THE PERIODS OF NS AND EP CYGNI

David J. Reiss
Maria Mitchell Observatory
Nantucket, MA 02554

Received: August 7, 1991

Abstract

An examination of photographic plates at the Maria Mitchell Observatory reveals that times of maxima of NS Cygni, an RR-Lyrae variable, cannot be represented by a single linear set of elements; the period of this star has changed at least three times between 1930 and 1990. It has returned at least once to a previous period, years after it had changed. Elements valid for 1983-1990 are:

$$JD_{max} = 2447220.6414 + 0.5503287\ E.$$

The period of EP Cygni, a Cepheid variable, has remained constant. Revised elements, valid for 1967-1990, are:

$$JD_{max} = 2444003.096 + 4.288963\ E.$$

1. NS Cygni

NS Cygni is an RR Lyrae star of subclass RRab. During the summer of 1983, Gary G. Smith examined photographic plates at the Maria Mitchell Observatory for 1916-1983 in order to determine if the star had deviated from the elements listed by Olmsted (1951):

$$JD_{max} = 2432081.556 + 0.550300\ E. \quad (1)$$

I continued the study, updating it through 1990. Annual light curves were created with phases calculated using the above elements, using brightness measurements estimated from the photographic plates. For some years, not enough measurements existed to obtain a reliable light curve.

In order to visualize periodic trends during the years examined, the annual light curves were superimposed on a representative light curve which had been created from the magnitude data from the light curve of 1987. This comparison was used, by matching the light curves as closely as possible, to determine the phase at which the star reached maximum magnitude for each year. This phase is the O-C (Observed minus Calculated) phase of maximum. The O-C residuals are shown in Figure 1. The error bars are subjective estimates of the uncertainty in matching the representative light curve to the yearly curves.

The O-C graph can be approximated by four linear segments, with a fifth one possible for the few years before JD 2427300 (1933). The graph suggests that, several times, the star has changed its period quickly and remained at a constant period before changing once again.

The slopes and intercepts taken from a least-squares fit of the four segments of the O-C diagram allowed the following elements for the segments to be computed using the method described by Belserene (1988):

$$\text{JD } 2427300\text{-}2429500,\ JD_{max} = 2428384.6269 \pm 0.0028 + 0.5502824 \pm 0.0000024\ E; \quad (2)$$

$$\text{JD } 2429500\text{-}2434600,\ JD_{max} = 2432996.1918 \pm 0.0029 + 0.5503135 \pm 0.0000014\ E; \quad (3)$$

$$\text{JD } 2434600\text{-}2445300,\ JD_{max} = 2442198.0804 \pm 0.0023 + 0.5502824 \pm 0.0000006\ E; \quad (4)$$

$$\text{JD } 2445300\text{-}2448000,\ JD_{max} = 2447220.6414 \pm 0.0017 + 0.5503287 \pm 0.0000012\ E. \quad (5)$$

Elements calculated from the earliest segment would not be convincing, considering the small number of points and their uncertainty.

It is evident from equations (2) and (4) that NS Cyg returned to the same period during JD 2434600-2445300 (1953 to 1982) as it had during JD 2427300-2429500 (1933 to 1939). It could also be argued that NS Cyg took a second such "rejump" during JD 2445300-2448000 (1983 to 1990) back to a period similar to the one it had during JD 2429500-2434600 (1940 to 1952), as indicated in equations (3) and (5). This structure, which Szabados (1977) called "stepwise" in O-C diagrams for Cepheids, has also been documented in RR Lyrae stars, including UY Boo, AT Ser, and AE Peg (Tsesevich 1972), so NS Cyg is not unusual. Of course, it cannot be implied that NS Cyg truly returned to exactly the same period on either of these two occasions, given the uncertainties involved.

Between period changes, the period of NS Cyg has remained quite constant, although the times at which the phase shifts have occurred do not seem to follow any particular pattern. With this knowledge, it can be hypothesized that NS Cygni will for a while longer follow the behavior characterized by the elements given in equation (5), which it has retained from 1983 to the present; however, the time at which the next period change will occur cannot be predicted. It will be interesting to see if the next period change will be to a period near or equal to 0.550282 day, as the pattern would suggest.

2. EP Cygni

Allen R. Loser reported, in an unpublished study of plates for the years 1967 to 1983 at the Maria Mitchell Observatory, that EP Cygni, a classical Cepheid, had not deviated from the elements given by Kholopov *et al.* (1985):

$$JD_{max} = 2437852.785 + 4.2889305\ E. \quad (6)$$

I updated his research through 1990 and confirmed this result. An O-C diagram computed from equation (6) is shown in Figure 2, with linear and parabolic least-squares curves added. The coefficient of E^2 in the parabolic fit differs from zero by only 55% of its mean error; therefore the curve is best described as linear. If the period has changed at all, it has only done so at a rate of $0.122 \times 10^{-5} \pm 0.272 \times 10^{-5}$ cycle per year. The linear least-squares data give the elements:

$$JD_{max} = 2444003.096 \pm 0.018 + 4.288963 \pm 0.000031\ E \quad (7)$$

for the years 1967 to the present.

This research was funded by the National Science Foundation grant AST-

8922809. It was conducted under the guidance of Dr. Emilia P. Belserene, whom I would like to thank for her patience and support. I would also like to thank Gary G. Smith and Allen R. Loser for their help in the inspection of over 2300 plates.

References

Belserene, E. P. 1988, *J. Amer. Assoc. Var. Star Obs.*, 17, 2.
Kholopov, P. N. *et al.* 1985, *General Catalogue of Variable Stars,* Fourth Edition, Moscow.
Olmsted, M. 1951, *Bull. Harvard Coll. Obs.*, No. 920.
Szabados, L. 1977, *Budapest Mitt.*, 6, No. 70.
Tsesevich, V. 1972, *Vistas in Astronomy,* Pergamon Press, Germany, 13.

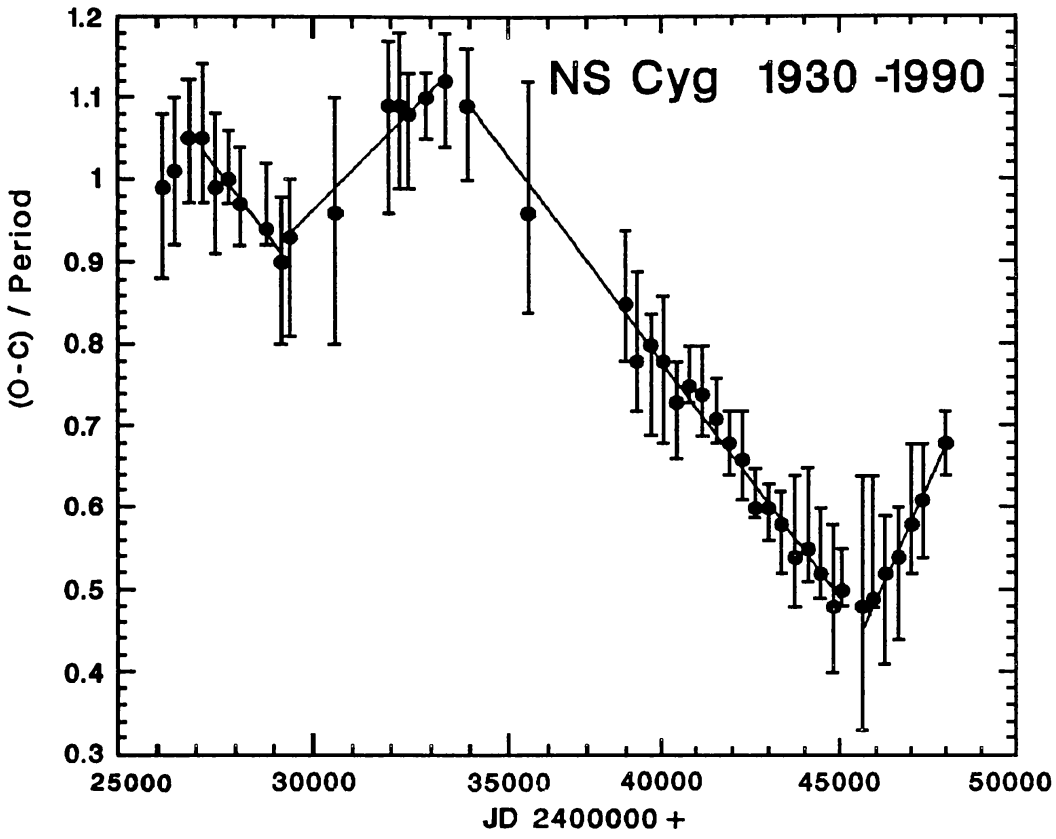

Figure 1. O-C diagram for NS Cygni for 1930 to 1990, with C defined by equation (1). Error bars represent subjective uncertainties in the determination of phases of maximum. The least squares fits are drawn for the four line segments, suggesting four successive constant periods.

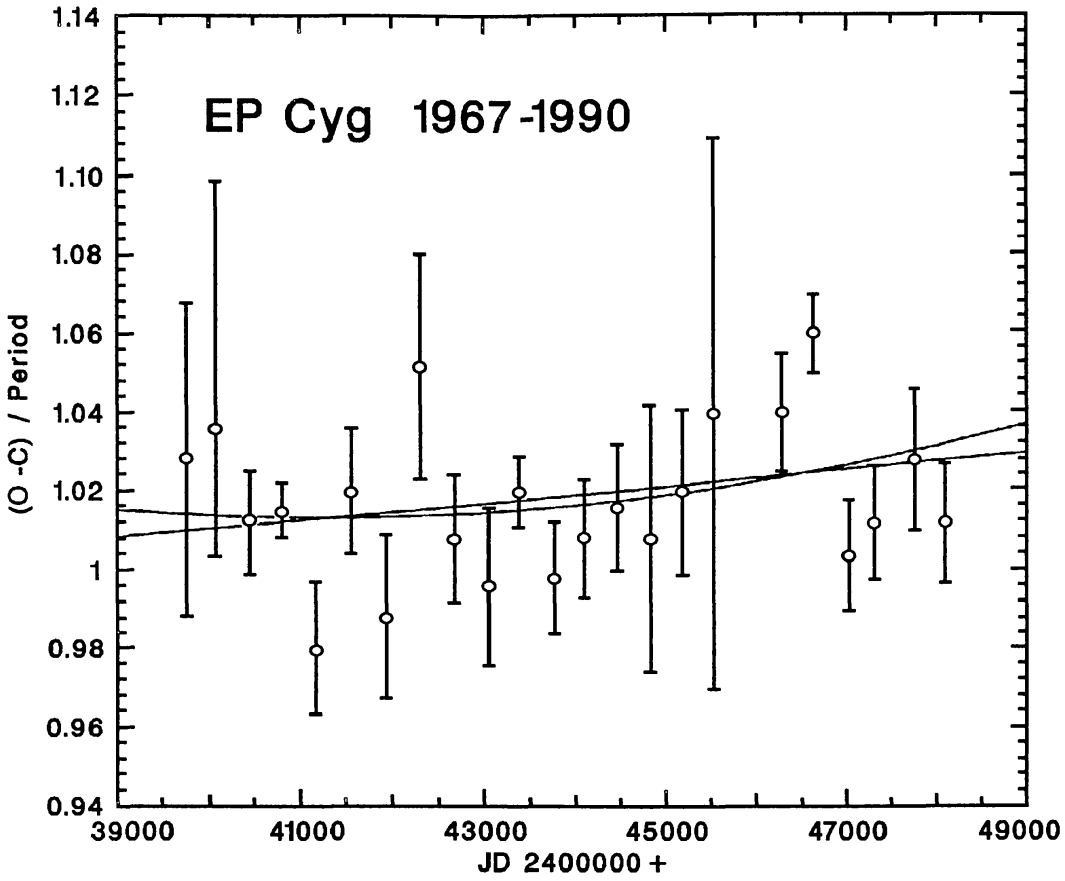

Figure 2. O-C diagram for EP Cygni for 1967 to 1990. Error bars indicate the uncertainties in the determination of yearly maxima. Least squares linear and parabolic fits are added. The parabolic fit is not significantly better than the linear, suggesting that the period has been constant.