Search for associations containing young stars (SACY). VIII.
An updated census of spectroscopic binary systems exhibiting hints of non-universal multiplicity among their associations

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CONTEXT

Nearby young associations offer one of the best opportunities for a detailed study of the properties of young stellar and substellar objects thanks to their proximity (<200 pc) and age (~5-150 Myr). Previous works have identified spectroscopic (<5 au) binaries, close (5-1000 au) visual binaries, and wide or extremely wide (1000-100 000 au) binaries in the young associations. In most of the previous analyses, single-lined spectroscopic binaries (SB1) were identified based on radial velocities variations. However, this apparent variation may also be caused by mechanisms unrelated to multiplicity. We seek to update the spectroscopy binary fraction of the Search for Associations Containing Young stars (SACY) sample, taking into consideration all possible biases in our identification of binary candidates, such as activity and rotation.

OBSERVATIONS AND LITERATURE DATA

The sample presented in this work is drawn from our database of young association members, as in Elliott et al. (2016a). The membership of each object to a given association was assessed using the convergence method described in Torres et al. (2006) and Torres et al. (2008) with the updated distances from the second Gaiadata release (Gaia DR2, Gaia Collaboration et al. 2018).

We use previously published data and high resolution spectra publicly available, mainly from the Fibre-fed Extended Range Échelle Spectrograph (**FEROS**; R ~ 50,000), High Accuracy Radial velocity Planet Searcher (**HARPS**; R ~ 115,000), Ultraviolet and Visual Echelle Spectrograph (**UVES**; R ~ 40,000; our own programs) and **Gaia DR2** (~ 98% of our sample coverage with 37% of objects with Gaia RV estimate).

The radial velocity values we obtained were cross-matched with the literature and then used to revise and update the spectroscopic binary (SB) fraction in each object of the SACY association. In order to better describe the CCF profile, we calculated a set of high-order cross-correlation features to determine the origin of the variations in radial velocities.

MEMBERSHIP ASSESSMENT

In order to assess any possible bias throughout this work with the use of our convergence method to build the census of the different associations (Torres et al. 2008), we followed an independent path, utilising the BANYAN Σ tool for young association membership.

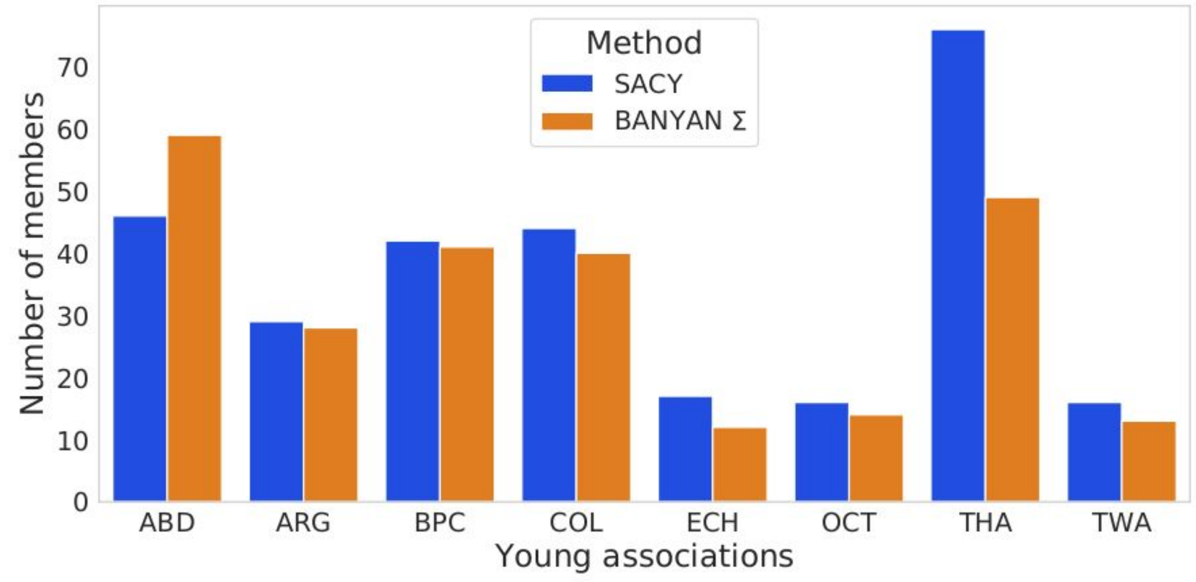
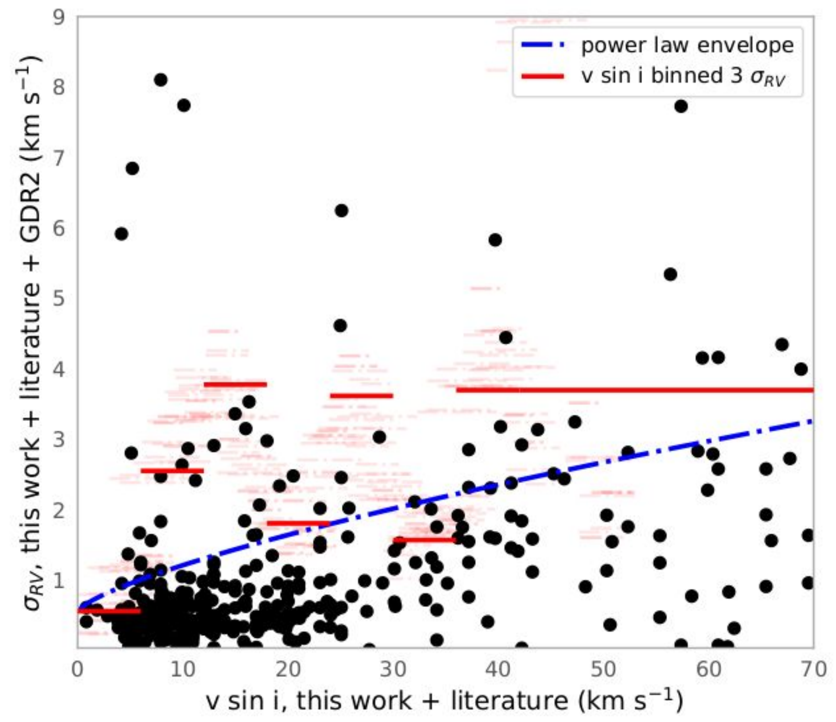


Fig. 1: Number of targets belonging to each young associations identified by our convergence method (SACY) and BANYAN Σ.

SB DETECTION



We made an initial list of systems to be further investigated by looking at both RV and vsini variation as a function of vsini. We set a 3σ boundary using binning statistics and a power-low envelope to identified as an SB candidate any target with RV variation above those thresholds.

We use the high-order CCF features, if possible, when investigating any potential RV variation to better conclude on the true nature of the object.

Fig. 2: Standard deviation in RV as a function of vsini for measurements calculated in this work. The 3σ value from binning in 6 km s−1 bins are represented by the red solid lines. The power-law envelope is represented by dash-dotted blue line.

RESULTS

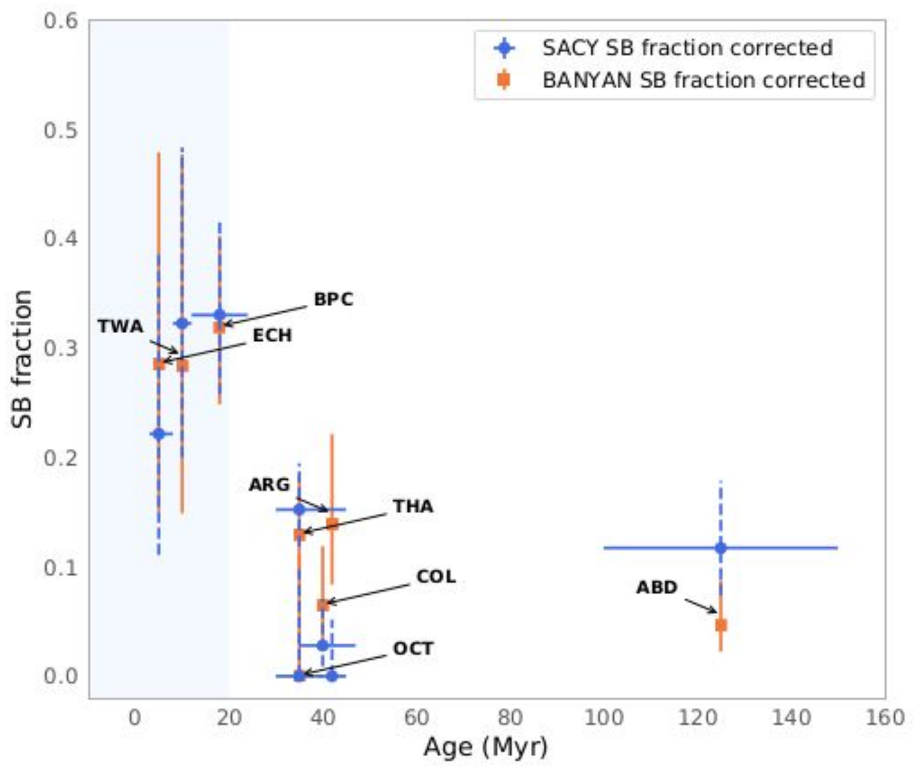


Fig. 3: Corrected SB fraction as a function of age (Myr) for membership estimation from our convergence method (blue dots) and BANYAN Σ (orange dots). The shaded area highlights the < 20 Myr zone in the figure.

We identified 68 SB candidates from our sample of 410 objects. We calculated the SB fraction for each SACY association and estimated a correction factor taking into account possible sensitivity issues and biases from the observations

Our results hint that at the possibility that the youngest associations have a higher SB fraction. Specifically, we found sensitivity-corrected SB fractions of 22-11+15% for ε Cha, 31-14+16% for TW Hya and 32-8+9% for β Pictoris, in contrast to the five oldest associations we have sampled (~35 - 125 Myr) which are ~10% or lower. This result seems independent of the methodology used to asses membership to the associations.

Similar results was obtained for the IN-SYNC (INfrared Spectroscopy of Young Nebulous Clusters) in Jaehnig et al. (2017). This scenario is proposed for clusters with typical densities of ≈ 30M pc^{-3} and may not be compatible with the typical densities of ≈ 0.01 stars pc^{-3} for loose associations such as those in the SACY sample.

The tentative variations in SB fraction could be related to differences in the primordial multiplicity depending on the formation history and environment of the associations (see Fig. 4). Hints supporting non-universal multiplicity among the SACY associations.

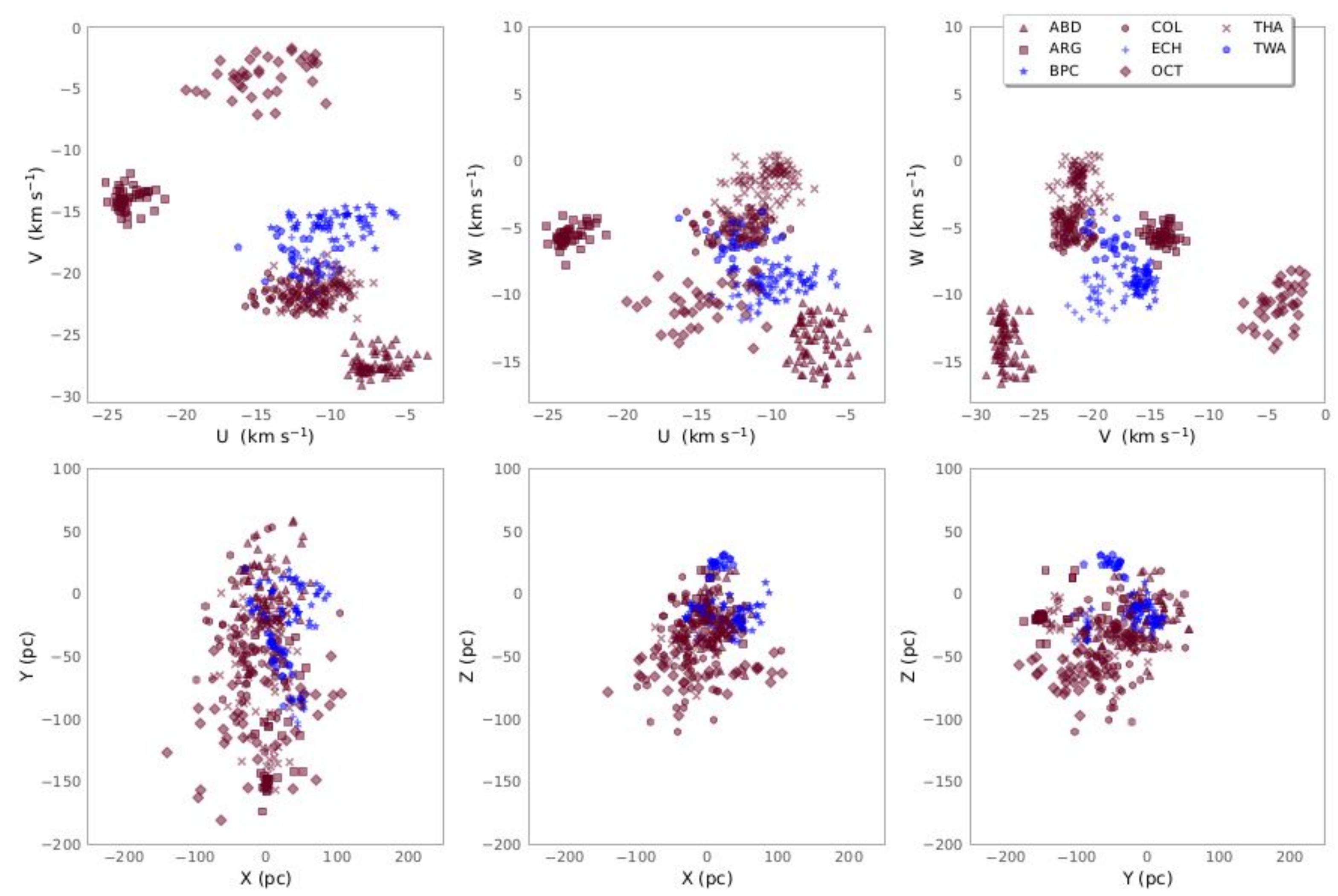


Fig. 4: Combinations of the sub-spaces of the UVWXYZ-space for the young associations in the SACY sample. The blue coloured symbols correspond to the three youngest associations (BPC, ECH and TWA). The full membership study and further analysis will be presented in Torres et al. (in prep.).

SUMMARY AND REMARKS

- We have estimated radial and rotational velocity for 1375 spectra using CCFs and compiled~400 RV measurements from the literature (including Gaia DR2, Gaia Collaboration et al. 2018).
- From the SBs identified in this work, ~ 77 % are also part of higher-order multiple systems (Elliott et al. 2016a; Elliott & Bayo 2016).
- ~ 92% of SBs in the three youngest associations studied here are part of a triple or high-order multiple system that stand in contrast with the ~67% for the five older associations (supporting the dissolution scenario, proposed by Sterzik & Tokovinin 2002).
- Interestingly the three highest spectroscopic binary fractions are for the three youngest associations (ε Cha ~22 %, TW Hya ~32 % and β Pictoris moving group ~33 %).
- The difference in the SB fraction remains tentative at the moment, we propose two possible explanations: an evolution effect (previously reported in denser environments) and a primordial non-universal multiplicity.

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