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

Number 4096

Konkoly Observatory
Budapest
3 October 1994

HU ISSN 0374 – 0676

REVISED EPHEMERIS OF THE SYMBIOTIC BINARY AG Dra

AG Dra is one of the most intensively monitored symbiotic stars. Its light-curve (LC) has been studied photographically since 1890 by Robinson (1966). Until 1930, the continuum of AG Dra had displayed a quiescent stage, but afterwards several eruptions have been observed. From 1965, multicolour photoelectric observations were performed by many authors. The periodic wave-like variation in the optical continuum was observed during quiescent stages. It is largest at the ultraviolet bands, $\Delta U \sim \Delta u \approx 1$ mag, and becomes smaller with increasing wavelength; by comparison $\Delta B \approx 0.3$ and $\Delta V \approx 0.1$ (e.g. Kaler 1987, Meinunger 1979). Meinunger (1979) from his U data established for the first time a 554 day period with a $U_{\rm max}$ epoch at JD 2 438 900. Consistence of this period with the orbital period of the binary was confirmed by radial velocity variations of the cool component measured by Garcia & Kenyon (1988). In accord with the Garcia & Kenyon's solution of the spectroscopic orbit, the minima in the U band correspond to the spectroscopic conjunction with the cool component in front. Recent UBV photometry confirmed this periodic variation. The data were mostly collected in our campaign's papers (Hric et al. 1991, 1993, 1994, Skopal et al. 1992, 1995).

The aim of this contribution is to determine an ephemeris for the minima in the ultraviolet domain. On this account we constructed the U/u LC from all the available data in the literature. Differential values of magnitudes in u published by Kaler (1987) and Kaler et al. (1987) were shifted by 9.7 mag to be approximately consistent with the star's brightness in the U band. The LC is shown in Fig. 1. It covers the period from 1974 March to 1994 September with the nine minima in the quiescence. Their positions were determined by the least squares fitting of the second degree polynom to the data under consideration. Results are summarized in Table 1. The linear regression of the minima positions at the epochs 1, 2, 3, 6, 8, 9, 10, 11 gives their ephemeris as

$$JD(U_{\rm min}) = 2\,442\,514.4(\pm 11.3) + 552.4(\pm 2.2) \times E. \qquad (1)$$

The minimum at JD≈2 442 577 was not used for determination of this ephemeris, because of its worse definition and a larger shift in its position with respect to the other minima. The maximum uncertainties $\Delta \rm JD_0 = 11.3$ d and ΔP =2.2 d were determined according to relations $\Delta \rm P = \Sigma E^{-1} \Delta Min/n$ and $\Delta \rm JD_0 = \Sigma \Delta Min/n$, in which n is the number of the minima used. For the uncertainty in the position of the minimum under consideration, ΔMin, we adopted the corresponding $O-C$ value, because of assuming a constant orbital period and the $O-C$ values are larger than the uncertainties in the position of individual minima. The minima indicated photographically in the historical LC, for example at ≈2 432 050, ≈2 433 760 (Sharov 1960), ≈2 434 790 (Luthardt 1983), agree well with those predicted by the ephemeris (1).

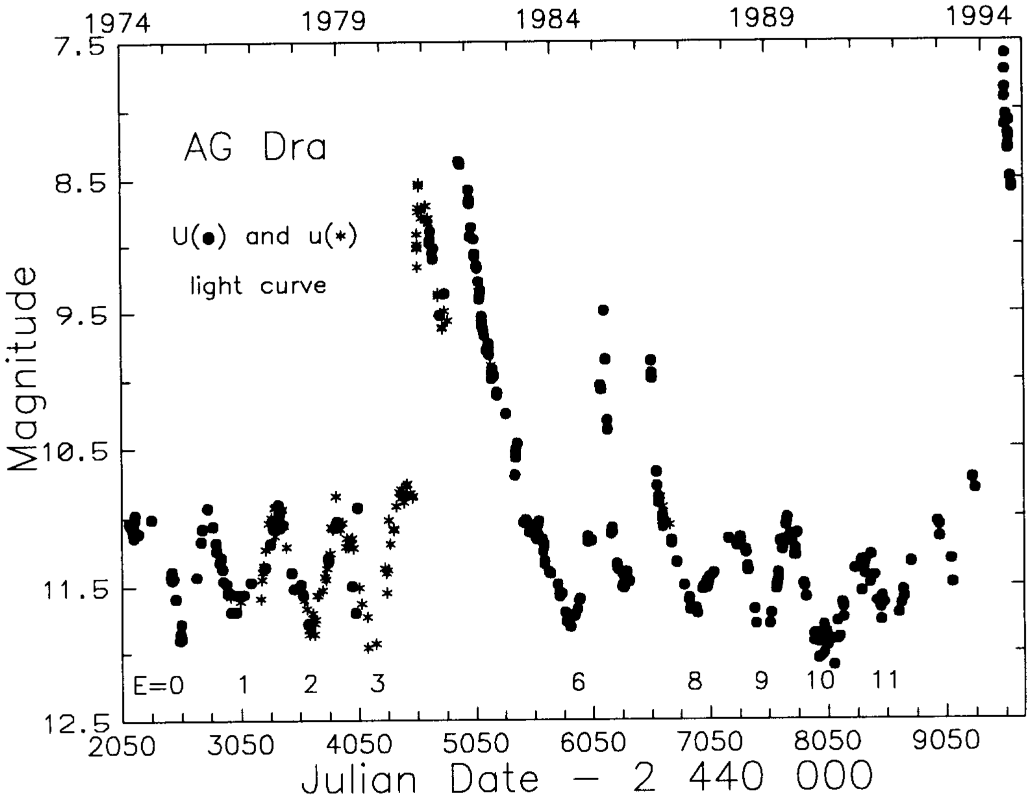

Figure 1. Compiled U/u light curve of AG Dra.

Table 1.

Epoch	$JD_{Min}(O)$	$JD_{Min}(C)$	$O-C$
0	2 442 577. ±14.?	2 442 514.4	62.6
1	43 064.8 ±3.0	43 066.8	−2.0
2	43 622.4 ±1.6	43 619.2	3.2
3	44 156.3 ±3.6	44 171.6	−15.3
6	45 853.4 ±2.0	45 828.8	24.6
8	46 920.4 ±2.0	46 933.6	−13.2
9	47 503.8 ±3.0	47 486.0	17.8
10	48 035.8 ±3.0	48 038.4	−2.6
11	48 579.4 ±3.0	48 590.8	−11.4

The $O-C$ diagram is shown in Fig. 2. Differences between the observed and computed positions of the minima are often far larger than the uncertainty of their determination. This reflects the fact that the individual minima differ from each other both in the shape and the position (cf. Fig. 1). Such behaviour cannot be ascribed to a reflection effect, because this effect can produce only a strictly regular shape of LCs. Moreover, due to a relatively small radius of the cool component ($< 50\,R_{\odot}$ as for its spectral type of $<$K4III), a very small fraction of the hot component radiation (approximately $<$0.4%, for the separation of the components of $400\,R_{\odot}$) will irradiate the facing cool component hemisphere, which is not sufficient to give rise of the 1 mag reflection effect (cf. Skopal 1994). It is suggested that the circumstellar matter located in the binary within the common potentials due to an outbursting activity of the hot component, is responsible for such a wave-like variation in the optical continuum (cf. Skopal et al., 1993).

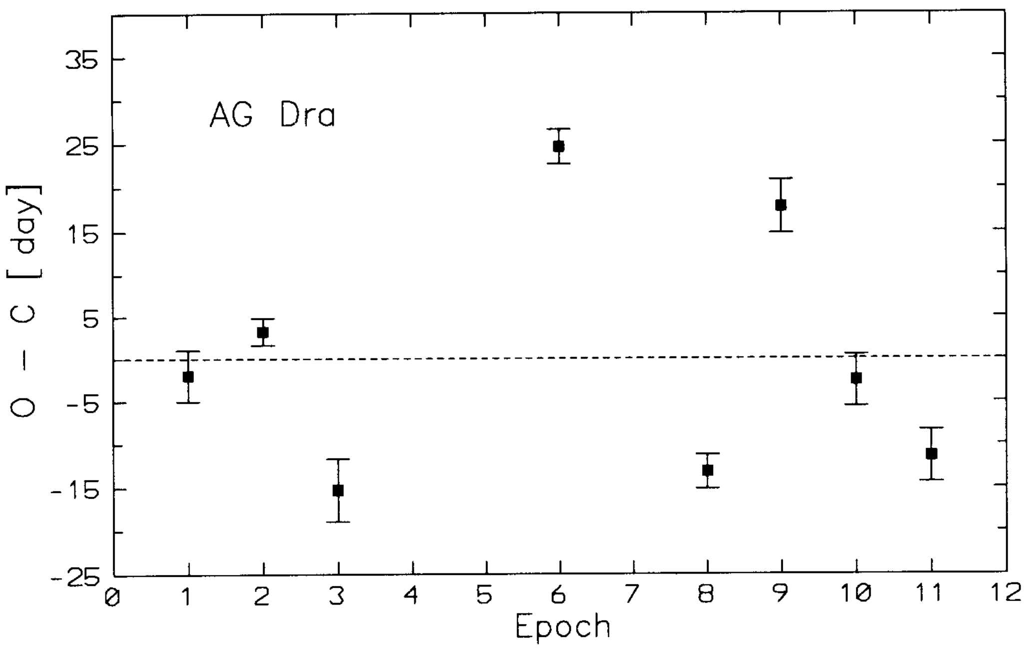

Figure 2
O−C diagram of the minima in the U/u light curve of AG Dra.

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