CONCLUDING REMARKS

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During the last four days we have seen a number of interesting and important results concerning problems which will certainly attract our attention in the years to come. To give examples, I would mention: formation of binaries, structure of contact systems, evolution with a common envelope, planetary nebulae with CBS nuclei, starspots and magnetic fields. As for individual objects, SS 433 would be obviously No. 1 on our list of highlights.

What seemed the most characteristic feature of this Symposium, however, was the relatively large number of papers and significant amount of discussion devoted to rather "old-fashioned" subjects. To be more specific - to the first mass-exchange phase of CBS and to objects produced during that phase. Any statistics would indeed show that U Cep or Algol were mentioned by name more frequently than Cyg X-1 or even SS 433! I have used the term "old-fashioned" to emphasize that these objects have been with us for many decades and also to remind you that we seemed to understand their evolutionary significance over 10 years ago, when the first evolutionary models brought us the solution of the Algol-paradox and provided clues to the origin of WR stars. I do not imply that we are old fashioned. It seems to me that we are taking another look at these problems for many good reasons, our main motivation being that a much better understanding of the first mass-exchange/mass-loss phase is a necessary condition for a complete, meaningful and consistent treatment of further phases responsible for the existence of all other, more exotic objects.

Under these circumstances I feel excused to concentrate my remarks just on those few old-fashioned problems. And I will start with a truly classical subject, namely with those good, clean, and apparently no longer interesting, detached main-sequence binaries. It is worthwhile to remember that they are still one of the main sources of our information on fundamental parameters of main sequence stars. Some of them show the apsidal motion (not even mentioned at this Symposium!), the only case when direct observations tell us something

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about the internal structure of the stars. Let me discuss in more detail one possible use of these systems. The Vogt-Russell theorem tells us that the mass and chemical composition uniquely determine all other parameters of the star; to include the evolutionary effects, we can add here another free parameter - the age. It was this basic principle that was used some 2-3 decades ago by Martin Schwarzschild and others to determine the helium content and the age of the Sun exclusively via the stellar model calculations. The same principle can be applied to the components of main sequence binaries. As for their masses, radii and luminosities, we know them much better than 20 years ago. We now know, or at least have the possibilities to determine their chemical composition; with the spectroscopic data now available not only from the visible region, but also from the ultraviolet, the abundance of helium or of any important heavier element needs not to be an unknown. In principle we are left with only one free, i.e. unknown parameter - the age, while four boundary conditions (two luminosities and two radii) are supplied by observations. Thus we should be able to test our models to see how good is our theory or - more specifically - how good is the physics which we put into our models. We may learn something of general importance for the theory of stellar structure. Even if we don't it is worth trying.

The phase of the mass-exchange following the main sequence was first dealt with in the 60s and it may now seem incredible how really successful we were at that time confining ourselves to the conservative, pure mass-exchange case. Part of the secret was, of course, that while most of the final parameters of the system may depend critically on the amount of mass and momentum lost from the system, those of the mass-loosing component depend primarily on its structure at the onset of the mass outflow. In the case of very massive binaries, we now know that the continuous mass loss via stellar wind is as important factor in their evolution as the most classical mode of mass outflow through L_1. As we have seen during the last few days, there is a fairly complete, although in many aspects only qualitative, picture starting with the main-sequence binaries, through the WR phase, up to the massive X-ray binaries. (It may be interesting to note that, although the X-ray binaries have been discussed quite adequately, the supernova explosion has not even been mentioned during this Symposium!) It has become evident that a much better understanding of the outflow mechanisms, flow patterns, and the efficiency of mass and momentum loss is badly needed to calculate improved evolutionary sequences. We still depend mostly on observational data on stellar wind from single stars. Similar data are needed for various types of binaries, while on the theoretical side further studies should be made of the modifications introduced by the duplicity effects (proximity of the Roche lobe, flow patterns near the mass-collecting component, etc.).

In the case of binaries of lower masses and luminosities we still believe that the mass outflow through L_1 occurring on a thermal time scale is the dominant mode. But compared to the original conservative case (total mass and angular momentum = const.) we seem to have moved to another extreme. Indeed, several papers have argued for nearly total mass loss from the system. Needless to say, we have known already for some time that there are Algols (e.g. AS Eri) that cannot be evolved back to the main sequence within the conservative case. In some cases there is observational evidence for the mass outflow from the system. Obviously this effect has to be incorporated into our picture. However, while doing so we should not rely too heavily on fragmentary evidence. To balance the arguments presented for the extremely non-conservative case, I wish now to make the following "conservative" remarks. We know that the low velocity outflow from L_1 leads to formation of a disk/ring and/or deposition of the material onto the surface of the mass-gaining component. While it is known - practically since Kuiper's time - that in the case of very large disks only a very small increase of velocity is needed to drive the material through the outer Lagrangian point, it is not obvious what could cause such an effect on a major scale; and we also know that the build-up of very large disks is seriously limited by the tidal effects. Of course, the situation may not be as simple during the rapid phases. To that end it is worthwhile to quote, however, one of the results presented during this Symposium, namely that when we do not allow the mass-gaining component to collect mass during that rapid phase, we end with a star which significantly deviates from the standard main sequence. Since this is not confirmed by observations we must conclude that even during the rapid phase we are closer to the conservative situation than to the other extreme. In fact we know systems (such as Beta Lyr) in which the effects of a major mass transfer during the rapid phase can still be seen. It is almost trivial to say that much can be learned from further studies of the mass-gaining primaries of Algols (in particular it is worthwhile to mention the problem of their chemical composition which - surprisingly - has been given very little attention during the last few days). The most important, however, is the problem of how effective the mass outflow can be in carrying away the angular momentum. For it is quite clear that our evidence for the non-conservative case refers primarily to the angular momentum loss rather than to the mass loss.

Finally, I wish to comment on what seems to be a renaissance of spectroscopic studies of many types of binaries, particularly those of the Algol type. This is mostly due to tremendous new technical possibilities, particularly in the ultraviolet, but also due to the stars themselves, which - like U Cep - do their best to attract more of our attention. And while the type of data and the resulting flow patterns are so similar to those published long ago by Struve and his collaborators, we should now rely more strongly on our present physical understanding of these phenomena, in particular on results obtained from hydrodynamical or even purely mechanical calculations. On the other hand we should remember that what often seems to be a single spectral line may in fact be a blend of several absorption and emission components. And even in the case of "clean" lines it is not always possible to identify uniquely the place of their origin. This is not to imply that there are no cases involving other effects, such as the magnetic fields or radiation pressure. We have to study them to make sure that our picture becomes more complete.

I now come to the most obvious and non-controversial part of my remarks. I believe it will be on behalf of all of us if I express our appreciation and gratitude to Mirek Plavec and members of the scientific organizing committee, to Don Fernie, Tom Bolton, and members of the local organizing committee, as well as to all astronomers, graduate students, secretaries, and all others from the David Dunlap Observatory and the Astronomy Department of the University of Toronto, for their energy, enthusiasm, hard work, and patience which made this Symposium a success and our stay here so pleasant. Let us thank them all.