THE INFLUENCE OF AN OUTFLOWING GASEOUS STREAM ON THE DETERMINATION OF MASSES OF SEMIDETACHED BINARY SYSTEMS

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ABSTRACT. A general model of gaseous streams in semidetached systems is proposed from the study of the eclipsing binary symbiotic stars CI Cyg and V 1329 Cyg. The influence of gaseous streams on the determination of the masses of semidetached systems is shown.

1. INTRODUCTION

The interpretation of the observational properties of semidetached binary systems is very difficult. The main problem is connected with the exact location of the line formation regions. The aim of this paper is to show that the lines used for the determination of the radial velocity curve are strongly affected by the gaseous streams forming an excretion disk around the system. The symbiotic stars reveal the best physical laboratories for a detailed study of the accretion and excretion processes including the exact locations of the line forming regions. In some systems it is possible to estimate the influence of gaseous streams on the radial-velocity curve and to obtain reliable values for the masses of the components. Moreover a model of gaseous streams in the system, which appears as a general model of semidetached binaries, can be made.

2. THE MODEL OF GASEOUS STREAMS

A model was made of gaseous streams in semidetached binaries from the detailed study of the two eclipsing binary symbiotic stars CI Cyg (Chochol et al. 1984) and V 1329 Cyg (Chochol and Vittone 1984). These symbiotic stars are highly interacting binaries. The loser is a cold M giant and the gainer, surrounded by an accretion disk, is a B9 main sequence star and a white dwarf in CI Cyg and V 1329 Cyg, respectively. Due to the impact of the accretion disk into the inflowing stream, which penetrates the disk, a turbulent region is

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formed. The turbulent region is responsible for flickerings, flares and eruptions. The outflowing stream from a turbulent region into the outer excretion disk, which surrounds both components was found. While the outburst is caused by the atmospheric expansion of an accreting star due to the mass transfer burst or due to the thermonuclear runaway in a hydrogen/helium rich envelope of the accreting white dwarf, the eruption is caused by the outflow of hot matter from the inner part of the accretion disk after the deep penetration of disk by the inflowing stream. Both cases can be distinguished by observations. The excretion is more important than the accretion. The mass and angular momentum escape from the system through L_2.

The influence of the outflowing stream from the turbulent region was studied in V 1329 Cyg by a careful analysis of the line splitting present in the spectrum. The radial velocity curve (dashed line in Fig. 1) published by Iijima et al. (1981) gave $f(M) = 23\ M_\odot$. From the assumption that the mass of accreting white dwarf is $1\ M_\odot$, a mass of $25\ M_\odot$ was derived for the cold component. The new radial velocity curve (full line in Fig. 1) reflects only the orbital motion of the accreting star. A more reliable $f(M) = 5.9\ M_\odot$ and a mass $7.6\ M_\odot$ for the cold component was derived.

3. THE LAW OF INTERACTING BINARIES AND ITS APPLICATIONS

The main characteristic of the outflowing gaseous stream in the semidetached systems can be formulated as a law of semidetached binaries: The outflowing gaseous stream preserves the characteristics of the accretion disk and the turbulent region in the outer excretion disk. The law is valid both for absorption and emission line objects. The hot turbulent region is responsible for the formation of emission lines. The hot matter from the turbulent region is carried away by the outflowing stream into the outer excretion disk. For this reason we observe the emission lines during the primary eclipse in some interacting binaries.

The proposed model appears as a general model of semidetached binaries and can be applied to Algol binaries, W Ser stars, ζ Aur stars, Be stars, novae, dwarf novae and symbiotic stars. The differences in various kinds of binaries depend on the nature of the loser and gainer, characteristics of the accretion disk, orbital period, cooling rate of the matter in the outer excretion disk, etc.

An application of this model to ε Aur (F0 Ia + ?) can explain the behavior of this very interesting eclipsing binary. The radial velocity curve of ε Aur is influenced by the gaseous streams to such an extent that it cannot be used for a reliable estimate of the masses. The mass function is overestimated. The main characteristics of the system can be obtained from the length of the eclipses and the assumption that the cold component fills up the Roche lobe:

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M_F = 13 $M_\odot$ (assumed), M_C = 0.143 $M_\odot$, R_F = 280 $R_\odot$, R_C = 480 $R_\odot$ and distance A = 4570 $R_\odot$. The cold component is a protostar, which can not evolve into a normal star owing to a large mass loss through the accretion and excretion disk.

If the asymmetric line profiles observed in Cyg X-1 are interpreted in the framework of this general model, the masses in the system may be overestimated. As a consequence, the presence of a black hole in this system is doubtful.

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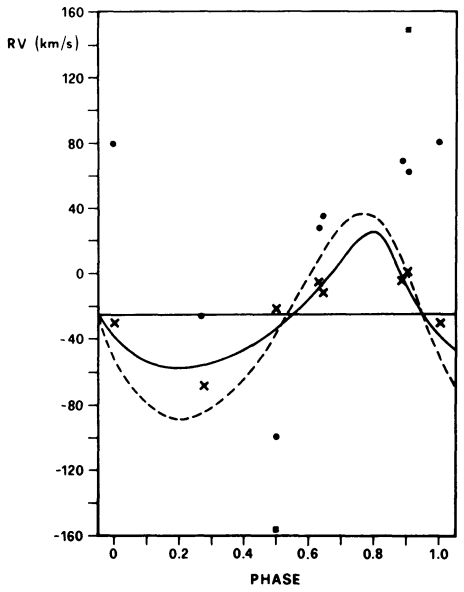

Fig. 1. Radial velocity curves of V 1329 Cyg. The full points and squares indicate the radial velocities of gaseous streams.

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DISCUSSION

BIANCHI: Gas streams in binary systems with mass exchange should produce distortion of the line profiles and theoretical models exist which predict the influence of accretion wakes on profiles. Can the problem addressed in your paper be solved by very high-resolution observations of the line profile at different phases?

CHOCHOL: Yes, the problem can be solved by a detailed study of line splitting using high-resolution spectra.

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