Revisiting the Cygnus OB associations

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Abstract

We have studied the validity of the historical Cygnus OB associations and have found that many do not show the kinematic coherence expected for true OB associations. We have revisited these groups by photometrically identifying thousands of OB stars across the region with an SED fitting process which combines photometry, astrometry, spectral and evolutionary models. We applied a flexible clustering method and identified seven kinematically-coherent new OB associations. We observe a distinct correlation between position and velocity for two sets of these associations that suggests an expansion pattern. Tracing the motion of the stars back in the past we find that the sets were at their closest around 7.9 and 8.5 Myr ago. We discuss whether this expansion is a natural by-product of the commonly observed size - velocity dispersion relation of molecular clouds, or requires an additional source of feedback to initiate the dispersal. Our results are published in Quintana & Wright (2021, 2022a, 2022b).

Introduction

OB associations are gravitationally unbound and low-density groups containing many OB stars (Ambartsumian 1947) and constitute the transition between star-forming regions and the galactic field population (Wright 2020). Albeit studied and listed for decades (see e.g. Humphreys 1978), most of them remain poorly known. In this work we revisit some of the historical Cygnus OB associations, in a region rich in massive stars (Reipurth & Schneider 2008).

New OB associations

Applying an SED fitting process we identify > 4000 candidate OB stars in Cygnus. With a flexible clustering algorithm, we identify seven new associations, more kinematically-coherent than the old associations (see Fig. 1). The new associations are found to expand in the l direction while three associations also expand in the b direction. See Quintana & Wright (2021) for details.

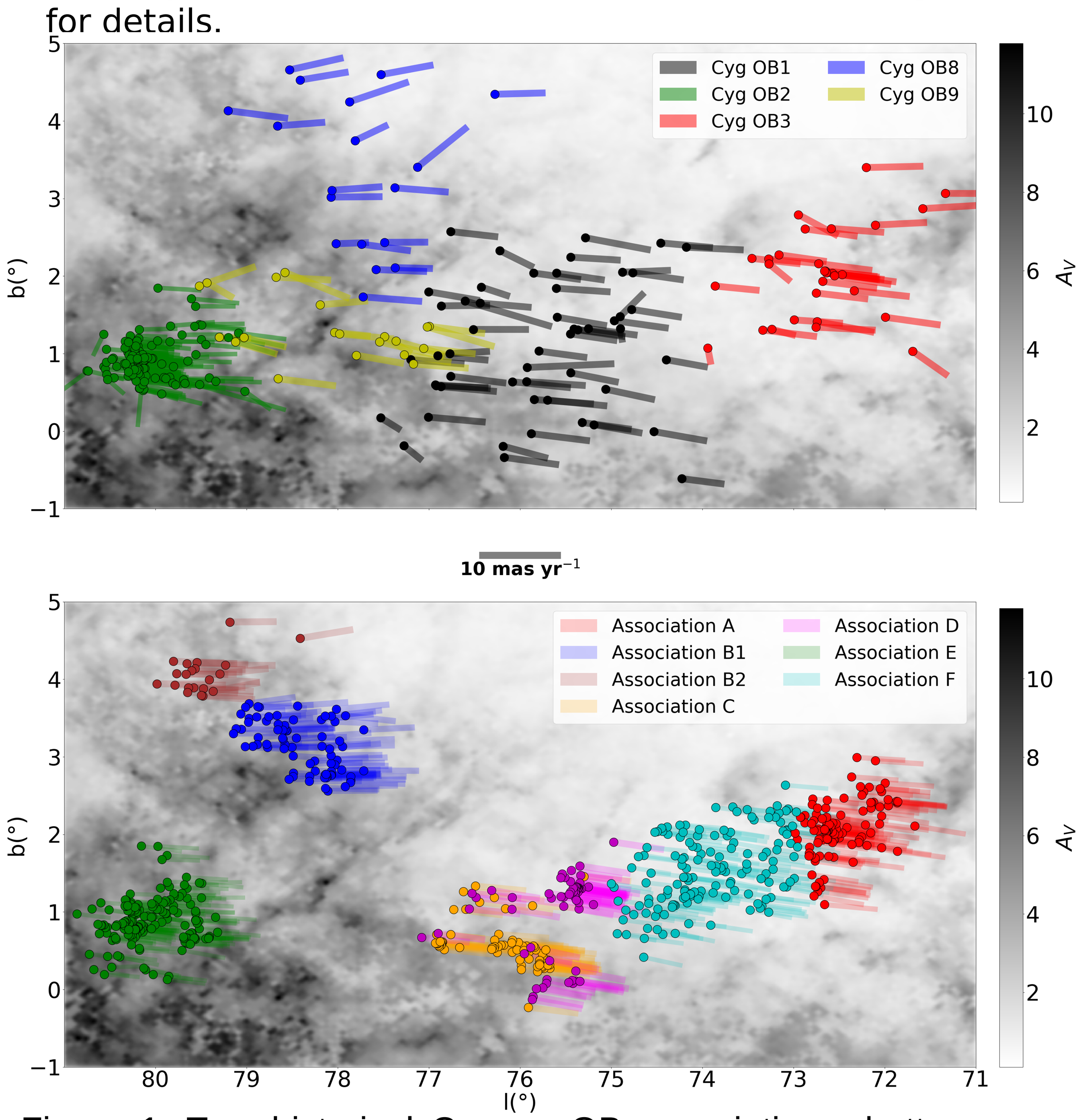

Figure 1: Top: historical Cygnus OB associations, bottom: new OB associations, with galactic proper motions as vectors and a background extinction map from Green et al. 2019.

Large-scale kinematics

We observe two large-scale kinematic patterns between position and proper motion in the l direction (see Fig. 2), similarly to those observed by Drew et al. 2021 in Carina, with a length-scale of ~ 150 pc and a velocity-scale of ~ 25 km/s.

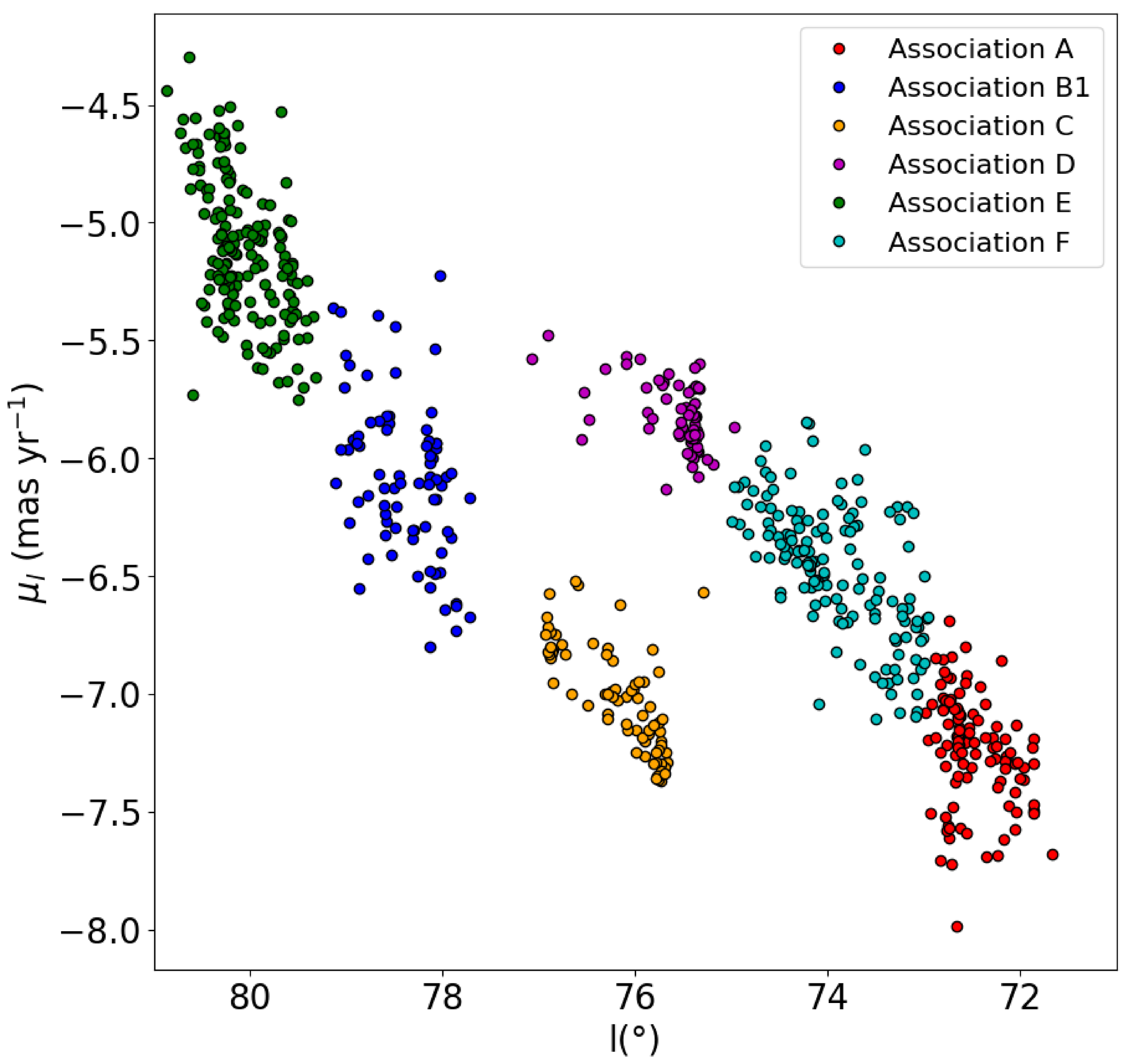

Figure 2: Galactic longitude as a function of proper motions in galactic longitude for the new OB associations.

Traceback

Using 3D kinematics, and an epicycle approximation from Fuchs et al. 2006, we trace back the motions of the associations along with six potentially related open clusters.

We find that the two sets of three associations reach their most compact 7.9 and 8.5 Myr ago, as shown in Figure 3. We estimate total kinetic energies of (0.54-1.21) × 10^{50} erg and momenta (0.66-1.26) x 10^6 $M_\odot$ km/s for each system.

There are a number of possible explanations for such an energetic expansion pattern. The first is that the observed expansion is simply a product of the turbulent expansion of the primordial molecular cloud, as quantified by the size - linewidth relationship commonly observed in molecular clusters (Larson 1981).

The second possibility is that the expansion of the region has been accelerated by an additional force, such as feedback from a previous generation of massive stars. Distinguishing between these scenarios will require a careful consideration of the expansion velocities and the energy and momentum present in the expanding groups.

See Quintana & Wright (2022b) for details.

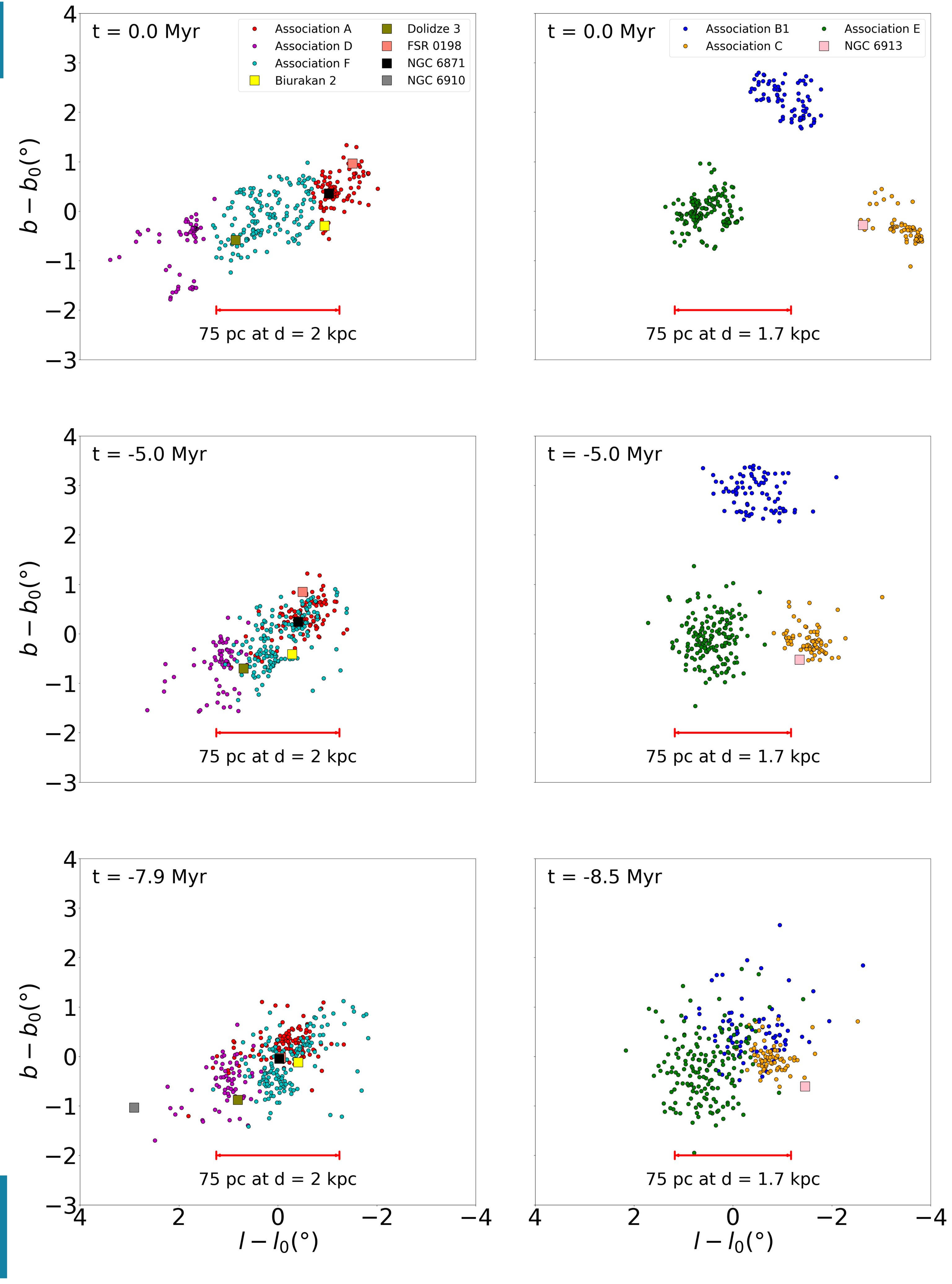

Figure 3: Results of the traceback calculations galactic coordinates for the associations and related open clusters, where l_0 and b_0 are the median coordinates for the associations. Left column is for associations ADF and right column for associations B1CE.

References

Ambartsumian V. A., 1947, Armenian SSR Academy of Sciences Press; Fuchs B., et al., 2006, MNRAS, 373, 993; Drew J. E., et al., 2021, MNRAS, 508, 4952; Green G. M., et al., 2019, ApJ, 887, 9; Großschedl J. E., et al.., 2021, A&A, 647, A91; Humphreys 1978, ApJS, 38,309; Larson R. B., 1981, Reipurth B., Schneider N., 2008, Star Formation and Young Clusters in Cygnus. The Northern Sky ASP Monograph Publications, University of Hawaii, p. 36; Quintana A. L., Wright N. J., 2021, MNRAS, 508, 2370; Quintana A. L., Wright N. J., 2022a, MNRAS, 511, 1224; Quintana A. L., Wright N. J., 2022b, preprint (arxiv:2205.15611); Walch S., Naab T., 2015, MNRAS, 451, 2757; Wright, 2020 New Astron. Rev., 90, 101549