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OB associations are not the expanded remnants of star clusters

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Abstract. We have performed structural and kinematic studies of the Cygnus OB2 and Scorpius-Centaurus OB associations to constrain their past evolution and formation. Both are physically and kinematically substructured, implying they could not have formed as dense star clusters, and their kinematics show no evidence for the radial expansion pattern predicted for expanding star clusters. We argue that OB associations instead form as low density, highly substructured, and globally super-virial star-forming complexes and, due to the lack of significant dynamical interactions amongst their members, have remained this way since.

1. Introduction

Determining the birth environments of young stars is important for understanding the star formation process, the formation and evolution of binary and planetary systems, and the origin of long-lived open and globular clusters. In the classic picture of clustered star formation, OB associations are thought to be the expanded remnants of dense star clusters disrupted by processes such as residual gas expulsion.

2. Cygnus OB2

Our proper motion (PM) study of Cyg OB2 (Wright et al. 2016) shows that despite the association being gravitationally unbound the motions of stars do not display a radial dispersal pattern (Figure 1, as predicted if the association had originally been a compact star cluster and is now dispersing (e.g., Hills 1980; Brown et al. 1997; Lada & Lada 2003). Only 60% of the kinetic energy in the PMs is in the radial direction, and that is divided equally between expansion and contraction. This disagrees with models of star cluster disruption by residual gas expulsion that predict the motions to be dominated by radial expansion.

The PMs also show kinematic substructure in the form of co-located groups of stars with similar motions (see Figure 1). This kinematic substructure echoes the physical substructure known to exist in Cyg OB2 (Wright et al. 2014) and argues for a non-clustered origin.

3. Scorpius-Centaurus

Using Gaia DR1 (Gaia Collaboration et al. 2016a,b) PMs for stars in the three subgroups of the Sco-Cen OB association we find a lack of radial expansion and prominent kinematic substructure. We have performed multiple tests for the expansion of the subgroups and find no evidence for coherent expansion patterns, despite the subgroups being gravitationally unbound. We also observe and measure kinematic substructure in the three subgroups that implies they were born with considerable substructure, much of which has survived to the present day.

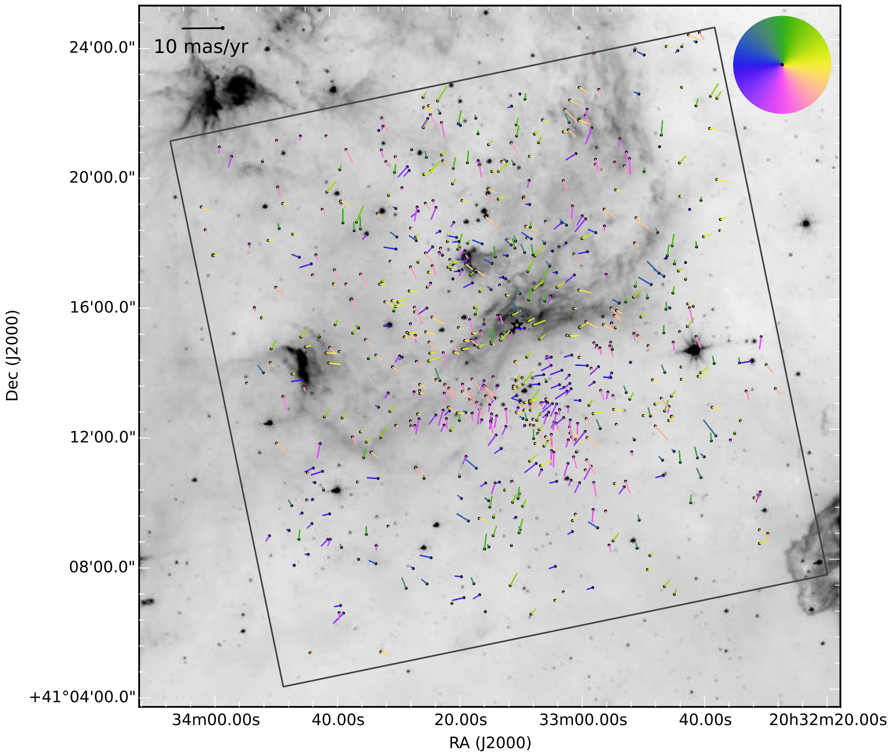

Fig. 1. PM map for 798 X-ray (Wright & Drake 2009; Wright et al. 2010b) and spectroscopically selected (Wright et al. 2015) members of Cyg OB2. Vectors coloured by their PM direction (see colour wheel).

4. Conclusions

We have presented results from two kinematics studies of OB associations that show no evidence for the associations or their subgroups having coherent expansion patterns. Instead they show evidence for kinematic substructure. We suggest that OB associations do not form as the expanded remnants of star clusters but as low-density and substructured complexes.

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