MASS LOSS IN ALGOL-TYPE STARS: IMPLICATION ON THEIR EVOLUTIONARY STAGE.

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ABSTRACT

We have examined the observational data of 102 Algols in order to clarify the implications on their evolutionary scenario of various assumptions concerning mass and angular momentum loss during mass transfer. We have found that case B mass exchange is strongly favoured for Algols of relatively low total mass ($\sim M < 7\ M_\odot$), while case A predominates, though not so widely as expected in Algols of higher total mass.

INTRODUCTION

It is now generally recognized that models of non conservative mass transfer, in which mass and orbital angular momentum loss is taken into account, can improve the agreement between theory and observational data of Algols. In order to investigate the effect of the processes of non-conservative mass transfer on the evolutionary status of Algol-type binaries, we have compiled and discussed the values of the total mass, the orbital period and the mass ratios of 102 Algols, as found in the recent literature. We clarify that in this study we mean by Algols a) semidetached (sd) systems whose less massive members filling them Roche lobes are apparently more advanced in evolution, (b) the systems with undersize subgiant components (sd-d systems), regarded as post-main sequence mass exchange cooler remnants, and (c) the early-type contact systems having recently undergone or undergoing mass transfer between the components. In our sample we have also included the best known Wolf-Rayet obiects GP Cep and V444 Cyg, since Wolf-Rayet obiects may be products of mass transfer in very massive binaries. The binaries considered in this study are: TW And, XZ And, RX Aqr, KO Aql, QY Aql, RW Ara, SX Aur, IM Aur, IU Aur, LY Aur, SU Boo, Y Cam, SZ Cam, S Cnc, RZ Cnc, R CMa, CV Car, RZ Cas, SX Cas, TV Cas, TW Cas, U Cep, RS Cep, XX Cep, XY Cep, GP Cep, U CrB, RW CrB, SW Cyg, UZ Cyg, VW Cyg, WW Cyg, ZZ Cyg, KU Cyg, MR Cyg, V444 Cyg,

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V548 Cyg, V729 Cyg, W Del, Z Dra, TW Dra, AI Dra, S Equ, AS Eri, RW Gem, RX Gem, RY Gem, AL Gem, X Gru, u Her, UX Her, AD Her, V338 Her, RX Hya, TT Hya, Y Leo, T LMi, δ Lib, β Lyr, TT Lyr, RW Mon, TU Mon, AR Mon, RV Oph, UU Oph, DN Ori, AQ Peg, AT Peg, AW Peg, DI Peg, β Per, RT Per, RW Per, RY Per, ST Per, DM Per, IZ Per, δ Pic, Y Psc, V Pup, XZ Pup, U Sge, RS Sgr, XZ Sgr, V356 Sgr, V505 Sgr, μ^1 Sco, V453 Sco, RY Sct, RZ Sct, λ Tau, RW Tau, X Tri, TX UMa, VV UMa, W UMi, S Vel, DL Vir, Z Vul, RS Vul, BE Vul, V78 ω Cen.

RESULTS AND DISCUSSION

Extending previous works generally based on the conservative assumption only (Ziółkowski 1976, Kreiner and Ziółkowski 1978), we have evaluated the initial (i.e., prior-mass-exchange) values of the orbital period (Po) and total mass (Mo) of each binary, computed according to the assumption of conservative mass transfer and the non-conservative approaches proposed in the literature (Tutukov,Yungelson, 1971; Plavec et al., 1973; Drobyshevski and Reznikov, 1974; Djakov and Reznikov, 1979; Vanbeveren et al., 1979). The positions of the binaries in the bilogarithmic plots of Po versus Mo-computed according to the above-mentioned approaches - with respect to the lines representing the initial orbital periods for a ZAMS contact system and for the transitions from case A to case B and from case B to case C mass transfer allow us to acquire information on the possible original status and on the evolution of our sample of close binaries.

Keeping in mind that the mass ratio of the main sequence progenitors of Algols is very lively to be near unity (Svechnikov, 1969; Kraicheva et al., 1978; Lucy and Ricco, 1979;Garmany et al., 1980; van't Veer, 1981), we have found that conservative calculations of mass exchange cannot account for the evolutionary scenario of a not negligible fractions (~ 20%) of our binaries (especially those with low total mass and low mass ratio). Besides, a large amount of angular momentum loss (characterized by a ratio between the specific orbital angular momentum of the lost matter and that of the original system equal to 2.5-3.0) is required for bringing the low-mass Algol-type binaries into a consistent picture.

Bearing in mind also the estimates of mass and angular momentum loss provided by Popov's (1970) surveys of statistical observational data of main sequence detached binaries and semidetached systems, we can state that pratically all Algol-type binaries with relatively low total mass ($\lesssim$ 7 M⊙) appear to be case B remnants. On the other hand, regarding systems of higher total mass (roughly M > 7 M⊙), case A mass transfer predominates, though not so widely as expected from comparison of theoretical evolutionary lifetimes.

Our results undoubtedly indicate a strong deficit of binaries

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originating from case A mass exchange. This fact may mean either that during the early stages of mass transfer a contact configuration,with the formations of a deep common envelope preventing the discovery of the binary, occurs more frequently in case A than in case B candidates or that progenitors undergoing case A mass transfer are very rare. This latter view is consistent with Svechnikov's (1969) and Kraicheva et al's 1978) finding that no close binaries with binary separations $A \lesssim 10R_{\odot}$ and primary to masses in the range $1.5 \leq M \leq 10\ M_{\odot}$ are observed (perhaps they cannot form).

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