A NEW LOOK AT SW BOOTIS

PETER O. TAYLOR
71 N.E. 28th Court
Boynton Beach, FL 33435

Abstract

Visual observations since 1965 indicate that the primary period of SW Bootis increased abruptly circa 1960. It is also suggested that fluctuations in amplitude may be due to a secondary period of $12^d.997$.

* * * * *

The RR Lyrae star SW Bootis was discovered photographically by S. Beljavski in 1914. Since that time the star has been investigated very sporadically, chiefly by Hoffmeister (1919, 1923), Kukarkin (1932), Tsesevich (1935), and Bonov (1955). Tsesevich proposed two sets of linear elements that indicated an abrupt increase in period around 1932. On the other hand, Bonov believed that the period was continually increasing, and so calculated an equation containing a quadratic term. Although he preferred this ephemeris, Bonov also up-dated the second set of Tsesevich's linear elements and noted that, with the exception of the maximum at discovery (uncertain in any case), the fit was equally good with either equation.

Figure 1 shows all maxima available to me since discovery, plotted according to the Bonov-refined Tsesevich relation:

$$\text{JD(hel.)primary max.} = 2426847.3840 + 0^d.51351108E_1. \qquad (1)$$

One can see that another abrupt increase in primary period of slightly lesser magnitude than the earlier change occurred shortly after Bonov's investigation, in (approximately) August 1960. All maxima after that date are based on visual estimates of the star by M. Baldwin, with actual times (heliocentric) of maximum determined by the author using Pogson analysis (Table 1). This final set of maxima was subjected to uniformly weighed least-squares analysis and yielded the following elements:

$$\text{JD(hel.)primary max.} = \text{JD}2442570.760 + 0^d.51352810E_2. \qquad (2)$$

The coefficient of determination, in this case a measure of the tightness of the linear relationship, exceeds 0.98 for the regression line formed by equation (2).

In view of the possibility of a period changing in proportion to time, an investigation was carried out to see if any single quadratic equation could describe all maxima within the accuracy of the data. However, none was found. It was also noted that, while Bonov's quadratic relation fits the pre-1955 data well, by May, 1977, the O - C values approached 2 hours.

During the investigation of the primary period, it became obvious that, although all observations (after 1960) were by a single observer (Baldwin) using the same comparison sequence, magnitudes at maximum light fluctuated between $10^m.6$ and $11^m.6$. Likewise, where they were available, magnitudes at minimum light also appeared to vary, between $12^m.9$ and $12^m.3$. In addition, it appeared that a relationship existed between the two; i.e., a brighter maximum correlated with a fainter minimum. Those magnitudes at maximum light (after 1960) that could be reasonably well defined, and their approximate times ($\pm 0^d.05$), were then subjected to the "rough scanning" routine of computer-based autoregressive analysis (Hammer 1977) run on the IBM 370/125 computer. The lowest harmonic for each trial period which proved statistically significant was then refined and plotted manually in the form of phase-magnitude diagrams until the most satisfactory relation (equation 3) was produced, namely

$$\text{JD(hel.)Secondary Max.} = 2441037.33 + 12\overset{d}{.}997E_3. \qquad (3)$$

The final diagram is shown in Figure 2, together with a similar plot of magnitudes at minimum light, obtained with the aid of the constant phase difference between times of maximum and minimum light, M - m = 0$\overset{P}{.}$126 (Bonov 1955). The period was checked for spurious periodicity and none was found. Application of the statistical F-test to the 12$\overset{d}{.}$997 period yielded a value better than 99% for rejection of the null hypothesis of non-periodicity.

An effort was made to ascertain the existence of a similar (periodic or magnitude-related) variation in O - C residual after removal of the basic trend, but this proved unsuccessful. This should not be construed as an indication that no such relationship exists, however. For a variety of reasons (the changing primary period, the nature of visual observations themselves, etc.) a small fluctuation could easily go undetected, especially in view of the limited amount of well-defined data on the star that is actually available.

Finally, it should be noted that without the systematic observations of M. Baldwin, who attempts to observe both pre-maximum and post-maximum phenomena at closely spaced intervals, certain of these effects would not become apparent. This is one indication of the value of the AAVSO - RR Lyrae program, and of the value of continual monitoring of these interesting stars, as well.

REFERENCES

Beljavski, S. 1914, Astron. Nachr. 198, 371.
Bonov, A.D. 1955, Budapest Mitteil., 3, No. 38.
Hammer, C. 1977, Autoregressive Data Analysis Program, (private communication).
Hoffmeister, C. 1919, Astron. Nachr. 208, 239.
______________ 1923, Astron. Nachr. 218, 321.
Kukarkin, B.V. 1932, Peremennye Zvezdy, Byull., 4, 135.
Tsesevich, V.P. 1935, Leningrad Univ. Astron. Obs. Bull. 4, 28.

TABLE I

Post-1960 Maxima

JD hel.max. 2400000+	E_1	$O - C_1$	JD hel.max. 2400000+	E_1	$O - C_1$
39916.853	25451	0$\overset{d}{.}$098	42871.689:	31205	0$\overset{d}{.}$192:
39917.872	25453	.090	42873.746	31209	.195
41036.841	27632	.119	42874.770	31211	.192
41059.447	27676	.130	42891.707	31244	.183
42155.832	29811	.169	42895.821	31252	.189
42476.791	30436	.184	42907.632	31275	.189
42509.643	30500	.171	43272.753	31986	0.204
42570.758	30619	0.178			

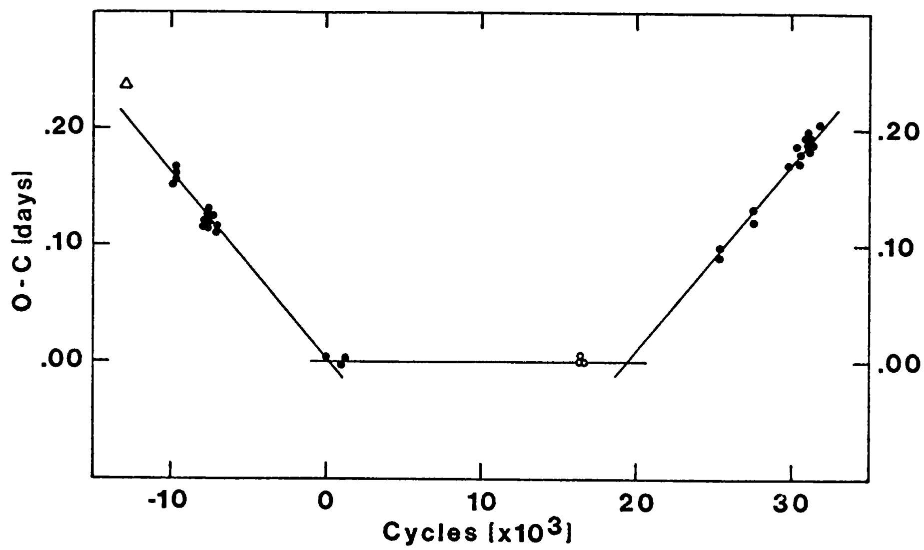

Figure 1. O-C diagram for all available maxima of SW Bootis, plotted in accordance with the Bonov-refined Tsesevich equation: JD 2426847.3840 + $0^{d}.51351108$E. The leftmost line results from the pre-1932 Tsesevich equation (see text). The rightmost line corresponds to the author's least-squares analysis (equation 2). Open circles are photographic times of maximum; filled circles represent visual times of maximum. The open triangle signifies the maximum at discovery (uncertain).

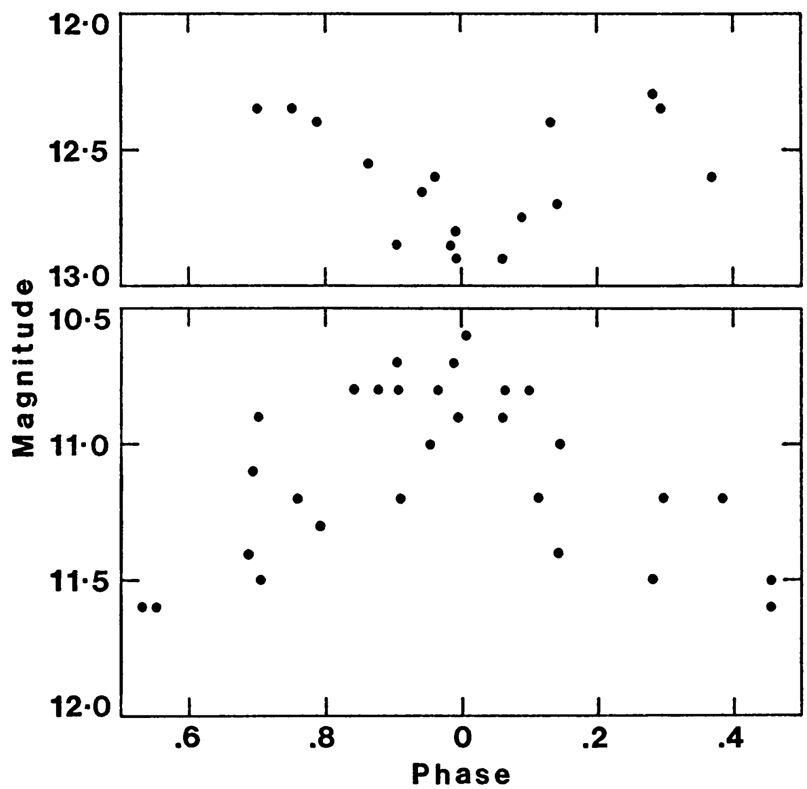

Figure 2. Phase-magnitude plot for the postulated $12^{d}.997$ secondary period of SW Bootis; magnitude at minimum light (upper) and magnitude at maximum light (lower). In general, the amplitude of the star appears greatest at times of brightest maximum.