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THE PERIOD BEHAVIOUR OF THE ECLIPSING BINARY LD 328

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LD 328 (GSC 3256-0458, $00^{\rm h}26^{\rm m}49\overset{\rm s}{.}09$, $+49^\circ40'35\overset{''}{.}7$ (USNO A2.0)), was discovered to be variable by Dahlmark (1999) during a photographic survey of the northern Milky Way. Dahlmark suggested that the star was an eclipsing binary with an amplitude of 1.0 mag at V, but was unable to find the period. The period has now been determined from Dahlmark's data and extensive visual observations, and its behaviour over most of the last century has been followed using further observations from the Harvard plate archive, and recent CCD observations.

LD 328 has been examined on plates of the Harvard College Observatory archive RH Patrol Series (1928–1952), limiting magnitude 14-15, Damon Patrol Series (1965–1990), limiting magnitude 14–15, and AC Series (1898–1954), limiting magnitude 12, although some are much fainter. The plates are blue sensitive and magnitudes of LD 328 have been estimated visually by Guilbault on 171 RH, 119 Damon and 27 AC Series plates against comparison stars with magnitudes from USNO A2.0 (Monet et al. 1998). The Harvard data provide 15 times of minima, although one timing is inconsistent with the others. Dahlmark's (1999) observations were made between 1967 and 1999 using Kodak 103aD + GG11 and TechPan 4415 + GG495 emulsion/filter combinations, giving approximately $m_{\rm pv}$ magnitudes, which were determined by visual comparison against nearby stars with GSC magnitudes. The light curve is previously unpublished and provides six times of minima. An extensive series of visual observations by Guilbault and Kinnunen, which initially allowed the period to be resolved, contain eleven times of minima, although all but the last of these are based on single observations. Recent CCD observations by Hager, Henden, James, Kaiser and Lubcke have provided a complete light curve at V, and most of the primary minimum in the red (unfiltered CCD). These observations provide accurate

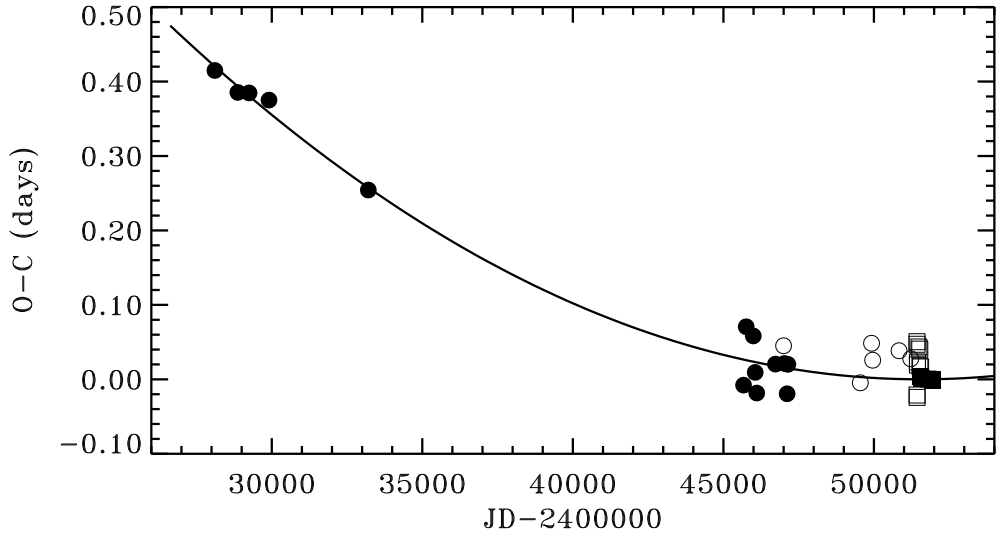

Figure 1. The $O-C$ diagram of the times of minima using the linear terms of the ephemeris, with the quadratic fit shown. The Harvard data are shown by filled circles, Dahlmark's data, open circles, visual data, open squares and CCD data, filled squares

timings of three primary minima and one secondary minimum, and are described in more detail by Lloyd et al. (2001).

All the times of minima have been collected in Table 1 and the $O-C$ diagram is shown in Figure 1. The residuals show clear curvature indicating a changing period. In fitting a parabolic ephemeris it has been necessary to give the CCD observations high weights to force the solution through them. Also, all but the first of Dahlmark's times of minima have been excluded from the solution as they appear to be systematically high, although it is not clear if this has any significance. The visual timings have also not been used as they are relatively recent and are much less reliable than the CCD timings. The adopted parabolic ephemeris is

$$\mathrm{HJD_I} = 2451559.2824(29) + 1.0838485(14) \times E + 9.0(7) \times 10^{-10} \times E^2$$

and is subject to small variations depending on the weights used. The $O-C$ diagram using the linear terms of the ephemeris in shown in Figure 1. The phase diagrams of the Harvard data for 1928–1951 and 1975–1989 are shown in Figure 2, and are constructed using a changing period. The linearized phase diagram of Dahlmark's data is shown in Figure 3.

Photometric modelling of the CCD observations by Lloyd et al. (2001) suggests that the system is a relatively cool Algol binary containing components of spectral type late A and late G, with the secondary probably filling its Roche lobe. The rate of period change, $\dot{P}/P = 5.6 \times 10^{-7}$ yr^{-1} is not unlike other Algol systems, and suggests that there is continuing mass transfer in the system.

The authors would like to thank Dr. Martha Hazen, Curator of the Astronomical Photograph Collection of the Harvard College Observatory, for access to the plates of this and other variable stars.

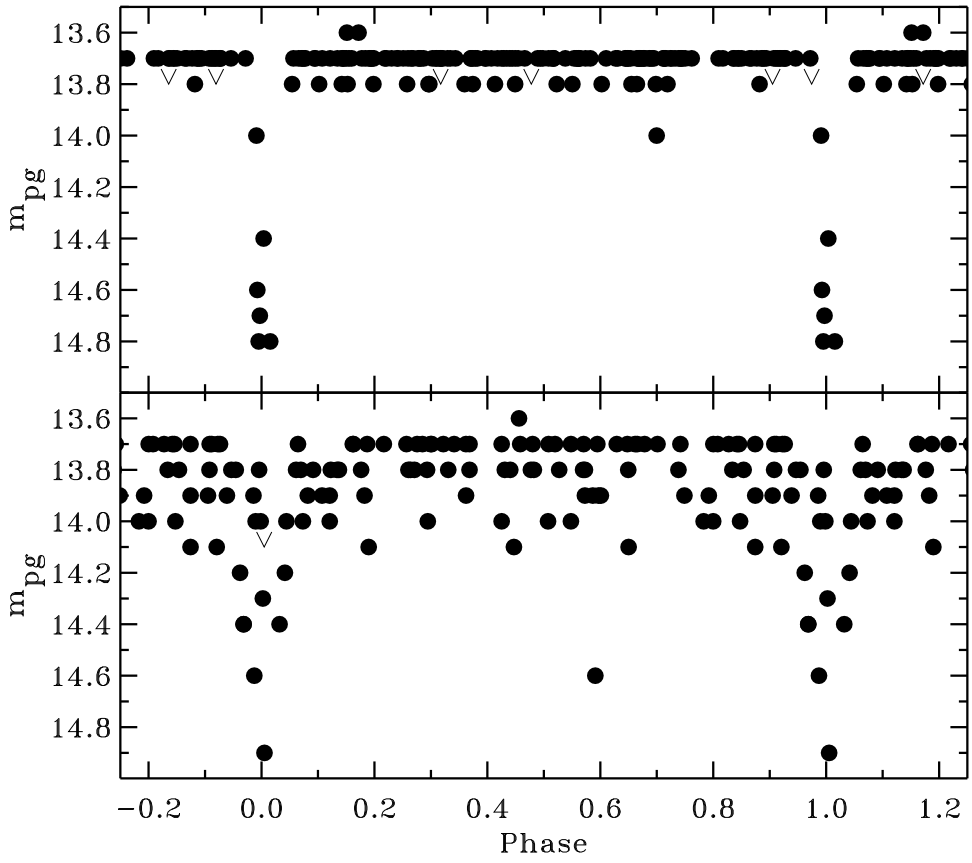

Figure 2. The linearized phase diagram of the early Harvard data, 1928–1951 (top), and the later Harvard data, 1975–1989 (bottom) folded using the parabolic ephemeris

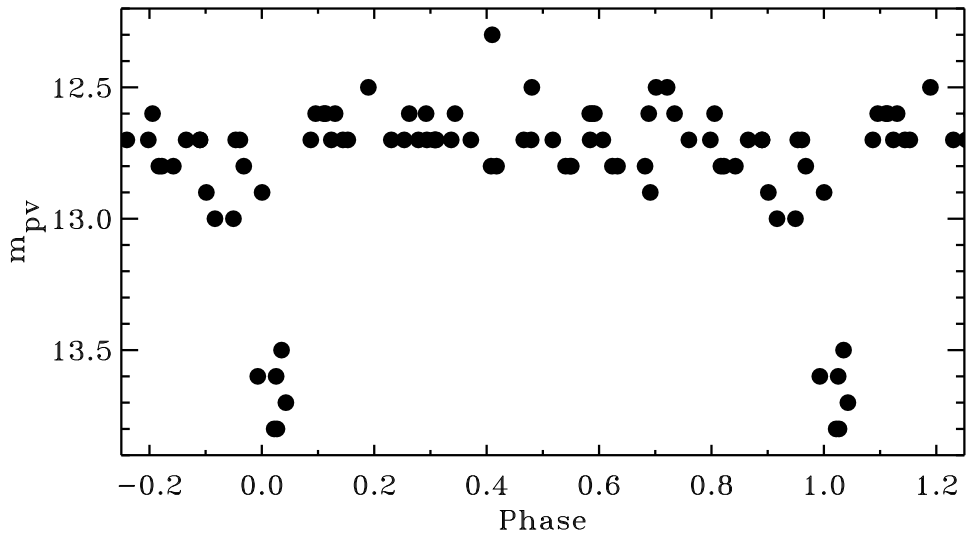

Figure 3. The linearized phase diagram of Dahlmark's data

Table 1: Times of minima of LD 328

HJD	Cycle	$O-C$	band	Observer
2428110.635	−21635	0.4149	pg	Guilbault
2428872.551	−20932	0.3854	pg	Guilbault
2429246.478	−20587	0.3847	pg	Guilbault
2429907.616	−19977	0.3751	pg	Guilbault
2433206.730	−16933	0.2543	pg	Guilbault
2445668.558	−5435	−0.0078	pg	Guilbault
2445757.512	−5353	0.0706	pg	Guilbault
2445991.611	−5137	0.0583	pg	Guilbault
2446055.509	−5078	0.0093	pg	Guilbault
2446107.506	−5030	−0.0184	pg	Guilbault
2446728.590	−4457	0.0204	pg	Guilbault
2446998.493	−4208	0.0451	pv	Dahlmark
2447028.817	−4180	0.0213	pg	Guilbault
2447116.568	−4099	−0.0194	pg	Guilbault
2447141.536	−4076	0.0201	pg	Guilbault
2447446.731	−3794	−0.4302	pg	Guilbault
2449546.571	−1857	−0.0047	pv	Dahlmark
2449919.468	−1513	0.0484	pv	Dahlmark
2449957.380	−1478	0.0257	pv	Dahlmark
2450835.310	−668	0.0384	pv	Dahlmark
2451223.317	−310	0.0276	pv	Dahlmark
2451430.355	−119	0.0506	vis	Kinnunen
2451431.4354	−118	0.0471	vis	Guilbault
2451432.4479	−117	−0.0242	vis	Guilbault
2451432.451	−117	−0.0211	vis	Kinnunen
2451443.3299	−107	0.0193	vis	Guilbault
2451443.334	−107	0.0234	vis	Kinnunen
2451493.211	−61	0.0434	vis	Kinnunen
2451522.4722	−34	0.0406	vis	Guilbault
2451525.7007	−31	0.0176	vis	Guilbault
2451549.5444	−9	0.0166	vis	Guilbault
2451559.2854	0	0.0034	ccd	James
2451585.2977	24	0.0014	ccd	James
2451821.574	242	0.0003	vis	Guilbault
2451931.5829†	343	−0.0015	V	Henden
2451937.5451	349	−0.0004	V	Lubcke
2451937.5456	349	0.0001	V	Kaiser

†: Secondary minimum

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