PERIOD CHANGES IN THE ECLIPSING BINARIES DG LACERTAE AND MZ LACERTAE

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Abstract

DG Lac and MZ Lac have been observed visually and studied on plates of the Sonneberg Sky Survey. The orbits of both systems proved to be eccentric. MZ Lac displays apsidal motion and DG Lac shows a reflection effect. The orbital period of DG Lac increased abruptly in the early 1960's.

1. Introduction

In the summer of 1988, Mr. H. Busch of the Hartha Observatory, Germany, kindly took me as a companion during his stay at the Sonneberg Observatory, which at that time belonged to the Academy of Sciences of the German Democratic Republic. My working program on MZ Lac was based on his suggestion, and I added the star DG Lac, which is situated only 10' away.

To start, I had listings from the data bank of minima of eclipsing binaries provided by the late Mr. Lichtenknecker, then leader of the eclipsing binary section of the German variable star society, BAV. The data bank, which has also been useful on other occasions, contains all the times of minima found in the literature, to a high degree of completeness and accuracy. According to this collection, neither of these stars had ever been measured photoelectrically. DG Lac had been discovered and classified in the Soviet Union (Parenago 1938; Florja 1940, 1949) and it had been studied after the war at Bamberg (Mauder 1960) and the Vatican Observatory (Miller and Wachmann 1971). Since 1970, it has been observed visually by Swiss and Czechoslovak observers. MZ Lac was discovered on the plates of the Vatican Observatory in 1971 by Miller and Wachmann, and since then it has been timed visually only in Czechoslovakia.

The Sonneberg Sky Survey, which was at my disposal, is reputed to be the second largest collection of astronomical plates in the world and it contains some 250,000 items. It is well organized and easy to use. Most of the plates were obtained with small cameras (6-cm to 8-cm) with exposure times of about one hour and their limiting magnitude is about magnitude 13. The star field containing the two stars was recorded on some 1,500 plates covering the years 1927-1988. All of them were cursorily examined, and 720 of them, including all plates showing either variable weaker than usual, were taken for estimation under a microscope using Argelander's comparison method. (No densitometer was used.) These 720 plates and 7 visual timings of primary minima of MZ Lac, made during the summer session of the Czechoslovak variable star observers in Ždánice in August 1990, represent the new observational material for this paper.

2. Results for MZ Lac

For primary minimum, altogether 52 timings were collected for the years 1939-1989. From them, new light elements were derived:

$$\text{Min I} = \underset{\pm 0.0023}{2438264.3452} + \underset{\pm 0.0000013}{3.1588204}\,E. \qquad (1)$$

Observational material for secondary minima consisted of 56 timings, 45 of which were new data derived from the 720 plates examined by the author covering the time interval 1929-1988. Figure 1 shows the phase of the secondary minimum computed from the elements in equation (1). The only possible reason for such a shift of the secondary minimum can be an apsidal motion, and the curve must be a part of a sinusoid. Application of the least squares method (including the period as an unknown) gives the dashed line in Figure 1. However, considering the form of the light curve and its changes (Figure 2), it is necessary to conclude that the period of rotation of the line of apsides must be longer.

In the author's opinion, the best approximation for the times of secondary minimum is represented by the solid curve in Figure 2, and it is given by the following formula:

$$\text{Min II} = \underset{\pm 0.0023}{2438265.9246} + \underset{\pm 0.0000013}{3.1588204}\,E - \underset{\pm 0.11}{0.91}\sin(\underset{\pm 0.000029}{0.000095}\,E - \underset{\pm 0.27}{0.74}). \qquad (2)$$

Physically, this formula means that the orbital ellipse has a large eccentricity, e = 0.47 ± 0.12; the period of apsidal motion is 570 ± 170 years.

3. Results for DG Lac

The entire material studied for this variable star consists of 135 times of minima; among them are 51 new ones. The secondary minimum, if any, is too shallow to be detected by our means. Figure 3 confirms the known fact that the period of light changes of DG Lac increased suddenly in the 1960's (Kholopov *et al.* 1985). The improved light elements are:

Before JD 2437300 (1961):

$$\text{Min I} = \underset{\pm 0.0079}{2437338.2616} + \underset{\pm 0.0000015}{2.2064362}\,E. \qquad (3)$$

Afterwards:

$$\text{Min I} = \underset{\pm 0.0044}{2437338.2615} + \underset{\pm 0.0000018}{2.2064994}\,E. \qquad (4)$$

Using light elements (3) and (4), the mean light curve shown in Figure 4 has been derived from the Sonneberg material. In that curve, the drop of brightness before phase 0.5 can be taken as a hint of an eccentrically placed secondary minimum. An indication of a reflection effect is seen in the course of the light changes during the interval between occultations. The decrease of brightness by about 0.1 magnitude from phase 0.55 to 0.9 is statistically significant; the probability of its being real exceeds 99%. The course of the curve between phases 0.1 and 0.4 seems more nearly horizontal, although the difference is not conclusive. The simplest explanation for such a change in the reflection effect would be the assumption that the stars are closest to each other shortly after primary minimum, but without photoelectric measures, we cannot say more.

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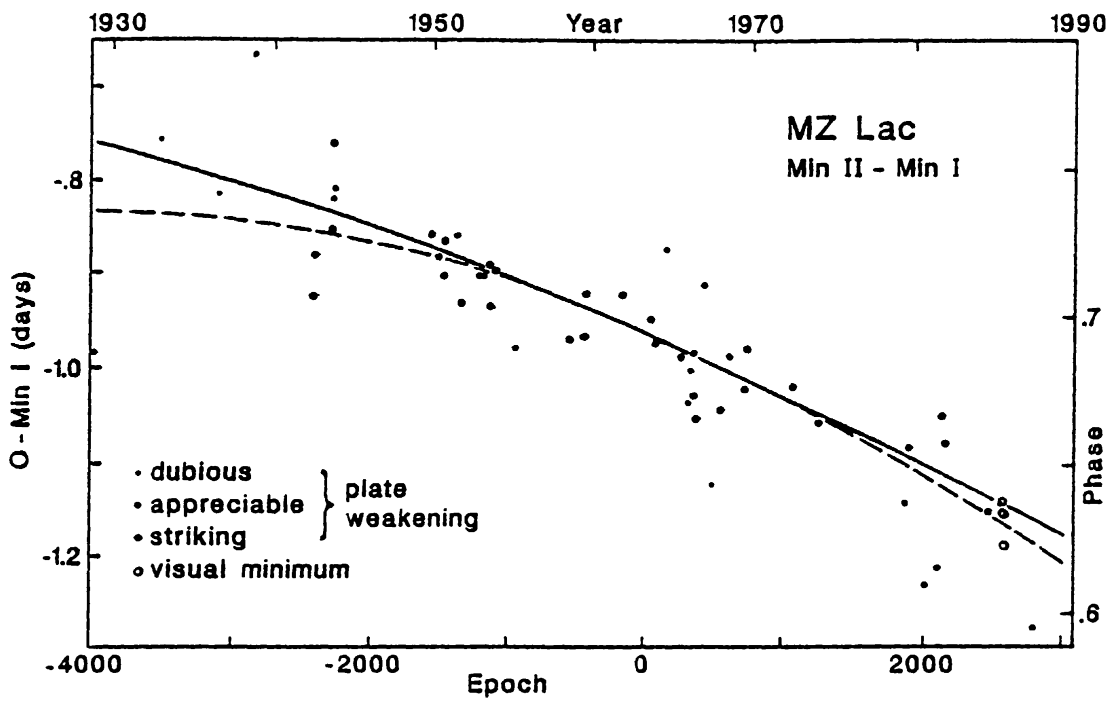

Figure 1. Known secondary minima of MZ Lac. The dashed line is a least-squares sine curve through the dots. The solid line shows an estimated improvement taking into account the development of the shape of the mean light curve in Figure 2.

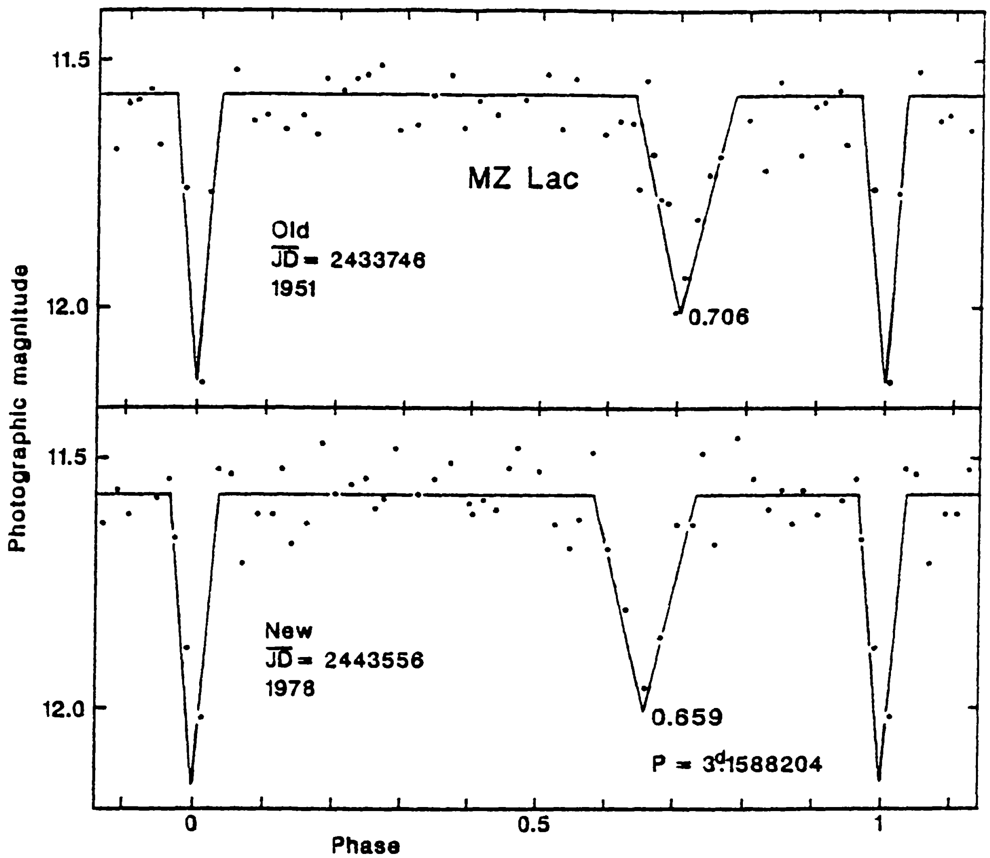

Figure 2. Changes of the mean light curve of MZ Lac. Note the shift of the phase of secondary minimum and its large and unchanged width. (DII/DI = 2.2 in both seasons.)

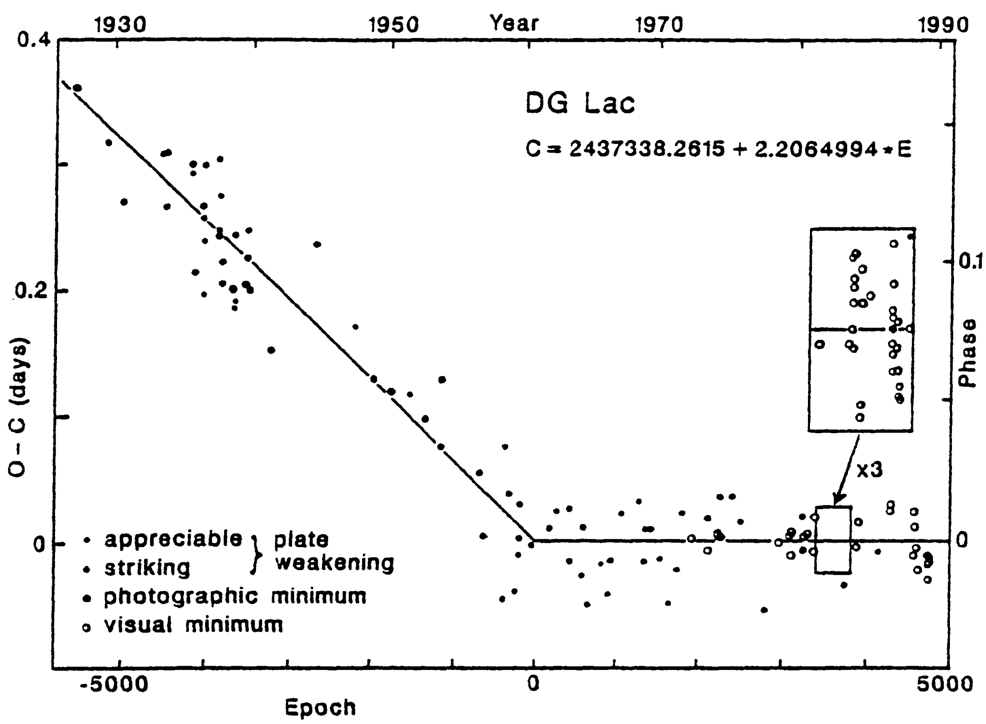

Figure 3. Known primary minima of DG Lac. The orbital period increased suddenly in about 1961.

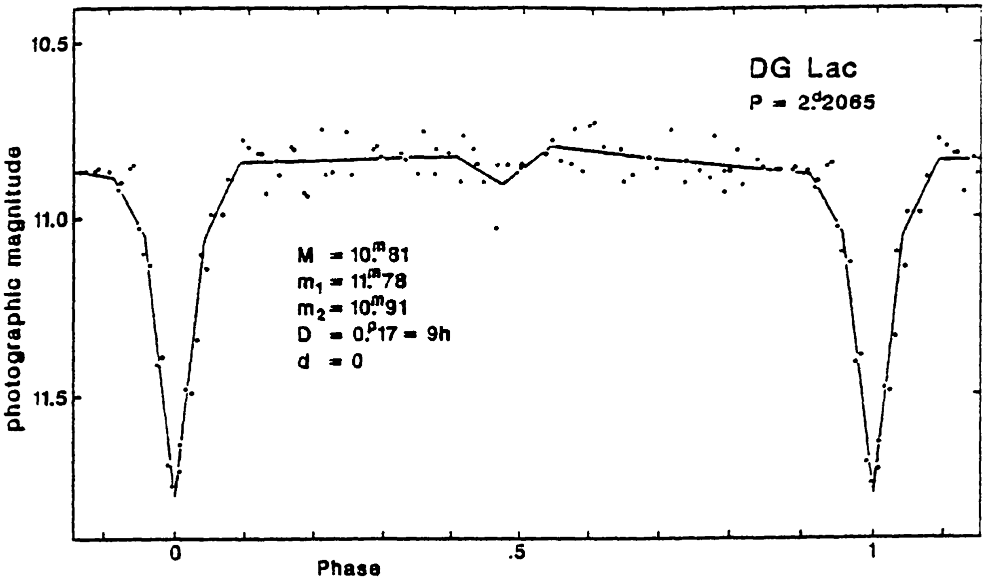

Figure 4. Mean light curve of DG Lac. If the difference in the course of the light curve before and after secondary minimum is real, this may mean that the binary system has its periastron passage around phase 0.3.

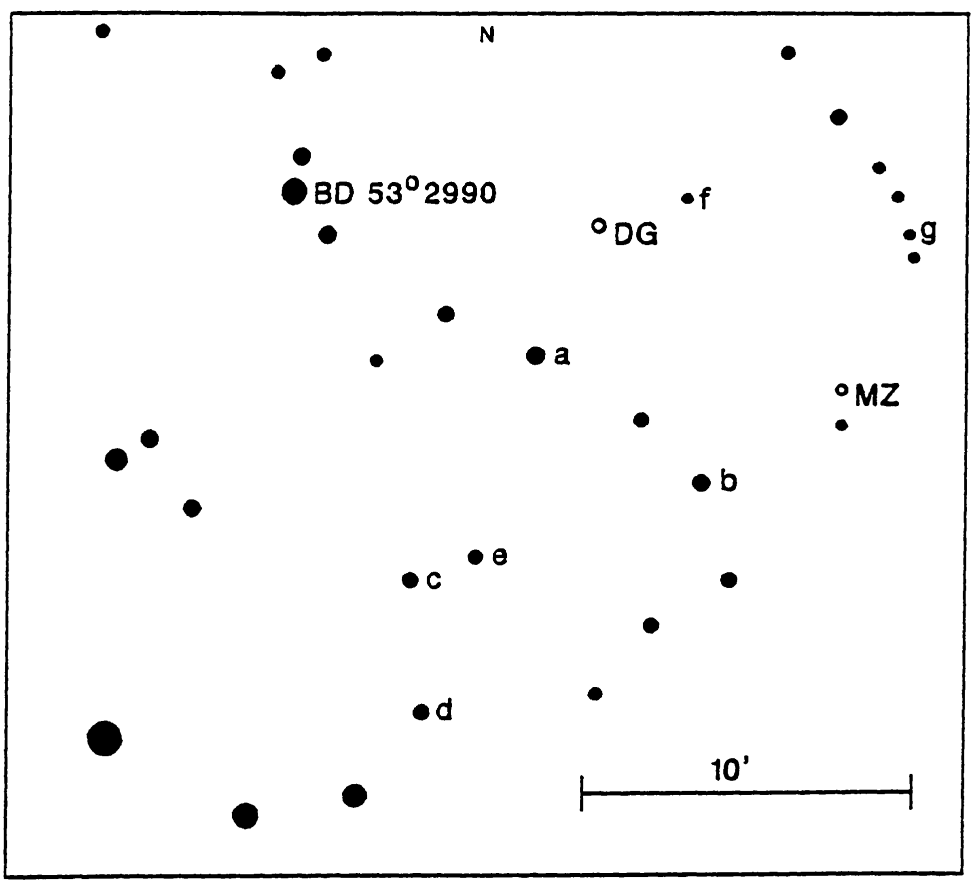

Figure 5. The finding chart for DG Lac and MZ Lac, with the set of comparison stars suitable for photographic observations.