FIFTH DISCUSSION SESSION

(Friday Evening; 8 September, 1972)

(following the review paper by K.-H. Böhm)

Chairman: A. B. UNDERHILL

Underhill: We thank Dr. Böhm for his masterly summary. Are there questions?

Plavec: Dr. Böhm, there exist two single-spectrum binaries in each of which the component we are able to see is obviously a helium star. They are υ Sgr and HD 30353 (also known as KS Per). They are certainly different from white dwarfs, but they are helium stars probably with pure helium atmospheres. The masses might be around one solar mass, but the stars have probably evolved into the red-giant region in the H–R diagram, so, as a very rough estimate, their radii may be about 15 solar radii. The effective temperature of KS Per – according to calculations by Danziger *et al.* (1967) – is approximately 10000 K, so it is more or less an A0 star, if you can call a helium star A0. Would such a star still generate a sufficiently strong acoustic outflow so that it builds a large and dense corona? Then mass outflow from such a star need not be explained as a consequence of the body of the star itself filling the critical lobe, but rather by the facts that the star has a corona dense enough, and there is sufficient drive for the material, that mass outflow would be governed by this mechanism.

Böhm: I would say that these stars should have strongly developed coronae. I forgot to mention that calculations for helium stars that are not white dwarfs have been carried out by Nariai (1969). He finds that stars along the main sequence, up to temperatures of about 20000 K, have a very strong acoustic output. Giant stars, however, will not have a strong mechanical flux up to quite such high temperatures. On the other hand, it is fairly certain that the mechanical flux will still be large at a temperature as low as 10000 K, and we should, therefore, expect the formation of a corona.

Wright: I was reading about emission lines in the spectra of M-type stars and Herzberg's suggestion (1948) that the coronae of these stars might contain mostly singly ionized iron, rather than highly ionized iron. Do you think that would be reasonable?

Böhm: Yes, I think it is generally accepted that stars of very late spectral types do not have true coronae, because their atmospheres have higher densities and, therefore, the convection velocities in their outer regions are lower. Consequently the acoustic output becomes smaller and the temperature of the corona is lower.

Underhill: You get into somewhat of a semantic problem whether 'corona' describes only plasma with a very high temperature – hundreds of thousands of degrees – around a star, or whether it also describes an extended, cool atmosphere (10000 K or less). I hesitate to use the term 'corona' for both types of extended atmosphere.

Böhm: Maybe I should qualify my answer. It is certain that these late-type stars would not have hot coronae.

Batten (ed.), Extended Atmospheres and Circumstellar Matter in Spectroscopic Binary Systems, 171–173.

Wright: Well, we do observe these emission lines. My real question was – can we say they come from a corona?

Underhill: Well, you do have extended atmospheres that are quite cool around Be stars or Ae stars. I mean the temperatures of the atmospheres would be 10000 K to 15000 K. You don't call these coronae; you call them extended atmospheres.

Wright: I was really wondering if Dr. Böhm's theory of a corona could be used to study these late-type atmospheres.

Underhill: The key to that is whether you have a source of mechanical energy that can be transposed into temperature. Then you end up with a very high temperature because the gas cannot radiate the energy away.

Böhm: Not necessarily, it depends on the mechanical flux.

Underhill: How large it is, of course, yes. But this question of helium stars and generating a lot of energy – there are other helium stars, the normal ones, such as Popper's star.

Böhm: But they possibly have higher temperatures. Just as for the main-sequence stars, the main question is whether or not the helium stars have a convection zone which ends somewhere in the atmosphere. Only in this case will velocities just below the atmosphere be sufficiently high to support a corona. In a helium star, the convection zone occurs at higher temperatures than it does in a hydrogen star, but if the temperature is too high, then even this convection zone no longer exists. A helium star with a temperature of 30000 K, having a surface gravity comparable to that of a main-sequence star, will have no surface convection and no corona.

Underhill: Well, the normal helium stars, the original ones you were talking about, probably have a temperature of the order of 15000 K to 20000 K. Those begin to come into the temperature range for convection zones, I believe.

Böhm: Yes.

Popper: Well, I'm really out of my depth here, but you did refer in passing to some question about the acoustical heating mechanism for the energy provided to the corona. Just before coming here, I read a review of a conference on convection (Heap *et al.*, 1972) – mainly with reference to the Sun – held at Greenbelt. I got the impression that this standard mechanism had very successfully been called into question. Is my impression of that review correct?

Böhm: No. As far as I understood it, certain computational procedures (for instance, basing calculations on weak shock theory) were called into question. Ulrich, in particular, thinks that the whole mechanism might not work because, in the Sun, it would require a certain part of the acoustic spectrum (corresponding to a period of 100 s or so). According to Ulrich, these waves should have been seen in the Sun, but so far they have not been detected. As far as I know, this is one of the stronger arguments against the mechanism, but I don't know how strong it really is from an observational point of view.

Underhill: That more or less agrees with what I remember of the discussion. Let's adjourn until tomorrow morning.

References

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