A SPOT STRUCTURE OF ACCRETION DISK OF U GEMINORUM

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ABSTRACT. On the basis of modelling of emission lines of dwarf novae U Gem, conclusion is made, that the observed orbital phase change of model parameters of a accretion disk can not be explained in frameworks of Keplerian velocity field in a disk. The reason of such change can be spiral shock in a accretion disk.

Key words: accretion, accretion disks - methods: individual (U Gem) - spectroscopy: data analysis

Introduction

U Gem is one of the best-studied cataclysmic variables of all time. It is the prototype of the dwarf nova class of cataclysmic variables. The photometric study of U Gem by Krzeminski (1965) showed that U Gem is an eclipsing binary system with an orbital period of 4^h15^m. In an optical spectrum U Gem dominate broad double-peaked emission lines of H I, He I and Ca II, arise from the accretion disk. Spectra of U Gem show also narrow emission line components which vary sinusoidally in wavelength (called "S-wave" component), and which have previously been ascribed to emission from the gas stream or the bright spot. On basis of the most full spectral researches U Gem Smak (1976) has made a conclusion, that the S-wave component is formed in stream close to the accretion disk. However Marsh et al (1990), applying Doppler tomography method, have determined, that the S-wave component comes from mixture of disk and stream matter, each of which has passed through a shock in the bright spot region. The velocity of the emission is then an average of the disk and stream velocities.

The aim of our work is to research a spot structure of the accretion disk of U Gem on basis of phase modelling of emission lines profiles. In paper Borisov and Neustroev (1996) we have presented a technique of calculation of emission lines profiles, formed in the nonuniform accretion disk. Results of these calculations have shown, that modelling of spectra, obtained in different phases of an orbital period, allows to estimate basic parameters of a spot (such as geometric sizes and luminosity) and to investigate a structure of the accretion disk.

Observations and modelling

The spectral data of U Gem were obtained during January 21, 1994 and December 5-6, 1994 with the 1000-channel television scanner and the spectrograph SP-124 of the 6-m telescope of the SAO. In January, 21 25 spectra were obtained in wavelength range $\lambda\lambda$3600-5600 Å with dispersion 1.9 Å/channel. In December, 5-6 23 spectra were obtained in wavelength range $\lambda\lambda$4400-5300 Å with dispersion 1.1 Å/channel. The spectra were taken with typical integration times of 300 seconds. Both series of spectra cover approximately identical phase range from 0.7 to 0.3. After modelling we obtained all basic parameters of the accretion disk and bright spot.

Discussion

In Fig. 1 we show the orbital phase dependence of the disk parameters. In case of driving substance in the disk on keplerian circular orbits a peak separation in emission lines mostly affects on the definition of parameter V should remain constant during an orbital period. However, it can be seen, that parameters, including V, is sinusoidally vary with a double wave for an orbital period (hypothesis about a constancy of parameters can be rejected with a confidence probability more than 99%). Moreover, explicit correlation between change of V, R and α is observed. Multiple correlation coefficient between V and parameters R and α for all lines is more than 0.72 with a confidence probability more than 96%. Such variability of parameters present in both data series and the phases of their modification are almost identical. The most interesting is the behaviour of a parameter V, as its change from a phase as a double wave for a period reveal about a deviation of a velocities field in the disk from circular keplerian. The similar effect was marked also by Marsh et al (1990). The possible reason of such parameters modification is the noncircular form of an exterior edge of the accretion disk.

A research of dynamics and stabilities of keplerian elliptic accretion disks have shown (Lyubarskij, Postnov and Prokhorov, 1994), that such disks should be stable formations. However modelling has shown, that the peak separation in emission lines, formed in the keplerian elliptic accretion disk will remain constant during an orbital period. Therefore, at preservation of a hypothesis about keplerian velocities in the disk the phase variability of the peak separation can be explained only by a deviation area of emission lines generation from a circle in the circular disk. For the elliptic disk the area of generation should have at least an eccentricity different from the disk.

Paczynski (1977) investigated the tidal effect of the secondary star upon the disk by integrating the orbits of test particles in the restricted three-body problem to determine the departures from a Keplerian velocity field in a pressureless disk. Paczynski (1977) found an elliptical distortion of the outer disk. The peak separation in emission lines, formed in such disk, will vary as

$$V = V_0 - \Delta V \times \cos 2\varphi \qquad (1)$$

where φ is a phase of an orbital period. The dependence of parameters obtained (Fig.1), however, will not agree with (1) because of a shift of phases which is about 90°, and therefore cannot be explained by the model Paczynski. Such a modification of an peak separation in lines can be caused by spiral shock in the accretion disk, obtained in many numerical hydrodynamic calculations (for example, Sawada and Matsuda, 1992). A research of influence of spiral chock on emission lines (Chakrabarti and Wiita, 1993) has shown, that the peak separation in such lines under certain conditions should really vary with an orbital phase. Unfortunately, work Chakrabarti and Wiita (1993) is one of a few, devoted to study of observed display of a accretion disk spiral structure . The unequivocal conclusion about the real reason of a phase assotiation of an peak separation in emission lines can be made only after detailed researches.

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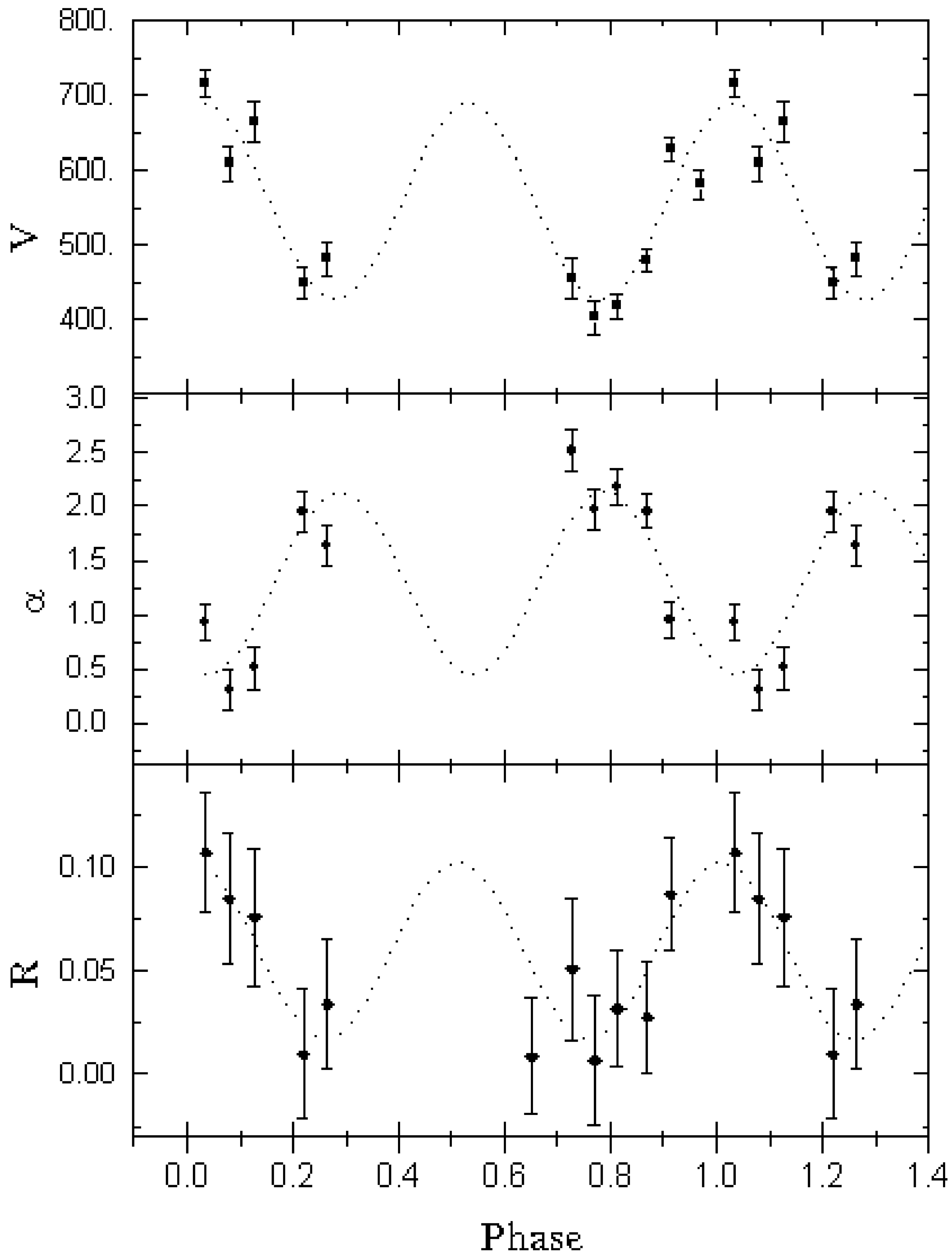

Figure 1. Variability of accretion disk model parameters with orbital phase (from modelling H_γ emission line).

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