SOLAR TYPE CONTACT BINARIES - THE INITIAL MASS RATIO DISTRIBUTION FUNCTION.

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From a study of the mass ratio function of magnetically active contact binaries it is shown that the great majority of newly formed systems must possess nearly equal components.

We define the mass ratio (q) of a binary as the ratio $q = m_2 / m_1 < 1$. The distribution function of the q's is given by what we call the mass ratio function (MRF). The determination of the MRF for contact binaries (CB) is one of the major problems which need to be solved, when we wish to obtain a better knowledge about their formation and evolution. In a previous study (Van 't Veer, 1978) we determined from the best information available for 27 W UMa stars, taking into account observational selection effects, the MRF of solar type CB's. This function which is displayed in fig 1 shows a gradual increase of the observed number of CB's towards the lower mass ratios. We call this function the actually observed or actual mass ratio function (AMRF). It represents the observed result produced by now existing CB's formed at different epochs with possibly different q's, and different physical and dynamical evolution since their formation. Clearly, for our understanding of CB's it is much more interesting to know the distribution function of the q's at the moment of formation. We call this function the initial mass ratio function (IMRF); it represents the mass ratio distribution function of CB's at the very beginning of their existence. It is the aim of this paper to investigate the IMRF by using our results concerning the AMRF and the dynamical evolution of solar type CB's studied earlier in a theoretical paper (Van 't Veer, 1979).

In general this problem may be solved if we possess reliable information about what we call the mass ratio evolution function(MREF). This new function defines the relation between q and time (t) for an arbitrary CB. It may be formulated by the general expression $q = q(t, q_i)$ where q_i is the initial mass ratio the CB had at its time of formation ($t = 0$). The actual mass ratio then becomes $q_a = q(t', q_i)$ where t' is the age of the CB, that means the time necessary for its evolution to q_a. Obviously the knowledge of both the IMRF and the MREF, for every q_i, combined

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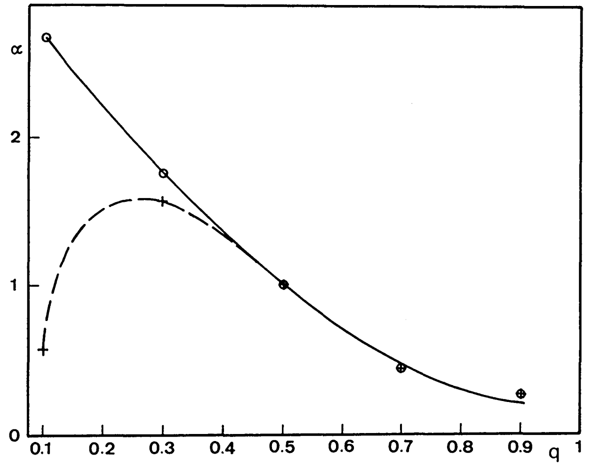

fig. 1 - The mass ratio function of solar type W UMa binaries (solid curve).

with an hypothesis on the rate of formation of CB's permits us to derive the AMRF. However we already know the AMRF and we are trying to investigate the IMRF. So our problem is precisely the inverse and cannot be solved by direct integration. We can, for the moment being, only try to see which IMRF may be considered as the best acceptable in order to give, in combination with a theoretically justified MREF, the observed AMRF. This may be done by an integration procedure we symbolically represent as AMRF = $\int$ (IMRF) (MREF) dt.

We do not enter into the mathematical details of this procedure, which will be published elsewhere, but we need to say some words about the MREF. In the litterature on this subject we find two ways of considering the dynamical evolution of a CB : 1. By using the hypothesis of conservation of angular momentum (AM). Most evolutionary models are based on this principle, 2. By considering the dynamical evolution as controlled by continuous loss of AM. This principle was defended mainly by Huang (1966), Okamoto and Sato (1970) and recently formulated quantitatively by Van 't Veer (1979).

Clearly the first way makes it possible to maintain a CB without changing the q during a very long time. In that case the IMRF may be about the same as the AMRF, that means a high formation rate of low - q CB's. The second way, which seems the more realistic for solar type CB's exhibiting magnetic activity, predicts a gradual but non linear decrease of the q for every synchronized CB, as long as the AM loss continues. The solid curve of fig 2 applies to the case of constant AM loss with time, it clearly shows the general trend of the decrease of q with time (on an arbitrary time scale) with the most rapid changes occuring for high q values (nearly equal components). The function of fig 2 is obtained by calculating the mass transfer $m_2 \rightarrow m_1$ necessary to equilibrate the AM loss of a synchronized CB involved by magnetic activity

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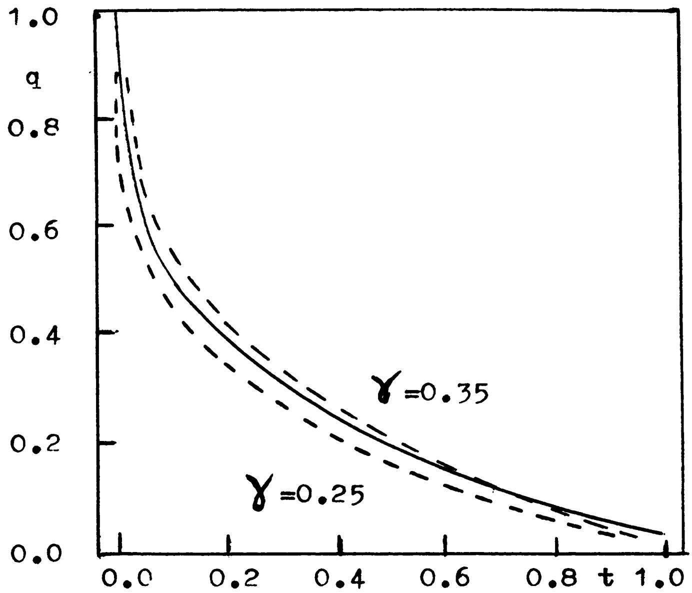

fig. 2 - The MREF of a synchronized CB with constant rate of AM loss.

(see Van 't Veer, 1979 for a detailed discussion of this matter). The general character of the resulting q variation may be given by an expression of the type $q(t) = 1 - t^{\gamma}$. A reasonably good fit is obtained for $0.25 < \gamma < 0.35$. With this theoretically derived MREF in hand we may now try to obtain information about the best IMRF that gives an AMRF compatible with the relation derived from the observational material. We only need to suppose that both the total number of CB's formed, as their frequency distribution are independent of time. So we reasonably consider the formation process of CB's as quantitatively unaltered since at least the birth of the oldest still existing CB.

We are aware of the fact that our development contains some weaknesses (constant loss of AM, discussed below, and lack of precision in our AMRF, which needs to be confirmed by new and more precise observation of q), but it seems nevertheless possible to draw some conclusions which may be briefly summarized as follows : the great majority of newly formed BC's must have high q's with at least 50% of them higher than $q = 0.8$. When we take into account the plausible tendency of a decreasing AM loss rate during the life of a CB, we are forced to admit a still higher production of the high-q CB's with respect to the low-q CB's. This effect may become so important that only the hypothesis of an exclusive production of CB's with equal components may explain the actually observed mass ratio distribution. For the time being however it is difficult to give any information on the change of AM loss rate and we summarize with the tentative conclusion that most, if not all, CB's will begin their life with nearly equal components.

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