CONCLUDING REMARKS

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This has been a very stimulating and important meeting. It has given a chance for theoreticians and observers to get together and discuss some of the problems that are worrying the astronomers in the field of close binaries.

In this Joint Discussion we have dealt with two main problems. There were two papers – one by Su-Shu Huang and the other by Roxburgh – on the question of the origin of close binaries. But the main bulk of the papers were on the problem of the evolution of close binaries after they have reached the main sequence. On the latter problem I would like to make a few comments. Let me start by reminding you that the problem of the Algol stars was posed many years ago when the single-lined system of R Canis Majoris was first observed. R Canis Majoris is characterized by a very small mass function. If one wants to play with the mass function in order to get an idea about the two masses, one ends up with the possibilities that either one of the components has a very small mass or that both components must have small masses.

The second question which is posed by the Algol systems is that of the sizes and masses as related to the spectral types and luminosities of the components. It was clear from the study of U Sagittae and U Cephei that the secondary components of the Algol systems are subgiants with masses much smaller than those of the main-sequence primary components, and this conclusion has found confirmation in many cases where direct determination of the masses of the two components has been possible. The problem of the Algol stars was dealt with several times, and I am very glad to see that three groups – there was going to be a fourth group that dropped out because the German group went ahead too fast – have attacked this problem in such a way that we can now understand very nicely how main-sequence systems can evolve into the systems where the primary component is a main-sequence star while the secondary is a subgiant whose mass can be quite small. Actually we have cases such as that of XZ Sagittarii, where the mass of the subgiant is of the order of 0·2 solar mass; and case B studied by Kippenhahn and Weigert shows how we can get an Algol system of this kind from a system originally on the main sequence.

We must not forget, however, that the spectra of the components – sometimes we can photograph the spectra of each component – appear quite normal. Even the spectrum of the subgiant looks very similar to that of a normal single subgiant star. Perhaps this is an observational fact, which we should keep in mind. There are now large telescopes in the Southern and Northern hemispheres, and we should try to

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analyze the spectra of the subgiant components obtained during minima, and compare them with those of the normal single subgiant stars.

One would expect abundance anomalies in such secondary components, and an attempt to try to derive observational evidence on the matter has been mentioned here; another attempt was made by Douglas Hall, while he was at Indiana University, by applying Strömgren's narrow-band photometry. His conclusion, which should be checked, was that perhaps the secondary components of Algol systems are CN-underabundant. We should try to go on in this direction.

Another application of narrow-band photometry to this type of project has been made by Sisteró, of the Córdoba Observatory, at the Cerro Tololo Interamerican Observatory in Chile. I still do not know what are the results, but I just mention it as another attempt to apply new techniques to Algol systems and try to secure further information.

As I have said, it seems to me that we are going in the right direction to try to explain what happens to a close binary when it starts evolving off the main sequence. But it also seems to me that the general feeling of the people who are making the computations is that now everything or rather every case can be explained by the results of the computations that have been made or are being made. I am afraid we will be put out of business if we could explain everything at once, so we should better not do that....

I think that we should try to consider whether there are other facts that should be taken into account in some cases. Mention has been made e.g., of β Lyrae, and mention has been made of the Wolf-Rayet stars. Let me remind you that although there has been quite a debate about the masses of the components of β Lyrae, at the present time everybody, or almost everybody, agrees that the secondary (less luminous) component is the more massive component. Yet the size of this object is much smaller than the size of the primary star. So we are dealing here with a system where the component from which the stronger stream originates, the component which appears to be more evolved, is more massive and much smaller than the primary component, which is a B8 II object. And there are quite a few systems where the secondary component seems to be underluminous, small and yet the more massive star. We should remember that such objects do exist, and that they may be very important for our understanding of some other type of evolution in close binaries.

The question of the Wolf-Rayet stars is still controversial. I think that Miss Underhill now favours the same opinion that I have been advocating for several years, namely that the Wolf-Rayet stars are contracting objects. Perhaps we both would like to see another set of computations, which will consider stars that are contracting along the Hayashi tracks. Perhaps we might get a kind of system similar to the Wolf-Rayet stars, or perhaps I may be shown to be wrong.

And there are other interesting systems. This afternoon, when listening to the papers, I felt that perhaps a review paper on the observational aspects, bringing to

this audience all the relevant observational facts collected over the years, might have been a very good idea. There is a great number of systems which are very interesting and which show effects that may be important enough to be taken into account in the computations – e.g., in cases when the masses of the components are large. The system HD 47 129, for instance, is a very interesting binary. There is a very large expanding envelope around the system, as it exists also in β Lyrae and in the Wolf-Rayet binaries. Thus the question of the mass loss to the system, as it has been considered by the Polish group, is a very important point in some cases, and the observations, in the case of HD 47 129, seem to indicate that radiation pressure may be a mechanism to pay attention to.

Very important also is the investigation of the German group into the problem of what will happen after one of the components of a close binary has become a white dwarf. Certainly, wherever we have to deal with eruptive phenomena, one of the components happens to be a white dwarf or a star which is becoming a white dwarf.

Before I finish, I should like to say just a few words on the peculiar A and metallic-line stars. It would seem to me that at present we still need some more information before being able to draw more definite conclusions. Some people, for instance, think that the Ap stars have not gone through the giant stage and are still unevolved; and there seems to exist observational evidence in favour of such a conclusion. As to the case of the metallic-line stars, there are many binaries – as Van den Heuvel has already mentioned here – in which both components display metallic-line spectra. Therefore if the metallic-line stars are evolved binaries, then the evolution may have started from a different kind of objects than those we have dealt with this afternoon.

Concluding these remarks, I should like to say that I was surprised to see so many people in this room interested in close binaries when there was another meeting going on, on quasars. I think this is very good, since it shows that astronomers remain interested in close binaries and, therefore, that we can expect much progress in this field in the near future. I think we can look forward either to the next meeting of the IAU, or to an earlier meeting where such progress will be reported. I think the people who have had the idea of holding this meeting here should be congratulated, because it has been a very good, stimulating meeting.