The Evolution of a Contact Binary

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Test calculations have been made to study the effects of central hydrogen depletion, luminosity exchange and mass exchange on the evolution of a contact binary. The Munich Henyey programme was adapted to allow the study of both components in a time-dependent way.

The first model considered was that of LUCY (Ap. J. 151, 1126) in which entropy is assumed to be at all times uniform throughout the adiabatic portion of a common convective envelope. This model was found to be unstable, in the sense that mass flows from the primary to the secondary in a time short compared with the nuclear time-scale.

Mass exchange on a nuclear time-scale could be achieved by departing from the LUCY condition and allowing an entropy difference to develop between the components. Such an entropy difference is however incompatible with Von Zeipel's theorem as applied to contact configurations, at any rate for those in hydrostatic equilibrium.

However, slow convective or circulatory motions between the components are to be expected in practice. These would be compatible with the existence of a very small, but finite entropy gradient within the common envelope. Models in which the entropies of the deep convective layers were *very nearly equal* were therefore studied. For these the mass exchange was found to occur in a time intermediate between the thermal time-scale and the nuclear time-scale.

For a 1.5 $M_\odot$ / 1.1 $M_\odot$ system of this type, the mass transfer occurred in a time of 2×10^8 yrs, the primary's surface cooling with respect to the secondary's surface at a fairly slow rate, due to the mass transfer. A further consequence of this mass transfer is that an effectively age-zero system will undergo a moderate displacement in the period-colour diagram, even though very little hydrogen depletion has occurred in either component.

Discussion to the paper of HAZLEHURST and MEYER-HOFMEISTER

SMAK: A stupid question: Is it obvious that the primary component — due to the evolutionary expansion — will transfer its mass to the secondary, thus causing both Roche lobes to shrink and making the situation worse? Apart from the physics involved, would it not be the smarter for the primary to collect mass from the secondary trying in that way to avoid overflowing the Roche lobe?

HAZLEHURST: No — it is not true that the size of the Roche lobes is the important quantity. What matters is the *relative* size of the Roche lobe of the primary with respect to that of the secondary. To first order this does not depend on the separation of the components.

KIPPENHAHN: Could Drs. HAZLEHURST and THOMAS explain to us in a few words what their two methods to construct contact systems have in common and where they differ?

THOMAS: To construct zero age contact systems we both use energy exchange to obtain the radii which will allow both stars to fill their Roche lobes. In addition to that Dr. HAZLEHURST only takes those solutions, where there is no difference in entropy in the outer convective zone, which can be achieved for certain masses of both stars only while with our method any two masses (with convective envelopes) can be brought in contact.

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