SOME THOUGHTS ON INTERACTING BINARY SYSTEMS

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ABSTRACT

I present here some thoughts on the theory and observation of interacting binary systems. The complex physical processes possible in these systems make our present understanding inconclusive. New types of observation (X-ray, EUV, radio) present new challenges to the theoretician. I discuss here those problems which seem to me to hold the most promise for future progress and relate the papers in this conference to these problems.

The interacting binary systems as a class have characteristics which make them both easy and difficult to study and understand. They are easy to study because they are nearby and relatively bright. They rotate so we can view them from different angles to derive the geometry of the interaction. They vary on time scales from milliseconds to months, giving us a chance to study processes. They are difficult to study because they are fully three-dimensional; the gas dynamics involves both thermal convection and probably shear flow turbulence; the time variability means that theoretical models cannot postulate a strictly steady state.

Some of the major topics of this conference have been: the physics of the mass transfer process, especially in Algols; the theory of evolution of binaries, including mass and angular momentum loss from the system; the RS CVn systems; contact systems; and the application of observations with IUE to the study of a wide variety of interacting systems. Although the reports on polarimetry represent a much smaller number of pages in this volume, they deserve special attention because of the potential power of this technique.

The important new techniques discussed in this volume are IUE observations and polarimetry. IUE data are presented by Dupree et al. (1.7), Drechsel et al. (4.7), Kondo et al. (5.10), Plavec (5.13), Hack et al. (5.16), Polidan and Peters (5.18), Kippenhahn (6.7), Holm et al.

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(8.4), Raymond et al. (8.6), Faraggianna (10.4), Stencel et al. (10.5), Keyes and Plavec (10.1) and Friedjung (10.2). These spectra typically have lines typified by transition region temperatures with species such as CIV and SiIV producing both absorption and emission. The absorption lines indicate expansion due to some form of gas streaming or stellar wind. The high optical depth in the absorption and the strength of the emission imply a significant population of these species which suggest the presence of a harder radiation source which perhaps cuts off in the soft X-ray spectral domain. Alternatively, the extended transition region could be powered by mechanical energy transport as is the sun. This seems less likely because of the implied volume which must be involved. The harder radiation could come from shocks in the system where highly supersonic gas streams intersect. The polarimetry techniques are well described by McLean (1.9) with applications presented by Piirola (5.12) and Simmons et al. (6. 5). I can only hope that this method is vigorously pursued since it seems capable of extracting information such as the inclination that we are accustomed to believe for non-eclipsing systems is inaccessible to a direct observational determination.

The theory of mass transfer and its application to Algol systems is discussed primarily in chapters 3 and 5. The presence of gas streams and their influence on the spectra is well documented. These stars are accepted to be the products of mass exchange with the bulk of the transferred matter staying in the system. I am concerned that the importance of the Benson expansion of the mass gaining star has not yet been evaluated for these systems. The paper by Webbink (3.5) and subsequent discussion clearly brings out this problem. Perhaps the difficulty lies with our assumption that the matter accreted on the mass gaining star is uniformly distributed over the stellar surface. If instead it arrives in a dense stream, the matter can cool radiatively to the stellar surface temperature before it expands and thus achieve a lower state of entropy. The Benson expansion might then not occur at all because of the heat sink this overcompressed matter represents.

The RS CVn systems have received considerable attention because of their soft X-ray and radio emission (papers 7.3 and 7.4). The starspot model along the lines discussed by Shore and Hall (7.2), Jakate (7.7) and Geyer (7.9) is attractive because it simultaneously provides a mechanism for the photometric irregularities and the non-thermal emission. This model may well be the correct description of the systems. However, I believe that several important theoretical questions must be answered. First, the large magnetic field implied by the starspot model almost certainly should involve detectable magnetic fields. This should be checked and it is conceivable that the starspot model could be severely restricted. Second, a clear mechanism favoring starspots in binary systems instead of single stars with similar rotation rates must be put forward. There are single stars with similar rotation rates but which lack the RS CVn characteristics. The suspicion in paper 7.2 is that this difference can be accounted for by a Babcock-type model. A quantitative demonstration that this idea works is presently lacking. I believe that we ought to recognize that forced non-radial oscillations are also a possible mechanism for both the photometric irregularities and the extra mechanical energy. In order for the oscillations to couple to the orbital motion, low-order g modes must be the ones involved. The square of the frequency of these modes is proportional to a mass weighted average of $(\nabla_{ad} - \nabla)$. Since most of the envelope is convective with this quantity negative, the modes must extend into the interior radiative zone and will have low frequencies. Slightly non-synchronous core rotation could be the source of energy for the oscillations. These ideas are admittedly rather speculative, but may be worth further investigation. Until it can be shown that a model of this type doesn't work, the starspot model cannot be proven by elimination.

The subject of contact binary theory has been discussed at length in the recent literature. The contact discontinuity theory by Shu and his collaborators has been the center of much of this discussion. The theory is quite startling in that it involves a temperature inversion which appears to be unphysical. The paper by Shu (9.1) does not come to grips with this particular issue because of the length of discussion which an adequate presentation would require and because the fact that the ideas are presented in earlier papers. The complexity of the hydrodynamic flow requires caution for an accurate treatment. The small scale of the temperature inversion means that the differences between isopotential, isobaric and isoentropic surfaces are crucial to the energy flow. I believe that the various disproofs of the Shu, Lubow and Anderson theory have not been adequately careful in defining appropriate closed surfaces. Shu in his review does point out other areas where the theory is inadequate. I hope that this interesting theory can be given a fair hearing and accepted or rejected for valid reasons.

Clearly, there is much which can be profitably studied in the field of interacting binaries. I have touched on only a few of the problems which I find interesting. Undoubtedly, the last chapter in the story of these systems is not yet even begun.