CCD PHOTOMETRY OF THE RR LYRAE STAR SS LEONIS

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Abstract

A new V light curve of the RR Lyrae star SS Leo shows no irregular fluctuations in brightness such as were reported by Skillen *et al.* (1987). The long term period changes of SS Leo are discussed: SS Leo has remained constant in period for at least 27 years.

1. Introduction

SS Leonis is a metal-poor RR Lyrae star with a period of 0.626 day (Kholopov *et al.* 1985). Skillen, Fernley, and Kilkenny (1987) reported unusual fluctuations in the brightness of SS Leo on the night of March 13/14, 1987, during the ascending branch of its light curve. Their UBV photoelectric photometry showed relatively sudden deviations both above and below the normal trend of rising light for SS Leo. These fluctuations were most pronounced in V-band, where rises and falls in brightness of more than half a magnitude were observed on a timescale of several minutes. Simultaneous infrared observations made with another telescope showed only the normal RR Lyrae-type light variation (Fernley *et al.* 1990). UBV observations of the ascending branch on April 9/10 showed no anomalies.

Skillen *et al.* (1987) noted that such fluctuations have never previously been reported for SS Leo, nor, to their knowledge, for any other RR Lyrae star. Although they could find no fault in the observations of March 13/14, they concluded that the reality of these fluctuations must be regarded as questionable until they had been independently confirmed.

To examine the stability of the light curve of SS Leo, and to update its ephemeris, we placed it on a program of charge-coupled device (CCD) photometry with the 0.6-m telescope at the Michigan State University Observatory.

2. Observations

SS Leo was observed 196 times on 17 nights between March 31 and June 8, 1991. All observations were made with a liquid nitrogen-cooled CCD camera and a 1024 x

1024 pixel Ford CCD chip. A V filter was used. The CCD pixels were binned 2 x 2 and a 472 x 472 pixel array was read out, giving a field of view approximately eleven arcmin square. Exposures were usually one minute in length. Dark frames and flat fields (usually dome flats, but occasionally twilight sky flats) were also obtained and the usual techniques of dark subtraction and flat field division were followed. Aperture photometry was then obtained for SS Leo and several comparison stars in the field with the routines in DAOPHOT (Stetson 1987). One star 3.2 arcmin east and 0.5 arcmin south of SS Leo was selected as the primary comparison star. Photometry of this star was obtained on the night of May 19/20, 1991, showing it to have V = 12.38 $\pm$ 0.02 and V-R = 0.1. The V-R color is close to that of SS Leo and differential color terms can be neglected in the reductions. The other, fainter, comparison stars in the SS Leo field were used only to confirm that the primary comparison star was itself not variable. The accuracy of a single observation of SS Leo is typically $\pm$0.02 to 0.03 magnitude.

3. Results

The CCD observations have been combined to produce the light curve shown in Figure 1. The scatter of the points about the mean curve is consistent with observational error alone. In particular, the full ascending branch of the light curve was observed on May 11/12, 1991 at intervals of approximately 3 minutes with no suggestion of the sudden, large light fluctuations reported by Skillen *et al.* Various portions of the rising branch were observed on five other nights, again with no hint of anomalous fluctuations. The sudden, small drop in brightness at phase 0.85, just before the start of rising light, has been observed by others (e.g. Fernley *et al.* 1990) and is apparently a genuine feature of the SS Leo light curve.

These observations do not prove that the brightness fluctuations reported by Skillen *et al.* (1987) were not real. They do, however, add to the body of observations showing only normal RR Lyrae behavior by SS Leo. The singular observations of March 13/14, 1987, remain unconfirmed.

Four maxima were observed. The estimated times of maximum light are reported in Table 1.

Table 1. Observed Maxima of SS Leo

$JD_{(hel.)}$	*O-C (days)*
2448353.635 $\pm$ 0.008	-0.002
2448388.707 $\pm$ 0.010	-0.004
2448390.591 $\pm$ 0.005	+0.001
2448405.623 $\pm$ 0.008	+0.000

4. Long Term Period Behavior

Fernley *et al.* (1990) found that times of observed maxima between JD 2438459 and JD 2447266 were well described by the ephemeris

$$\text{Max}(JD_{hel.}) = 2438459.2687 + 0.62634476\ E. \quad (1)$$

When the times of maximum in this paper are added to those in the compilations of Fernley *et al.* and Tsesevich (1966), there are a total of 23 times of maximum available with which to discuss the long term period behavior of SS Leo. O-C values

have been calculated for these times of maximum according to the equation (1) ephemeris. Figure 2 shows a plot of O-C versus Julian Date. Times of maxima after JD 2438000 are probably accurate to 0.01 day or better; earlier times of maximum may occasionally be more uncertain.

As has previously been noted (see Tsesevich 1966, and references therein), the period of SS Leo has not been constant over its entire observed history. The general trend of the observations is described by the parabolic curve shown in Figure 2 which corresponds to the elements:

$$\text{Max}(JD_{\text{hel.}}) = 2415485.064 + 0.62633405\,E + 8.31 \times 10^{-11}\,E^2. \quad (2)$$

However, maxima since JD 2438000 are better described by the linear ephemeris in equation (1) horizontal line in Figure 2. For our newly observed maxima, the O-C values relative to equation (1) are listed in Table 1. The four O-C values are small, and there is no significant evidence of any period change of SS Leo since JD 2438500.

5. Acknowledgements

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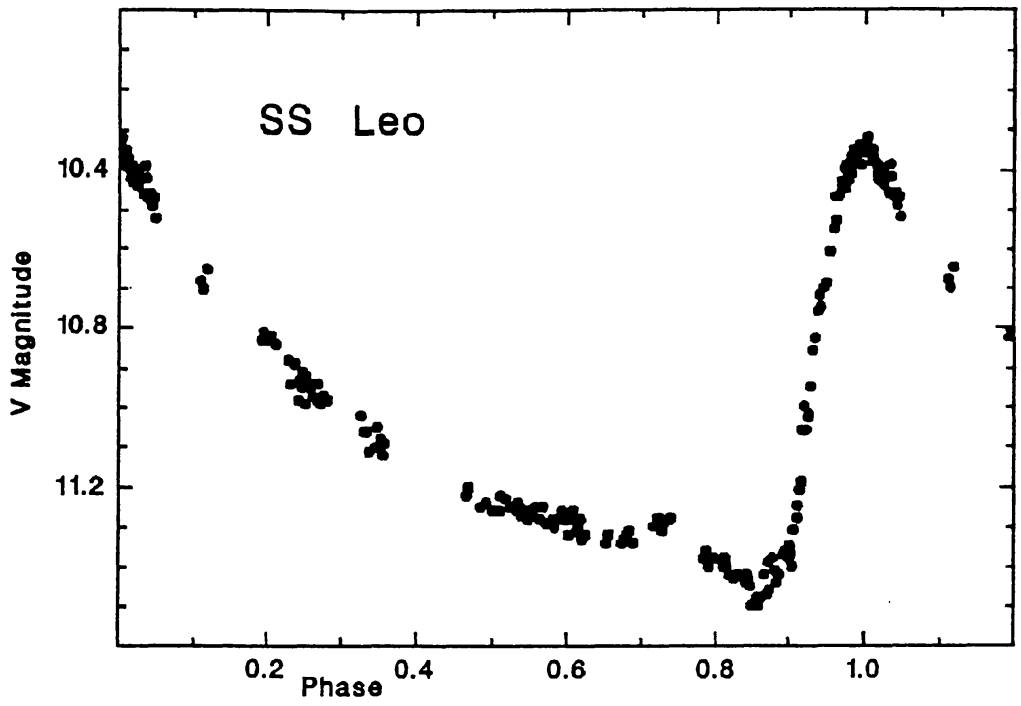

Figure 1. Light curve for SS Leo constructed from the CCD observations. Phases were calculated from the ephemeris in equation (1).

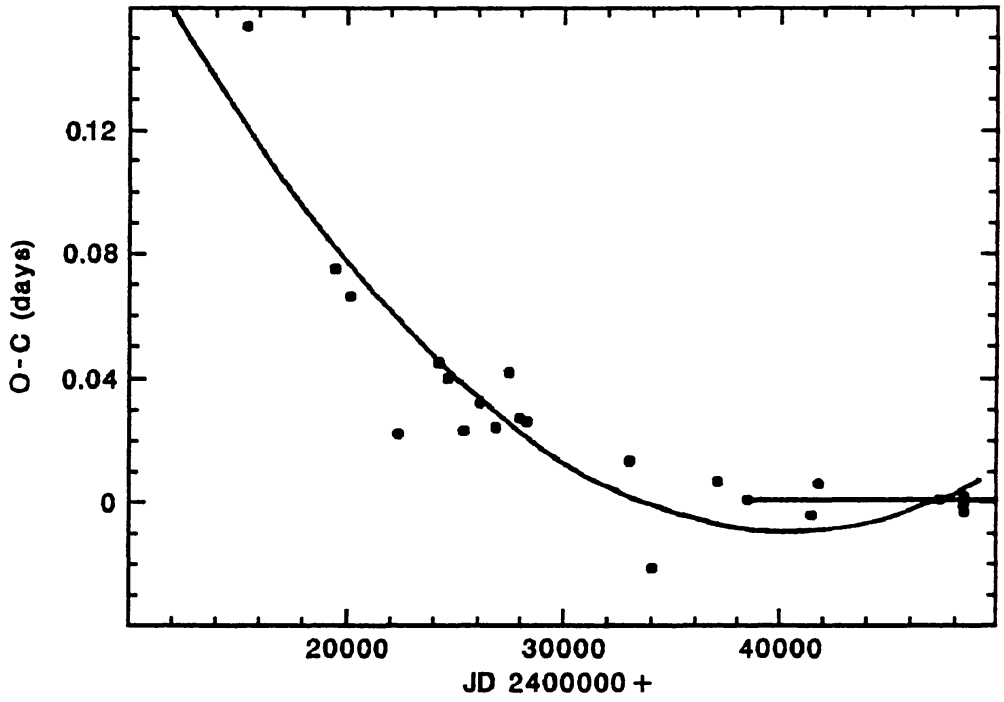

Figure 2. O-C diagram for SS Leo. Parabolic and linear fits to the data are indicated, as described in the text.