NEW MINIMA TIMINGS FOR V1010 OPHIUCHI

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Abstract

In 1982, minima of the short-period eclipsing binary V1010 Ophiuchi were found to occur more than 2.5 hours earlier than predicted by the light elements in the 3rd edition of the **General Catalogue of Variable Stars** (GCVS). Twenty-six visual and photoelectric times of mid-eclipse during 1982-1986 are reported. O-C residuals from revised light elements in the 4th edition of the GCVS remain significant, and improved elements by Williams and Guinan are noted. The observations also indicate a time-keeping or calculating error in the times of minima given by Hamdy *et al.* in **IBVS** 2818.

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V1010 Ophiuchi is a 6th magnitude eclipsing binary of the Beta Lyrae type, with a period of 0.6614 day. The amplitude of light variation in **V** is 0.8 magnitude in primary eclipse and 0.35 magnitude in secondary eclipse. At minimum there is an interval of constant light, the primary eclipse being a transit.

Light variability was discovered at Bamberg in 1964, and Schoffel and Kohler (1965) published light elements that were adopted in the 3rd edition of the **General Catalogue of Variable Stars** (Kukarkin *et al.* (1969):

$$\text{Min. I} = \text{JD } 2425827.455 + 0^{d}.661436\ n. \qquad (1)$$

J. Ashbrook (private communication) noted that these elements might be in error, as they were derived from two small sets of minima separated by 30 years. He suggested an observational check, and one of us (DBW) compared two published primary minima in 1965 (Robinson 1965; 1966) with equation (1). The O-C residuals were -0.001 day and -0.006 day, indicating that the elements were satisfactory at that time.

In 1982, however, new observations revealed that minima were occurring more than 2.5 hours earlier than predicted by equation (1). Additional visual timings were obtained during the following four observing seasons.

Analysis of these new observations and published times of minima indicated that the period of V1010 Oph is decreasing, but the photographic and visual data did not permit a very accurate period

value to be derived. Only four photoelectric times of minima, all obtained in 1968, appeared in the literature (Leung 1974). An invitation was therefore issued through the AAVSO for photoelectric timings during the 1985 observing season.

Pazzi, Milton, and Wasson succeeded in obtaining adequate coverage of both branches of a primary eclipse. Pazzi and Wasson also obtained incomplete runs that included a portion of one branch and the total phase at minimum. Howard Louth of Sedro Woolley, Washington, and Frank J. Melillo of North Valley Stream, New York, also contributed incomplete photoelectric runs, and Marvin E. Baldwin of Butlerville, Indiana, timed two minima visually.

The resulting times of mid-eclipse are listed in Table I. The visual timings and the complete photoelectric runs were reduced by the tracing paper method. The incomplete photoelectric runs were reduced by using a complete, high-quality photoeletric light curve as an overlay to define the time of mid-eclipse.

The new 4th edition of the **General Catalogue of Variable Stars** (Kholopov *et al.* 1985) included quadratic light elements for V1010 Oph, based on observations before 1978:

$$\text{Min. I} = \text{JD } 2438937.7690 + 0^{d}.66142613\ n - 3.87 \times 10^{-10}\ n^{2}. \quad (2)$$

The table gives O-C residuals according to these elements as well as the improved elements in a recently completed period study of V1010 Oph by Williams and Guinan (1987):

$$\text{Min. I} = \text{JD } 2440015.2367 + 0^{d}.6614274\ n - 3.4 \times 10^{-10}\ n^{2}. \quad (3)$$

Coincidentally, Hamdy *et al.* (1985) obtained 12 photoelectric times of minima of V1010 Oph during the 1985 season. However, their published times of mid-eclipse contain either a time-keeping or calculating error of about +0.25 day. The extended period study of Williams and Guinan, which includes 16 additional photoelectric timings between 1968-1986, confirms the results in Table I, as indicated by the very small O-C residuals to Equation (3).

At 6th magnitude, V1010 Oph is a good object for photoelectric work by small campus observatories and suitably equipped amateurs. The fairly strong quadratic term in the light elements reveals V1010 Oph as an active binary system in a rapid stage of evolution. A continuous record of photoelectrically determined times of minima will have considerable value to future investigators. The common comparison star in all photoelectric observations is SAO 160104, magnitude 6.1, spectral type A0, which is one degree north of V1010 Oph.

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TABLE I

V1010 Ophiuchi, heliocentric times of primary mid-eclipse.

Helio. JD		Method	O-C (Eq.2)	O-C (Eq.3)	Observer
2445171.708		vis	+0^d.032	+0^d.004	Williams
173.689	*	vis	+0.029	+0.001	Williams
173.697		vis	+0.037	+0.009	Williams
179.646		vis	+0.033	+0.005	Williams
493.823		vis	+0.036	+0.006	Williams
501.755		vis	+0.031	+0.001	Williams
511.677		vis	+0.032	+0.002	Williams
511.678	*	vis	+0.033	+0.003	Williams
882.738		vis	+0.037	+0.006	Williams
888.684		vis	+0.031	-0.001	Williams
888.686	*	vis	+0.033	+0.001	Williams
46210.790		vis	+0.026	-0.007	Baldwin
210.810		vis	+0.046	+0.013	Williams
230.646		vis	+0.039	+0.006	Williams
239.8999		pe	+0.0339	+0.0001	Milton
248.504	*	vis	+0.039	+0.006	Williams
255.7739	*	pe/i	+0.0336	0.0000	Louth
263.714		vis	+0.037	+0.003	Williams
263.714		vis	+0.037	+0.003	Baldwin
269.667		vis	+0.037	+0.003	Williams
271.6486		pe/i	+0.0343	+0.0005	Melillo
272.3101		pe/i	+0.0343	+0.0006	Pazzi
274.2942		pe	+0.0342	+0.0004	Pazzi
302.7340		pe/i	+0.0330	-0.0009	Wasson
308.6884		pe	+0.0347	+0.0008	Wasson
599.718		vis	+0.041	+0.005	Williams

* A normal time of minimum, determined from a composite light curve of all observations for the season.

NB: vis = visual, pe = photoelectric, pe/i = incomplete photoelectric run.