The Extended R CrA Young Association

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Abstract. Observing ROSAT sources in an area covering \(\sim 30\%\) of the
Southern Hemisphere, including the R CrA Association, we found evidences
that this nearby association may be much larger than previously thought.
Although in the survey we found many young stars near the R CrA, there are 20 young stars with properties that characterize them as possibly belonging to the R CrA association. From the nine known members with measured proper motions and radial velocities, we obtain the mean space velocity components for the Association relative to the Sun:
\[(U, V, W) = (-3.8 \pm 1.2, -14.3 \pm 1.7, -8.3 \pm 2.0)\) km/s. The new young stars with similar space velocities are in a projected diameter of \(\sim 35^\circ\). At a distance of \(\sim 100\) pc, this represents a size of \(\sim 60\) pc, similar to the spread in the kinematical distances obtained assuming the above space velocity components. If the original velocity dispersion during star formation was equal to the dispersion of the velocity vector moduli (\(\sim 3\) km/s), then the age of the association should be \(\sim 10\) Myr to reach this size. In this way, the classical T Tauri spectroscopic binary V4046 Sgr could be a member of the association.

1. Introduction

In Torres et al. and de la Reza et al. in these proceedings we describe the SACY project. There we present the GAYA, a large nearby young association near the South Pole. Another of the possible associations examined was that around the exotic spectroscopic binary (SB) classical T Tauri star (CTT) V4046 Sgr. We noted then that around the R CrA association (CAA) there are many young stars with similar kinematics forming a complex about 60 pc in diameter. A similar work, deeper in X-ray emission but less in angular extent, has been presented by Neuhäuser et al. (2000).

Frinck (1999) had already suggested that some of the stars associated with ROSAT sources could be PMS stars ejected from star forming clouds. The

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population of X-ray sources around star forming clouds seems to be represented by a mixture of PMS and young MS objects.

2. Results

In addition to the stars in the SACY we observed also some hot members of the CAA to obtain their radial velocities. From these data and those in the literature we established a set of nine bona fide CAA members with known radial velocities and proper motions (we re-analysed some cases for this work). Adopting the distance of the CAA as 129 pc (Marraco & Rydgren, 1981) - five bona fide members that have been measured by Hipparcos have parallaxes consistent with this value - we obtained the space velocities:

\[(U, V, W) = (-3.8 \pm 1.2, -14.3 \pm 1.7, -8.3 \pm 2.0) \text{ km/s}\]

In Figure 1a we show the (U,V) plane for these members and the SACY’s stars having trigonometric parallaxes. The position of the CAA in this plane is distinct of any other concentration and there are very few other selected Hipparcos stars near this position. Although the above scattering 3 km/s could be explained by observational errors, it may also reflect a large original velocity dispersion during star formation. We analysed the observations as in Torres et al. in these proceedings. Taking the above space velocities, we used the kinematical method, described in Torres et al. (2000), to estimate the distances and space velocities for the stars with no reliable Hipparcos parallaxes. The concentration in the CAA position in the (U,V) plane is enhanced (Figure 1b).
Figure 2. Celestial polar projection of the young stars observed in SACY. Circles are probable members of the proposed extension of the R CrA association. Triangles are the bona fide members the R CrA association. As it is very compact in this scale there is a great superposition of triangles. Plus are for the other young stars (Li I lines stronger than the Pleiades). Note that almost all young stars near the R CrA association are kinematically probable members of its extension. PZ Tel, proposed by Zuckerman and Webb (2000) to be a TucA member, is one of the probable members of the extended association.
As only stars within $17\text{H} < \text{RA} < 21\text{H}$ are in this position (Figure 2) - exactly where there are no proposed members for the GAYA - for sake of visualization in Figure 1b we converge the stars outside the above range of RA to the UVW of the GAYA. The concentration is mainly formed by the nine bona fide stars and 21 stars from SACY (four in common to Neuhäuser et al. 2000). In Figure 2 it is clear that these 21 new probable members may be very far from the clouds of the CAA, forming an “extended CAA” (ECA).

It is yet difficult to be sure about the boundaries of the ECA, mainly to the west where our survey began. In fact, the extension is mainly in that direction and it should be noted that this is the correct one for the “external agent” that must have influenced the appearance of the CAA cloud complex (Graham, 1991). The very interesting SB2 CTT V4046 Sgr (not a X-ray source) may be a member of the ECA. In that case we obtain a kinematical parallax of 15.2 mas, somewhat larger than the value of 12.0 mas obtained from evolutionary scenarios (Quast et al. 2000).

The mean distance of the 21 new members is 100 pc (Figure 3a). Observational bias will favor the discovery of nearby members, but the spread in distance of $\sim 80$ pc is roughly consistent with the apparent size of the ECA. In fact, the 30 stars are distributed in a projected area with a diameter of $\sim 35^\circ$, that is, a size of $\sim 60$ pc.

If the original velocity dispersion during star formation was similar to the average modulus of the velocity vectors ($\sim 3\text{ km/s}$), it would take $\sim 10$ Myr to reach the size of $\sim 60$ pc. This is similar to the evolutionary age (Neuhäuser et al. 2000). Actually, we deduced an age somewhat larger ($\sim 15$ Myr) as we are using closer distances. But these values are within the uncertainties. Anyway, the new members seem to be older than the bona fide ones. On the other hand, Figure 3a suggests that the ECA is expanding.

One of the best confirmations of the PTT nature of the proposed members is the behavior of the Li lines. In the same spectral range the previously known TTS in the CAA have a similar $W_{\text{Li}}$ distribution to the ECA showing that there is no significantly different Lithium depletion between them (Figure 3b). We re-analysed the Li abundances of some of these TTS. Like other authors we obtained abundances from the Li resonance line $\lambda 6707$ above the interstellar ones. But using the high quality FEROS spectra we could use the $\lambda 6103$ line, which is very sensitive to abundances, and the obtained values dropped to the interstellar ones.

3. Conclusions

Exploring a region covering about 30% of the Southern Hemisphere we found evidences of a great extension of the young CAA and it seems to include the very interesting SB2 CTT V4046 Sgr. The extended region is presently represented by at least 20 members, having an age of $\sim 10$ Myr.

The distances of its members cover an interval from nearly 60 to about 140 pc (at a mean distance of $\sim 100$ pc) giving a diameter of $\sim 80$ pc, compatible with the size produced after $\sim 10$ Myr by an initial velocity dispersion of $\sim 3$ km/s. If real, the early CAA was a very turbulent environment.
Almost all young stars in this region are kinematically possible members. Although we found many other young stars in the vast observed austral sky region, only around the CAA there are viable candidates for the ECA. This seems very hard to be a chance coincidence and we propose that the CAA complex is a very large and young association, resulting from a turbulent initial phase, that is now visualised by the cloud format. The ECA may be connected with the Upper Scorpius association, as both have similar distances and ages, forming a spatial sequence (see Sartori, in these proceedings).

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Figure 3. a): U velocites as a function of the obtained distances for the probable members of the extended R CrA association. There is an indication that this proposed association is in expansion. b): W_{Li} (m˚A) as a function of temperature for the extended (circles) and the R CrA (plus) associations.