A GENTLE PROCESS FOR THE FORMATION OF ALGOLS

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ABSTRACT. This work is concerned with binary systems that we call 'moderately close'. These are systems in which the primary (by which we mean the initially more massive star) fills its Roche lobe when it is on the giant branch with a deep convective envelope but before helium ignition (late case B). We find that if the mass ratio $q(= M_1/M_2) < q_{crit} = 0.7$ when the primary fills its Roche lobe positive feedback will lead to a rapid hydrodynamic phase of mass transfer which will probably lead to common envelope evolution and thence to either coalescence or possibly to a close binary in a planetary nebula. Although most Algols have probably filled their Roche lobes before evolving off the main-sequence we find that some could not have and are therefore 'moderately close'. Since rapid overflow is unlikely to lead to an Algol-like system there must be some way of avoiding it. The most likely possibility is that the primary can lose sufficient mass to reduce q below q_{crit} before overflow begins. Ordinary mass loss rates are insufficient but evidence that enhanced mass loss does take place is provided by RS CVn systems that have inverted mass ratios but have not yet begun mass transfer. We postulate that the cause of enhanced mass loss lies in the heating of the corona by by magnetic fields maintained by an $\alpha - \omega$ dynamo which is enhanced by tidal effects associated with corotation. In order to model the the effects of enhanced mass loss we ignore the details and adopt an empirical approach calibrating a simple formula with the RS CVn system Z Her. Using further empirical relations (deduced from detailed stellar models) that describe the evolution of red giants we have investigated the effect on a large number of systems of various initial mass ratios and periods. These are notable in that some systems can now enter a much gentler Algol-like overflow phase and others are prevented from transferring mass altogether. We have also investigated the effects of enhanced angular momentum loss induced by corotation of the wind in the strong magnetic fields and consider this in relation to observed period changes. We find that a typical 'moderately close' Algol-like system evolves through an RS CVn like system and then possibly a symbiotic state before becoming an Algol and then goes on through a red giant-white dwarf state which may become symbiotic before ending up as a double white dwarf system in either a close or wide orbit depending on how much mass is lost before the secondary fills its Roche lobe.

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