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The age distribution of open clusters as a function of Trumpler's classifications

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Abstract. The age distribution of open clusters has been obtained as a function of Trumpler's central concentration and range in brightness classes. It is concluded that the observed age distribution of open clusters for different Trumpler's classes within 1 kpc is not seriously affected by the selection effects. On the assumption that the rate of formation of clusters is constant, the lifetime of the clusters have been obtained. It is found that the lifetime decreases systematically from 1.3×10^8 yr to 0.5×10^8 yr. The lifetimes obtained for classes 1, 2 and 3 according to a range in the brightness of the clusters, are 2.3×10^8 yr, 1.3×10^8 yr and 1.0×10^8 yr respectively. It is found that the rich clusters have a relatively higher central concentration than the medium and poor clusters.

Key words : open clusters—cluster lifetime

1. Introduction

Typical lifetime of an open cluster is rather short compared to the age of the Galaxy, but there exists a wide spread in the individual lifetimes. The observed age distribution of an open cluster can be explained on the basis of dynamical dissolution of the clusters. Trumpler (1930) has classified open clusters on the basis of three parameters namely central concentration, range in brightness of cluster members, and the number of stars in clusters. Janes & Adler (1982) and Pandey & Mahra (1986) have obtained the lifetimes of clusters of different richness classes. Pandey, Bhatt & Mahra (1987) have also obtained the lifetimes of the open cluster as a function of their linear diameters. The linear diameters of open clusters vary considerably from 2 to 16 pc depending on the constitution of the cluster (Trumpler 1930). The classification of Trumpler's concentration class and mass spectrum i.e. the magnitude range of cluster members is of importance for the study of the law governing the constitution and evolution of star clusters and consequently the galactic structure. Trumpler has pointed out that the concentration of cluster members also depends on the richness of the cluster. Prata's

(1971) theoretical study has suggested that the lifetimes of open clusters would depend on the cluster structure. We have therefore quantitatively investigated the lifetimes of open clusters as a function of Trumpler's concentration class and range in brightness of the cluster members.

2. Observational data and age statistics

We have taken the cluster ages, Trumpler's concentration class and range in brightness from the catalogue prepared by Lynga (1983). Trumpler (1930) has classified the open clusters into four categories (I, II, III, and IV) in order of decreasing degree of their central concentration. Further in each of the four main groups of clusters three subdivisions were made according to the range in brightness of the cluster members designated by 1, 2 and 3 for nearly the same, medium range, and wide range in magnitude of the cluster members respectively.

On the basis of Kolmogorov-Smirnov test it is concluded that the age distributions of the open clusters for different Trumpler's concentration and range in brightness classes within 1000 pc does not seem to be affected by selection effects (Wielen 1971; Pandey & Mahra 1986). Assuming a constant rate of formation of clusters, we have deduced statistical information about the total lifetimes of open clusters from the observed age distribution of clusters within 1000 pc. We have excluded the clusters having age less than 10^7 yr since the very young clusters are less stable than normal open clusters.

The age distribution of open clusters for various Trumpler's classes according to central concentration and range in brightness of cluster members has been statistically deduced from the observed frequency $\nu(\tau)$ of the clusters. The resulting frequencies $\nu(\tau) = \Delta n/\Delta\tau$ of clusters within 1000 pc as a function of age for various concentration classes and for different range in brightness classes have been tabulated in tables 1 and 2 respectively.

Table 1. Age distribution of open clusters within 1000 pc for different Trumpler's concentration classes

Trumpler's class	Frequency $\nu(\tau)$ in the interval of log τ						
	7.0–7.59	7.6–7.99	8.0–8.39	8.4–8.79	8.8–9.19	9.2–9.59	9.6–9.99
I	10.0	8.3	4.0	0.53	0.11	0.13	0.033
II	17.8*		6.0	2.40	0.63	0.04	0.02
III	20.0	8.3	6.0	2.11	0.53	—	—
IV	10.0	3.3	2.0	0.26	—	—	—

*The interval here is larger because of insufficient cluster data.

3. Total lifetime

The total lifetime of a cluster is the period between its formation and total disintegration. The percentage of clusters $P(\tau)$ which will reach the age τ has been obtained using the relation (Wielen 1971)

$$\nu(\tau) = \nu(0)\, P(\tau),$$

where $\nu(0)$ is the initial frequency of the clusters. The relation between $P(\tau)$ and age τ for different concentration and range in brightness classes are given in figures 1 and 2 respectively. Using Kolmogorov-Smirnov test it is found that at 90% confidence level the $P(\tau)$ distribution for different Trumpler's classes are

Table 2. Age distribution of open clusters within 1000 pc for different Trumpler's range in brightness classes

Trumpler's class	Frequency $\nu(\tau)$ in the interval of log τ						
	7.0–7.59	7.6–7.99	8.0–8.39	8.4–8.79	8.8–8.19	9.2–9.59	9.6–9.99
1	3.0	3.0	2.0	1.1	0.1	0.04	—
2	17.0	12.0	9.0	1.8	0.95	0.13	0.03
3	30.0	23.0	7.0	1.8	0.21	0.01	—

Table 3. Lifetime as a function of Trumpler's classes.

Trumpler's class		log $\tau_{1/2}$	$\tau_{1/2} \div 10^8$ yr
Concentration class	I	8.12 ± 0.04	1.3
	II	8.05 ± 0.04	1.1
	III	7.85 ± 0.04	0.7
	IV	7.72 ± 0.04	0.5
Range in brightness class	1	8.36 ± 0.04	2.3
	2	8.12 ± 0.04	1.3
	3	8.00 ± 0.04	1.0

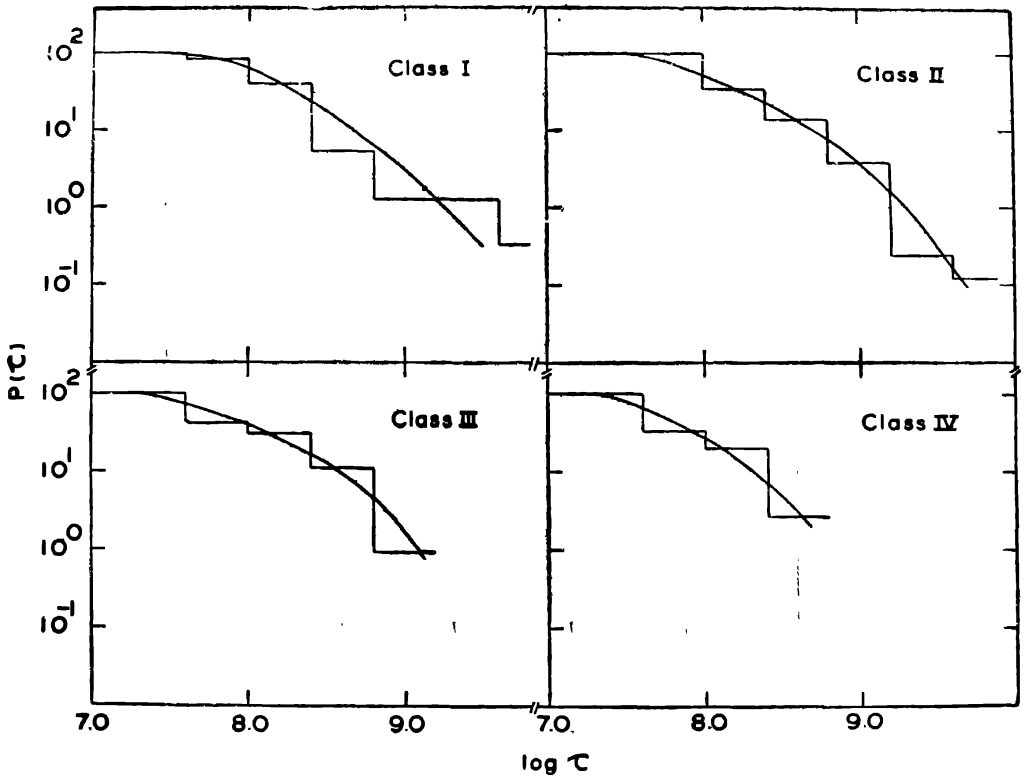

Figure 1. The relation between $P(\tau)$ and age τ for different concentration classes,

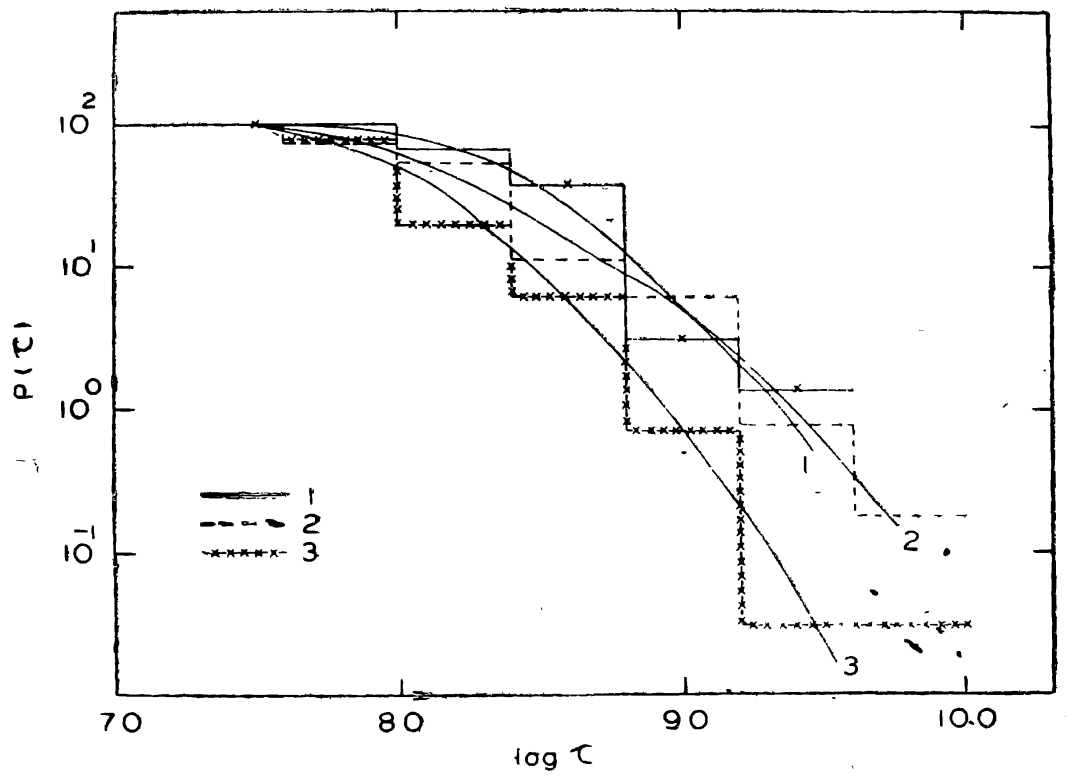

Figure 2. The relation between $P(\tau)$ and age τ for different range in brightness classes.

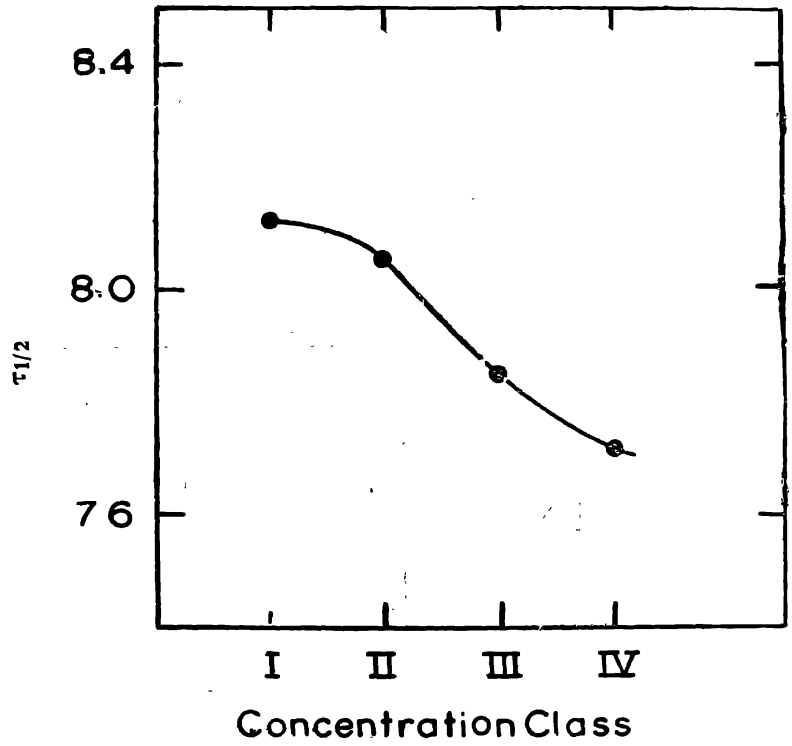

Figure 3. Lifetime $\tau_{1/2}$ as a function of different concentration classes.

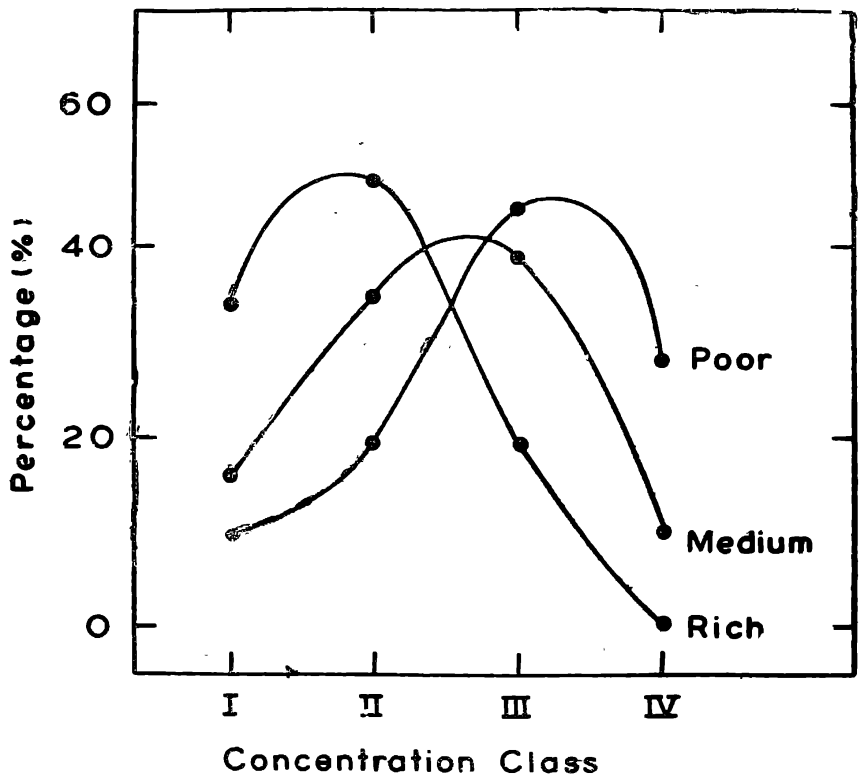

Figure 4. A plot of percentage of clusters against concentration class for different richness classes.

significantly different except the two distributions for concentration classes I and II.

The lifetimes $\tau_{1/2}$ defined as the time in which 50% of the total clusters in the sample shall be disintegrated, for different Trumpler's classes obtained from figure 1 and figure 2, are tabulated in table 2. An average error in the determination log $\tau_{1/2}$ has been estimated to be $\pm$ 0.04. The $\tau_{1/2}$ values decrease systematically with the range in brightness class. The variation of $\tau_{1/2}$ with the central concentration class is shown in figure 3 and it is concluded that the lifetime decreases systematically from 1.3×10^8 yr to 0.5×10^8 yr with the central concentration class. Janes *et al.* (1988) have found a longevity of about 1.0×10^8 yr for the bound open clusters. Mathieu (1986) has shown from direct radial velocity measurements that some well known very young clusters are in fact unbound and have a wide range in brightness of cluster members and these clusters are expected to dissolve in just a few million years. A relatively shorter lifetime of loosely bound clusters has also been pointed out by Prata (1971). Aarseth (1973) has also concluded that the models of somewhat sparse clusters are less stable.

Trumpler (1930) has pointed out that the degree of central concentration and richness of the open clusters are correlated with each other. We have plotted the variation of the percentage of cluster within 1000 pc, with the concentration class for various richness classes in figure 4 and we find that this percentage for various richness classes varies systematically with the central concentration class.

The peak of percentage variations for rich, medium and poor classes occurs between I and II, II and III, III and IV central concentration classes respectively. The most of the rich clusters have higher central concentration than the medium and poor clusters.

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