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Binary Stars in the Orion Nebula Cluster

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Abstract. We report on a high-spatial-resolution survey for binary stars in the periphery of the Orion Nebula Cluster, at 5–15 arcmin (0.65 – 2 pc) from the cluster center. We observed 228 stars with adaptive optics systems, in order to find companions at separations of 0.13 – 1.12 arcsec (60 – 500 AU), and detected 13 new binaries. Combined with the results of Petr (1998), we have a sample of 275 objects, about half of which have masses from the literature and high probabilities to be cluster members. We used an improved method to derive the completeness limits of the observations, which takes into account the elongated point spread function of stars at relatively large distances from the adaptive optics guide star. The multiplicity of stars with masses $>2\,M_\odot$ is found to be significantly larger than that of low-mass stars. The companion star frequency of low-mass stars is comparable to that of main-sequence M-dwarfs, less than half that of solar-type main-sequence stars, and 3.5 to 5 times lower than in the Taurus-Auriga and Scorpius-Centaurus star-forming regions. We find the binary frequency of low-mass stars in the periphery of the cluster to be the same or only slightly higher than for stars in the cluster core ($< 3'$ from θ^1C Ori). This is in contrast to the prediction of the theory that the low binary frequency in the cluster is caused by the disruption of binaries due to dynamical interactions. There are two ways out of this dilemma: Either the initial binary frequency in the Orion Nebula Cluster was lower than in Taurus-Auriga, or the Orion Nebula Cluster was originally much denser and dynamically more active. A detailed report of this work has been published in *Astronomy & Astrophysics* (Köhler *et al.* 2006).

Keywords. techniques: high angular resolution, binaries: close, stars: formation, stars: pre–main-sequence open clusters and associations: individual (Orion Nebula Cluster)

1. Introduction

Stellar multiplicity is very high among young low-mass stars, with companion star frequencies close to 100 % for young stars in well-known nearby star-forming T associations like Taurus-Auriga (Leinert *et al.* 1993, Ghez *et al.* 1993, Ghez *et al.* 1997, Duchêne 1999). On the other hand, high binary frequencies are *not* observed among low-mass stars in stellar clusters like the Orion Nebula Cluster (e.g., Prosser *et al.* 1994, Padgett *et al.* 1997, Petr *et al.* 1998, Petr 1998, Simon *et al.* 1999, Scally *et al.* 1999, McCaughrean 2001). The reason for this discrepancy is still unclear. Theoretical explanations include:

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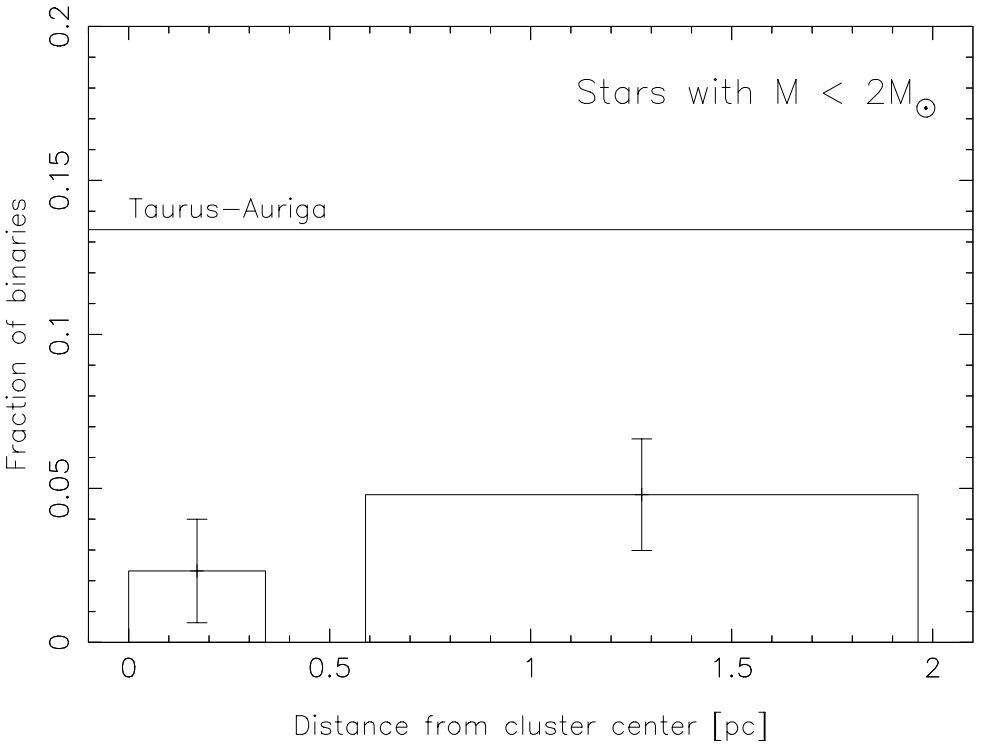

Figure 1. The binary frequency of low-mass stars ($M<2M_{\odot}$) in the center and the periphery of the Orion Nebula Cluster.

• Binaries are destroyed in close encounters with other stars (e.g., Kroupa 1995, Kroupa *et al.* 1999)

• The formation rate of binaries depends on the precollapse cloud conditions (e.g., temperature) (Durisen & Sterzik 1994, Sterzik *et al.* 2003)

The interaction time scale depends on the stellar density, so less binaries should be destroyed in the outer parts of the cluster.

2. Observations and Results

Our target list comprises some 230 stars in 52 fields, located at $5' - 15'$ (0.7 – 2 pc) from the cluster center. The adaptive optics systems at the 3.6-m telescope on La Silla and the Keck Telescope on Mauna Kea were used to observe them in the K-band. We found 13 companions in the separation range $0''.13 - 1''.12$ (60 – 500 AU). For comparison, we use the sample by Petr (1998), which contains 114 stars in the cluster core ($<3'$ or 0.4 pc from the center). We find the binary frequency of low-mass stars in the periphery of the cluster to be only slightly higher than in the core. In particular, the binary frequency in the periphery is significantly lower than in Taurus–Auriga.

3. Conclusions

We find no statistically significant difference of the binary frequency of low-mass stars between core and periphery. These results do not support the hypothesis that the binary frequency in Orion was initially as high as in Taurus and later reduced by dynamical interactions, unless the Orion Nebula Cluster was much denser in the past.

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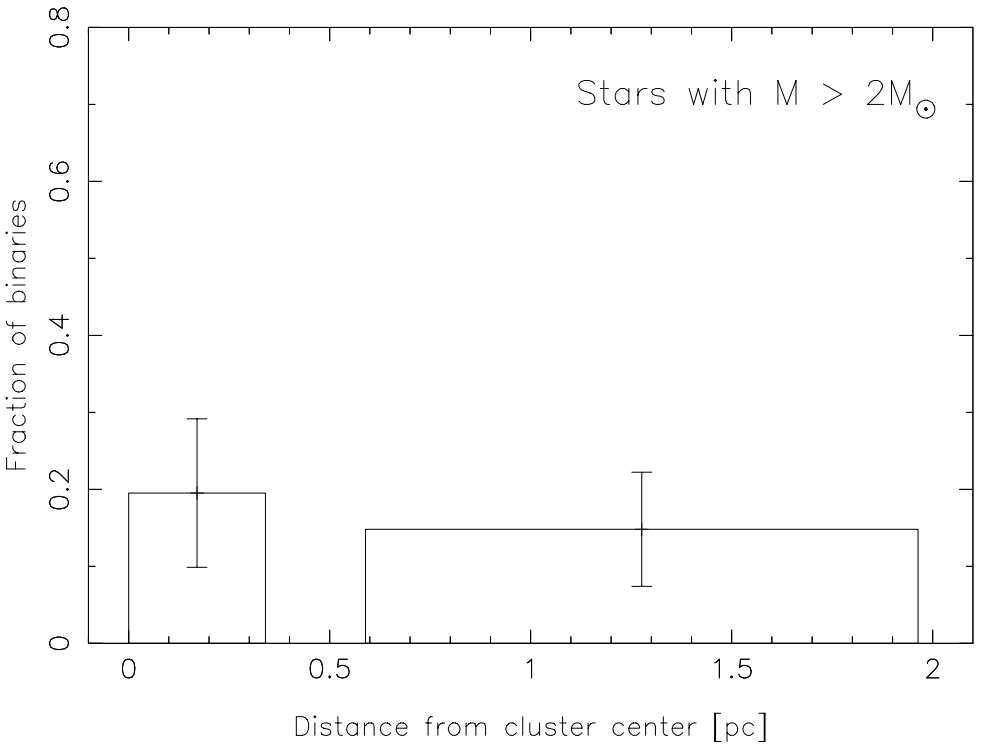

Figure 2. The binary frequency of intermediate- to high-mass stars ($M>2M_{\odot}$) in the center and the periphery of the Orion Nebula Cluster.

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