CONTACT BINARY EVOLUTION AND ANGULAR MOMENTUM LOSS

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Some fundamental problems connected with the evolution of W UMa stars are considered. While no generally accepted theory for the evolution of these systems exists, different scenarios lead to single stars on a nuclear or thermal time scale, or even to dwarf novae. The cycling and contact discontinuity models for zero age systems have gained much attention during the last few years. The contact discontinuity hypothesis has been heavily criticized on physical grounds, and the cycling at small mass ratios will probably be too violent leading to overcontact. On the other hand, there is increasing evidence of strong magnetic activity in short period solar type binaries, including W UMa stars (spots, flares, strong chromospheres and coronae etc.). This points to enhanced dynamo action inside rapidly rotating components of solar type close binaries. Extrapolating from single stars one finds that this may efficiently brake the orbital rotation. With an angular momentum loss rate of about 10^{43} g cm^2 s^{-1} per year corresponding to the thermal time scale of the secondary the scenario, where the angular momentum loss controls the zero age contact evolution, seems at least possible. This scenario needs an (hypothetical) equilibrium process between the degree of contact and magnetic activity, damping the angular momentum loss if the contact becomes too thick, so that marginal contact will be preserved. If the angular momentum loss time scale is longer (comparable to the nuclear time scale of the primary), the system is likely to evolve towards more extreme mass ratios and with less violent cycling. (The complete paper will be published elsewhere.)

DISCUSSION

Nariai: Do you take into account spin angular momentum?

Vilhu: Yes. At large values of the mass ratio $q = M_2/M_1$, its effect is negligible; but at very small values ($q < 0.2$), it is essential for very close binaries.

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Roxburgh: I should perhaps caution stellar astronomers who wish to derive the properties of stellar winds from solar type or late type systems by extraporating from the solar wind. We do not know whether the solar corona is heated by acoustic waves or by Joule heating. We do not know how the strength of a dynamo generated by differential rotation depends on the rotational velocity. We do not know how the fraction of the surface of the sun (or star) that has magnetic field lines that open to the interstellar medium depends on the field strength. Our models of the solar wind are based on physical assumptions that are often invalid in the models so derived. At large radii, the solar wind becomes weakly collisional and we do not have an adequate theory of weakly collisional plasmas. We can not explain the observed properties of the solar wind at the earth. Since we can not yet understand and explain the mass loss from the sun, where we have detailed measurements, I must express my reservations about extrapolating from simple models of the solar wind to models of stellar winds.

Vilhu: I agree with you, Ian. I used the Wilson-Skumanich sun-Hyades-Pleiades Ω^3-relation and its extrapolation to high rotational velocities just as an order of magnitude estimate to see what is potentially possible. And this gives for a typical W UMa star $dJ/dt > 10^{44}$ g cm^2 s^{-1} per year. If the true value is much below this, say $\sim 10^{42}$-10^{43} g cm^2 s^{-1}, then it is likely to be one of the dominant factors determining the evolution of these close binaries. There is increasing evidence of period-magnetic activity relations for solar-type close binaries that is even stronger than for single stars (e.g. Ca K-line reversals, Stawikowski and Glebowski 1980), and UV surface fluxes from chromospheres and transition regions (Dupree et al. 1979). For both dynamo theories and evolution of very close binaries, it is important to check and to extend these relations.

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