POSSIBLE PROGENITORS OF SOME NOVA-LIKE VARIABLES

(Abstract)

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Evolution of contact binaries was followed with the help of the modified evolutionary codes by Paczyński (Vilhu, 1973), and based on the concepts of a common convective envelope (Lucy, 1968) and energy exchange between the adiabatic parts (Moss and Whelan, 1970). Similarly as was done by Biermann and Thomas (1973), we do not demand equal specific entropies (equal K-values) for the components. The energy losing component should have a smaller K (higher effective temperature). Many observed W UMa-systems can be explained by models with unequal K-values and small degree of contact (superadiabatic energy exchange) (Whelan *et al.*, 1973). For stability reasons, allowing no entropy differences between the components, Hazlehurst and Meyer-Hofmeister (1973) found a qualitatively different evolution for contact systems. To avoid instabilities for models with unequal K-values, some physical mechanism keeping mass and energy exchanges in equilibrium with the 'degree of contact' must exist. Only a qualitative picture of the possible process can be given (see description by Biermann and Thomas, 1971, and also a discussion after the paper by Hazlehurst and Meyer-Hofmeister, 1971).

When studying the hypothesis that U Geminorum stars are descendants of W UMa-systems (Kraft, 1962), we are faced with the problem of how a white dwarf can be formed in a very close system of small mass (small angular momentum). Only case B evolution, which implies large initial separation (large angular momentum) or very large initial mass ratio, can finally produce white dwarfs of considerable mass ($\gtrsim 0.2\ M_\odot$) (see e.g. Refsdal and Weigert, 1971).

As a rule, case A evolution sooner or later leads to a contact system. Figure 1 illustrates evolution of one possible such a system, starting from two homogeneous main sequence stars ($0.45\ M_\odot + 1.35\ M_\odot$, phase A). At phase B the heavier star fills its Roche lobe when hydrogen is nearly exhausted in its core (X nearly zero up to $M_r = 0.02\ M_\odot$), and a contact system is formed during the rapid phase (phase C). From this point contact evolution is followed, with transfer of mass from the secondary to the primary, and of energy in the opposite direction. Gravitational energy terms were included also in the secondary, showing no essential difference when the secondaries were approximated by thermal equilibrium models. The evolutionary track of the secondary, when energy is pushed into its envelope, turned out to be very sensitive to its hydrogen profile. For the initial parameters used, it moves nearly parallel to its Hayashi-line but, due to its helium-rich envelope, at phase D ($1.635\ M_\odot + 0.165\ M_\odot$) it becomes hotter than the primary, and the energy exchange must stop. Numerically the secondary can be made cooler, and the energy transfer continued, if part of the

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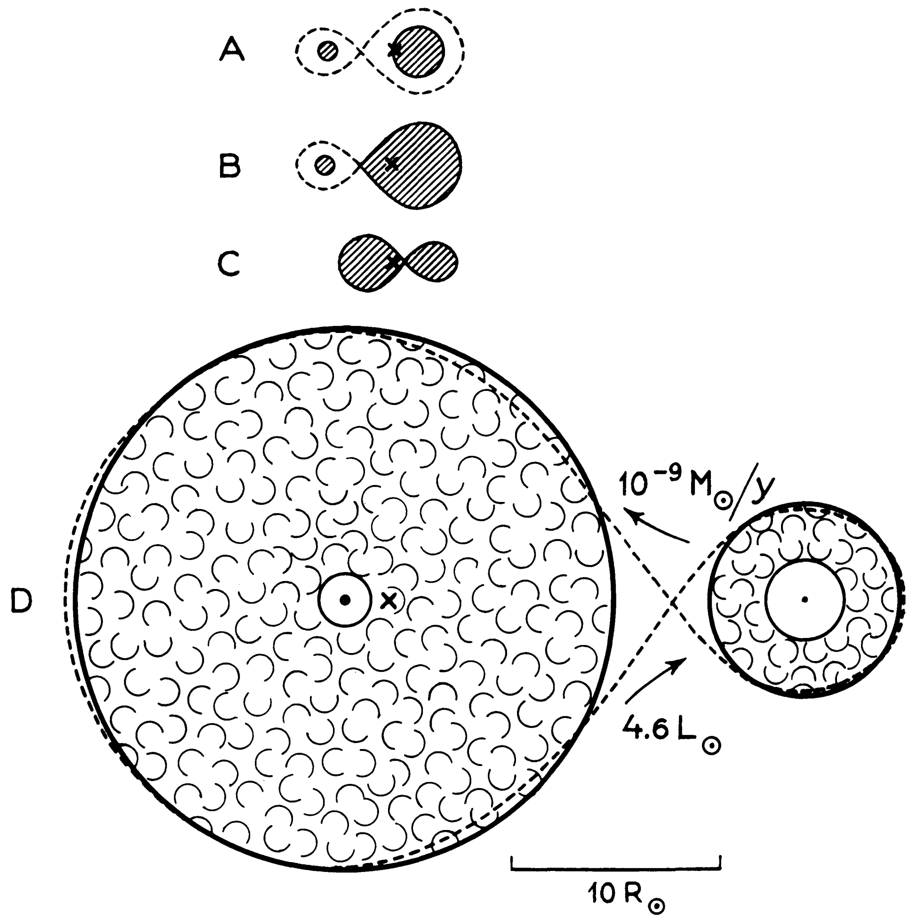

Fig. 1.

energy exchange is assumed to take place at the border of the radiative core and convective envelope, which assumption seems to be quite artificial. At phase D, however, the primary already has a considerably large helium-core of 0.24 $M_\odot$.

Starting from two homogeneous stars in contact (the models by Biermann and Thomas, 1973; the systems 1 and 2 by Vilhu, 1973), a final set-up illustrated as phase C may also be reached, although the time-scale considerations by Biermann and Thomas (1973) do not seem to favour this. This question is important in deciding whether also models for W UMa-stars (nearly homogeneous and contact systems) evolve in the manner illustrated.

After phase D only a qualitative picture of the further evolution can be given. Mass and angular momentum loss seem to be necessary, and finally the system may resemble an U Geminorum star consisting of a white dwarf (0.24 $M_\odot$), and a post main sequence star of nearly the same mass filling up its Roche lobe. Surprisingly, both

W UMa- and U Gem-systems seem to obey the same relation between angular momentum and total mass ($J \propto M_{\text{tot}}^{5/3}$), which may be partly due to the definition and partly to the fact that a nearly main sequence star fills its Roche lobe.

The validity of the above evolutionary picture should be critically studied. It remains also to be solved how a still bigger ($\approx 0.5\ M_{\odot}$) helium-core can be formed, and what initial parameters lead to the evolutionary scheme described.

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