Improvement of the orbital period of the symbiotic binary FG Ser by using archival photographic and new photoelectric observations.

S. Shugarov (1, 2) and E. Kolotilov (2).

1) Astronomical Institute of the Slovak Academy of Sciences,Tatranská Lomnica, Slovakia
2) Sternberg Astronomical Institute, Moscow State University by M.V. Lomonosov, Moscow, Russia

Abstract
The archival photographic and new photoelectric observations of the symbiotic star FG Ser were used to find a more precise value of the orbital period, P=629.4(1.0) days.

Introduction

The photographic archive of the Sternberg Astronomical Institute (SAI) of the Moscow State University contains more than 50,000 photographic plates obtained by telescopes with a diameter of the lens or mirror from 10 to 70 cm. The first plate was obtained in 1894. The archive is suitable for refining the light curves of eclipsing binaries and rectification of their orbital periods using a large time interval of observations. The symbiotic star FG Ser was taken as an example.

Historical review.

The variability of FG Ser (=S10363 = AS296) was discovered by C. Hoffmeister (1968) on the photoplates of the Sonneberg observatory, the largest European astronomical plate collection. He classified the object as a variable star with brightness variations in the range 13.5 - 14.5 mag.

The outburst of FG Ser was detected by Munari (1988) in June 30, 1988, when the object brightened to 10 mag. Iijima (1988) and Gutierrez et al. (1990) discussed the spectroscopy of FG Ser symbiotic star during the outbust and in quiescence and derived some physical parameters of this object. The first reliable model of the system was presented by Mürset et al. (2000) using the high resolution spectroscopy.

Munari (1993) used the photographic plates archive of the Asiago Observatory as well as new photoelectric and visual observations to show that the object is an eclipsing binary with the orbital period of 650 days. Later Munari (1995) used the new photometric observations to refine the value of the period to P = 658 days. Kurochkin (1993) investigated the object on archival photographic plates of the SAI taken in 1949–1987 (JD 2433129 – 2446979) and determined its orbital period to 630 days. Mürset et al. (2000) combined the measured radial velocity variations for the red giant secondary with published eclipse photometry and determined the binary orbital period of 650 days.

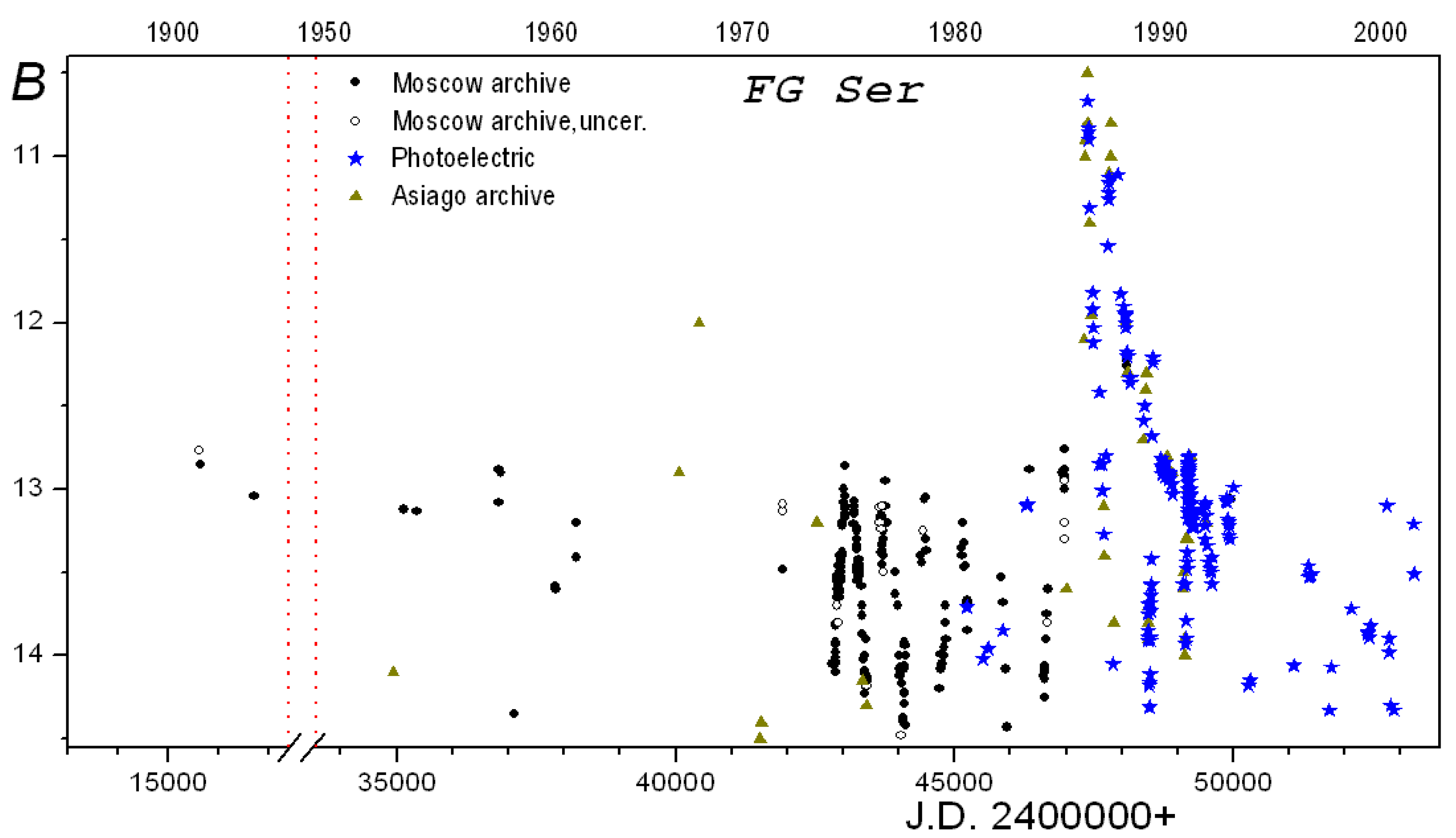

Fig. 1. The historical light curve of FG Ser. Uncertain observations are marked by open circles.

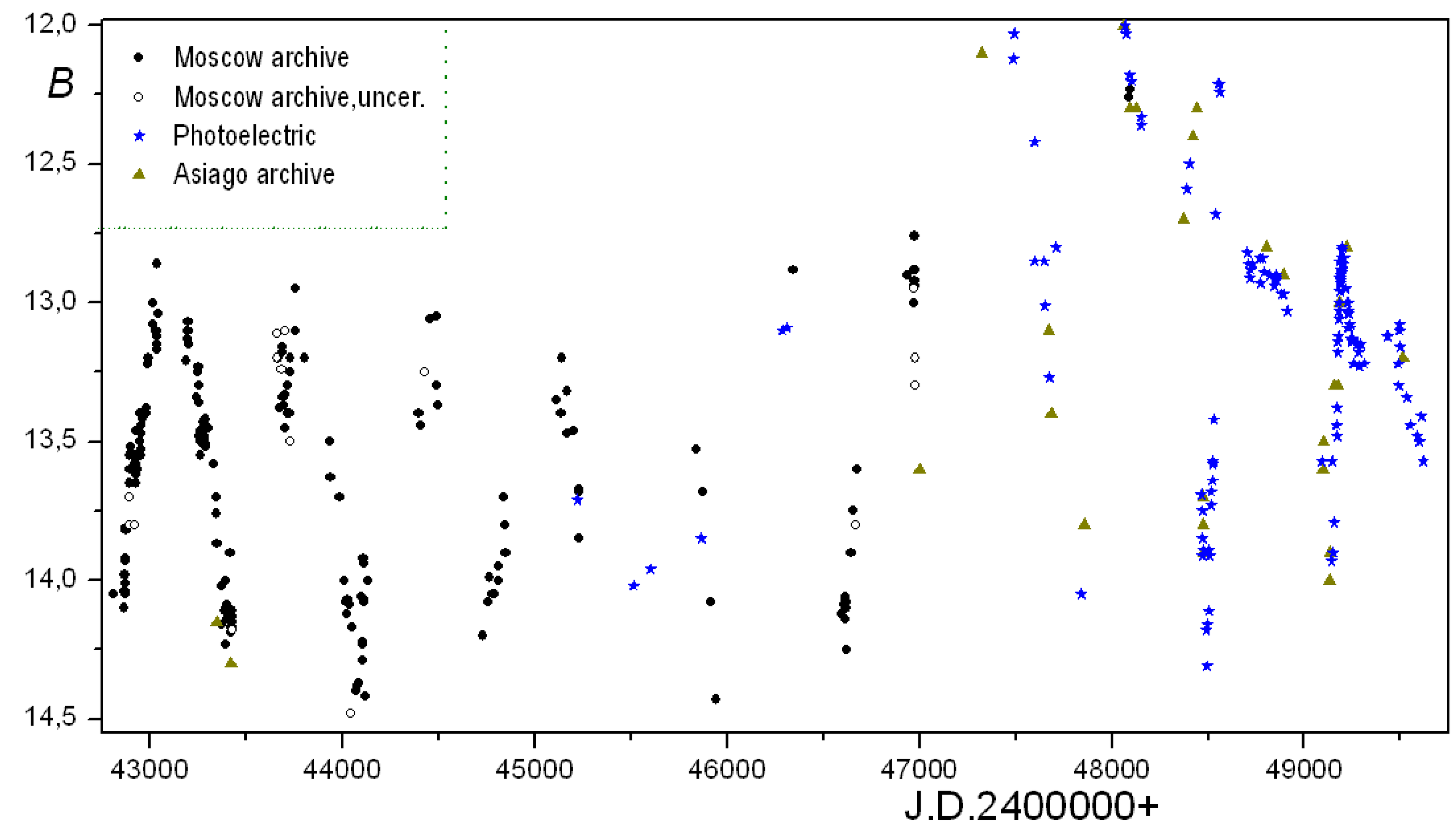

Fig. 2. The light curve taken in 1976–1994 (except the outburst in 1988)

New investigates and results

We remeasured FG Ser on photoplates of the SAI archive, using the new photometric standard sequence published by Henden and Munari (2000). We measured also earlier photoplates taken in 1901–1904. Unfortunately, the observations of the FG Ser region were not accomplished during the years 1905–1948. As a result, we have photographic observations of FG Ser taken by 10-cm, 16-cm and 40-cm telescopes at the time intervals 1901–1904 (2415612 – 2416699) and 1949–1995 (JD 2435362– 2449949). Photometric system on these telescopes and photoplates was closed to the passband *B* of Johnson. We obtained totaly 229 measurements. For the analysis of the light curve, we added photoelectric and archive photographic observations by Munari (1992, 1995) at the Observatory of Asiago. Our new photoelectric observations, obtained in 1995–2004 with the 60-cm Zeiss-telescope located in the Crimean Laboratory of the SAI MSU, have also been added for the study of this object. The light curve of all observations of FG Ser is presented in Fig. 1. The light curve taken in 1976–1994 (except the outburst in 1988) is displayed in Fig. 2. Our and Munari (1992, 1995) photoelectric observations in the *B* passband are marked by asterisks. The agreement of photographic observations of the Moscow and Asiago archives with photoelectric data is about 0.1 mag. Therefore, we could refine the orbital period using all observations, without separation into photoelectric and photographic ones. As a result, we found the new ephemeris for the time of eclipses:

JD (min) = 2443452(7) + 629.4(1.0) x E

The phase light curve of the data < 12.5 mag, constructed with this ephemeris, is shown in Fig. 3. The graph of the O–C residuals, including the outburst in 1988, is shown in Fig. 4. The moment of the eclipse during the outburst is indicated by an arrow. There is no significant time shift for this eclipse relatively to another eclipses. This study shows that the archival data can give a valuable contribution to the reconstruction of the long-term light curve, which can be successfully used for a light curve analysis.

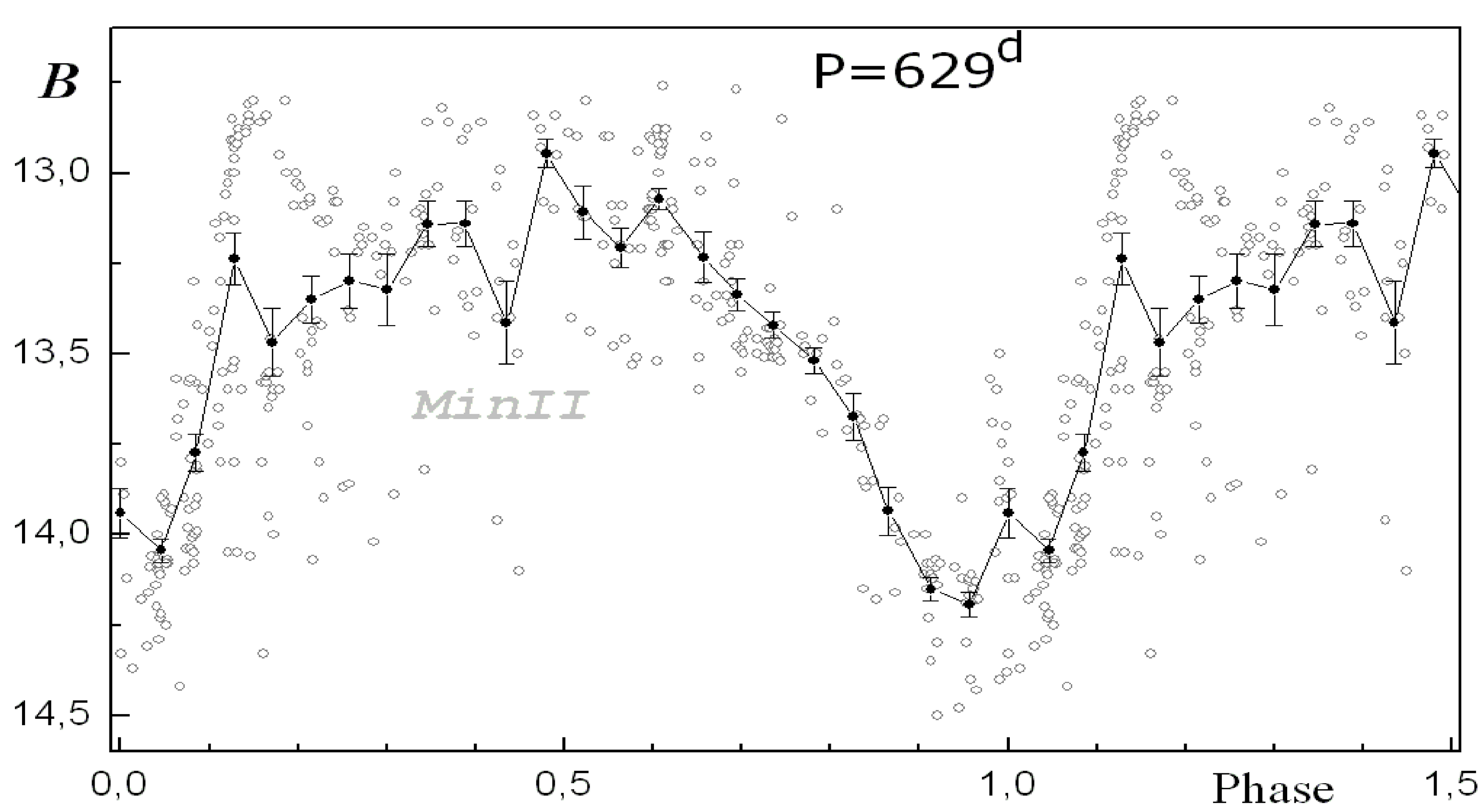

Fig. 3. The phase light curve of FG Ser.

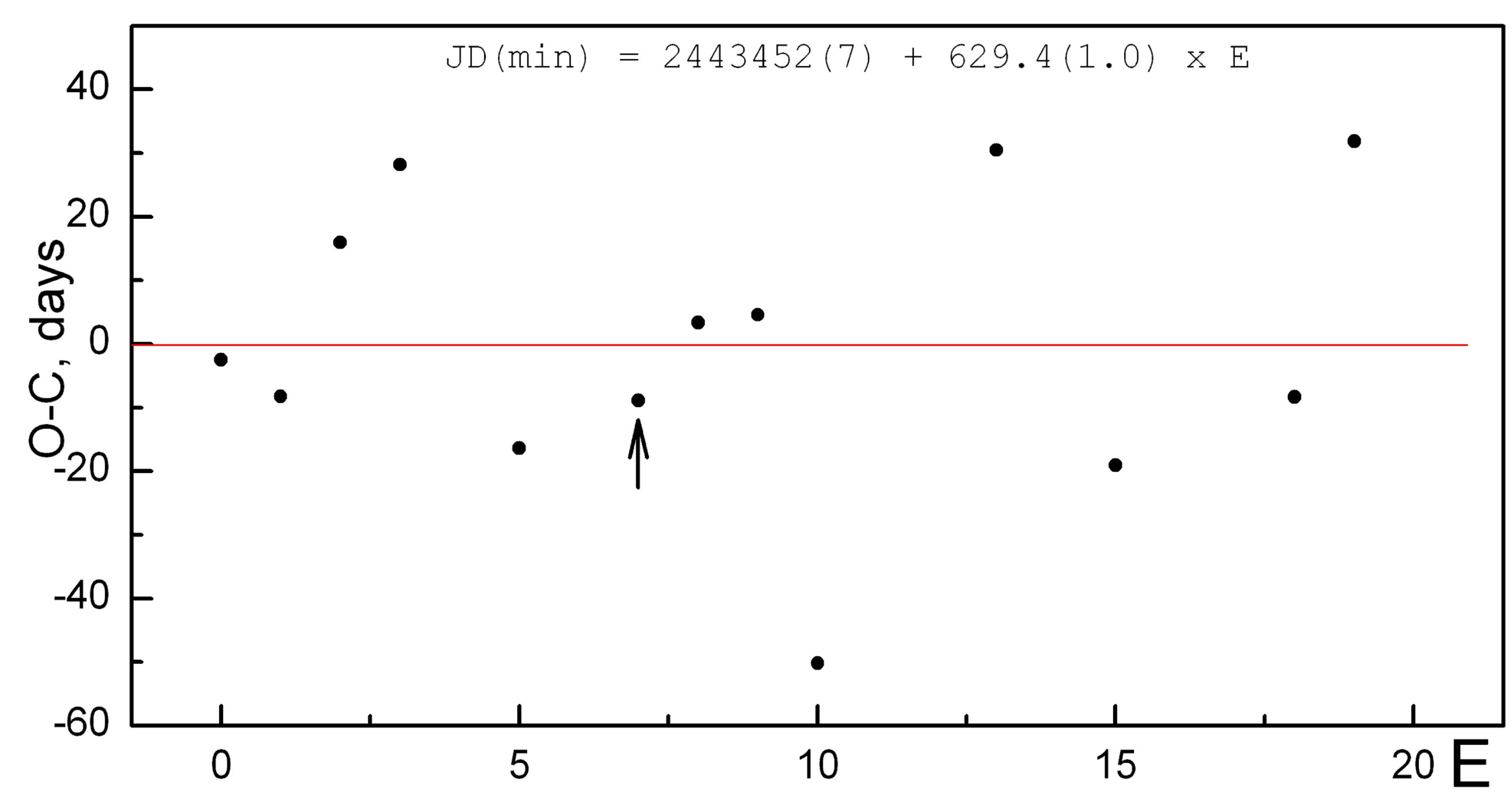

Fig. 4. The graph of the O–C residuals for FG Ser. The moment of the eclipse during the outburst is indicated by an arrow.

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