PHOTOMETRIC AND SPECTROPHOTOMETRIC OBSERVATIONS OF THE CLASSICAL SYMBIOTIC STAR YY Her

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ABSTRACT The spectrophotometric and photometric observations of the classical symbiotic star YY Her both during its quiescent state and during a strong outburst in 1993 are presented.

Key words: Stars: binary: symbiotic; stars: individual: YY Her.

We carried out UBV-photometric, spectrophotometric and high-dispersion spectral observations of classical symbiotic star YY Her using 0.6-m and 1.25-m telescopes of the Crimean Laboratory of the Sternberg Astronomical Institute, and 1.8-m telescope of the Padua Observatory in Asiago (Italy). The results of the observations were published by Tatarnikova et al. (2001) (and references therein).

Figure 1 shows the UBV light curves of the classical symbiotic star YY Her both during its quiescent state and during a strong outburst in 1993.

The variability of the U-brightness in the quiescent state is due to eclipse of most part of the nebula by cool component and the great amplitude of the primary minimum ($\Delta U \approx 1.^m6$) is indirect evidence that the line of sight is close to the binary orbital plane. The minimum in 1997 (third from the beginning of the outburst) is characterized by long-time phase ($\sim 0.17P$, where $P = 586^d$ is the orbital period) of constant lowest brightness. If we consider this minimum in the framework of classical model of eclipse of hot component and circumstellar envelope, the main contributer to the filter U, this would mean that cool component of YY Her fills its Roche lobe for anything real relation M_{hot}/M_{giant}.

In the quiescent state the red giant's radiation dominate in visual lights even at phases near photometric maxima. Therefore, at this time, the visual light curve characterize the variability of the cool component of YY Her. The existence of the shallow ($\leq 0.^m2$) secondary minimum in the visual lights may be connected with the ellipsoidal shape of the red giant. This would mean that the cool component of YY Her fills essential part of its tidal volume.

Figure 2 presents UV+optical spectrum of YY Her, which was obtained near maximum of brightness during strong outburst in 1993. In the quiescent state the energy distribution of YY Her in UV and optical diapasons may be represented in terms of three-component spherical model (hot subdwarf + gaseous nebula + red giant). But in the active phase the essential excess of near-UV radiation was observed. The energy distribution in the spectrum of this additional warm component (may be accretion disk) may be represented with sufficient precision by means of Planck's curve for black body radiation with $T_{warm} \approx 13000$ K. The luminosity of the warm component was near $\sim 10\%$ from the luminosity of the hot component.

On the Figure 2 the thin line indicate dereddened total UV+optical spectrum of YY Her during outburst (color excess $E(\mathrm{B-V}) = 0.^m2$); the thick line - calculated continuum energy distribution of the star in the "spherical + warm component" model; dashed lines - contributions of the radiation sources forming the total emergent flux: hot subdwarf, warm component, cool component (M3.5III) and the nebula, which absorb all Lc-photons of the hot component. The energy distribution in the spectra of first two components are black body curves with $T_{hot} = 82000$ K and $T_{warm} = 13000$ K.

In the maximum of the outburst the bolometric flux from the hot component increased by a factor of ~ 10 and its temperature decreased from $\sim 10^5 K$ to $\sim 6 \times 10^4 K$. The active period of YY Her lasted about 7 years and finished in 2000.

The main features of YY Her are:

1. The great amplitude of luminosity's growth for active hot component. Among all well-studied classical symbiotic stars (with prototype Z And) YY Her has the maximum amplitude of luminosity's change during outburst of the hot component.

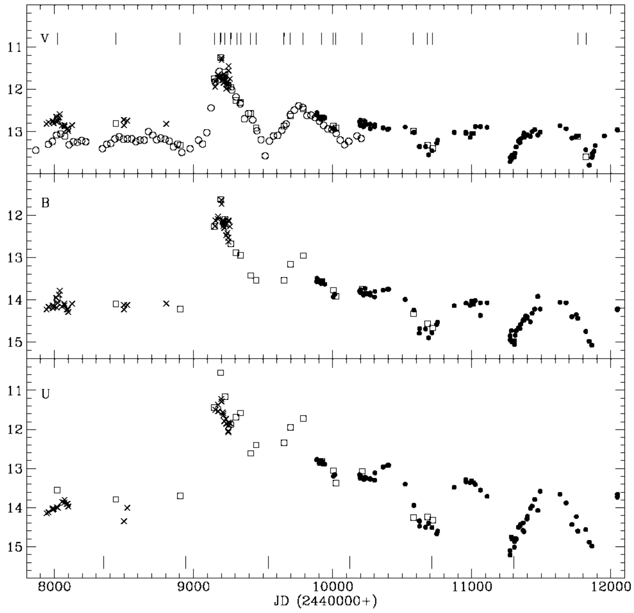

Figure 1: Light curves of YY Her in the U, B and V bands. Open circles and crosses are, respectively, visual and photoelectric brightness estimates from Munari et al. (1997), filled circles are our data. Open squares are brightness estimates obtained by convolving the spectra with the transmission curves of the corresponding filters. The vertical ticks near the horizontal axes (bottom) indicate the dates of minima in the visual light curve, calculated using the ephemeris from Tatarnikova et al. (2001). For the visual light curve, the vertical ticks indicate dates of spectrophotometric observations.

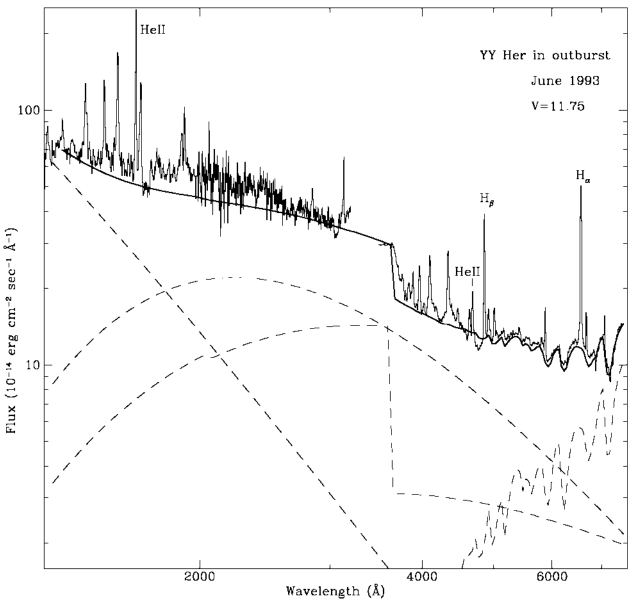

Figure 2: The UV+optical spectrum of YY Her. The solid thick line indicates the calculated continuum energy distribution of the star. The energy distribution in the spectra of the radiation sources forming the total emergent flux (hot component + warm component + M3.5 red giant + gaseous nebula) are shown by dashed lines.

2. The existence of bright HeII-lines in the maximum of outburst. But these lines totally disappeared from the typical spectrum of the active classical symbiotic star and its hot component's energy distribution is similar to A-F supergiants.

3. The appearance of the new structure element (warm component) during outburst.

The first feature doesn't allow to describe the active state of YY Her in the framework of thermonuclear runaway model because, according to theoretical calculations the growth of the hot component's luminosity must be ≤ 3 times.

The appearance of the warm radiation source is the strong argument for standard model of disk accretion. However this model could not explain the decrease of the hot component's temperature during transition from quiescent to active state.

The decrease of the temperature is connected with intensification of mass loss rate of the hot component during outburst, which, as one suppose, directly depend on the luminosity of the star. In this case the effective temperature of the hot component of YY Her in the maximum of outburst must be one of the lowest values among temperatures, characterized for hot components of classical symbiotic stars. But we have another picture.

References

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