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Merger and disruption lifetimes of binary star clusters in the Large Magellanic Cloud[1]

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Abstract. We have computed the times of merger due to mutual gravitational interaction and disruption by the tidal field of the LMC and by passing giant molecular clouds of binary star clusters in the Large Magellanic Cloud as a function of separation of the components. As expected, close pairs merge while wide pairs are disrupted by the tidal field and by the passing giant molecular clouds. The total effect of the three processes shows that a pair with a separation of about 15 pc has the maximum probability of survival and the corresponding lifetime is $< 5 \times 10^7$ yr. A comparison with the observed separation histogram shows good agreement.

Key words : galaxy dynamics - binary star clusters - LMC

1. Introduction

The existence of binary star clusters (BCs) in the Large Magellanic Cloud and the Small Magellanic Cloud has been recently established on statistical grounds (Bhatia & Hatzidimitriou 1988; Hatzidimitriou & Bhatia 1989), from the analysis of the structure of NGC 2214 (Bhatia & MacGillivray 1988) and from integrated CCD photometry (Bhatia *et al.* 1989); it is of interest to estimate the dynamical lifetime of BCs with different separations, and to check if it is in agreement with the ages available for some BCs recorded in paper I, where we had indicated that the positions of the pairs recorded correlated well with those of young and very young clusters in the LMC, hence indicating that the BCs are also likely to be young.

The lifetime of a BC depends on the interplay of various forces : (i) disruption by the tidal field of the Large Magellanic Cloud (LMC); (ii) mutual gravitational interaction which usually leads to merger and sometimes to disruption of one of the components; and (iii) disruption by passing giant molecular clouds (GMCs). In this paper we estimate the magnitude of the three effects—as well as the combined effect—as a function of separation of the two components of a BC for different cases. We make a comparison with the observed separation histogram of paper I.

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2. Theoretical background

We have estimated the various time scales as follows : (i) the time of mutual merging t_m from N-body simulations using the NBODY 2 code of S. J. Aarseth; (ii) the time of disruption t_t of the BC due to the tidal field of the LMC by using the observed tidal field (Elson *et al.* 1987) to compute the rate of transfer of energy under the impulsive approximation. The tidal field at a distance of $R \approx 2^\circ$ from the centre of the LMC was used; (iii) the time of disruption t_d by passing GMCs using the formulation developed by Bahcall *et al.* (1985) for the disruption of binary stars.

The total lifetime t_{tot} is given by summing up the three rates:

$$t_{tot}^{-1} = t_m^{-1} + t_t^{-1} + t_d^{-1}.$$

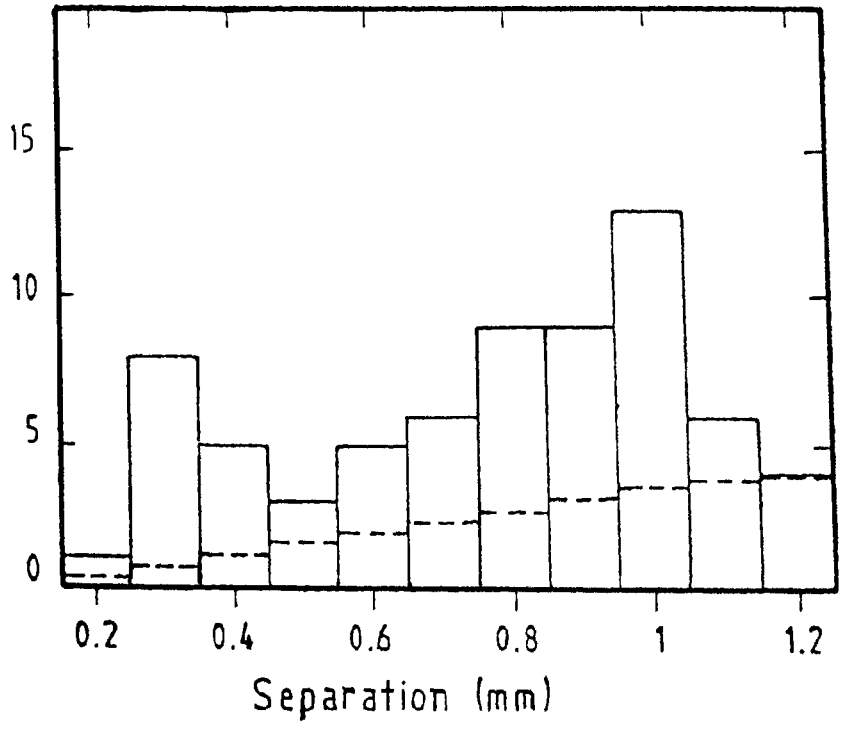

Figure 1. Distribution of the centre-to-centre separation of the parts. Dashed line indicates the number expected from chance line-up.

3. Results and discussion

The observed separation histogram from Bhatia & Hatzidimitriou (1988) is shown in figure 1. Figure 2 displays the computed result from which it is seen that: (i) the total life time of a BC varies from $\sim 10^7$ yr to a maximum of $\sim 5 \times 10^7$ yr, (ii) the peak of the age-separation distribution depends on the the parameters chosen and varies from $\sim$ 10 pc to $\sim$ 19 pc.

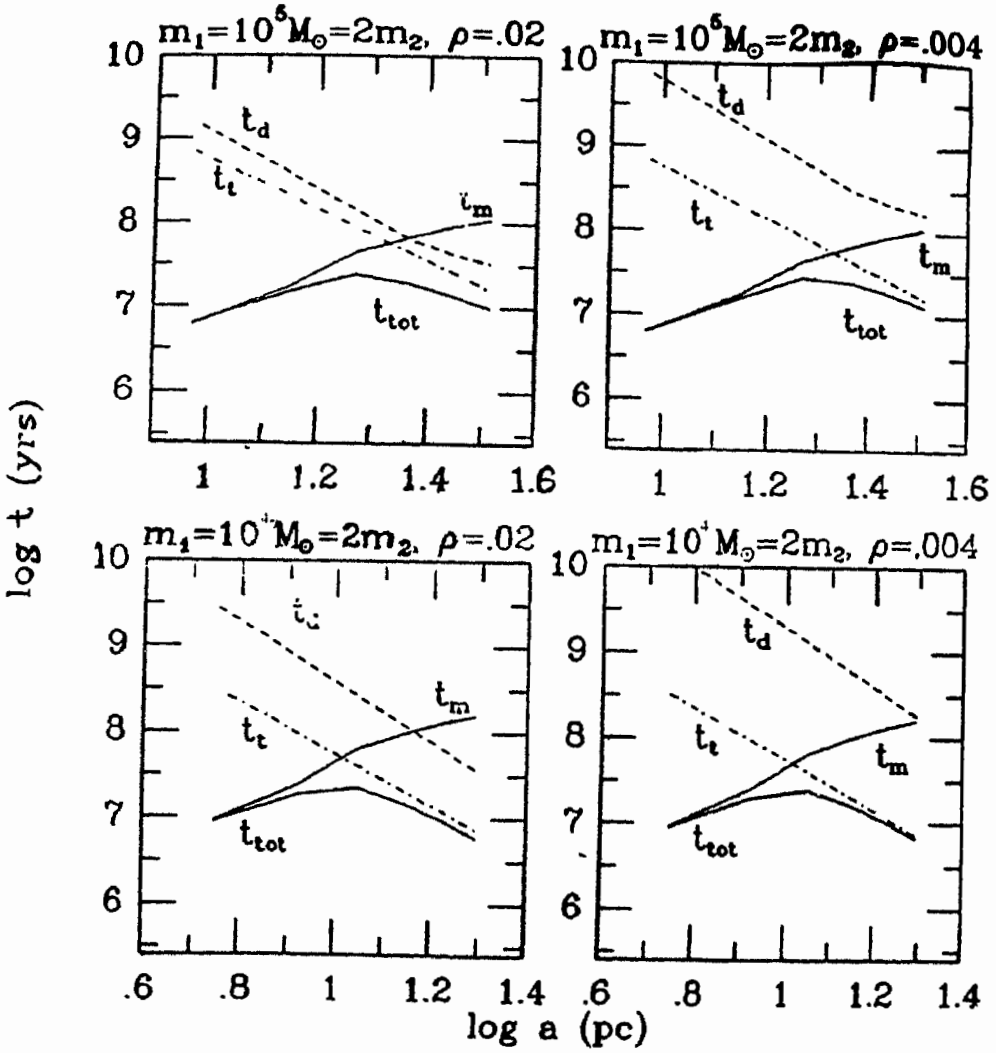

Figure 2. The computed time-scales as a function of separation (for symbols see text) for different masses. ρ gives the assumed density of GMC's in units of $M_\odot/pc^3$.

Comparison of figure 2 with figure 1 shows reasonable agreement regarding the peak of the distribution, which for the observed distribution occurs at ~ 16 pc (for a distance modulus of 18.4 for the LMC). Detailed discussion of the results will be presented elsewhere.

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