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# THE FIRST *BVRI* LIGHT CURVES AND ANALYSIS OF THE SHORT-PERIOD ALGOL-TYPE BINARY DI Hya

MANIMANIS, V. N.; NIARCHOS, P. G.

Dept. of Astrophysics, Astronomy and Mechanics, Faculty of Physics, National & Kapodistrian University of Athens, Athens, Greece. e-mail: vmaniman@phys.uoa.gr

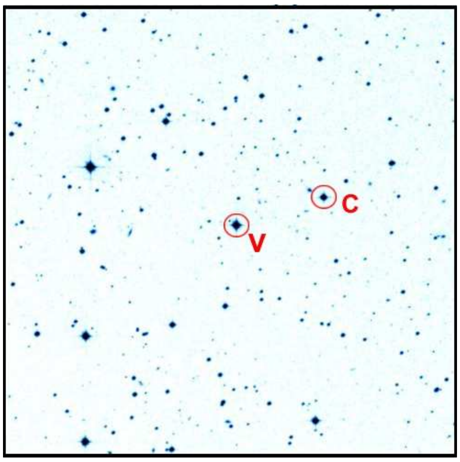


**Figure 1.** $14' \times 14'$ finding chart with the comparison (C) star marked; DI Hya is marked with a V. North is up and east is to the left.

The eclipsing binary DI Hydrae (AN 203.1932), included by Budding et al. (2004) in their list of Algols was observed in our search for near-contact variables. The only published light curve of DI Hya before this work appears to be an unfiltered (visual) one by Brelstaff, presented by Isles (1988). The observations were made at the South African Astronomical Observatory Sutherland Station, using the 1.0 m Cassegrain telescope equipped with a CCD camera, liquid-nitrogen cooled at 180.5 K, with $1024 \times 1024$ imaging pixels binned to $512 \times 512$. The field of view was $5\farcm3 \times 5\farcm3$. The *BVRI* filters were used. The dates of the observations of DI Hya were 13, 21, 22 and 23 January 2006. The star 2MASS J 09065133-1231368 (USNO-B1.0 0774-0251554), located $172''$ WNW of the variable, was used as a comparison star.

Approximately 350 observational points were secured in each filter, namely 351 in blue, 349 in yellow, 349 in red and 348 in the infrared. The period of the system is 0.6147132 days. The heights of the two maxima are equal within the observational error in all bands. The secondary minimum is shallow and deepens considerably at longer wavelengths; this fact indicates a large temperature difference between the components. DI Hya is known to have a spectral type of A6+[G8IV].

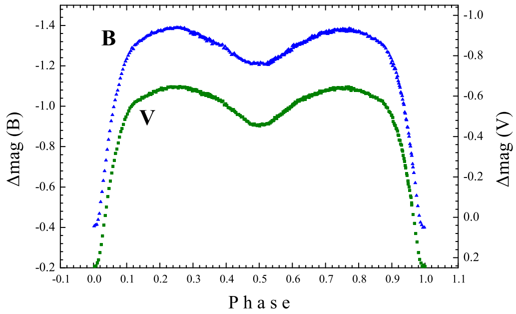


**Figure 2.** The complete $B$ (upper) and $V$ (lower) light curves of DI Hya.

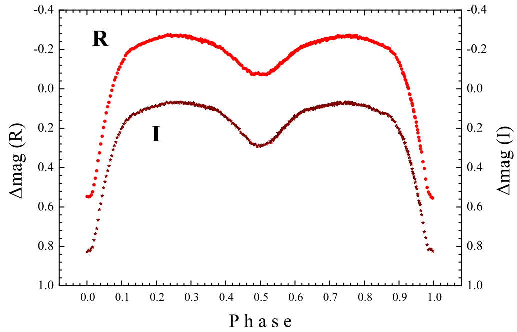


**Figure 3.** The complete $R$ (upper) and $I$ (lower) light curves of DI Hya.

Two times of minimum were extracted from our data, the secondary minimum at $HJD2453757.45928 \pm 0.0008$ and the primary at $HJD2453758.38132 \pm 0.0007$. The latter was used as a basis for the ephemeris used, combined with the above orbital period of the system.

All the observational points of all filters were used in order to analyze the light curves with Wilson-Devinney program's PHOEBE 0.28 version (Prša & Zwitter 2005) and obtain a photometric solution of the light curves. We solved the light curves assuming that there are no spots on the components of the system, since no asymmetry indicative of spots is present. Since no double-line spectroscopy was available, initial values for the mass ratio ($q = 0.42$) and for the inclination ($i = 83°$) were adopted from the tables by Budding et al. (2004). Initial values of the system's other parameters were derived from the LC part of the Wilson-Devinney programme. Also, the standard values for gravity darkening coefficients and bolometric albedos according to the spectral types of the components were used. The values of the limb darkening coefficients are automatically interpolated step-by-step by the PHOEBE program according to the Van Hamme (1993) tables. The results converged assuming semi-detached (with either star filling its Roche lobe), as well as detached configuration for the system. The minimum $\chi^2$ rms value averaged for all filters was achieved with the mode in which the primary fills its Roche lobe (Mode 4) (these errors are reduced chi-squared values as they appear in the PHOEBE main programme). In particular, this mode gave an rms $\chi^2$ of 0.1214, while the mode in which the secondary fills its Roche lobe gave an rms $\chi^2$ of 0.1271 and the mode for a detached configuration 0.1232 (Mode 2). Table 1 shows the two best solutions we obtained (the Modes 4 and 2 of the original Wilson-Devinney program). The large difference between the mass ratios of the two solutions suggests a spectroscopic mass ratio is needed for a definite study of the system.

The theoretical light curves of our Mode 4 solution, along with the observed ones, are shown in Figure 4. A cross-sectional surface outline of the system is given in Figure 5 and a three-dimensional model of the system is shown in Figure 6. The relatively short distance between the two stars (the centre of mass of the system is inside the body of the primary) supports the assertion that this is a near-contact system, and therefore it was correctly included by Shaw (1994) in his second catalog of such binary systems.

Since no double-line spectroscopy is available, the only way to estimate absolute parameters is to make assumptions about the absolute magnitude or the mass of the primary and use the value of q obtained photometrically. Assuming that the primary has a mass of 2.01 solar masses, the value for a normal MS star of its spectral type, we get the following

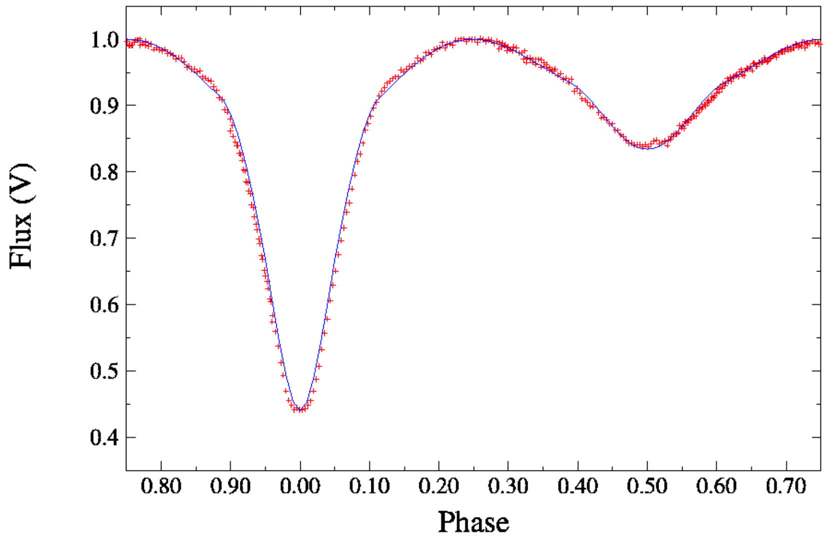


**Figure 4.** The observational points and the theoretical light curve fitting for our model (Mode for semi-detached systems of the W-D program) and for the *V* light curve of DI Hya.

absolute elements for DI Hya in solar units from our Mode 4 solution's geometrical and physical characteristics:

$$R_1 = 1.870 \pm 0.002 \qquad R_2 = 1.362 \pm 0.002$$
$$L_1 = 13.59 \pm 0.37 \qquad L_2 = 1.389 \pm 0.016$$
$$M_1 = 2.01 \text{ (assumed)} \qquad M_2 = 1.42 \pm 0.070$$

and the bolometric absolute magnitudes:

$$M_{bol(1)} = 1.92 \qquad \text{and} \qquad M_{bol(2)} = 4.39$$

According to them, the primary component is located relatively close to the ZAMS line (for stars of solar metallicity) in the mass-radius diagram, indicating an only slightly evolved star, while the secondary component seems to have evolved slightly more. In the region occupied by the 16 near-contact systems studied by Niarchos & Manimanis (2002), these stars appear relatively unevolved, especially the secondary.

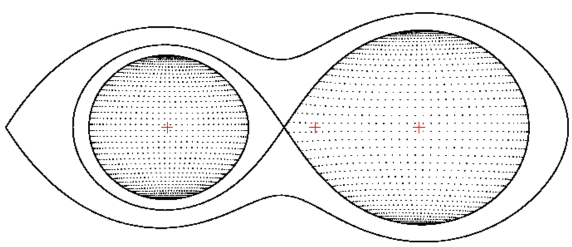

**Figure 5.** A cross-sectional surface outline of DI Hya at phase 0.75 (Max II) for our solution using Mode 4 of the W-D program.

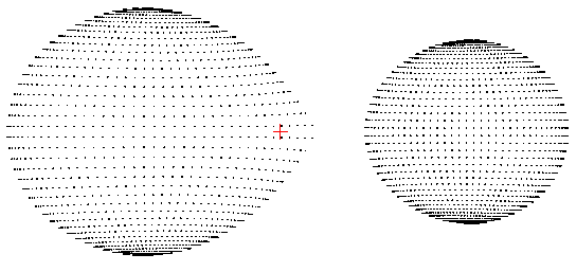

**Figure 6.** Three-dimensional model of the system of DI Hya as it appears at phase 0.25 (at Max I). The centre of mass of the system (red cross) is inside the body of the primary.

Table 1: Light curve solution of DI Hydrae

| Parameter | Mode 4 | Mode 2 |
|---|---|---|
| $i$ (degrees) | 82.14 | 84.38 |
| $T_1$ (K) | 8100* | 8100* |
| $T_2$ (K) | 5328 | 4558 |
| $g_1$, $g_2$ | $1.0^*, 0.32^*$ | $1.0^*, 0.32^*$ |
| $A_1$, $A_2$ | $1.0^*, 0.5^*$ | $1.0^*$, $0.5^*$ |
| $q = M_2/M_1$ | 0.7066 | 0.5151 |
| $\Omega_1$ | 3.2550* | 3.0851 |
| $\Omega_2$ | 3.5793 | 3.1052 |
| $L_1/(L_1 + L_2)$ $(B)$ | 0.9552 | 0.9787 |
| $L_1/(L_1 + L_2)$ $(V)$ | 0.9088 | 0.9629 |
| $L_1/(L_1 + L_2)$ $(R)$ | 0.8708 | 0.9401 |
| $L_1/(L_1 + L_2)$ $(I)$ | 0.8237 | 0.9162 |
| $r_1$(back) | 0.436 | 0.422 |
| $r_1$(side) | 0.407 | 0.402 |
| $r_1$(pole) | 0.385 | 0.384 |
| $r_1$(volume) | 0.408 | 0.402 |
| $r_2$(back) | 0.310 | 0.298 |
| $r_2$(side) | 0.295 | 0.280 |
| $r_2$(pole) | 0.286 | 0.271 |
| $r_2$(volume) | 0.297 | 0.283 |
| $\chi^2$ | 0.1214 | 0.1232 |

*assumed

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