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Tidal Radii and Masses of Galactic Open Clusters

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Abstract. For 236 of 650 Galactic open clusters identified in the ASCC-2.5 catalogue, we determine tidal radii from a three-parameter fit of King's profiles to the observed integrated density distribution of cluster members. The results are used to calibrate the observed sizes of the remaining clusters to a uniform scale of tidal radii of open clusters in the Solar neighbourhood. The tidal masses are computed from tidal radii. Within a distance of 850 pc where our sample is complete, the observed distributions of cluster masses can be explained by a general mass loss in open clusters with increasing age.

Keywords. open clusters and associations: general, Galaxy: kinematics and dynamics

1. Data and methods

For the determination of tidal radii of open clusters, we used the homogeneous set of cluster parameters derived for 650 open clusters with reliable membership based on data of the ASCC-2.5 catalogue (for more details see Röser *et al.*, this volume). For each cluster, we constructed integrated density profiles of cluster members corrected for the background. The profiles were fitted with three-parameter King's profiles in the integrated form

$$n(r) = \pi\, r_c^2 k \left\{ \ln[1 + (r/r_c)^2] - 4\frac{\left[1 + (r/r_c)^2\right]^{1/2} - 1}{\left[1 + (r_t/r_c)^2\right]^{1/2}} + \frac{(r/r_c)^2}{1 + (r_t/r_c)^2} \right\} \tag{1.1}$$

where $n(r)$ is the number of stars within a circle of radius r, and r_c, r_t, k are the unknowns i.e., core radius, tidal radius, and normalization factor, respectively. As a result, we obtained King's parameters together with their *rms* errors for 236 open clusters of our sample (Piskunov *et al.* 2007).

Since King's method assumes spherical systems, we checked whether ellipticity of open clusters can impact the determination of tidal radii. We found that the orientation of clusters in the Galaxy is random and the average ellipticity is too small to produce a prominent systematic bias. We also checked if a distance dependent bias is present. To estimate the effect, we constructed a semi-empirical model of clusters based on apparent luminosity functions of cluster members and field stars. "Moving" clusters away from the Sun, we found that, on average, the standard approach produces smaller tidal radii with increasing distance. The original tidal radii were corrected for this bias.

The subsample of 236 clusters with tidal radii obtained with the King model is not complete to a given distance from the Sun. A relation between the measured tidal radii

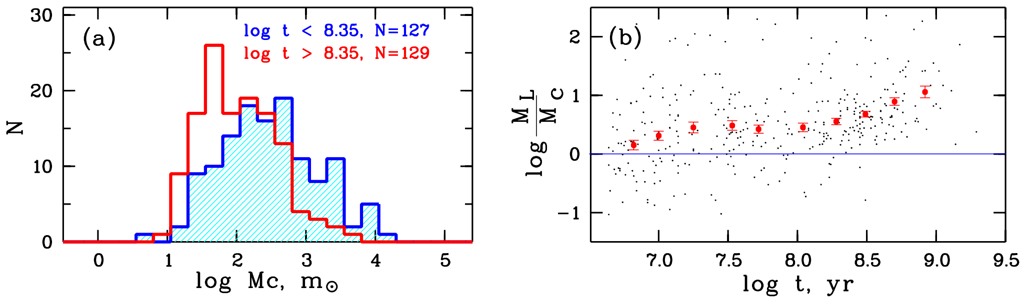

Figure 1. Masses of open clusters. **(a)**: Distribution of tidal masses of 256 open clusters within a distance of 850 pc. The hatched histogram is for clusters younger than 225 Myr, open – for clusters older than 225 Myr. **(b)**: Comparison of the tidal masses M_c with masses M_L by Lamers *et al.* 2005. Large circles with error bars indicate a running average of $\log M_L/M_c$ with a ($\log t$)-bin of 0.5 and a step of 0.25.

r_t^m and the semi-major axis of the projected distribution of cluster members of 236 clusters was used to compute calibrated tidal radii r_t^c for all 650 clusters. No systematic differences were found between r_t^m and r_t^c depending on cluster distances or ages.

2. Tidal masses of open clusters

For each cluster, the tidal mass M_c was computed from the tidal radius as

$$M_c = \frac{4\,A\,(A-B)\,r_t^3}{G} \tag{2.1}$$

where A, B are Oort's constants valid at the galactocentric distance of the cluster, and G is the gravitational constant.

Within a distance of 850 pc where our sample is complete, about 70% of the clusters have masses $log(M_c/M_\odot)$ between 1.5 and 2.8. However, the mass distributions of clusters younger and older than 225 Myr show significant differences (Fig. 1a). The asymmetric shape and shift of the histogram of the older group indicate a general mass loss in open clusters with increasing age. On average, the dependence of tidal masses from the cluster age can be expressed as $\log M_c = (-0.34 \pm 0.07) \times (\log t - 6) + (2.99 \pm 0.15)$.

A hint at MF evolution in open clusters is also obtained from a comparison of our tidal masses with mass estimates M_L based on star counts (Lamers *et al.* 2005). M_L were derived by extrapolation of the normalized Salpeter IMF to low mass stars down to $0.15\,m_\odot$. Both mass estimates are in agreement for the youngest clusters where dynamical evolution had no time to change the IMF (Fig. 1b). However, at $\log t > 7.25$ the difference becomes significant. This indicates that, already in relatively young clusters, the actual MF differs from the Salpeter IMF, and the difference is increasing with cluster age.

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