars in this sky area. We included them in our candidate list to establish if they could be members of this young moving group. Between September 2009 and November 2010, we acquired intermediate- and high-resolution spectra (IDS@INT, FOCES@2.2m, and Sophie@T193), deriving their spectral type, physical parameters and radial velocities. Finally, we studied the age, kinematics, and chromospheric activity of all the observed targets.

3 Properties of pre-main-sequence sources and Pleiades-like stars

We found 14 young sources (circles in Fig. 1) for which the estimated age is rather similar to that of the four comoving T Tauri stars (asterisks), and 22 "older" Pleiades-like sources (squares). They form two distinct stellar populations located in different areas (Fig. 2, left panel). The youngest sources (including the six *RasTyc* sources), for which the lithium content ranges between that of the members of the ϵ Chamaeleontis (6 Myr) and Tucana-Horologium (30 Myr) associations, are mostly projected in front of the CO Cepheus void, in the Cepheus Flare region. The Pleiades-like sources are mainly located towards the Galactic plane. We also bring out a smaller concentration (inside the big open square in Fig. 2, right panel) composed of three young multiple systems. Up to now, these sources are identified as being one spectroscopic binary, one visual binary and one visual binary whose primary component is a spectroscopic binary (Klutsch et al. 2011).

With an estimated age of $5 - 15$ Myr and an average radial velocity of -8 ± 2 km s^{-1}, all the youngest stars newly discovered in the CO Cepheus void show the same properties as the four comoving T Tauri stars already found by us in this region. In particular, they all display very similar proper motions, both those with and without radial velocity data (hexagons and circles, respectively, in the right panel of Fig. 2 and the lower panel of Fig. 3). All these properties support the assumption that they likely have a common origin.

We selected all the sources brighter than $K_s = 10$ mag (dots in the lower panel of Fig. 3) from the PPMXL

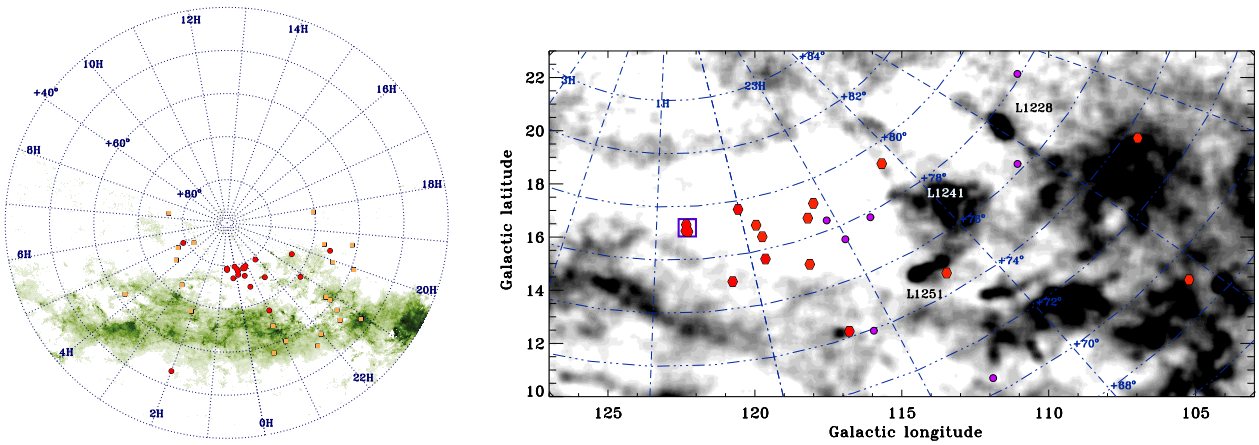

Fig. 2. Left: Spatial distribution of the young stars highlighted in Fig. 1, overplotted on the extinction (A_v) map of Dobashi et al. (2005). **Right:** Zoom on the CO Cepheus void. We plot all the young stars, both with (hexagons) and without (circles) accurate radial velocity measurements. Note that all the sources for which the information on radial velocity is missing were classified as T Tauri stars by Tachihara et al. (2005). On both panels, the six *RasTyc* sources are included in the list of the youngest stars with radial velocity data (red symbols).

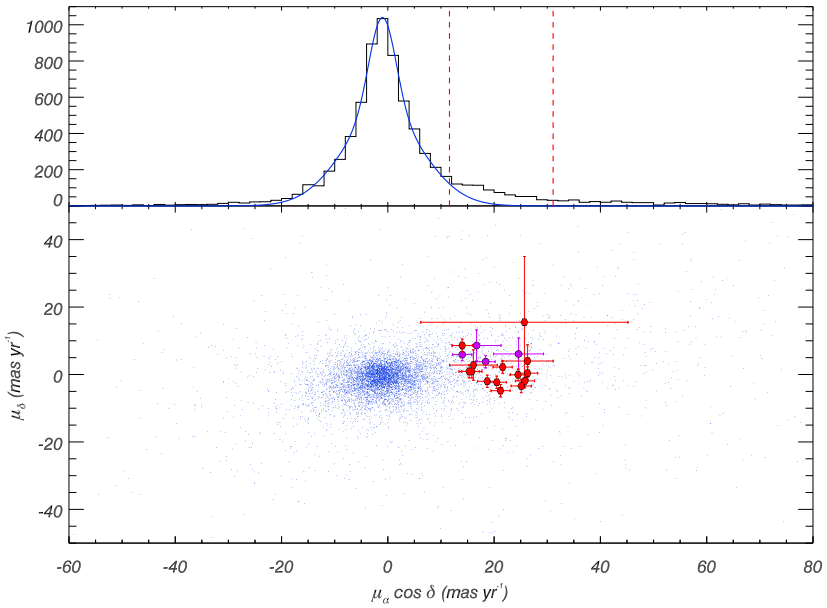

Fig. 3. Top: Histogram of the proper motions in right ascension for all the stars in the CO Cepheus void that are brighter than $K_s = 10$ mag. The curve correspond to the fit of this distribution, and the two vertical lines delimit the range of proper motions of our candidates. **Bottom:** Distribution of proper motion values of all the selected stars (dots). We also overplot the proper motions (and associate errors) of all young stars towards the CO Cepheus void, both with (hexagons) and without (circles) radial velocity measurements.

catalog (Roeser et al. 2010), using a cone search (radius = 5°) that covers all the sky area devoid of interstellar matter. The comparison between the distribution of the proper motions in right ascension and its fit emphasized an excess of sources within the range of proper motions of our candidates (delimited by two vertical lines in the upper panel of Fig. 3), which are slightly larger than the average value derived from the field stars. About 10% of the selected PPMXL sources display such a characteristic, while only a few are identified as young stars. This could be the result of the unknown supernova shock expected to be at the origin of this CO void (Grenier et al. 1989), or larger dynamical process(es) in the Galaxy.

One of the youngest sources, located outside the Cepheus area (see Fig. 2, left panel), was already rejected from the list of likely candidates of the association. Among the five remaining targets, 4 are fast rotators ($v \sin i > 20$ km s^{-1}), but we cannot exclude that they are spectroscopic binaries seen close to conjunction.

4 Conclusions

We present the latest findings of our work aiming at the identification of new members of the young moving group recently discovered towards the CO Cepheus void. Thanks to our spectroscopic observations, we identified two distinct populations of lithium-rich stars that are spatially and kinematically separated. Sources with a lithium abundance similar to that of the Pleiades cluster members are mostly projected towards the Galactic plane, while the youngest stars (age = 5 – 15 Myr) are mainly located in the sky area surrounding the CO Cepheus void. The latter stars have properties (age, proper motions, radial velocity, ...) rather similar to those derived for the four comoving T Tauri stars already found in this region.

During the last decade, several young stars (age $<$ 50 Myr) were discovered and they mainly belong to young associations and moving groups visible from the southern hemisphere. Though few members of the β Pictoris and AB Dor moving groups are located in the northern hemisphere, this new concentration of young comoving stars in front of the CO Cepheus void likely forms the first young association found northward of $\delta = +30$ deg.

This group is located in the vicinity of the Cepheus-Cassiopeia complex, which is an active star-forming region. Additional data, such as those from the future Gaia mission, will certainly shed light on an eventual link between these two structures and on the process of stellar formation outside the typical star-forming regions.

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References

da Silva, L., Torres, C. A. O., de La Reza, R., et al. 2009, A&A, 508, 833

Dame, T. M., Hartmann, D., & Thaddeus, P. 2001, ApJ, 547, 792

Dobashi, K., Uehara, H., Kandori, R., et al. 2005, PASJ, 57, 1

Frasca, A., Guillout, P., Klutsch, A., et al. 2012, in preparation

Grenier, I. A., Lebrun, F., Arnaud, M., Dame, T. M., & Thaddeus, P. 1989, ApJ, 347, 231

Guillout, P., Frasca, A., Klutsch, A., Marilli, E., & Montes, D. 2010, A&A, 520, A94

Guillout, P., Klutsch, A., Frasca, A., et al. 2009, A&A, 504, 829

Kirk, J. M., Ward-Thompson, D., Di Francesco, J., et al. 2009, ApJS, 185, 198

Kiss, Z. T., Tóth, L. V., Krause, O., Kun, M., & Stickel, M. 2006, A&A, 453, 923

Klutsch, A. 2008, PhD thesis, Observatoire de Strasbourg, Universié Louis Pasteur

Klutsch, A., Montes, D., Guillout, P., et al. 2011, in ASP Conference Series, Vol. 448, 16th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, ed. C. Johns-Krull, M. K. Browning, & A. A. West, 661

Kun, M. 2008, in Handbook of Star Forming Regions, Volume I, ed. Reipurth, B. (ASP Monograph Publications), 240

Kun, M., Balog, Z., Kenyon, S. J., Mamajek, E. E., & Gutermuth, R. A. 2009, ApJS, 185, 451

Kun, M., Kiss, Z. T., & Balog, Z. 2008, in Handbook of Star Forming Regions, Volume I, ed. Reipurth, B. (ASP Monograph Publications), 136

Pineau, F.-X., Motch, C., Carrera, F., et al. 2011, A&A, 527, A126

Roeser, S., Demleitner, M., & Schilbach, E. 2010, AJ, 139, 2440

Tachihara, K., Neuhäuser, R., Kun, M., & Fukui, Y. 2005, A&A, 437, 919