Hα EMISSION LINE PROFILES IN THE SPECTRUM OF ALGOL

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We have investigated variations in the strength and profile of the Hα emission line in the spectrum of Algol using 145 16 Å mm^{-1} spectrograms obtained during the period September, 1976 to December, 1977. The Hα emission line profile has been extracted by subtracting the absorption contributions of the three stars in the system. The resulting data set has been analyzed to look for variations related to orbital phase as well as shorter and longer term variations.

The emission profile is very similar to that usually seen in Be stars. It is not the type of profile usually associated with a disk. The V and R peaks are separated by 100 km s^{-1} during most of the orbit. The velocities of the maximum and minima on the profile repeat remarkably from orbit to orbit, even when there are large changes in the emission strength. All of the major features on the profile follow the velocity curve of the primary star with two exceptions noted below.

The emission profiles show a weak extended red wing in the quarter period centered approximately on primary eclipse and a similar extended blue wing around the time of secondary eclipse which may be due to a gas stream flowing from the secondary to the primary. The most marked orbital variation occurs in the V/R ratio and the velocities of the V and R peaks. Over most of the orbit $V/R \simeq 1$ and the V and R velocities follow the primary star velocity curve. Near $\phi = 0.22$ $V/R < 1$ and the R velocity increases by about 80 km s^{-1}. One-half period later $V/R > 1$ and the V velocity decreases by a similar amount. We believe these variations are due to aspect variations of a stream of gas moving tangentially to the surface of the primary star at an angle of 25° - 30° toward the trailing hemisphere from the substellar point. This is probably due to the reflection of the gas stream from the secondary star off a shock wave in the outer atmosphere of the primary star.

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The central dip (self-absorption?) in the emission profile is most pronounced in the half of the orbit centered on primary eclipse, and most of the emission profile variability seems to occur in the interval from $0^{\mathrm{P}}.75$ to $0^{\mathrm{P}}.9$. The interpretation of these variations is not clear, but they may arise from interactions between the gas stream and the primary star.

The emission line strength implies that the gas density is at least 10^{10} cm^{-3}, assuming the entire volume of the Roche lobe surrounding the primary star is filled by the emitting material. If the disk/shell is highly flattened, the density may exceed 10^{12} cm^{-3}. The emission line strength can change by large amounts in less than one-half orbital period. If these changes are associated with expulsion of material from Roche lobe around the primary, the total energy released must be greater than 10^{37} ergs.

DISCUSSION FOLLOWING BOLTON AND ZUBROD

Budding

I have a few points to make. First I don't think the German data can be taken to unambiguously show that material around the primary extends to the Roche-limiting surface. The fit which I showed, for example, would require the disk radius to be about 30% greater than the photosphere radius. Second, I would like to know something about your formulary for the density calculations. What do you do about non-LTE effects, how are collisions accounted for and so on? Third, the paper of Lubow and Shu predicts certain definite features for the stream, like its thickness and the angle at which it departs from the LI region. Can you find any confirmation of these details in your observational results?

Bolton

First, if the disk does not fill up the Roche lobe in the plane then the densities I estimate would be increased--substantially increased if I adopt your number for the radius for the disk. The density calculation was done by assuming standard case B recombination theory. I assumed that the Hα emission originates from material uniformly distributed in the emitting volume.

I'm sure that we can derive some of the stream parameters once we begin work on the data obtained during eclipse.

Pringle

(i) May I congratulate you on being the first person today to present a mass transfer stream that actually obeys Newton's laws?

Iii) There are difficulties in associating the X-ray emission

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from β Per with the spot where the stream of transferred material strikes the primary star. One of these is that the X-ray emission is visible at phases when the spot is not.

Bolton

I agree, and that worries me. On the other hand the X-ray data presently available is spotty and not very good. Also, we don't know how large the X-ray emitting region produced by impact of the gas stream should be.

Rajamohan

Part of the Hα emission profile observed could arise in the hemisphere of the cool secondary that faces the primary star all the time, as most of these systems are synchronous rotators. The phase-dependent profile and velocity variation of this emission component which would blend with the Hα profile associated with the primary component should be taken into account before realistic models for gas streams in Algol systems are proposed. Spectroscopic reflection effects have not been given serious consideration so far in analysis of close binary systems.

Bolton

I have double-checked my profiles for this effect at the quadratures where emission from the secondary would be most readily distinguishable. There is no evidence for such emission at $V_{sec} \pm V_{rot}$ (synchr.).