Dynamical Evolution of Dense Stellar Systems
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On the Origin of the Orion Trapezium System

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Abstract. Numerical SPH simulations of supersonic gravo-turbulent fragmentation of a proto-cluster cloud ($1000\,M_\odot$) suggest that the cloud develops a few subclusters (star+gas systems) which subsequently merge into a single cluster entity. Each subcluster carries one most massive star (likely multiple), thus the merging of subclusters results in a central Trapezium-type system, as observed in the core of the Orion Nebula cluster.

Keywords. star formation, young star cluster, multiple systems, Orion Nebula

1. Introduction

The origin of massive stars and their multiplicity has become one of the hottest topics in stellar astrophysics (see, for example, the recent review of Zinnecker & Yorke 2007). Many if not most of the high-mass stars appear to originate in dense star clusters (e.g. Zinnecker *et al.* 1993, Lada & Lada 2003), although isolated massive star formation may also occur (de Wit *et al.* 2005). Here, in this short contribution, we are concerned to explain the occasional occurrence of Trapezium-type systems in the centers of dense clusters (Abt 1986, Garcia & Mermilliod 2001). Such Trapezium type configurations of massive stars, unstable as they are, may be evidence for primordial mass segregation in young OB clusters (Bonnell & Davies 1998, McMillan *et al.* 2007).

2. SPH simulations of hierarchical young star cluster formation

The stellar cluster forms through the hierarchical fragmentation of a turbulent molecular cloud. The relevant numerical evolutionary simulations of a $1000\,M_\odot$ cloud by Bonnell *et al.* (2003) are shown in Fig. 1 (top 4 panels): each panel shows a region of 1 parsec per side. The logarithm of the gas column density is plotted. The stars are indicated by the (yellow) dots. The four panels capture the evolution of the $1000\,M_\odot$ system at times of 1.0, 1.4, 1.8 and 2.4 initial free-fall times ($t_{ff} = 2 \times 10^5$ yr). The turbulence causes shocks to form in the molecular cloud, dissipating kinetic energy and producing filamentary structure which fragment to form dense cores and individual stars (panel A). The stars fall towards local potential minima and hence form subclusters (panel B). These subclusters evolve by accreting more stars and gas, ejecting stars, and by merging with other subclusters (panel C). There is one massive star per subcluster. The final state of the simulation is a single, centrally condensed cluster with little substructure but with 4 massive stars, one from each subcluster (Trapezium-system + 400 stars) (panel D).

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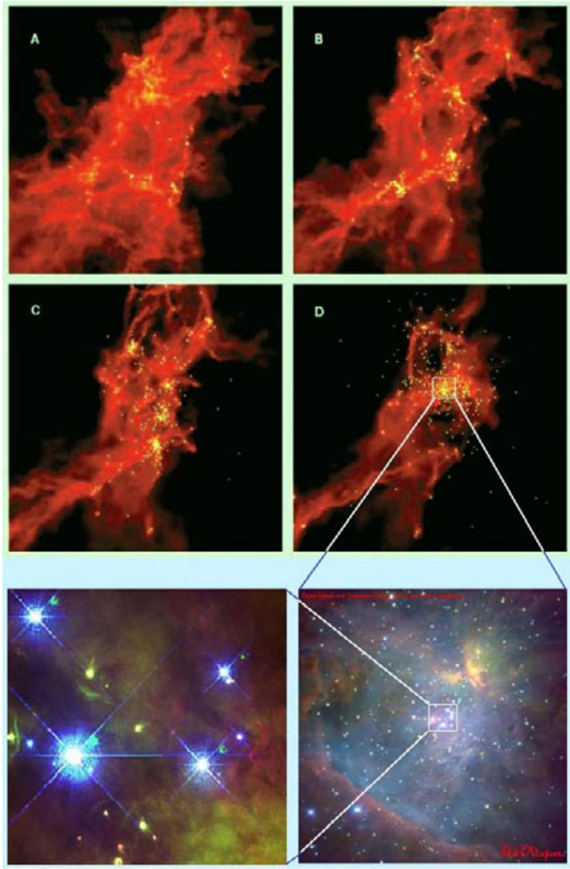

Figure 1. Collapse of a $1000\,M_\odot$ molecular cloud and the hierarchical merging of subclusters (top 4 panels, see text). Comparison with the Orion Trapezium Cluster (bottom 2 panels; left: Orion Trapezium system HST/WFPC2 nb-optical image (Bally *et al.* 1998), right: Orion Trapezium cluster IRTF infrared JKL image (McCaughrean *et al.* 1994)).

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References

Abt, H. A. 1986, *ApJ*, 304, 688
Bally, J. Sutherland, R. S., Devine, D., & Johnstone, D. 1998, *AJ*, 116, 293
Bonnell, I. A. & Davies, M. B. 1998, *MNRAS*, 295, 691
Bonnell, I. A., Bate, M. R., & Vine St., G. 2003, *MNRAS*, 343, 413
de Wit, W. J., Testi, L., Palla, F., & Zinnecker, H. 2005, *A&A*, 437, 247
García, B. & Mermilliod, J. C. 2001, *A&A*, 368, 122
Lada, C. J. & Lada, E. A. 2003, *Ann. Rev. A&A*, 41, 57
McCaughrean, M. J., Zinnecker, H., & Rayner, J. T. 1994, *ASSL*, 190, 13
McMillan, S. L. W., Vesperini, E., & Portegies Zwart, S. F. 2007, *ApJ*, 655, L45
Zinnecker, H. 1986, IAU Symp. 116, 271
Zinnecker, H., McCaughrean, M. J., & Wilking, B. A. 1993, In: *Protostars and Planets III*, pp. 429
Zinnecker, H. & Yorke, H. W. 2007, *Ann. Rev. A&A*, 45, 481, arXiv:0707.1279 (astro-ph)