PHOTOGRAPHIC STUDIES OF NEGLECTED VARIABLES, III: ST, SU, SV, AND NSV 1966 LEPORIS

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Abstract

The variable stars ST, SU, SV, and NSV 1966 Lep were discovered at Bamberg in 1974. The three stars with official designations entered the *General Catalogue of Variable Stars* without known periods. Neither type nor period was determined for NSV 1966. Investigation of these variables on Harvard plates confirms SU Lep as an eclipsing binary with minima three times deeper than initially reported. ST and SV Lep are confirmed as Mira variables. NSV 1966 is also a very red Mira variable. Periods, magnitude ranges, and accurate positions for all four stars are reported.

1. Introduction

This paper continues a series of reports (Williams 1992, 1996) on variable stars with unknown or uncertain types and periods based on observations obtained from the Harvard College Observatory photographic plate archive. The four variables discussed below were discovered (Markworth 1974) during the highly successful photographic search program initiated by the Remeis Observatory in Bamberg, Germany, and later joined by the University of Florida.

All observations in this report are photographic blue magnitudes. Comparison star sequences were established by eye estimates using photoelectric B magnitudes of stars in nearby fields of the *Guide Star Photometric Catalog* (Lasker *et al.* 1988).

In the following analyses, I have not included the Bamberg data from Markworth (1974). The Bamberg photo-red observations of the Mira variables at maximum should be about 2 magnitudes brighter than the Harvard blue data, but they are not. This suggests that the Bamberg plates did not catch the true maxima. The small magnitude range reported for the eclipsing variable SU Lep, compared to the deep minima reported below, indicates that the fainter Bamberg observations were closer to the first or last contacts than to mid-eclipse. These considerations explain why the periods of these variables were not found.

2. ST Leporis

The variable ST Lep = BV 1609 is listed in the *General Catalogue of Variable Stars* (GCVS) (Kholopov *et al.* 1985) as a Mira variable, range 12–<16 R, and period possibly 700/n days. I estimated ST Lep on 376 plates of the Damon, RH, RB, and MF series. Analysis of these observations showed that ST Lep is a Mira star with a range of 12.0–16.8 ptg. Times of 17 plate maxima are listed in Table 1. There appears to be a color term affecting the magnitudes of red variables on the pre-1952 RH, RB, and MF plates compared to the recent Damon plates (1980–1988), the Damon plates showing maxima of Mira stars several tenths of a magnitude brighter than on the old plates. For ST Lep, plate maxima are therefore considered to be observations of 12.4–12.9 ptg on the old plates and 11.8–12.3 on the Damon plates. A least-squares

Table 1. Plate maxima of ST Lep.

JD 2400000+	*m(ptg)*	*E*	*O-C*
27756	12.4	-29	-1
28400	12.4	-26	-1
28612	12.8	-25	-4
29486	12.5	-21	+12
29671	12.9	-20	-18
30344	12.9	-17	+11
31856	12.7	-10	+20
32042	12.9	-9	-9
33983	12.7	0	0
42120	12.0	+38	-22
43841	12.0	+46	-18
44274	12.0	+48	-15
44934	11.8	+51	+1
46435	12.2	+58	-1
46876	12.0	+60	+11
47093	12.0	+61	+13
47539	12.0	+63	+30

solution of the times listed in Table 1 resulted in the following light elements:

$$HJD_{max} = \underset{\pm 4}{2433983} + \underset{\pm 0.1}{214\overset{d}{.}7}\,E \tag{1}$$

Observed minus calculated (O-C) residuals from these elements are listed in Table 1. ST Lep is found in the *Guide Star Catalog* (STScI 1989) as GSC 5343-1135. The J2000 position is RA $05^h\ 19^m\ 25.5^s$, Dec -13° 50' 55".

3. SU Leporis

SU Lep = BV 1610 is listed in the GCVS as an Algol-type eclipsing binary, range 12.2–12.8 R, with period possibly 2.993/n days. I initially estimated SU Lep on 314 plates of the Damon, RH, and RB series. More than a dozen plates were found on which SU Lep was 0.5 to 1.0 magnitude fainter than the normal maximum of 13.2 ptg, and on a few plates the variable was invisible, fainter than 13.8. However, these data frustrated every attempt to find a unique period. Later, I had an opportunity to estimate SU Lep on 163 of the MF plates, which reach to 16th magnitude. On these plates I found seven minima as faint as 15.1–15.4 ptg, which are listed in Table 2. Clearly, the previous faint observations were not near enough to the time of mid-eclipse to define the period. As luck would have it, two of the deep minima appeared on plates exposed just three days apart. This revealed the period and showed that the initial estimate by Markworth (1974) was close, with n = 1. SU Lep is an Algol-type eclipsing binary with a range of 13.2–15.4 ptg. Least-squares analysis of the times in Table 2 produced the following light elements:

$$HJD_{min} = \underset{\pm 0.011}{2429602.512} + \underset{\pm 0.000033}{3\overset{d}{.}057900}\,E \tag{2}$$

O-C residuals from this ephemeris are listed in Table 2. SU Lep is found in the *Guide Star Catalog* as GSC 5344-105. The J2000 position is RA $05^h\ 22^m\ 42.2^s$, Dec -13° 47' 51".

Table 2. Plate minima of SU Lep.

HJD 2400000+	*m(ptg)*	*E*	*O-C*
27746.378	15.2	-607	+0.011
27807.515	15.4	-587	-0.010
29602.537	15.4	0	+0.025
29605.535	15.1	+1	-0.035
29697.312	15.1	+31	+0.005
29746.214	15.1	+47	-0.019
29819.647	15.3	+71	+0.024

4. SV Leporis

SV Lep = BV 1613 is listed in the GCVS as a Mira variable, range 11.6–14.5 R, with an unknown period. I estimated this star on 376 plates of the RH, RB, MF, and Damon series. These observations show that SV Lep is a Mira variable with a range of 11.8–<16.0 ptg. Times of 26 plate maxima, 12.0–12.6 ptg for the old plates and 11.8–12.4 for the Damon plates, are listed in Table 3. Least-squares analysis of these times produced the following light elements:

$$\mathrm{HJD}_{\mathrm{max}} = \underset{\pm 3}{2432882} + \underset{\pm 0.1}{174\overset{d}{.}6}\,\mathrm{E} \tag{3}$$

O-C residuals from this ephemeris are listed in Table 3. SV Lep is found in the *Guide Star Catalog* as GSC 5344-982. The J2000 position is RA $05^h\,25^m\,43.6^s$, Dec -14° 23' 32".

5. NSV 1966

NSV 1966 = BV 1612 first came to my notice when I discovered its large variation while comparing photographs of this region with the blink microscope at Indiana University's Goethe Link Observatory. NSV 1966 appears in the *New Catalogue of Suspected Variable Stars* (NSV) (Kholopov *et al.* 1982) as a variable of unknown type, range 11.7–<14.7 R. I estimated this variable on 297 plates of the RH, RB, and MF series. These observations show that NSV 1966 is a Mira variable with a range of 11.5–16.2 ptg. Comparison of the Palomar Observatory Sky Survey prints shows that this star is very red. Nine times of plate maxima, 11.5–12.2 ptg, are listed in Table 4. Least-squares analysis of these maxima resulted in the following light elements:

$$\mathrm{HJD}_{\mathrm{max}} = \underset{\pm 7}{2430076} + \underset{\pm 2}{387^{d}}\,\mathrm{E} \tag{4}$$

O-C residuals from this ephemeris are listed in Table 4. NSV 1966 is found in the *Guide Star Catalog* as GSC 5336-1349. The J2000 position is RA $05^h\,24^m\,27.8^s$, Dec -10° 39' 24".

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Table 3. Plate maxima of SV Lep.

JD 2400000+	*m(ptg)*	*E*	*O-C*
25591	12.6	-42	+42
25913	12.5	-40	+15
26762	12.3	-35	-9
27128	12.6	-33	+8
27454	12.0	-31	-16
28155	12.4	-27	-13
28511	12.2	-25	-6
28877	12.6	-23	+11
29202	12.1	-21	-14
29913	12.0	-17	-1
30591	12.6	-13	-21
31134	12.6	-10	-2
31312	12.3	-9	+1
32178	12.3	-4	-6
32888	12.5	0	+6
42120	11.8	+53	-16
42476	11.8	+55	-9
43543	12.0	+61	+10
44226	12.0	+65	-5
44579	12.2	+67	-1
45813	12.2	+74	+10
45980	12.0	+75	+3
46851	11.8	+80	+1
47201	12.2	+82	+2
47380	12.0	+83	+6
47556	12.3	+84	+7

Table 4. Plate maxima of NSV 1966.

JD 2400000+	*m(ptg)*	*E*	*O-C*
27395	12.0	-7	+28
28511	12.1	-4	-17
29311	12.0	-2	+9
29672	11.7	-1	-17
30055	11.8	0	-21
30460	11.5	1	-3
32042	12.2	5	+31
32795	11.7	7	+10
33152	11.6	8	-20

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