A Giant Step: from Milli- to Micro-arcsecond Astrometry
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Mass segregation effects in very young open clusters

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Abstract. We derived proper motions and membership probabilities of stars in the regions of two very young ($\sim 2-4$ Myr-old) open clusters NGC 2244 and NGC 6530. Both clusters show clear evidence of mass segregation, which provides strong support for the suggestion that the observed mass segregation is – at least partially – due to the way in which star formation has proceeded in these complex star-forming regions ("primordial" mass segregation).

Keywords. open clusters and associations: general, open clusters and associations: individual (NGC2244), open clusters and associations: individual (NGC6530)

1. Introduction

Open clusters are important stellar systems for understanding star formation processes. One of the important aspects in open cluster studies is related to the effect of mass segregation. In some previous work on young open clusters, including the Orion Nebula Cluster (Hillenbrand 1997) and R136 (e.g. Campbell *et al.*1992, Brandl *et al.* 1996) the authors found evidences for mass segregation. However, the question is, for such young star clusters, whether this effect is mainly the result of dynamical evolution or possibly primordial in nature.

In the present work (see Chen *et al.* (2007) for details), based on photographic plate material with longer time baselines than the published previously, we determined proper motions and membership probabilities of stars in the regions of two young open clusters NGC 2244 and NGC 6530, both with ages younger than 5 Myr. Furthermore, we investigate the possible effects of mass segregation in these very young open clusters. The observed spatial mass segregation might be due to a combined effect of initial conditions and relaxation process.

2. Mass segregation in NGC 2244 and NGC 6530

The observational data are from the historical photographic plates taken by the 40cm double astrograph with focal length of 6.9m at Sheshan Station of Shanghai Astronomical Observatory, Chinese Academy of Sciences. The observational time baseline is 34 and 87 years for open cluster NGC 2244 and NGC 6530, respectively. From this photographic data, for each cluster, we determined the proper motion of stars (495 stars in NGC 2244 and 364 stars in NGC 6530) in a one square degree area centered on the cluster, and estimated their membership probabilities using a maximum likelihood principle(Wang 1997, Zhao & He 1987).

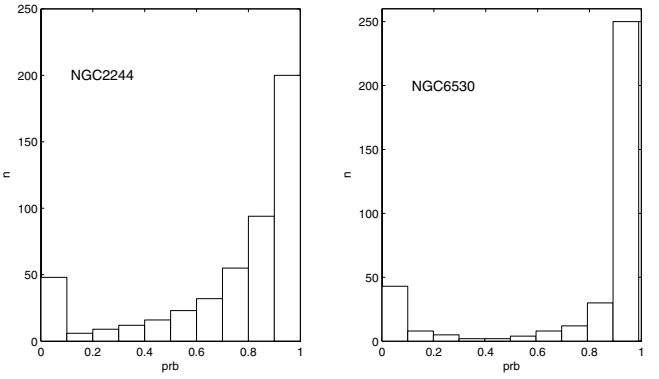

Figure 1. Histogram of the stellar membership probabilities. *Left panel:* 495 stars in the region of NGC 2244; *Right panel:* 364 stars in region of NGC 6530.

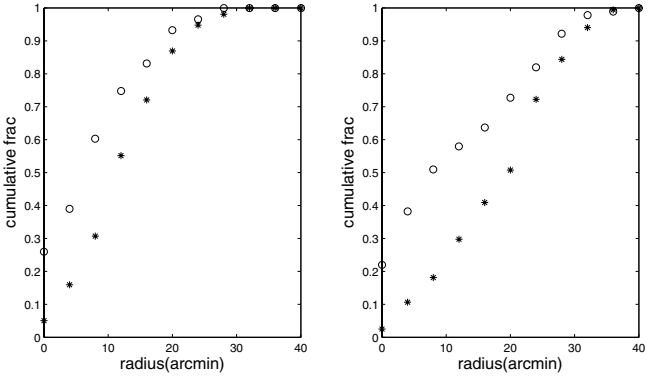

Figure 2. Normalized cumulative radial number density profile for members of NGC 2244 (left) with $m_B \leqslant 13$ (o) and $m_B > 13$ (∗) and NGC 6530 (right) with $m_B \leqslant 12$ (o) and $m_B > 12$ (∗). Results from Chen *et al.* (2007)

Figure 1 shows the histogram of membership probabilities for NGC 2244 (left) and NGC 6530 (right). From this figure one can deduce that the discrimination of membership for NGC 2244 is quite effective. Of the total of 495 stars, about 16%, or 78 stars, have probabilities in the range of $0.3 < p < 0.7$. For NGC 6530, the separation of members from the field stars is even more effective, with only a few stars having probabilities around $p = 0.5$, i.e., only 4.4% (or 16 stars) have $0.3 < p < 0.7$; 451 stars have $p \geqslant 0.9$.

Since the cluster stars are located at the same distance, and because most of them are main sequence stars, we can use luminosity instead of mass to study the (mass/luminosity) segregation effects.

To examine the mass segregation effects, we investigated the radial density distributions of member stars ($p \geqslant 0.9$) in different luminosity ranges which are shown in Fig. 2 (left for NGC 2244 and right for NGC 6530). In each cluster, a position-dependent LF is found. In essence, brighter (or massive) stars are more concentrated towards the inner part in both of the clusters. This indicates an evident luminosity or mass segregation effect.

We conclude that both open clusters, NGC 6530 and NGC 2244, show clear evidence of mass (luminosity) segregation. These two clusters were too young for this to have only been caused by dynamical relaxation processes, and the observed segregation might be due to a combination of both initial conditions and dynamical evolutions. Therefore, our

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results are supporting the "primordial mass segregation" scenarios, such as the "competitive accretion" model. (see Larson 1991, Bonnell *et al.* 2001a, Bonnell *et al.* 2001b)

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