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UBVR PHOTOMETRY OF THE SYMBIOTIC STAR AG Dra IN ITS 1994 OUTBURST

AG Draconis is a symbiotic binary with an orbital period of ~552.4 days (Skopal 1994a) consisting of a relatively early cool component of spectral type < K4III (Kenyon & Fernandez-Castro 1987) and a compact hot component of $T \sim 1.2 \times 10^5$ K (Mürset et al. 1991). Since 1930, AG Dra has exhibited a series of outbursts – in 1936, 1951, 1966, 1980, 1985. The light curve of each outburst has a double peaked profile with the peak separation of $\leq P_{\rm orb}$, and the minimum located close, but slightly shifted after the spectroscopic conjunction – cool component in front. Luthardt (1983) found that the brighter outburst lasts a longer time.

In 1994 June, the visual magnitude estimates indicated that AG Dra has entered the new bright outburst (IAU Circ. 6009). Viotti, Gonzales-Riestra & Rossi (1994) observed AG Dra with the IUE satellite at the end of June and the beginning of July. They found that the ultraviolet spectrum is qualitatively similar to that of the 1980 outburst, but the line and continuum fluxes appear more intense. Optical spectrum exhibits a hot continuum with very strong HI, HeI and HeII 468 nm emissions. Balmer lines display P-Cyg absorption at −220 km/s and emission wings extended to $\sim \pm$ 400 km/s (Viotti 1994).

In our contribution we present the *UBVR* photoelectric photometry confirming the current bright outburst of AG Dra. The observations were made in the standard *UBV* system using a one-channel photoelectric photometer installed in the Cassegrain focus of the 0.6/7.5 m reflectors of the Skalnaté Pleso, Stará Lesná and Hlohovec Observatories. The stars BD+67°925 (V=9.88, $B-V$=0.56, $U-B$=−0.04), HD 145991 (V=9.26, $B-V$=0.74, $U-B$=0.31) and SAO 16935 ($m_{\rm v}$=9.8, $m_{\rm pg}$=10.6) were used as the comparison and the check stars, respectively. For details of observations see Skopal et al. (1990). Observations of AG Dra are collected in Table 1. Observations at Hlohovec observatory were taken by Petrík and Karlovský (1994). Figure 1 shows the *UBV* photometry according to the data published in the literature, and covering the period of 1980 to 1994 August. During the current outburst, the star's brightness reached a maximum on July 16, 17 when U ~7.7-7.6, B ~8.8 and V ~8.5. Such values correspond to the very bright outburst of AG Dra. The measurements made at the end of July and in August display a gradual decrease of the star's brightness in all filters (Fig. 2). In accord with the shape of the light curve observed during outbursts, we predict the same development of the optical continuum as, for example, in the 1980 outburst. The star's brightness should reach a minimum in 1995 January, afterwards, following an increase peaked sometimes in the summer of 1995, should decline from the outburst.

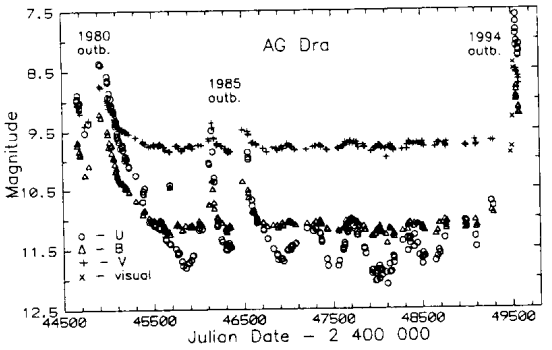

Figure 1. UBV light curves of AG Dra covering the period of 1980 to 1994 August.

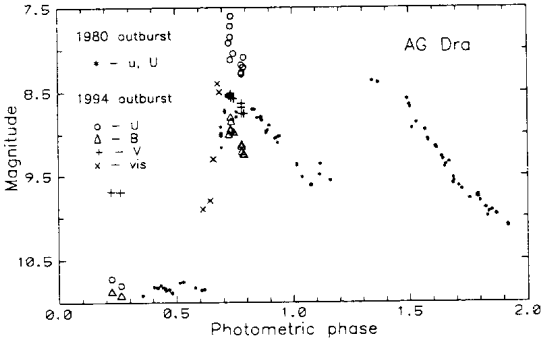

Figure 2. Compiled u and U light curve of the 1980 outburst compared to the UBV and visual photometry of the current (1994) outburst. The ephemeris for the minima in U was taken after Skopal (1994a).

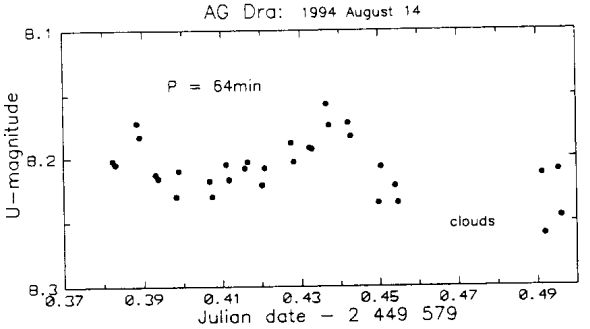

Figure 3. Observation in the U light made on 1994 August 14.

Table 1

UBVR photometry of AG Dra

Date	Julian Date	*U*	*B*	*V*	ΔR	Obs
1993 Oct 5	49266.49	10.727	10.869	9.692		SP
1993 Oct 27	49288.40	10.805	10.915	9.695		SP
1994 Jul 12	49545.55	7.92	9.00	8.55		H
1994 Jul 14	49548.47	8.12	8.93	8.52		H
1994 Jul 15	49549.45	7.85	8.79	8.55		H
1994 Jul 16	49549.51	7.72	8.95	8.51		H
1994 Jul 16	49550.47	7.60	8.84	8.57		H
1994 Jul 23	49556.52	8.046	8.969	8.575	−1.504	SP
1994 Aug 9	49574.48	8.273	9.116	8.673	−1.436	SP
1994 Aug 10	49575.41	8.270	9.207	8.749	−1.395	SP
1994 Aug 14	49579.43	8.207	9.233	8.754		SL
1994 Aug 15	49580.37	8.09	9.24	8.75		H

ΔR = AG Dra – BD+67°925

Observatory: SP – Skalnaté Pleso, SL – Stará Lesná, H – Hlohovec

Our observation taken on 1994 August 14/15 at Stará Lesná shows ∼0.05 mag variations in the *U* band with the period of ∼64 minutes (Fig. 3). No short-term flickering variability was indicated. If this is a rotational period, then the *U* pseudophotosphere has the radius of $\sim 0.5\,R_\odot$ (for Keplerian rotation and $M_{hot} = 1\,M_\odot$), which is similar to ~ 0.1-$0.2\,R_\odot$ derived by Leibowitz & Formiggini (1992) for the 1980 outburst (the hot component luminosity in quiescence of $15\,L_\odot$ was adopted after Mürset et al. [1991]).

Skopal (1994b) suggested that the major increase in the star's brightness and the phase dependent light variation developed during the outburst of AX Per are caused by the emission region on the cool component hemisphere facing the hot component and its differing visibility in different orbital phases of the binary. This effect results from collision of the mass ejected by the hot component with the red giant atmosphere. Hydrogen flash on the white dwarf surface causes an increase of the hot component radius, which fills up the critical surface very easily because of nonsynchronous rotation, and triggers the mass transfer from the hot component to the cool one. The same model can be applied to AG Dra because both mass outflow from, and rotation of the outbursting star are directly observed in the AG Dra spectrum. Moreover, Leibowitz & Formiggini (1992), analysing spectral energy distribution in the 1980 outburst, revealed that outbursts of AG Dra are triggered by events in the atmosphere of the cool giant, associated with the liberation of mechanical energy. All these facts strongly support the above mentioned idea on the nature of the wave-like modulation of the light developed during outbursts in some symbiotic stars.

AG Dra is currently included in the observing programme of the Skalnaté Pleso Observatory. The further data will be published in Contrib. Astron. Obs. Skalnaté Pleso, 25 within the long-term observational campaign of symbiotic stars.

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