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Long-term photometry of the symbiotic nova HM Sge

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Abstract. The long-term photometry of the symbiotic nova HM Sge obtained from 1976 to 2003 is presented including new UBV photoelectric and $UBVRI$ CCD data gathered in 1998-2003. The archive photographic plates were used to estimate the brightness of the object after the outburst in 1975. These data together with post-outburst visual observations from international databases are discussed. The outburst of the nova, with a maximum in August 1975, was followed by two minima of brightness which lasted ∼750 days and ∼2100 days, respectively. The descending branch of the minimum I was detected only in photographic data, the ascending branch was also detected in UBV bands. The minimum II was visible only in the U band. The minima were probably caused by the eclipses of the hot component (white dwarf surrounded by an accretion disk) and the hot shocked region formed by colliding winds of the components by a Mira variable. The orbital period of the Mira is certainly longer than the interval of observations of 28 years. Our CCD IR data clearly show the pulsation of the Mira variable. It is shown that the nova-like outburst of HM Sge was triggered by a mass-transfer burst from the Mira variable to the hot component during its periastron passage on an eccentric orbit. These mass-transfer bursts were reponsible also for the postoutburst activity of the system.

Key words: stars – binaries – symbiotic – photometry – HM Sge

1. Introduction

HM Sge is a member of a small subgroup of symbiotic stars, called symbiotic novae, also including V1329 Cyg and V1016 Cyg, in which an outburst leads to a nebular spectrum (Mürset & Nussbaumer, 1994). Symbiotic novae are wide

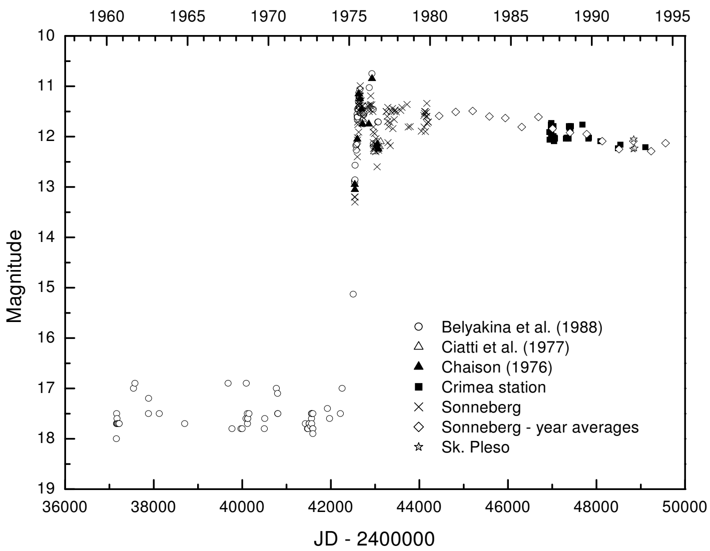

Figure 1. The historical photographic light curve of HM Sge.

interacting binaries where matter from a late-type giant is transferred onto the surface of the compact companion. The nova-like optical outburst ($\Delta m \sim 5-7$ mag), lasting decades, is caused by a thermonuclear runaway on the surface of a wind-accreting white dwarf after a critical amount of material has been accumulated (Mikolajewska & Kenyon, 1992). Most of the symbiotic novae, including HM Sge, contain a Mira variable (Munari, 1997) and belong to the group of D-type symbiotics.

The symbiotic nova HM Sge underwent its nova-like outburst in 1975 when it brightened from $m_{pg} \sim 17.6$ to $m_{pg} = 11.1$ mag in August 1975 (Belyakina *et al.*, 1988). Since then, the brightness of the object has been slowly decreasing with some degree of photometric variability.

Infrared variability of the object was discovered by Slovak (1978). Taranova & Yudin (1983) showed that the variations are consistent with Mira variable pulsations and Whitelock (1987) determined its period of pulsation as 540 days. The preoutburst photographic observations of Belyakina *et al.* (1988) phased with this period by Arkhipova *et al.* (1994) showed that the brightness increases occurred at phases near the maximum of the IR light of the Mira. The long term $JHKLM$ photometry taken during 1978-99 allowed Taranova & Schenavrin (2000) to improve the period of pulsation of Mira to (535±5) days. They derived its radius as 540 $R_\odot$, luminosity 10^4 $L_\odot$ and effective temperature 2600 K (see also Bogdanov & Taranova, 2001). The dust envelope of HM Sge, with the radius 1500 $R_\odot$, reached its maximum density around the maximum of the $J - K$ index in 1988. In the same time the maximum of radiation in M passband was observed.

The orbital period of HM Sge has not yet been determined. Kenny & Taylor (1998) analyzed radio features at 22.5 GHz, which evolved in separation and position angle, by a model of orbital colliding winds. The derived orbital elements implied a highly inclined orbit ($i = 78° \pm 4°$) with a period of 80^{+60}_{-20} years. Richards *et al.* (1999) proposed the orbital period P = (90±20) years from an apparent rotation of radio components at 5 GHz. Bogdanov & Taranova (2001) suggested a 15.3-year orbital period from observed variations of IR brightness and colours. Schmid & Schild (2002) used spectropolarimetry of Raman lines to estimate the 50-year orbital period of HM Sge. Arkhipova *et al.* (2004) suggested a 6.3-year orbital period from the decreases of intensity of the infrared continuum, which occurred in 1995 and 2001.

The aim of our paper is to summarize UBV photoelectric photometry of HM Sge taken from 1976 to 2003 including our new UBV photometry obtained at the Skalnaté Pleso and Stará Lesná Observatories (1998-2003) and CCD $UBVRI$ photometry taken at Moscow, Crimea and Stará Lesná (1999-2003). We also present the photographic magnitude estimates of HM Sge from Crimea, Sonneberg and Skalnaté Pleso archive plates taken between the years of 1975-1997 and post-outburst visual estimates from international databases. Possible explanations of brightness variations after the outburst of HM Sge in 1975 are discussed.

2. Published photoelectric data and UBV reference light curves

It is well known that there are the differences in the UBV data of novae taken by different instruments, due to the diversity of the spectral sensitivity of photomultipliers, differences in transparency of the B and V filters and the presence of nebular continuum and emission lines in spectra, which are responsible for the shift of the standard UBV magnitudes (see e.g., Chochol *et al.*, 1993). Therefore, it is reasonable to construct a reference light curve, using long-term observations taken at one observatory with nearly identical instruments.

Photoelectric observations of HM Sge used for reference UBV light curves were carried out at the Crimean Observatory using a 0.64 m telescope from 1976 to 1985 (Belyakina *et al.*, 1988) and the Crimean station of the Sternberg Astronomical Institute using a 0.6 m telescope from 1979 to 1993 (Arkhipova *et al.*, 1994), from 1994 to 2002 (Arkhipova *et al.*, 2004) and in 2003 (Arkhipova, 2003). Comparison of the UBV observations taken simultaneously in the years 1979-85 did not show any shift. Therefore, all data can be taken as a homogeneous sequence.

The photoelectric photometry is moreover influenced by the fact that HM Sge and the star [NSA79] 8 (Noskova *et al.* 1979) in an angular distance 8" from HM Sge with U=14.5, B=14.2, V=13.6 (Arkhipova *et al.*, 2004) form an optical pair. Due to the fact that both stars were included in the aperture with the diameter 27" of arc, Arkhipova *et al.* (2004) corrected their UBV data of HM Sge gathered from 1994 until 2002 for the light of the faint component. In our reference light curve of HM Sge, we removed the light of this component also from the data of Arkhipova *et al.* (1994) and Belyakina *et al.* (1988).

3. Observations and data reduction

3.1. Photoelectric observations

Table 1. The photoelectric U, B, V magnitudes of HM Sge obtained at the Skalnaté Pleso and Stará Lesná (typed in *italics*) observatories. JD = JD* + 2 400 000

JD*	U	B	V	JD*	U	B	V
50960	11.65	12.36	11.68	51178			11.79
51035	11.78	12.31	11.66	51435	*11.82*	*12.52*	*11.74*
51038	11.67	12.47	11.84	51451	*11.73*	*12.53*	*11.79*
51056	11.72	12.51		51511	11.76	12.43	11.75
51061	11.71	12.57	11.75	51668	*11.72*	*12.40*	*11.67*
51079	11.85	12.55	11.88	51700	11.73	12.39	11.71
51091		12.35	11.69	51776	*11.74*	*12.46*	*11.79*
51108	11.75	12.51	11.78	52484	*11.86*	*12.52*	*11.97*
51110	11.79	12.58	11.86	52504		*12.51*	*11.86*
51113	11.81	12.45	11.80	52518	*11.95*	*12.55*	*11.94*
51118		12.39	11.71	52522	*11.86*	*12.63*	*12.03*
51130	11.73	12.50	11.73	52591	*11.88*	*12.63*	*11.97*
51137		12.38	11.82	52820		*12.72*	*12.03*
51142	11.79	12.58	11.87	52868	*11.95*	*12.72*	*12.14*
51159	11.75	12.39	11.74				

Our UBV photoelectric photometry of HM Sge was obtained at the Skalnaté Pleso (SP) and Stará Lesná (SL) Observatories from 1998 to 2003. In both cases a single-channel photoelectric photometer installed at the Cassegrain focus of the 0.6 m reflector was used. The SP observations were carried out using standard UBV filters and a photomultiplier HAMAMATSU R 4457P. Standard UBV filters were employed at SL using the photomultiplier EMI 9789 QB. We used HD 353437 (U=9.5, B=9.71, V=9.47; sp. type A0) and GSC 1602-1401 (U=12.38, B=11.94, V=11.36) as comparison and check stars, respectively. The comparison star was found to be stable within 0.01 mag in all passbands. Data reduction, atmospheric extinction correction and transformation to the international UBV system were carried out using the standard procedure. Our SP and SL data were corrected for the light of the nearby faint component.

The resulting UBV magnitudes, given in Table 1, are averages of all individual observations obtained during one night. The mean error of the average did not exceed 0.02 mag and 0.01 mag in the U and B, V passbands, respectively. In Fig. 2 our SP and SL data were shifted by $\Delta U = -0.15$, $\Delta B = -0.05$ mag and $\Delta V = 0.15$ mag to be compatible with the reference light curve.

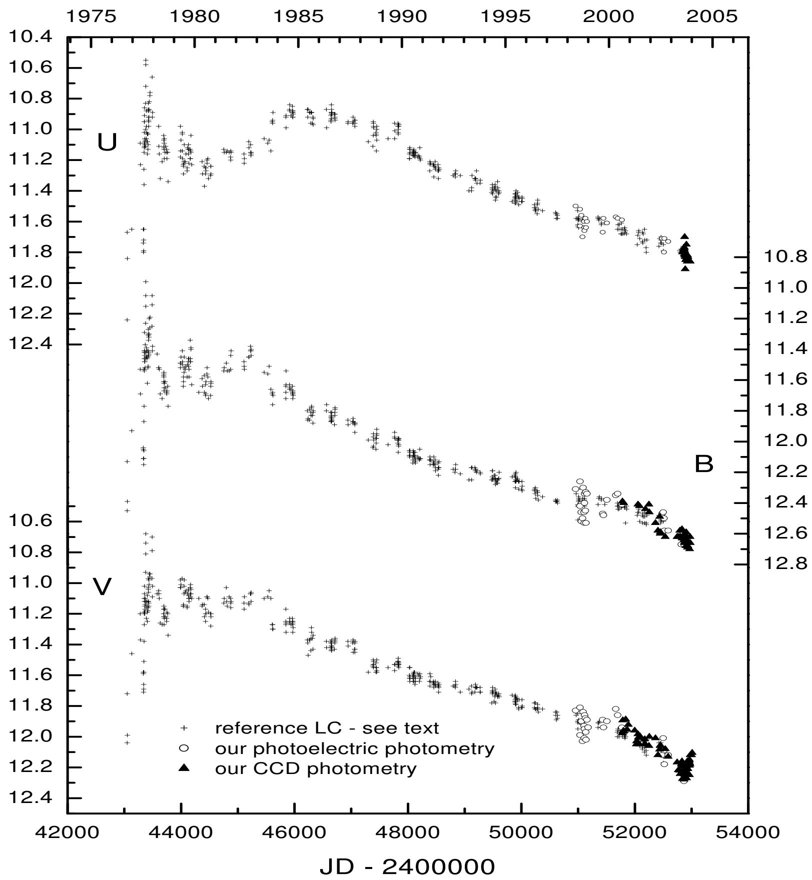

Figure 2. U, B, V light curves of HM Sge.

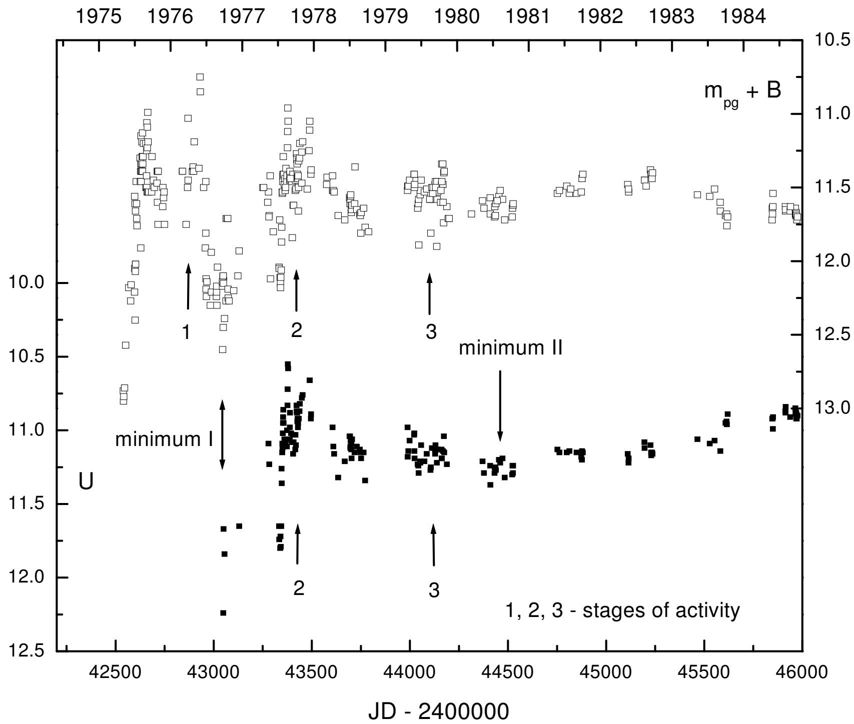

Figure 3. Detailed view of the B/m_{pg} and U light curves of HM Sge around the maximum of brightness.

3.2. CCD photometry

Our CCD *UBVRI* observations were taken with portable SBIG ST6, ST7, ST8 and Apogee Ap7p cameras mounted in the Cassegrain focus of the 0.6 m and 0.38 m telescopes of the Crimean station of the Sternberg Astronomical Institute as well as 0.7 m telescope of this institute in Moscow. In 2003, we obtained $UBV(RI)_C$ CCD observations of HM Sge by the SBIG ST10-XME camera mounted in the 2.5 m Newton focus of the new 0.5 m telescope at the Stará Lesná Observatory. We used GSC 1602.2023 (U = 12.9, B = 12.57, V = 11.96, R = 11.76, I = 10.95) and GSC 1602.2369 (U = 14.32, B = 13.28, V = 11.90, R = 11.18, I = 9.92) as comparison and check stars, respectively. Their *UBV* magnitudes were published by Noskova *et al.* (1979), the *RI* magnitudes were determined and corrected to the international Johnson system in our paper using the photoelectric standard star HD169981 (Mendoza, 1967). For the determination of the CCD magnitudes we have used the standard MIDAS package.

Table 2. The CCD U, B, V, R, I magnitudes of HM Sge obtained at Crimea, Moscow and Stará Lesná observatories. The number of frames obtained during one night by the ST10 camera is also given. JD = JD* + 2 400 000

JD*	U	B	V	R	I	Camera
51781.38		12.39	11.978	11.003	10.558	ST7
51789.29			11.893	10.949	10.602	ST7
51798.26			11.962	10.982	10.438	ST7
51804.26		12.40	11.966	10.983	10.325	ST7
51839.16			11.888	10.795	9.214	ST6
51863.17				10.703	8.716	ST8
51866.17			11.954	10.675	8.665	ST7
51879.17				10.676	8.694	ST8
51887.15			11.922	10.629	8.389	ST7
51998.54			11.960	10.797	8.966	ST6
52027.54			12.049	10.851	9.136	ST7
52033.48			12.030	10.851	8.917	ST7
52055.47		12.41	11.984	10.853	9.351	ST6
52065.35			12.005	10.855	9.336	ST6
52084.34		12.42	12.049	10.897	9.592	ST6
52090.35			11.997	10.910	9.469	ST6
52173.39			12.048	11.000	10.000	ST7
52175.35			12.016	11.039	10.000	ST7
52189.26		12.44	12.050	11.096	10.035	ST7
52248.23		12.41	12.060	11.054	10.235	ST7
52254.15		12.46	12.000	11.037	10.200	ST7
52364.55		12.53	12.010	10.951	9.525	ST6
52406.49		12.58	12.120	10.809	8.661	ST6
52439.53		12.49	12.083	10.890	8.838	ST7
52447.46		12.60	12.060	10.897	8.905	ST7
52451.43		12.59	12.056	10.903	8.937	ST7
52535.24		12.62	12.080	11.004	9.275	ST7
52587.32			12.130	11.141	9.675	ST7
52821.38		12.58	12.180	11.203	10.771	Ap7p
52832.38		12.57	12.160	11.266	10.740	Ap7p
52836.45		12.63	12.192	11.246	10.727	ST7
52901.40		12.68	12.250	11.160	9.320	Ap7p
52902.32		12.68	12.240	11.130	9.323	Ap7p
52904.35		12.59	12.240	11.094	9.305	ST7
52907.39		12.62	12.250	11.104	9.290	ST7
52910.32	11.75	12.62	12.200	11.090	9.217	Ap7p
52913.30		12.62	12.190	11.080	9.185	Ap7p
52914.39			12.270	11.090	9.220	ST7
52916.37			12.230	11.102	9.215	ST7
52965.16			12.150	11.048	9.040	ST7
52968.17		12.70	12.170	11.050	9.002	ST7
52973.15		12.62	12.180	11.052	9.028	ST7
52977.14	11.86	12.66	12.120	11.070	8.966	AP7p
52745.55		12.62 17	12.167 17	11.239 17	10.646 16	ST10
52766.52		12.62 12	12.218 12	11.233 12	10.725 11	ST10
52793.47		12.58 11	12.221 11	11.223 11	10.736 11	ST10
52799.51		12.62 10	12.242 10	11.197 15	10.719 5	ST10
52840.35	11.80 10	12.62 10	12.274 10		10.693 10	ST10
52867.37		12.62 11	12.228 11	11.243 11	10.461 9	ST10

Table 2. (continued)

JD*	U		B		V		R		I		Camera
52868.38	11.78	23	12.62	28	12.220	31	11.204	37	10.499	27	ST10
52869.33	11.77	4	12.64	9	12.278	6	11.191	6	10.501	8	ST10
52872.35	11.78	10	12.63	4	12.262	5	11.191	11	10.391	5	ST10
52876.30	11.77	3	12.63	4	12.246	6	11.189	4	10.268	5	ST10
52877.29	11.79	3	12.60	4	12.216	4	11.210	4	10.182	3	ST10
52878.29	11.70	3	12.62	4	12.234	4	11.189	4	10.182	4	ST10
52879.29	11.82	6	12.66	6	12.240	5	11.185	5	10.122	5	ST10
52880.31	11.81	3	12.63	3	12.230	3	11.190	3	10.088	3	ST10
52882.29	11.81	4	12.65	4	12.240	4	11.140	4	9.990	4	ST10
52888.46	11.83	4	12.62	3	12.190	3	11.135	3	9.647	3	ST10
52889.38	11.81	4	12.61	4	12.200	4	11.130	3	9.630	3	ST10
52890.41	11.91	4	12.64	5	12.220	5	11.135	5	9.606	5	ST10
52891.33			12.65	10	12.210	10	11.110	9	9.739	10	ST10
52896.42			12.63	9	12.230	10	11.070	10	9.702	10	ST10
52898.29	11.85	7	12.62	7	12.230	7	11.070	7	9.617	5	ST10
52901.32			12.65	10	12.220	10	11.075	8	9.617	10	ST10
52914.30	11.84	9	12.64	10	12.210	10	11.080	10	9.481	10	ST10
52925.31	11.86	8	12.65	8	12.160	10	11.105	10	9.328	9	ST10
52931.32	11.82	8	12.69	10	12.240	10	11.095	10	9.195	10	ST10
52937.25	11.83	10	12.68	10	12.210	10	11.110	10	9.161	10	ST10
52949.21					12.169	13	11.097	12	8.949	11	ST10
52952.22					12.169	9	11.112	10	8.938	8	ST10
52953.21					12.156	7	11.111	7	8.911	6	ST10
52956.21					12.157	10	11.128	8	8.920	9	ST10
52964.21					12.189	10	11.086	7	8.953	8	ST10
52965.20					12.250	12	11.132	10	8.953	7	ST10
53000.17					12.120	12	11.150	10	8.889	11	ST10
53011.19					12.105	12	11.161	10	8.856	11	ST10

Our CCD data of HM Sge require the shift of $\Delta B = 0.07$ mag and $\Delta V = 0.11$ mag for the ST6, ST7 CCD cameras and $\Delta U = -0.55$ mag and $\Delta B = 0.03$ mag for the Ap7p CCD camera, to be compatible with the reference light curve. Corresponding shifts for the ST10 CCD camera are $\Delta U = -0.55$ mag, $\Delta B = -0.3$ mag and $\Delta V = -0.42$ mag. The resulting U, B and V magnitudes are presented in Table 2.

Due to the different spectral sensitivity of the CCD cameras, different sets of the filters used for the observations and strong changes of the colour indices of the Mira variable connected with pulsations, the calculation of the resulting R and I magnitudes is more complicated than in the U, B and V passbands. The coefficients k_i in the transformation formulae from the instrumental r and i magnitudes to the international Johnson R and I magnitudes

$$R = r + k_1(v - r) + k_2, \quad (1)$$

$$I = i + k_3(r - i) + k_4, \quad (2)$$

were determined for different CCD cameras as follows: ST6,7,8 (k_1 = 0.13, k_2 = –0.05, k_3 = –0.25, k_4 = 0.2); Ap7p (k_1 = 0, k_2 = 0.2, k_3 = –0.1, k_4 = 0.23); ST10 (k_1 = –0.5, k_2 = 0.38, k_3 = –0.7, k_4 = –0.27). It is important to note that k_2 and k_4 coefficients are valid for the comparison star GSC 1602-2023, only. The formulae (1) and (2) were used to find the R and I magnitudes presented in Table 2. For CCD observations taken by ST6,7,8 and Ap7p camera only one or two frames were taken during the night. The number of CCD frames taken by ST10 CCD camera, used for the calculation of the average magnitude during one night, follows the corrected CCD data presented in Table 2.

As seen in Fig. 4, our R and I CCD photometry clearly confirms the presence of a 535-day pulsation of the Mira component.

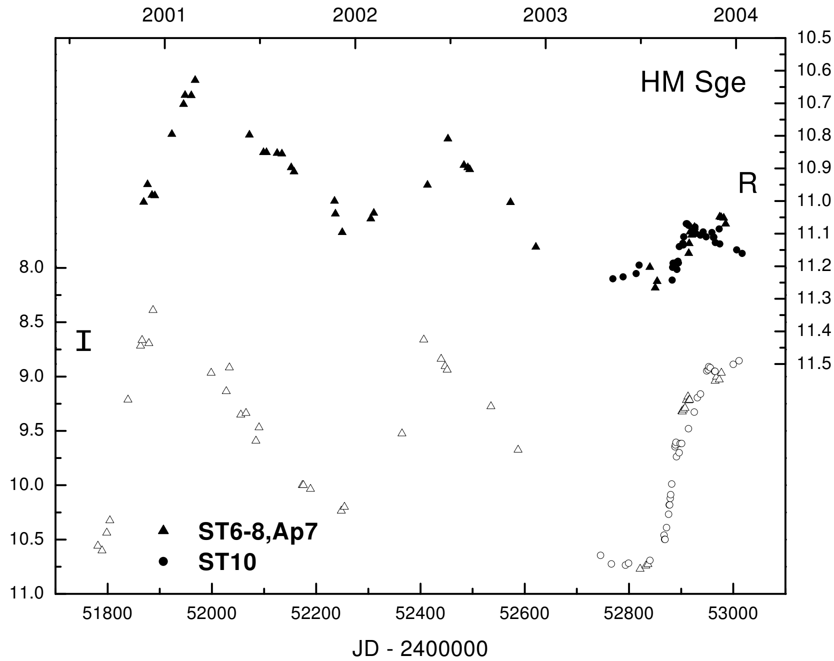

Figure 4. R and I light curves of HM Sge.

3.3. Photographic data

We measured 463 photographic plates of HM Sge taken from 1975 to 1994 from the Sonneberg (S), Crimea (C) and Skalnaté Pleso (SP) archives. The data were gathered using the 0.4 m astrograph of the Crimean Station of the Sternberg

Table 3. Photographic magnitudes of HM Sge. For the description of the symbols see the text. JD = JD* + 2 400 000

JD*	m_{pg}	Obs.	JD*	m_{pg}	Obs.	JD*	m_{pg}	Obs.
46937	11.91	C	42631	11.39	S	43254	11.50	S
46943	12.06	C	42632	11.34	S	43275	11.60	S
46971	11.82	C	42633	11.19	S	43281	11.70	S
46973	11.76	C	42634	11.39	S	43287	11.42	S
46973	11.85	C	42636	11.29	S	43289	12.12	S
46974	12.02	C	42637	11.39	S	43303	11.80	S
46975	11.85	C	42637	11.29	S	43336	11.72	S
46977	11.79	C	42638	11.34	S	43340	12.18	S
46978	11.73	C	42639	11.29	S	43365	11.50	S
46979	11.76	C	42654	11.50	S	43391	11.44	S
46979	11.88	C	42658	11.50	S	43400	11.84	S
47013	11.82	C	42661	11.09	S	43431	11.66	S
47026	11.99	C	42664	10.99	S	43432	11.50	S
47027	11.79	C	42665	11.19	S	43449	11.47	S
47035	12.04	C	42685	11.29	S	43477	11.51	S
47042	12.09	C	42697	11.50	S	43575	11.48	S
47055	12.02	C	42711	11.47	S	43605	11.42	S
47061	12.04	C	42712	11.39	S	43720	11.36	S
47310	12.04	C	42713	11.60	S	43749	11.81	S
47324	12.02	C	42714	11.39	S	43789	11.80	S
47358	12.02	C	42717	11.39	S	44045	11.89	S
47367	12.04	C	42740	11.63	S	44100	11.58	S
47379	11.79	C	42741	11.50	S	44106	11.81	S
47383	11.82	C	42840	11.39	S	44116	11.54	S
47407	11.88	C	42841	11.39	S	44118	11.50	S
47420	11.79	C	42866	11.50	S	44131	11.50	S
47681	11.76	C	42869	11.45	S	44136	11.90	S
47818	12.04	C	42891	11.39	S	44156	11.60	S
47825	12.02	C	42895	11.36	S	44158	11.52	S
48091	12.09	C	42897	11.39	S	44167	11.34	S
48486	12.23	C	42900	11.19	S	44169	11.60	S
48540	12.16	C	42924	11.37	S	44171	11.74	S
49104	12.21	C	42948	11.50	S	44195	11.71	S
48828	12.25	SP	42957	11.91	S	44200	11.71	S
48862	12.23	SP	42959	11.81	S	44445	11.59	S 13
48841	12.05	SP	42961	12.12	S	44819	11.51	S 8
42534	13.20	S	42962	12.24	S	45204	11.49	S 10
42545	13.30	S	42987	11.94	S	45581	11.60	S 15
42546	13.20	S	42988	12.21	S	45940	11.63	S 24
42596	12.21	S	43013	12.24	S	46310	11.81	S 57
42599	12.40	S	43014	12.21	S	46688	11.61	S 20
42600	12.07	S	43015	12.17	S	47008	11.84	S 16
42601	12.02	S	43016	12.30	S	47402	11.92	S 30
42602	12.02	S	43019	12.04	S	47778	11.95	S 23
42607	11.71	S	43044	12.17	S	48128	12.09	S 32
42609	11.76	S	43045	12.60	S	48508	12.25	S 26
42627	11.39	S	43073	12.19	S	48832	12.09	S 27
42628	11.91	S	43078	12.27	S	49232	12.29	S 12
42629	11.34	S	43250	11.50	S	49558	12.13	S 18

Astronomical Institute. All observations in Sonneberg were obtained using the 6 cm sky-patrol telescope. A few observations were obtained using the 0.3 m astrograph at the Skalnaté Pleso Observatory. Photographic magnitudes were estimated visually using the Nijland – Blazhko method and the photometric sequence of comparison stars published by Noskova *et al.* (1979). Because of different types of telescopes and plate sensitivities (i.e., different λ_{eff}), the data taken at different observatories exhibit small relative shifts. Our resulting photographic magnitudes given in Table 3 were already shifted to be in agreement with the reference B light curve. The mean error of our estimates is about 0.3 mag. Due to the large scatter of photographic observations from Sonneberg after 1979, we give mean annual values instead of individual observations. The number of observations included into the mean values are presented in the last column of Table 3.

Our data together with published m_{pg} observations (Chaisson, 1976; Ciatti *et al.*, 1977; Belyakina *et al.*, 1988) were used to construct the historical m_{pg} light curve shown in Fig. 1. Chaisson (1976) data were shifted by –0.25 mag to be in agreement with other data.

3.4. Visual data

We also used visual estimates from the AFOEV (Association Française des Observateurs d'Etoiles Variables), AAVSO (American Association of Variable Stars Observers), VSOLJ (Variable Stars Observers League of Japan) and VSNET (Variable Stars Network) databases from 1977 to 2003. After removing the "unsure" (:) and "fainter than" (<) data, altogether 3942 visual estimates were used. Due to the large scatter of the original data, 20-day averages together with their running means are displayed in Fig. 5.

4. Analysis of the data

Prior to 1975, the brightness of HM Sge fluctuated between 16.9 and 18.1 mag and partly reflected the pulsation of the Mira variable (Arkhipova *et al.*, 1994). According to Belyakina *et al.* (1988), the outburst started between July 1974 and April 1975. Yudin *et al.* (1994) used linear extrapolation of the rising branch of m_{pg} light curve to find the beginning of the outburst at JD 2442406 (December 24, 1974). According to Belyakina *et al.* (1988) the nova reached its maximum of $m_{pg} = 11.13$ mag at JD 2442637 (August 12, 1975).

As it is possible to see from Fig.3, post maximum light curves of the nova can be characterized by the presence of an eclipse of the hot component by the Mira companion. The eclipse started at JD 2442665, reached a minimum at JD 2443045 and ended at JD 2443422. The descending branch of the eclipse was detected only in m_{pg} data, the minimum and ascending branch were also detected in the UBV data. The decrease of brightness in the center of the eclipse (minimum I) reached $\Delta U = 1.59$, $\Delta B = 1.34$, and $\Delta V = 1.2$ mag. This

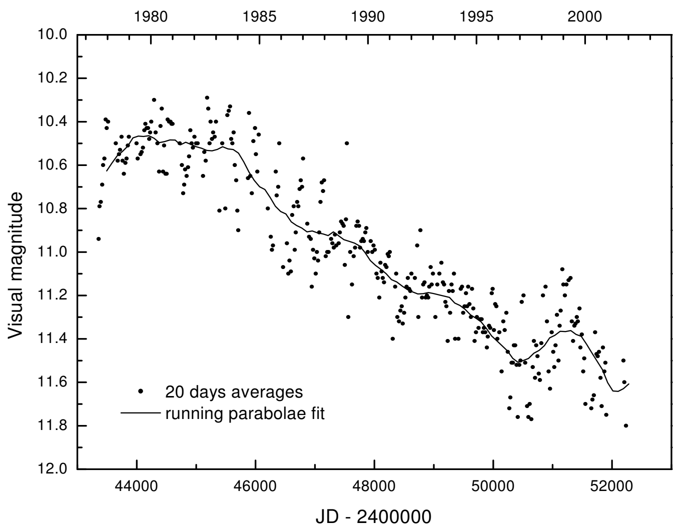

Figure 5. Visual light curve of HM Sge.

eclipse was followed by the second eclipse visible only in the U band. It started at JD 2443496, reached a minimum at JD 2444483 and ended at JD 2445619. The decrease of brightness in the minimum II was $\Delta U = 0.47$ mag. This was probably caused by partial eclipse of the hot, eccentrically located, shocked and photoionized interaction zone of two colliding winds, by the Mira companion. The existence of this zone has been proved by Formiggini *et al.* (1995).

During the eclipses, the light curve of HM Sge was influenced by the three stages of activity (see Fig. 3) of the system caused by the mass transfer bursts from Mira to the hot component. It occured in periastron of the long-period orbit, when pulsating Mira approached its Roche lobe. The mass transfer bursts were clearly detected during the second stage of activity in UBV bands. This consisted of two minima at JD 2443339 and JD 2443405 followed by two maxima at JD 2443378 and JD 2443490. Corresponding amplitudes of the light variations in U reached 1.25 mag and 0.5 mag, respectively. Due to seasonal gaps in observations, only the secondary maxima of the first and the third stage of activity were detected at JD 2442930 and 2444020, respectively. The stages of activity repeat with 535-day period of pulsations of the Mira variable. The main outburst of the nova was also triggered by the mass transfer burst from the Mira companion around JD 2442395 (Dec. 13, 1974).

The behaviour of the U light curve can be characterized by a prolonged maximum which was influenced by the eclipse and lasted until JD 2446700.

Thereafter, an almost linear decline was detected. Evolution of the B, V and visual light curves was almost similar. Their prolonged maximum lasted only until $\sim$ JD 2445600. An almost linear decline until JD 2451700 was disturbed by wave-like variations. Thereafter, a steeper decline, more pronounced in V than B, was detected. This decline is probably caused by a secondary eclipse during which the hot component with surrounding nebula started to eclipse the Mira companion. This conclusion is also supported by the recent continuous decline of brightness in R and I passbands (see Fig. 4) after subtracting Mira pulsations.

A detailed description of the long-term behaviour of the $U-B$ and $B-V$ colour indices has been recently published by Arkhipova *et al.* (2004). Therefore, we do not include it into our paper.

5. Discussion

No doubt the symbiotic nova HM Sge includes a pulsating Mira and an accreting white dwarf that underwent a thermonuclear outburst in 1974, leading directly to a nebular spectrum. According to the ionization model of symbiotic binaries, the hot luminous component ionizes the neutral wind of the giant giving rise to the nebula in the system. The fast wind from the hot object interacts with the slow wind from the Mira variable and forms a shocked and photoionized interaction zone, the main source of the U continuum. The position of this zone is shifted by orbital motion from a line connecting the centers of the components. The minimum I and II were caused by the eclipses of the hot component and hot interaction zone by a Mira companion moving on a long period eccentric orbit. A recent deviation of brightness decrease in the V band from a linear trend and brightness decrease in the RI band observed after 2001 suggest that the hot component surrounded by the nebula started to eclipse Mira companion. If this is the case, then the interval between the primary and secondary minima on a long-period orbit is at least 28 years.

Our CCD RI photometry clearly shows a 535-day pulsation period of the Mira variable, present in the system. Recurrent mass transfer bursts from Mira variable in the periastron of their long-period orbit to the hot component triggered main outburst of the nova in December 1974 due to a TNR on the surface of the white dwarf. They were also responsible for individual flares in the accretion disk of the hot white dwarf. The existence of this disk is supported by the 3D simulation of the wind accretion by the compact star (Theuns & Jorissen, 1993) and observational evidence for the presence of a precessing accretion disk and jets in the system (Corradi *et al.*, 1999). The accretion-powered burst and outflow from accretion disk can be responsible for the observed brightenings. The wave-like variations visible in photoelectric V and visual light curve on the decline from the main outburst (with an $\approx$ 6-years period) can be caused by a precessing accretion disk.

Alternatively, HM Sge could be interpreted as a triple system, whose inner, unresolved binary has an orbital period of 6.3 years. This period was proposed by Arkhipova *et al.* (2004) due to the presence of a deep minima of the infrared continuum intensity which occurred in 1995 and 2001. They interpreted it as a result of variable dust obscuration of the cool component due to the orbital motion in agreement with the scenario proposed by Munari (1988). The radiation from the hot component inhibits dust formation everywhere in the Mira's wind except in a shadow cone. The passage of this cone through the line-of-sight, during an orbital revolution, could cause the observed obscuration. The maximum of the density of the dust, or the maximum of the radiation in the M passband, was detected in HM Sge by Taranova & Schenavrin (2000) in 1988, when also the $J - K$ colour index reached maximum. The maximum of this index was detected also in 1982 (Munari & Whitelock, 1989). If HM Sge is a triple system, the wave-like variations in V and visual light curve are caused by orbital motion. The wave-like variations of the continuum in symbiotic systems, caused by the orbital motion, are well documented (see e.g., Skopal, 2001). Parimucha *et al.* (2002) suggested that the similar system - symbiotic nova V1016 Cyg can be a triple system, with the orbital period of the inner binary 15.1 years.

Further observations are necessary to decide if HM Sge is a binary or triple system.

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