COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 5046

Konkoly Observatory
Budapest
14 March 2001

HU ISSN 0374 – 0676

YY Her — SECONDARY ECLIPSES IN THE SYSTEM REVEALED

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The star YY Her belongs to the classical symbiotic binaries with nova-like outbursts. It was discovered to be a variable by Wolf (1919). On the basis of the next observations (Plaut 1932 and Böhme 1938) it has been classified as an irregular variable. Finally Herbig (1950) described the spectrum in detail and identified it as symbiotic. YY Herculis is a little bit fainter than most of the long-term monitored symbiotic stars, which is the reason that the historical light curve has been covered insufficiently and unhomogeneously so far. The photometric history has been described by Munari et al. (1997b). There have been observed 4 large outbursts and 6 small eruptions since 1890. The last large outburst which appeared in 1993 was studied in detail by Tatarnikova et al. (2000). Munari et al. (1997a) and Munari et al. (1997b) on the basis of analysis of all photometric and spectroscopic data excluded eclipses as the cause of the light variability.

The new photometric observational material presented in this paper was performed with the Newton 180/700 telescope equipped with an originally constructed CCD Camera based on Texas Instruments chip TC 211 and using B (440 nm), V (540 nm), R (680 nm), and I (825 nm) filters for modified Johnson–Kron–Cousins system. The magnitudes of the comparison stars for CCD photometry were obtained through the calibration on the basis of the standard stars published in Landolt (1973, 1983, 1992). The observations were secured from July 2, 1995 till November 29, 2000. All data are collected in Table 1 and are depicted in Figure 1. The observational errors do not exceed $0\overset{m}{.}03$ for B, $0\overset{m}{.}02$ for V, and $0\overset{m}{.}01$ for R and I colours, respectively.

There are three deep minima and one smaller drop (may be two) of the brightness evident on the light curve in all four colours. Despite a certain mismatch between the times of deep minima and ephemeris published by Munari et al. (1997b) the mutual distance of the minima suggests their connection to the orbital period. Since the drop of the deep minima in B colour reaches one magnitude, the heating effect proposed by Munari et al. (1997b) could not be invoked to explain the variation (Skopal 1996). Smaller minima, clearly visible at our light curves (Figure 1) were not mentioned yet in the literature.

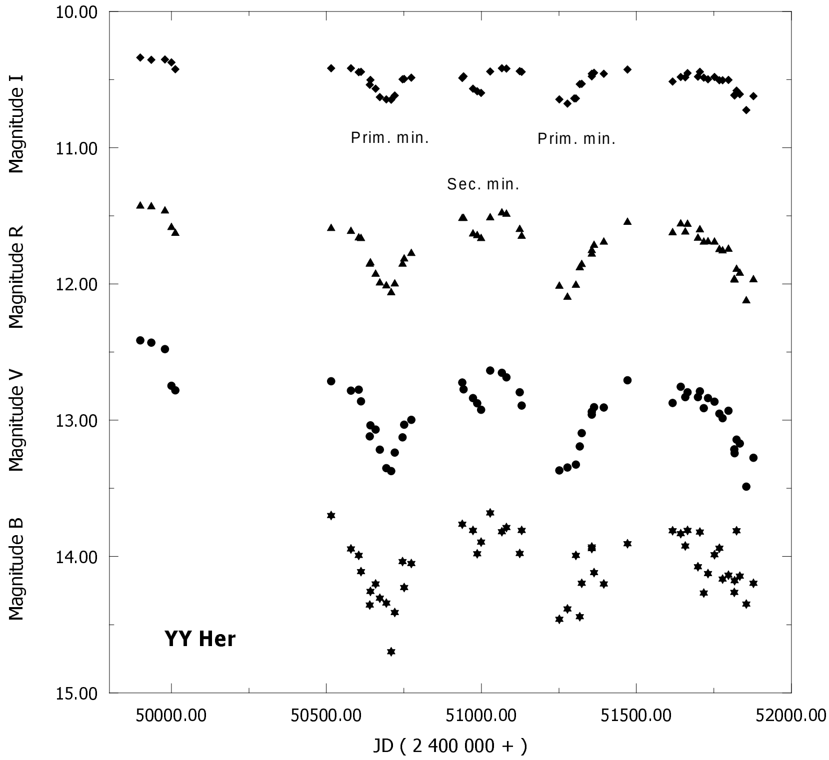

Figure 1. CCD light curves of YY Herculis in B, V, R, and I colours. Primary and secondary minima are marked

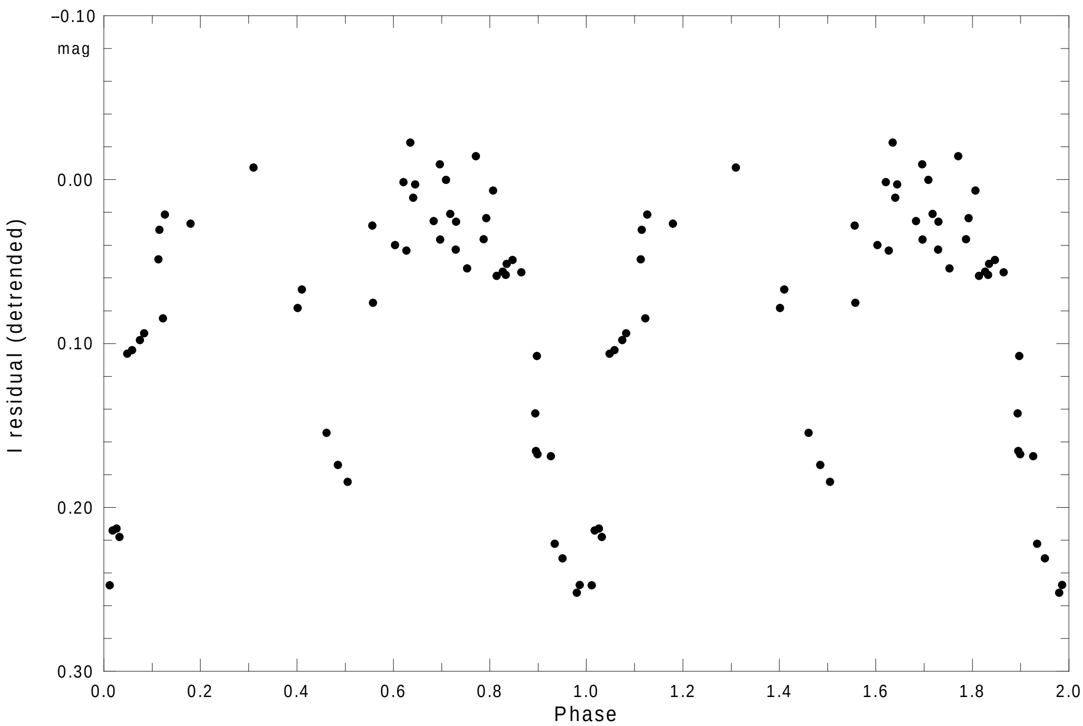

Figure 2. Phase diagram of YY Her in I colour

Table 1: CCD photometric observations of YY Herculis

$JD_{hel} - 2400000$	B_c	V_c	R_c	I_c	$JD_{hel} - 2400000$	B_c	V_c	R_c	I_c
49899.4157	'*'	12.42	11.43	10.34	51123.2626	14.00	12.80	11.60	10.44
49935.3954	'*'	12.43	11.43	10.36	51130.2594	13.81	12.89	11.65	10.44
49979.3559	'*'	12.48	11.47	10.35	51250.6112	14.46	13.37	12.02	10.65
50000.3220	'*'	12.75	11.59	10.37	51277.5430	14.39	13.35	12.10	10.68
50012.3261	'*'	12.78	11.63	10.42	51299.4134	'*'	'*'	'*'	10.64
50515.6262	13.70	12.76	11.59	10.42	51304.4071	13.99	13.33	12.01	10.64
50579.4392	13.94	12.78	11.61	10.42	51317.4335	14.44	13.19	11.88	10.53
50604.4002	13.99	12.78	11.66	10.45	51323.4164	14.20	13.10	11.86	10.53
50611.4272	14.11	12.86	11.67	10.44	51355.4073	13.93	12.96	11.78	10.48
50639.4201	14.36	13.12	11.86	10.54	51356.3779	13.94	12.94	11.76	10.46
50641.4184	14.26	13.04	11.84	10.50	51363.4100	14.12	12.91	11.72	10.45
50658.3890	14.20	13.07	11.93	10.57	51394.3846	14.20	12.91	11.69	10.46
50672.3839	14.31	13.22	11.99	10.63	51471.3315	13.91	12.71	11.55	10.43
50693.3355	14.34	13.35	12.02	10.65	51616.6201	13.81	12.87	11.62	10.52
50708.3134	14.70	13.37	12.07	10.65	51643.5527	13.83	12.75	11.56	10.48
50720.3281	14.41	13.24	12.00	10.62	51657.4787	13.92	12.83	11.62	10.49
50745.2722	14.04	13.13	11.86	10.50	51665.4733	13.81	12.80	11.56	10.45
50750.2660	14.23	13.03	11.82	10.50	51698.4447	14.08	12.83	11.67	10.48
50773.2227	14.05	13.00	11.78	10.49	51705.4399	13.82	12.79	11.60	10.44
50937.4498	13.76	12.72	11.52	10.49	51717.4404	14.27	12.91	11.69	10.49
50942.4581	'*'	12.77	11.52	10.48	51731.4458	14.13	12.84	11.69	10.50
50972.4199	13.81	12.84	11.63	10.57	51751.4599	13.99	12.86	11.69	10.48
50986.4108	13.98	12.88	11.65	10.59	51767.3990	13.94	12.95	11.75	10.51
50998.4593	13.89	12.92	11.67	10.60	51778.3671	14.17	12.99	11.76	10.51
51028.4116	13.68	12.64	11.51	10.44	51797.3235	14.14	12.93	11.75	10.50
51066.3218	13.82	12.65	11.48	10.42	51815.2950	14.26	13.21	11.97	10.61
51080.3115	13.79	12.69	11.49	10.42	51817.2966	14.18	13.24	11.97	10.62

All data were taken at the Beluša Private Observatory

Therefore we performed detailed period analysis of all data accessible to us. Our new data were supplemented by older data secured in the frame of the international campaign of long-term monitoring of symbiotic stars (Hric and Skopal 1989) at the Kryonerion, Skalnaté Pleso and Wroclaw observatories. Moreover the UBV photoelectric photometry published by Munari et al. (1997a,b) and Tatarnikova et al. (2000) as well as IR photoelectric photometry by Munari et al. (1997b) were adopted.

We removed the stages of activity from the data, determined zero points for particular observatories and detrended the data due to unmonotonous decline after the outburst in 1993. Such reduced data have undergone in the detailed period analysis. We found in the data a very pronounced period around 587 d as well as its half value in all the five colours. On the basis of the results we can explain the deep minima in the sense of the eclipses of the hot component by the cool giant. We tried to explain the secondary minima by pulsation of the cool giant like in our previous papers for AG Dra (Friedjung et al. 1998, Petrík et al. 1998 and Gális et al. 1999). Such explanation is not very probable for YY Herculis because the secondary minima are relatively narrow, quite deep and they appeared exactly in the middle between two primary minima.

The most probable explanation of the secondary minimum is the eclipses of the cool giant by the circumstellar envelope around the hot component. When discussing the light curve shape it is necessary to mention the distinctive features on the smooth light curve running. The abrupt drop of brightness at orbital phase 0.88 as well as the rise of brightness at orbital phase 0.12 can be explained by the eclipse of the white dwarf in the system. The next drop in brightness at phase 0.94 is probably due to eclipse of the bright spot. The striking rise of brightness at orbital phase 0.55 and consecutive short-term variations (flickering) is probably connected with bright spot appearance. Moreover we have information about a circular orbit from the position of secondary minima. For better understanding of the particular features see Figure 2.

For determination of the times of primary minima we have selected the best covered minimum in V colour during the period of JD 2450500–2450937. As a result we can present the ephemeris of primary minima as follows:

$$\mathrm{JD(I)_{min}} = 2450701\overset{\mathrm{d}}{.}6 \pm 1^{\mathrm{d}} + 587\overset{\mathrm{d}}{.}54 \pm 0\overset{\mathrm{d}}{.}5 \times E.$$

We can summarize, that the secondary minima were revealed in this study and they are prescribed to the eclipses of the cool giant by the envelope around the hot component. Moreover, the confirmed existence of the primary minima agrees with the suggestion mentioned by Tatarnikova et al. (2000).

We have to emphasize that for confirmation of our model it is inevitable to cover the light curve at least in phase interval 0.25–0.65 during this observational season. We would like to call up an observational campaign dedicated to this object by the method of photoelectric or CCD photometry in $UBVRI$ colours. In order to cover the secondary minimum short observations are desirable with one-week frequency. There is a strong suspicion for the rapid variability (flickering) after the orbital phase of 0.55 (mid of October 2001). For the purpose of flickering activity study it is necessary to obtain few-hours data per night in any colour, most preferably in U and B. Charts with comparison stars are available in electronic form as ps files upon request (via e-mail) from the authors. We would like to ask the participants of this campaign to send the observational data in electronic form in the format of Heliocentric Julian Date and the corresponding magnitude.

Acknowledgements: This work has been supported through the Slovak Academy of Sciences grant No. 1008/21 and Pedagogical Faculty, Trnava University grant No. 1/98.

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