COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4588

Konkoly Observatory
Budapest
28 April 1998
HU ISSN 0374 – 0676

RECENT OUTBURST OF AG Dra HAS FINISHED

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The symbiotic star AG Draconis is a binary with the orbital period of 554 days (Meinunger 1979). It consists of a red giant of the spectral type <KIII (Kenyon and Fernandez-Castro 1987) with a mass of 1.5 $M_\odot$ and a white dwarf with the effective temperature of T_{eff} = 1.2×10^5 K and the mass of 0.5 $M_\odot$. Garcia (1986) found an orbital separation of 400 $R_\odot$. Huang, Friedjung and Zhou (1994) confirmed that the cool component is a yellow star and is therefore less cool than most cool components of symbiotic binaries. AG Draconis has been very intensively monitored symbiotic star since 1890 photographically (Robinson 1966) and since 1965 photoelectrically as well. Until 1930, its light curve (LC) displayed a quiescent stage, but there have been observed several outbursts afterwards (1936, 1951, 1966, 1980, 1985, 1994) with the maximum amplitude of around 4 magnitudes.

We have intensively monitored this star in the last years, especially from 1994, when the last series of eruptions begun (Petrík and Hric 1994).

The photoelectric observational material discussed in this paper was obtained in the interval between July 12, 1994 and February 17, 1998, at the Hlohovec, Skalnaté Pleso and Stará Lesná Observatories (Cassegrain 600/7500, single-channel photometer with digital converter). The moments of the individual observations and U, B, V magnitudes are listed in Table 1. The accuracy of the photoelectric observations did not exceed 0.03 mag (U) and 0.02 mag (B, V). The star BD + 67°925 having V=9.88 mag, B−V=0.56 mag and U−B=−0.04 mag (Skopal and Chochol 1994) was used as a comparison.

Photoelectric data, which were not obtained by us, were collected in the frame of the international photometric campaign of symbiotic stars (Hric et al. 1996 and references therein) and were adopted from Meinunger (1979), Kaler (1987), Iijima et al. (1987), Petrík and Hric (1994), Montagni et al. (1996), Mikolajewski (1997), Greiner et al. (1997) and Tomova and Tomov (1998). Historical light curves (LCs) for the system of AG Draconis are presented in Figure 1.

Many authors studied the problem of periodicities in this system and number of them (Meinunger 1979, Iijima 1987, Skopal 1994, Bastian 1998) had proposed the ephemeris for the basic orbital period or for the outburst occurrence. Unfortunately, except of some

notes about the shorter, but not determined exactly, time intervals between the outburst's peaks, there was no rigorous period analysis performed for this system. Bastian (1998) has used the visual data provided by the AFOEV observers to determine the basic period in the whole set of data, spanning around 20 years. He found P = 380 days as the period of outbursts. Nevertheless, there are longer intervals between some outbursts (> 380 days), not covered by any increase of visual brightness (cf. Fig. 1 in Bastian 1998).

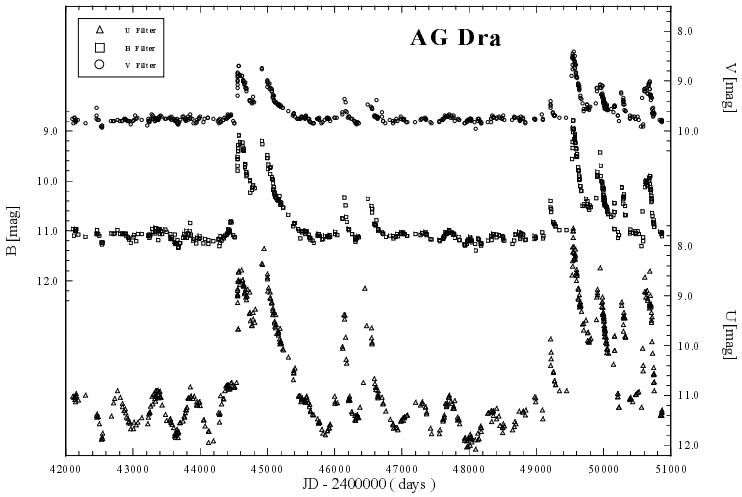

Figure 1. Historical light curves of AG Draconis in U, B and V colours

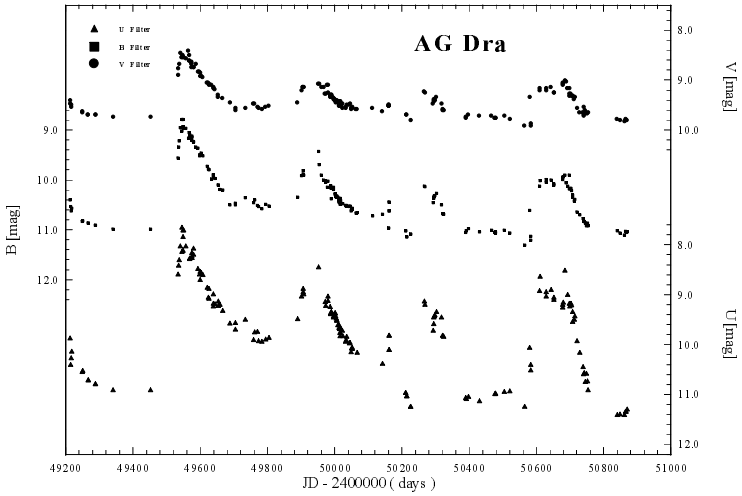

Figure 2. Recent outburst period of AG Draconis captured from August, 1993 to February, 1998

Our historical LCs cover roughly the same time interval as in Bastian (1998) and contain photoelectric photometry from the literature above. The wave-like variations are clearly visible in all colours, interrupted from time to time by the active phase. Each such active phase contains several outbursts. (1980-1981, 1985-1986, 1994-1997).

That's why we decided to divide all data to active and quiet stages and analyze them separately for the possible periodicities. Fourier period analysis revealed two significant groups of periods, each one characteristic for different stage of AG Dra. Table 2 shows the exactly obtained periods for each colour and the stage of this symbiotic/recurrent nova.

Table 1: Photoelectric observations of AG Draconis

JD_{hel} −2 400 000	U	B	V	ΔR	Obs	JD_{hel} −2 400 000	U	B	V	ΔR	Obs
49266.494	10.73	10.87	9.69	-	SP	49987.343	9.37	10.15	9.35	−1.00	SP
49288.400	10.81	10.92	9.70	-	SP	49989.371	-	10.38	9.29	-	HL
49545.55	7.92	9.00	8.55	-	HL	49989.377	9.36	10.17	9.30	−1.04	SP
49548.46	-	8.93	8.52	-	HL	49996.640	9.46	10.15	9.36	−1.04	SP
49549.45	7.66	8.79	8.55	-	HL	50001.400	9.39	10.29	9.40	-	HL
49549.51	7.72	8.95	8.51	-	HL	50001.423	9.37	10.28	9.39	-	SL
49550.45	7.84	9.09	8.50	-	HL	50002.361	9.44	10.32	9.43	-	SL
49550.47	7.60	8.84	8.57	-	HL	50004.396	9.48	10.34	9.45	-	SL
49550.46	7.72	8.97	8.54	-	HL	50005.633	9.52	10.32	9.43	−1.00	SP
49556.516	8.05	8.97	8.58	−1.50	SP	50006.596	9.54	10.33	9.40	−1.02	SP
49574.41	8.24	9.14	8.66	-	HL	50008.634	9.62	10.35	9.44	−0.99	SP
49574.430	8.18	9.14	8.63	-	HL	50013.370	9.68	10.45	9.51	-	SL
49574.476	8.27	9.12	8.67	−1.44	SP	50013.401	-	10.43	9.45	-	HL
49575.405	8.27	9.21	8.75	−1.40	SP	50014.655	9.70	10.44	9.52	−0.90	SP
49579.428	8.21	9.23	8.75	-	SL	50015.317	9.78	10.44	9.47	-	HL
49580.36	8.09	9.24	8.75	-	HL	50015.331	9.78	10.44	9.47	-	HL
49592.528	8.50	9.37	8.84	−1.32	SP	50015.536	9.67	10.37	9.43	−1.02	SP
49597.49	8.60	9.52	8.84	-	HL	50016.308	9.67	10.42	9.48	−0.97	SP
49600.31	8.50	9.61	8.97	-	HL	50016.366	9.84	10.49	9.44	-	HL
49600.498	8.55	9.50	8.92	−1.26	SP	50017.462	9.70	10.41	9.45	−0.95	SP
49602.517	8.58	9.46	8.92	−1.26	SP	50018.439	9.71	10.46	9.57	-	SL
49608.30	8.62	9.52	8.95	−1.22	SP	50022.413	9.73	10.81	9.47	-	HL
49620.610	8.87	9.72	9.05	−1.16	SP	50031.578	9.96	10.52	9.56	-	SP
49626.559	8.89	9.79	9.09	−1.13	SP	50034.637	9.92	10.53	9.53	−0.91	SP
49638.538	9.00	9.90	9.16	-	SP	50035.662	9.85	10.51	9.50	−0.93	SP
49653.43	9.23	10.10	9.29	-	HL	50043.660	9.99	10.53	9.50	−0.92	SP
49653.650	9.15	10.10	9.33	-	SP	50044.619	9.99	10.52	9.48	−0.94	SP
49658.50	9.21	10.19	9.76	-	HL	50049.680	10.09	10.60	9.57	−0.87	SP
49666.415	9.34	10.20	9.36	-	SP	50051.660	10.10	10.58	9.56	−0.86	SP
49688.30	9.59	10.50	9.45	-	HL	50052.625	10.08	10.57	9.53	−0.89	SP
49705.228	9.58	10.47	9.56	-	SL	50067.267	10.17	10.65	9.59	-	SL
49705.288	9.72	10.51	9.60	-	SL	50159.46	-	10.97	9.51	-	HL
49734.565	9.51	10.36	9.57	-	SP	50161.56	9.83	10.45	9.52	-	HL
49759.268	9.92	10.45	9.48	-	SL	50162.47	10.12	10.62	9.50	-	HL
49762.459	9.77	10.41	9.47	-	SP	50211.40	10.98	11.02	-	-	HL
49769.534	9.76	10.51	9.55	-	SP	50214.38	11.05	11.14	9.69	-	HL
49783.613	9.95	10.58	9.58	-	HL	50226.35	11.26	11.09	9.81	-	HL
49805.315	9.87	10.52	9.52	-	SL	50580.55	10.07	10.61	9.34	-	HL
49818.584	9.95	10.52	9.52	−0.79	SP	50583.51	10.53	11.13	9.87	-	HL
49854.366	9.56	10.47	9.54	−0.79	SP	50583.53	10.42	11.21	9.92	-	HL
49861.371	9.81	10.48	9.52	-	SP	50609.42	8.94	10.12	9.21	-	HL
49864.372	9.74	10.46	9.52	−0.85	SP	50610.42	8.65	10.01	9.12	-	HL
49889.511	9.50	10.34	9.46	−0.87	SP	50685.42	8.53	9.91	9.01	-	HL
49900.465	9.05	9.92	9.21	−1.07	SP	50688.37	9.33	10.06	9.04	-	HL
49905.419	8.89	9.81	9.15	−1.14	SP	50693.45	9.01	10.13	9.16	-	HL
49906.469	8.96	9.88	9.14	-	B	50697.44	9.66	9.90	9.17	-	HL
49907.439	9.00	9.90	9.15	-	B	50707.39	9.36	10.30	9.32	-	HL
49907.471	9.05	9.85	9.18	−1.10	SP	50708.39	9.55	10.35	9.32	-	HL
49921.393	8.70	9.68	9.02	-	SL	50712.39	9.51	10.41	9.37	-	HL
49924.544	8.78	9.70	9.03	−1.19	SP	50714.37	9.44	10.39	9.35	-	HL
49925.432	8.72	9.58	8.98	−1.23	SP	50721.37	9.94	10.65	9.56	-	HL
49926.448	8.79	9.62	9.02	−1.12	SP	50742.371	-	-	9.55	-	HL
49942.320	8.78	9.74	9.11	-	SL	50745.334	10.76	10.87	9.61	-	HL
49943.485	8.75	9.67	9.06	−1.22	SP	50749.345	10.59	10.92	9.64	-	HL
49952.378	8.46	9.43	9.08	-	HL	50751.299	10.75	10.87	9.67	-	HL
49967.331	-	10.00	9.14	-	HL	50753.356	10.93	10.92	9.64	-	HL
49968.329	9.18	10.03	9.25	−1.07	SP	50840.308	11.42	11.02	9.78	-	SL
49970.329	9.18	10.02	9.25	-	SP	50849.533	11.41	11.07	9.80	-	SL
49978.384	-	10.15	9.10	-	HL	50862.467	11.42	11.11	9.82	-	SL
49979.42	9.05	-	9.10	-	HL	50865.319	11.35	11.03	9.79	-	SL
49979.610	9.14	10.03	9.26	−1.07	SP	50866.308	11.35	11.05	9.81	-	SL
49986.35	9.26	10.15	9.32	-	HL	50870.329	11.31	11.04	9.80	-	SL

Obs = Observatory: SP - Skalnaté Pleso, SL - Stará Lesná, HL - Hlohovec, B - Brno

Table 2: Periodicities (in days) obtained for the different stages of AG Draconis in various bands

	P_U [d]	P_B [d]	P_V [d]
quiet stage	552.49	549.8	529.9
active stage	354.11	352.1	353.1

We can summarize, that there are two periods in general: i) one of 552.486 days which was determined as the orbital one by Meinunger (1979) and Kenyon and Garcia (1986) and ii) one of about 350 days. The latter reflects probably the pulsations and irradiation effect in the atmosphere/envelope of the cold component. We suppose that the source of the brightness increase during the outburst could be connected with the red giant (Friedjung et al. *in press*). This is in agreement with the fact that the pulsation period appeared during the active stages in all colours and during quiescence only in longer wavelengths.

Another problem of the interpretation is the duration of the 1994-1997 active stage. Our last points from Table 1 show probably the end of this recent outburst activity after 3.5 years. (Nevertheless we strongly encourage any interested observers to stay with this star as long as possible.)

We point out, that this was the most active stage of AG Dra, since four outbursts appeared during four years on the LC (Fig. 2).

It is of particular interest, whether these four outbursts belong to the same physical mechanism or not, despite the fact, that they appeared with the period of 350 d. As for the outbursts in 1980-1981 and 1985-1986, Mikolajewska et al. (1995) mentioned, that the UV behaviour of them was absolutely different, those in 1980-1981 became bluer while those of 1985-1986 became redder.

Acknowledgements: We wish to thank the director of the Hlohovec Observatory J. Krištofovič for his support as well as M. Bachratý for obtaining part of the observations. This work has been supported through the Slovak Academy of Sciences grant No. 5016/98.

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