ON THE LOCATION OF GAS STREAMS IN ALGOL SYSTEMS

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Seven years ago, at the Parksville Symposium, I reported on first results obtained from light curves of typical Algol systems which were discussed according to principles taking into account the presence of gas streams. According to this modified method the reflection parameter is derived from parts of the light curve outside eclipses which are least influenced by gas stream effects. Light curves rectified in this manner, or expressed more exactly, roughly released from reflection and ellipticity effects, only in parts display a horizontal course, in the surplus in intensity after primary eclipse and by part also before it. This indicates an additional light source visible during about half the orbital period. On the preceding side of the primary eclipse a loss in intensity is frequently also observed, which is caused by absorption effects of the gas stream, and often overlaps the surplus intensity.

Figure 1 gives an example of a conventionally rectified light curve with distortions unexplained by the author (Knipe 1974). Here, for XZ Sgr, the reflection parameter is not zero, as Knipe derived, but reflection has its normal course, as it is seen from the second quarter of the light curve, and the surplus in intensity after primary eclipse is clearly present.

Also, the light curves of the primary eclipses are distorted by gas stream effects. For this reason the geometric parameters of the system, the relative radii of the components, and the inclination of the orbit should be derived first of all in accordance with the observed geometric data, especially phases of contacts. Then among the remaining confined possibilities one has to search for that combination of parameters which gives an efficient representation of the observations. Of course, a smooth adaptation to the light curve outside the eclipses must be included.

Figure 2 gives an example found to be typical in carrying out this method. The data are taken from working documents used for the photometric study of U Cep by Hall and Walter (1974). The figure represents the differences between observed and computed intensities for U Cep in total eclipse and the following phases for a sequence of approximate

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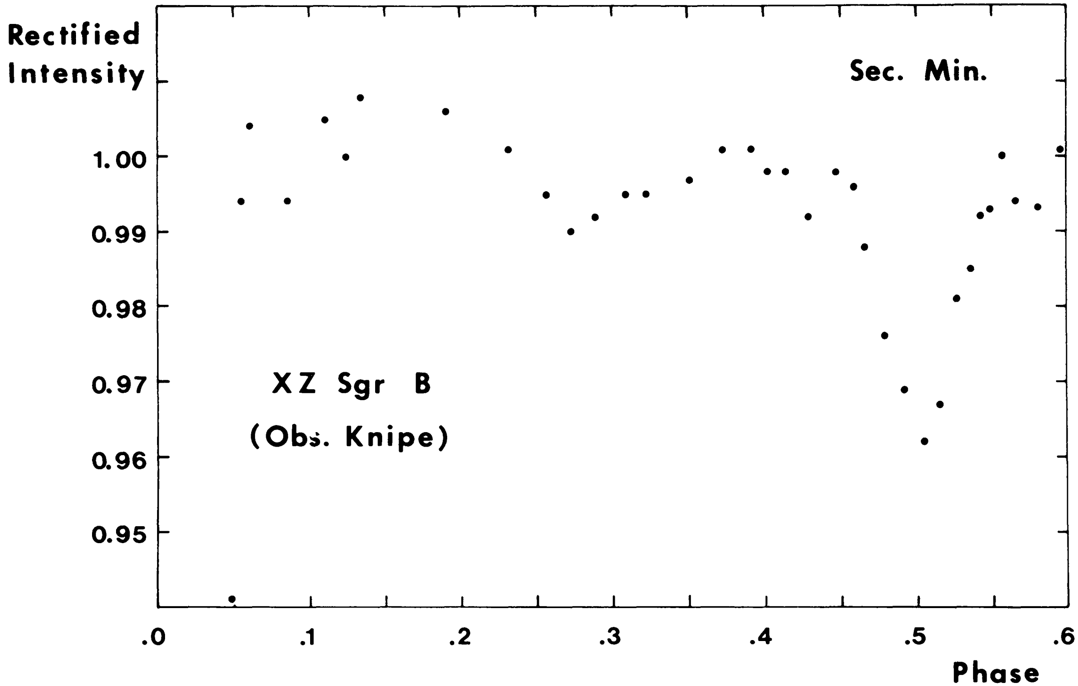

Figure 1. Rectified intensities of normal points for the first half of the light curve outside primary eclipse, given by Knipe (1974) from his observations of XZ Sgr in B. Here, additional light from the hot spot is seen until phase 0.25; the intensity variation between phases 0.25–0.4 is caused by reflection. The figure is taken from the article on XZ Sgr by Kappelmann and Walter, Astron. Astrophys. Suppl., in press.

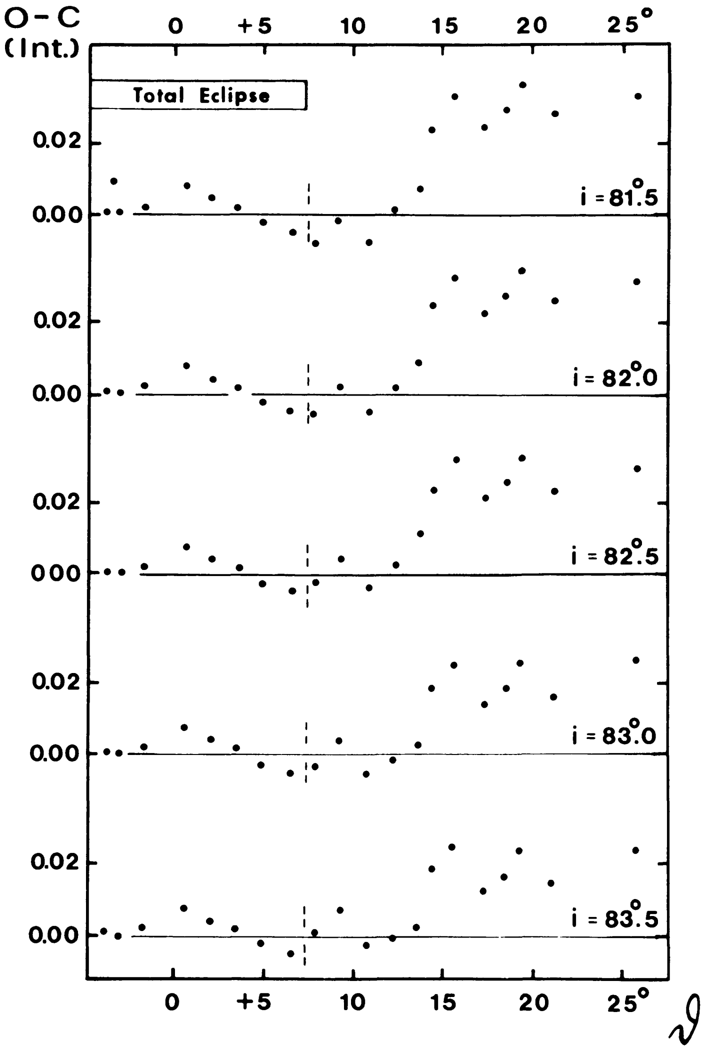

Figure 2. Representation of the light curve of U Cep (observer Tschudovitchev) for a part of the primary eclipse with use of geometric parameters r_1, r_2, and i derived from contact phases. See text. Ordinates are the differences between observed and computed intensities.

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solutions, where the inclination is chosen as the free parameter, while the radii are determined from contact conditions. It is seen that after a short phase interval following the third contact there is a rather sudden increase in intensity of about 2-3% of the intensity of the uneclipsed system. This is a typical effect. We ascribe it to the reappearance of a hot region on the primary component. Similar losses in intensity are also observed on the descending branches. From the phases of disappearance and reappearance the hot regions can be located on the disks of the primaries. In most cases they were found to be situated near the polar regions.

According to the modified method to date the following systems have been investigated: SW Cyg (Walter 1971), TW And (Ammann and Walter 1973), Y Psc (Walter 1973), U Cep (Hall and Walter 1974), RX Gem (Hall and Walter 1975), RW Ara (Walter 1976), X Gru (Schulz and Walter 1976), TW Dra (Walter 1977), and XZ Sgr (Kappelmann and Walter 1979). In all systems polar hot spots on the primary components were found, although, as in the case of Y Psc, not at each epoch of observation. In U Cep and RX Gem equatorial spots were also found, and in RX Gem a ring around the primary.

The presence of hot spots near polar regions suggests the existence of magnetic forces which cause ionized matter to leave the orbital plane. Probably the primary component works like a coaxial magnetic dipole, and its main body rotates synchronously with the subgiant in its orbit. Then that part of the gas stream which reaches the polar region has its steady site relative to the components, and the eclipse of the polar spot will coincide with the primary eclipse, as is observed.

However, a branch of the gas stream which flows from the subgiant into a high latitude region of the primary does not flow on the shortest way, but is first shifted away by Coriolis forces alongside the trailing hemisphere of this component and reaches the polar region along magnetic lines on a curved path. It is interesting to note that Batten (1974) observed a component of the CaII K absorption line (as well as Mg+-lines) in the spectrum of U Cep, which "appears with a velocity of about -200 km/s at around phase $0\overset{p}{.}57$ and then rapidly decreases in velocity, merging itself in the central component of the line by $0\overset{p}{.}63$". These observations were made at a normal state of the system. Hall and Walter (1974) suggested that this line originates from particles of the polar branch of the gas stream which cause the polar spot, and which are forced to change the direction of their velocities within a short phase interval in the described manner.

Let us now ask what happens in times of extremely large mass transfer. It seems obvious that near the orbital plane the magnetized layers around the primary are pushed aside by the overflowing matter and that the equatorial spot on the trailing hemisphere and ring-like structures are strengthened. However, what occurs later on, when the largest outbreaks of matter from the subgiant are passed over and the outbreaks become weaker? One may expect that in this state the magnetic field is going to restore its former structure. It begins again to approach near the equatorial regions. Because the transferring matter is diminished, this matter is no longer able to push aside the plasma of the magnetic field as nearly completely as before, but can only disturb it and cause a wide and deep field of turbulent motions on the trailing side of the primary component. Perturbations of this kind can then appear and disappear within intervals of several days. Presumably they can effect large absorptions of the light of the primary, especially at phases which are situated near those, where at normal states of mass transfer, the large variations of radial velocities of the mentioned lines are observed; that is, around phase 0.6. Indeed, in late 1975 extremely strong variations in the light curve of U Cep were observed by Olson (1978) and Kondo et al. (1978), the largest ones near phase 0.6. To explain this, Olson (1978) suggested the formation of a short-lived large cool spot covering about 80% of the projected area of the B star around this phase.

This report may be finished by a short comment on results about elliptical spectroscopic orbits of typical Algol systems with periods between 4 and 15 d and main sequence primaries of spectral type A. In a forthcoming paper (Walter 1979) I show that these systems have circular orbits. The apparent ellipticity of the orbits and the position of the periastron are artifacts connected with the different strengths of the polar and equatorial branches of the gas stream in these Algol systems.

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COMMENTS FOLLOWING WALTER

de Loore

Can you give an order of magnitude estimate of these magnetic fields? If they are sufficiently large (say some 1000 gauss) they could be measured by Zeeman analyzers. Do such measurements exist?

Walter

As far as I know such measurements do not exist. Roughly estimated magnetic fields of some hundred gauss could be sufficient.

Smak

I want to use this opportunity to put a commercial on XZ Sgr: It belongs to that group of extreme Algols, exemplified by AS Eri and DN Ori, which have very low mass, highly overluminous secondaries. It certainly deserves more photometric and spectroscopic attention.

Walter

I observed this system in UBV at La Silla in 1972-74. The observations and the results from their evaluation are in print [Kappelmann and Walter, Astron. Astrophys. Suppl.].

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