Chromospherically active binaries members of young stellar kinematic groups

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Abstract.

We present a kinematic study of a large sample of chromospherically active binaries (CAB) in order to determine their membership to representative young disk stellar kinematic groups: the Local Association (Pleiades moving group, 20 - 150 Myr), Ursa Mayor group (Sirius supercluster, 300 Myr), Hyades supercluster (800 Myr), IC 2391 supercluster (35 Myr) and Castor moving group (200 Myr). Precise measurements of proper motions and parallaxes taken from Hipparcos Catalogue and published radial velocity measurements are used to calculate Galactic space motions (U, V, W) in order to determine the membership of the selected stars to the different stellar kinematic groups.

1. Introduction

Activity-rotation and activity-age relationships have been found in many studies of late-type stars. The rotation rate moderates the dynamo mechanism which generates and amplifies the magnetic fields in the convective zone, but there is a further relationship between rotation and age. Rotation rates decline with age because stars lose angular momentum through the coupling of the magnetic field and stellar mass loss, and thus there is an indirect trend of decreasing activity with increasing age. Chromospherically active binaries (CAB) are detached binary systems with cool components characterized by strong chromospheric, transition region, and coronal activity. CAB can lose angular momentum, but maintain high rotation rates and activity levels by a decrease in their component separation (synchronization of rotation and orbital periods). Samples of CAB with the same age are of maximum interest to better understand the magnetic activity of these systems.

Some late-type spectroscopic binaries have been identified as members of well known open clusters (Montes 1999, and references therein), but only a few are well known CAB. Stellar kinematic groups (SKG) are kinematically coherent groups of stars that share a common origin, and thus offer another way to compile samples of stars with the same age. The youngest and best documented SKG are: the Hyades supercluster (Eggen 1992b) associated with the Hyades cluster (600 Myr), the Ursa Mayor group (Sirius supercluster) (Eggen 1992a, 1998; Soderblom & Mayor 1993) associated with the UMa cluster (300 Myr), the Local Association or Pleiades moving group associated with the Pleiades and several
other young open clusters and associations (age ranges from about 20 to 150 Myr) (Eggen 1992c), the IC 2391 supercluster (35-55 Myr) (Eggen 1995), and the Castor moving group (200 Myr) (Barrado y Navascués 1998). The existence of these SKG has been rather controversial in the literature, but recent studies (Chereul et al. 1999, Dehnen 1998, Asiain et al. 1999, Skuljan et al. 1999) using astrometric data taken from Hipparcos not only confirm the existence of classical young moving groups, but also detect finer structures in space velocity and age. Well known members of these SKG are mainly early-type stars and few studies have been centered in late-type stars (see Montes et al. 1999, and Montes 2000 (this proceedings)). In this contribution we present a kinematic study of a large sample of CAB in order to determine their membership to representative young disk SKG. Precise measurements of proper motions and parallaxes taken from Hipparcos Catalogue and published radial velocity measurements are used to calculate Galactic space motions (U, V, W).

2. Sample of CAB and parameters

A total of 205 CAB with complete kinematic input have been included in this study. The systems have been selected from different sources:

- Previously established members of stellar kinematic groups based in photometric and kinematic properties (several papers by Olin Eggen).
- Possible new candidates found in our previous kinematic study of late-type stars (Montes et al. 1999).
- The 206 CAB included in the "Catalog of Chromospherically Active Binary Stars" (Strassmeier et al. 1993).
- Some of the CAB included in the candidate list of Strassmeier et al. (1993)
- Other late-type stars recently identified in the literature as CAB, including X-ray/EUV selected stars. (Jeffries et al. 1995, Henry et al. 1995).
In order to determine the membership of this sample to the different stellar kinematic groups we have studied the distribution of stars in the space velocity by calculating the Galactic space-velocity components (U, V, W) in a right-handed coordinated system (positive in the directions of the Galactic center, Galactic rotation, and the North Galactic Pole, respectively). The procedures in Johnson & Soderblom (1987) were used to calculate U, V, W, and their associated errors.

Parallaxes and proper motions are taken from Hipparcos Catalogue (ESA, 1997); PPM (Positions and Proper Motions) Catalogue (Röser et al, 1994); ACT Reference Catalog (Urban et al. 1997); and TCR (Tycho Reference Catalogue) (Hog et al. 1998). We have only included in the study stars with significant trigonometric parallaxes (π ≥ 3σπ). In some cases, when trigonometric parallaxes are not available, we adopted spectroscopic parallaxes. Radial velocities are primarily taken from the system’s center of mass radial velocity listed in Strassmeir et al. (1993) catalog or other more recent orbital determination found in the literature. Some radial velocities are also taken from the WEB (Wilson Evans Batten) compilation (Duflot et al. 1995), and from other references given in SIMBAD.

3. (U, V) and (W, V) diagrams

The (U, V) and (W, V) planes (Boettlinger Diagram) for the whole sample are plotted in Fig. 1. All the stars fall in the range of U (-130, 120) and V (-90, 40) except two stars with very large space velocities: CM Dra (U = -105.35, V = -19.35) and Gl 629.2A (U = -88.24, V = -172.06) which result to be old Population II binaries. We have divided the sample in three groups according to their luminosity class (V, IV, and III). The stars of the three groups are plotted in this figure with different symbols and colors. Fig. 2 is an enlargement of the central region of Fig. 1 including the boundaries (dashed line) that determine the young disk population as defined by Eggen (1984, 1989).
the young disk population as defined by Eggen (1984, 1989). As it can be seen in this figure a large number of BY Dra stars (luminosity class V) seems to fall inside of the boundaries of the young star region, but a considerable number of subgiants and giants also fall in this region. A detailed kinematic study will be the subject of a future work, for a previous kinematic study see Eker (1992).

In Fig. 3 we have plotted each star with its associated error, in the central region of the (U, V) and (W, V) diagrams. Stars with trigonometric parallaxes have been plotted in black and stars with spectroscopic parallaxes in blue. The uncertainties are in general modest, except some cases with large errors, which correspond to stars with small trigonometric parallaxes.

We focus this contribution in the identification of a preliminary list of CAB possible members of some of the five young moving groups above mentioned. In base of the concentrations in (U, V) and (W, V) planes around the central position of the different moving groups (see Fig. 4) we have classified the stars of our sample as members of one of these moving groups or as other possible young disk stars if their classification is not clear but it is inside or near the boundaries (dashed line) of the young disk population. In Tables 1 to 5 we list the candidate stars for each moving group. We give the name, coordinates (FK5 1950.0), radial velocity ($V_r$) and the error in km/s, parallax ($\pi$) and the error in milli arc second (mas), proper motions $\mu_{\alpha}$ and $\mu_{\delta}$ and their errors in mas per year (mas/yr), and the U, V, W, calculated components with their associated errors in km/s. In the last column we mark with Y previously established members of the stellar kinematic group and Y? possible new members in base of their position in the (U, V) plane.

\footnote{Tables 1 to 5 available at \url{http://www.ucm.es/info/Astrof/cabs_yskg.html}}
4. Membership and ages

For some of the CAB listed in Tables 1 to 5, for which accurate determinations of their stellar parameters are available, stellar ages have been obtained (Barraodo et al. 1994, B94 hereafter) by using evolutionary tracks. In the following we comment some particular cases for each moving group.

**LOCAL ASSOCIATION**

Four CABS (V640 Cas AB, EP Eri, HD 102077, V772 Her) have been previously identified as members of the Local Association. LX Per was classified as member of α Per open cluster, but the space velocities calculated here indicate it is member of the Hyades supercluster. The ages calculated by B94 for TW Lep (94 Myr) and BM CVn (65 Myr) are compatible with their membership. The B94's age of the doubtful members xi UMa B (6 Gyr), σ² CrB (4 Gyr), and ER Vul (4 Gyr) indicates they are not members. The case of V772 Her is not clear since it seems to be a certain member, Batten et al. (1979) suggest an age as the Pleiades, but the B94's age is 3 Gyr.

**IC 2391**

Only five CAB could be included in this group of which TZ For, HD 54371, HD 58738A are previously established members.

**CASTOR MOVING GROUP**

YY Gem (Castor C) is one of the stars that define this moving group and its membership has been confirmed by Barrado y Navascués (1998). VV Mon was initially included as a possible member but the age of 2.6 Gyr calculated by B94 indicated it is not a member.

**URSA MAJOR GROUP**

The age calculated by B94 for ε UMi (446 Myr) is compatible with its membership, however the evolutionary status of this system is complicated. UV CrB
with an age of 5 Gyr (B94) should be rejected as possible member.

**HYADES SUPERCLUSTER**

Some CAB are previously established members of the Hyades open cluster (V1136 Tau, V818 Tau, HD 27149, HD 27691, V918 Tau, V808 Tau, QY Aur) and are plotted with a different symbol in Fig. 4. Previously established members of the supercluster are: ADS 48A (GJ 4A), V471 Tau, and DH Leo. The age calculated by B94 for 93 Leo (933 Myr) is close to the Hyades ages, but the age of HD 131832 (93 Myr) is too young and the ages of HD 3196 (1.7 Gyr), RZ Eri (2.2 Gyr), and LU Hya (4.3 Gyr) are too old to be members.

**OTHER POSSIBLE YOUNG DISK STARS**

In this group of other possible young disk CAB we found several young stars as calculated by B94, but also some old stars.

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