STATISTICAL PROPERTIES OF ALGOL-TYPE SYSTEMS

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ABSTRACT

We have inspected the observational data of 114 Algol-type binaries in order to clarify some general aspects of their evolutionary scenario. Through a comparison with the corresponding available statistical analyses of large sample of eclipsing and spectroscopic binaries, we have found a larger than normal concentration of low values of masses, binary separations and specific orbital angular momenta for Algol-type stars. Furthemore, high mass ratios predominate in massive and early-type Algol systems, whereas high total masses are generally accompanied by less prominent oversized and overluminous properties of the mass-losing components.

INTRODUCTION

Extending previous investigations on the observational data of Algol-type systems, based on a fairly small sample (Ziolkowski, 1969; Popov, 1970; Stothers, 1973; De Grève and Vanbeveren, 1980; De Grève, 1980), we have attempted a statistical inspection of their properties. To be more precise, we have examined the distribution of the masses, mass ratios, radii, orbital periods, spectral types, luminosities, orbital angular momenta, and binary separations of 114 Algol-type binaries. Although our sample of Algol-type binaries is seriously biased by observational selection effects, a study of the distribution of their properties, compared to the corresponding distribution (already discussed in the literature) for spectroscopic and/or eclipsing binaries as a whole (Kraicheva et al. 1978; Staniucha, 1979; Trimble and Cheung, 1976; Farinella et al. 1979). furnishes information on how some binary parameters vary as mass transfer processes occur. We have considered the following binaries: TW And, XZ And, RY Aql, KO Aql, QY Aql, V337 Aql, V346 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,

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QZ Car, RX Cas, RZ Cas, SX Cas, TV Cas, TW Cas, AB Cas, U Cep, RS Cep, XX Cep, XY Cep, GT Cep, TZ CrA, U CrB, RW CrB, SW Cyg, UZ Cyg, VW Cyg, WW Cyg, ZZ Cyg, KU Cyg, MR Cyg, V448 Cyg, V463 Cyg, 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, μ Her, SZ Her, UX Her, AD Her, V338 Her, RX Hya, TT Hya, Y Leo, T LMi, RS Lep, δ Lib, β Lyr, TT Lyr, RW Mon, TU Mon, AR Mon, AU 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, Y Psc, V Pup, XY 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, HU Tau X Tri, TX UMa, VV UMa, W UMi, RT UMi, S Vel, DL Vir, Z Vul, RS Vul, BE Vul, V78ω Cen.

RESULTS

The values of the masses and radii of the binaries considered have been taken from the literature. The temperatures of the primary components have been evaluated in accordance with the spectral classifications found on the literature, on the basis of the temperature scale presented by Popper (1980). The temperatures of the secondary components have not been generally taken from the literature, which provides quite inhomogeneous (scale-dependent) evaluations; they are instead our own homogeneous average photometric estimates obtained from the primary's temperature adopted and the ratio of the surface brightnesses resulting from lightcurve analyses published in the literature.

The available observational data indicate that several mass-gaining components tend to be oversized (compared to the main sequence) in the mass-radius plane and overluminous in the HR diagram; but these components do not exhibit a tendency toward overluminous properties in the mass-luminosity plane. This behaviour is consistent with the view that these stars are slightly swollen by mass accretion processes, but, at the same time, have luminosities reduced by fast differential rotation brought about by mass exchange.

The larger than normal concentration of low values of masses, binary separations, and specific orbital angular momenta constitutes a strong argument for an appreciable loss of mass and angular momentum in the course of Algol evolution.

In spite of the observational selection effects, which act against the detection of binaries with wide separations and very small mass ratios (and, hence, should lead to a deficiency of such systems), no significant correlation between binary separation and mass ratio is discernible. This probably means that an intrinsic anti-correlation, masked by selection effects, is indeed present in our sample. This is what is expected as a result of mass transfer processes, provided that the loss of angular momentum from Algool binaries is not extremely large.

It is of interest that high mass ratios predominate in massive and early-type Algol systems. Moreover, the larger the total mass of an Algol systems is, the less prominent the oversized and overluminous properties of its mass-losing members, whose spectral types appear to correlate fairly well (especially in the high temperature range) with those of their companions. Large radius and luminosity excesses of the mass-losing members (with respect to main sequence values) have also a tendency to go with long orbital periods. These features are related to the general traits of conservative and quasi-conservative mass transfer theory, since we expect larger final mass ratios and smaller radius and luminosity excesses of the mass-losing components for case A mass exchange remnants (very probably absent in the moderate-mass range) than for case B systems and for binaries less advanced in the final slow phase of mass exchange.

CONCLUSIONS

To summarize the major conclusions of our study, our survey of the properties of Algol-type binaries provides fresh evidence of the important role played by processes of non-conservative mass transfer. Certainly, the simple available models of non-conservative mass transfer (Yungelson, 1971; Drobyshevski and Reznikov, 1974; Vanbeveren et al., 1979), which yield a qualitative scenario fairly similar to the conservative one, give in several cases an improved agreement with the observations - e.g., final orbital periods, secondary radii and luminosities closer to those observed than in the conservative theory are attained. But, unfortunately, these models are so few in number that a detailed confrontation between theory and observations for a large set of binary parameters is barely meaningful. At this point we cannot yet state whether the relaxation of conservative assumptions may be sufficient to give a fully consistent picture of Algol-type binaries. However, optimistic suppositions in this sense seems to be discouraged by the fact that the available non-conservative evolutionary calculations appear to be somewhat inadequate to account for the observed moderate luminosities of the mass - losing components of Algol-type systems.

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