TWO STARS IN SAGITTARIUS WITH CHANGING PERIODS

PAMELA R. KNIGHT
Maria Mitchell Observatory
Nantucket, Massachusetts

My work at The Maria Mitchell Observatory during the summer of 1972 was done on stars in VSF 193 in Sagittarius. In this paper I would like to discuss two stars which were found to have changing periods - one a long period Mira type and the other a short period RR Lyrae type. The first of these stars, temporarily designated as B15, (RA $18^h\ 20^m\ 52^s$, Dec. $-28^\circ\ 27'.8$, 1900, mag. range 12.6-14.5pg), was discovered at Nantucket during the summer of 1971 by Karen Kwitter. I re-estimated it on approximately 500 NA plates and about 200 MF and B plates by comparing its brightness on each plate to standard comparison stars. Next the magnitude estimates were plotted against Julian day on a scale of 100 days to the inch, and some pieces of light curves began to be visible.

The first value for the period which seemed to fit the NA estimates fairly well was 117 days. Using graphic means to superimpose the different cycles on each other, it became obvious that this period was slightly too long. It was gradually revised downward. In doing so, however, it was found that a period of 115.5 days seemed to fit the first half of the NA estimates best (JD 36000-39000), while a slightly shorter period of 114.5 days was best for the later half of these plates (JD 39000-41500). Now the question was - what period would be best for the long stretch of early Harvard plates from JD 26000-33000? It turned out that the period which fit these data best was 115.3 days. Since this period worked for the longest time span, an O-C curve was plotted for this period. The difference between the observed and the computed maxima was plotted against Julian day for several well defined maxima (Figure 1). The scatter of points from JD 26000-38000 is within an acceptable range, but it can be seen that at about JD 38000, the curve drops off, indicating a shorter period after this point in time. The conclusion drawn was that the star had a period of 115.3 days (JD_{max} 36035) which shortened to 114.5 days (JD_{max} 39370) sometime around JD 38000.

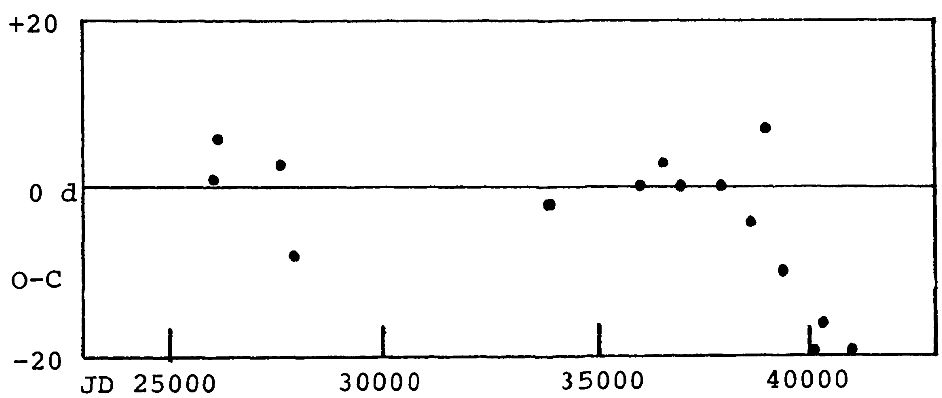

Figure 1. O-C diagram, Star B15, P = 115.3 days

The second star to be discussed also had a changing period, but because of its nature, finding the period for this star was much more time consuming. The star was discovered by Miss Hoffleit and its published number is Chart 77; I.B.V.S., 1972, No. 660 (RA $18^h\ 20^m\ 13^s$, Dec. $-21°\ 16'.8$, 1900, range 12.5-14.3pg).

After estimating the NA plates, day runs were plotted on a scale of one day to the inch, since it was obvious from the raw data that this star had a period of less than a day. A span of 100 days which included several good maxima was first studied and phases were calculated for each estimate by multiplying the Julian day by the reciprocal period. The first period which looked reasonable was slightly over 1/2 day (p^{-1} =1.957). The plot of phases against magnitudes seemed to have two maxima, which indicated that the period might only be 1/2 as long, or 1/4 day. This light curve was then refined and other groups of 100 days were gradually added. The period which looked best for a group of 300 days had a reciprocal of 3.9102, although there were still several bothersome points which were out of place.

At this point, spurious period corrections for a year and a day were applied. When the correction for the sidereal day common interval of the observations, 1.0027, was subtracted from the best looking reciprocal, it seemed to improve matters. More and more groups of observations were added in and the reciprocal period of 2.90891 looked fairly good for most of the NA points. Because several points were still in embarrassing positions on the light curve, another spurious period correction was tried, which brought the reciprocal down to 1.90620. Working around this period, a good curve was obtained for the NA observations at p^{-1}=1.90618 (Figure 2A), while the MF and B plates looked best at p^{-1}=1.906195 (Figure 2B). By making small corrections, the two groups of points were found to fit best together at p^{-1}=1.906186 or P=.524608 days (Fig.2C).

Here is where the problem of the changing period came in. RR Lyrae stars generally have a rather sharp ascent to maximum and a slower, more gradual falling off to minimum. The star obeyed this general rule, but the combined curve showed too much scatter in the ascent. The observations were then divided into five groups and the best position for the phase of ascent was determined from the graph of each group. Next an O-C curve was prepared, plotting the phase of ascent for each of the five groups versus the average Julian day for the group. The points were found to lie on a parabolic path, implying that an additional correction term was needed. (Figure 2E).

The equation used to solve for the needed correction was:

$$\phi_P = (JD - JD_O)P^{-1} + n + kn^2 \qquad (1)$$

where n = the integer number of epochs since JD_O, and k = the correction factor. From Figure 2E, JD_O is the point where the tangent touches the curve, JD 32000. The perpendicular distance from this tangent to the curve at any point is equal to O-C (the difference between the observed and computed phases), which is the same as the kn^2 term at the end of equation (1). What this all means is that the star has a period which changes in a regular fashion over time according to this equation.

The next step was to solve for k, which turned out to be a very small number, $1.9x10^{-10}$. Multiplying equation (1) through by the initial period, we obtain:

$$\phi_d = (JD - JD_o) + n(P_o + Kn) \qquad (2)$$

where p_o = the period at JD_o, and $K = k(p_o)$, our new correction factor. Solving for K, we obtain $K = .997 \times 10^{-10}$. The new period which fits any particular Julian day observation can thus be found by multiplying K by the number of epochs which have elapsed since JD_o and adding the result to p_o. The phases for all the observations were recomputed, taking the correction factor into account for each one. When the light curve was plotted for the last time, the scatter in the ascending branch was considerably reduced (Figure 2D). The period now stands at .524608 days at JD 32000, and substituting in all our values, the final equation then becomes:

$$\phi = (JD - JD_o 32000) + n[.524608 + (.997x10^{-10})n] \qquad (3)$$

There are two possibilities for a star with a changing period - either its period may change abruptly at some point in time due to a sudden event in the star, or it may change constantly in time according to some function. The long period star B15 which I first discussed would appear to have changed suddenly. However, it is possible that if observations were made on this star for many more years, its changing period might be seen to fit some regular curve. As for the RR Lyrae star, we have seen that its period changes over time as a function of n.

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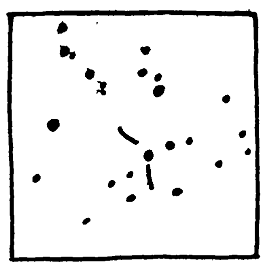

B-15 Finder chart 10'x10'
South up.

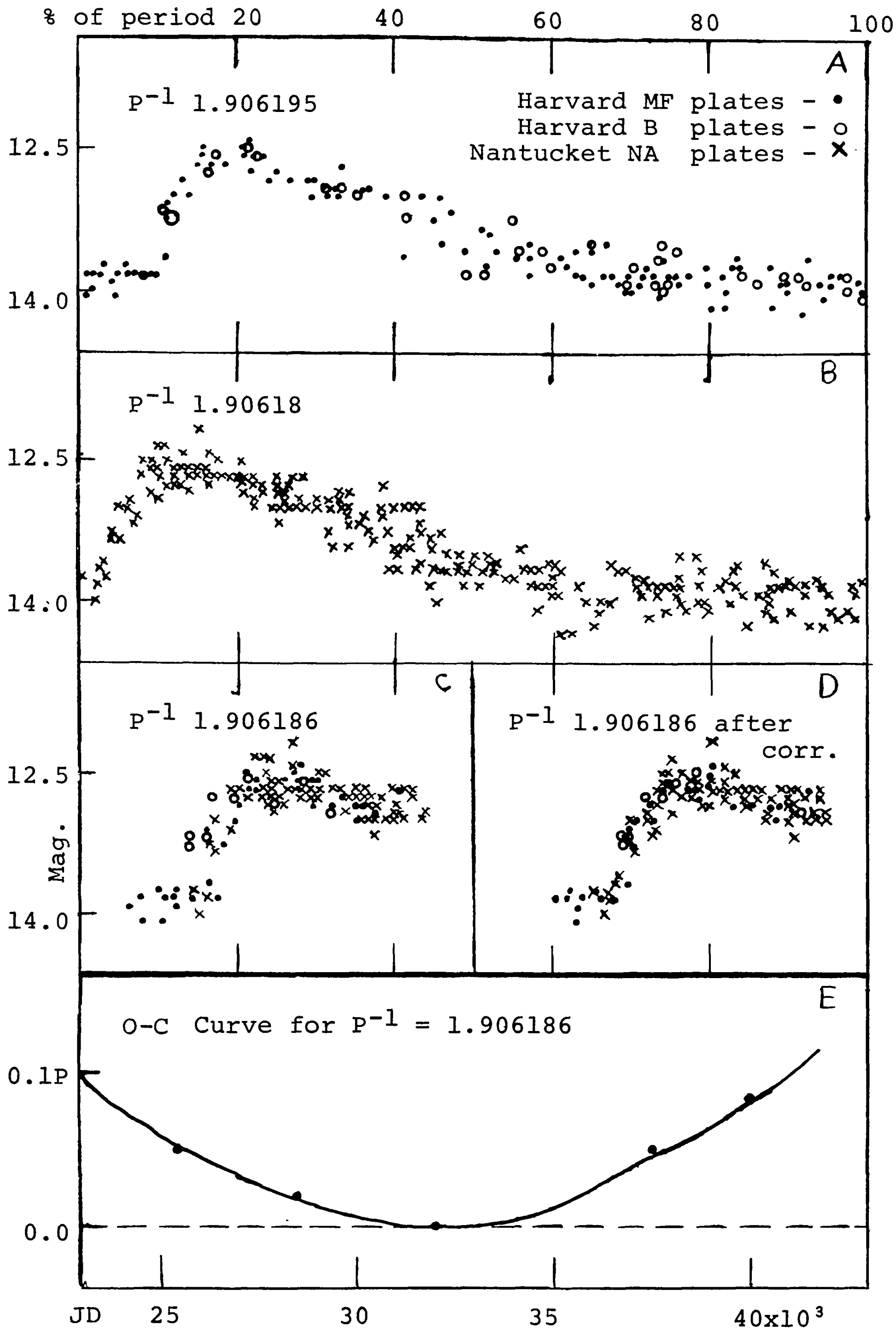

Figure 2.- Chart 77