AAVSO OBSERVATIONS OF LONG PERIOD VARIABLE STARS 1900 - 1975: MAXIMUM AND MINIMUM MAGNITUDES AND O-C DIAGRAMS

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Abstract

The data for 391 long period variable stars, collected by members of the AAVSO, are now available in the form of O-C diagrams and plots of maximum and minimum magnitudes. Examples are shown and preliminary results are discussed.

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Over the past seventy-five years, millions of observations of long period variable (LPV) stars have been contributed by AAVSO observers. From these data, using the AAVSO mean curves, the Julian Dates and magnitudes of observed maxima and minima were determined by Annie J. Cannon, and AAVSO Directors Leon Campbell, Margaret W. Mayall, and Janet A. Mattei, respectively covering the period 1900 - 1975.

The computerization and the compilation of these data on 391 stars were organized and completed under the direction of J. A. Mattei and E. O. Waagen at AAVSO Headquarters. Further analysis, aimed at searching for long-term changes in the amplitude and in the period of pulsation, was carried out by P. Kowalsky and J. Percy at the University of Toronto.

The LPV stars are expected to show changes in their pulsation periods because their other fundamental properties are changing as the stars evolve quickly up the asymptotic giant branch. The nature of the observed period changes should provide further constraints on the theoretical models used to explain these stars.

A useful tool for the examination of period changes is the O-C diagram, a plot of O-C (Observed date of maximum minus Calculated dates of maximum) versus cycle number. If the actual period of the star is constant and equal to the mean period used for the calculated dates, the O-C diagram will show points scattered around the horizontal line O-C = 0. However, if the actual period is constant but longer than the mean period used, the quantity O-C increases steadily, resulting in a straight line with positive slope on the O-C diagram. Similarly, if the actual period is constant but shorter than the mean period used, the O-C diagram will show a straight line with negative slope. (See Figure 1 for an interesting but rare example of an LPV star whose O-C diagram shows a large, abrupt period change, from one constant period which is shorter than the mean period, to one which is longer.) For a star whose period is increasing at a constant rate, the mean period will only represent the actual period at some half-way point in the data set, with the actual period spending the first half of the data set catching up to the mean, and the second half overtaking it. This results in a parabola opening upwards on the O-C diagram. The opposite occurs for stars with constantly decreasing periods. R Aquilae and W Draconis are well-known examples of LPV stars whose periods of pulsation are changing at a constant rate.

O-C diagrams, and plots of mean magnitudes at maximum and minimum brightness versus cycle number were made for the 391 LPV stars. Only 10% of the O-C diagrams show random scatter. Approximately 20% have a parabolic shape, with the number evenly split between those with increasing periods and those with decreasing periods. About 10% of the O-C diagrams describe one cycle of a sine curve, suggesting a possible regular, repeating pattern of period changes about the mean period. If this interpretation is correct, the data show that a 150-day star can exhibit regular period changes of 0.4 days every 55 cycles, and a 420-day star can exhibit regular period changes of 11 days every 25 cycles. The remaining O-C diagrams show behavior ranging from intermittent period changes to continually repeating period changes of varying amplitude and/or duration. (See Figure 2 for an example.) Despite the variety of O-C diagrams, almost all of the magnitude plots show the mean maximum and minimum brightness of these stars to be constant. There are a few exceptions which show a constant increase or decrease in the amplitude of the light curve throughout the data set.

Future work will involve a detailed study of the type, size, and frequency of the observed period changes. Any correlations of the period change data with other properties of these stars, e.g. period and spectral type, will be investigated.

The analysis of these data was made possible by a grant from the J. P. Bickell Foundation of Toronto. We thank the AAVSO observers for their untiring efforts to provide the millions of observations which made this analysis possible.

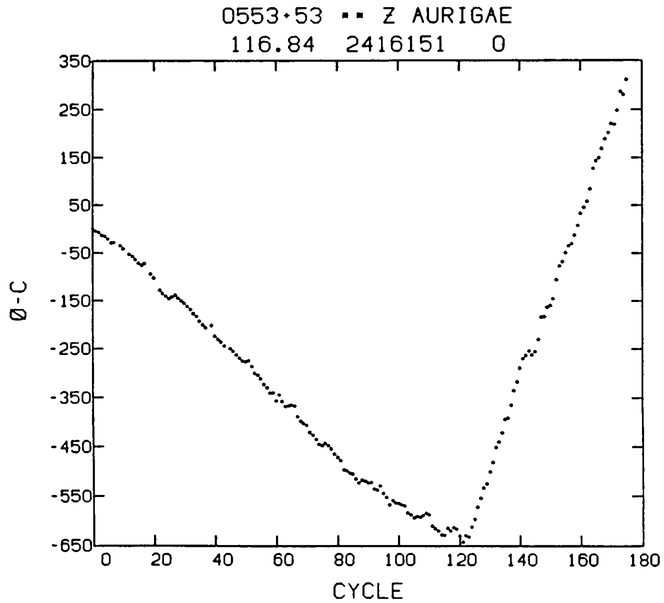
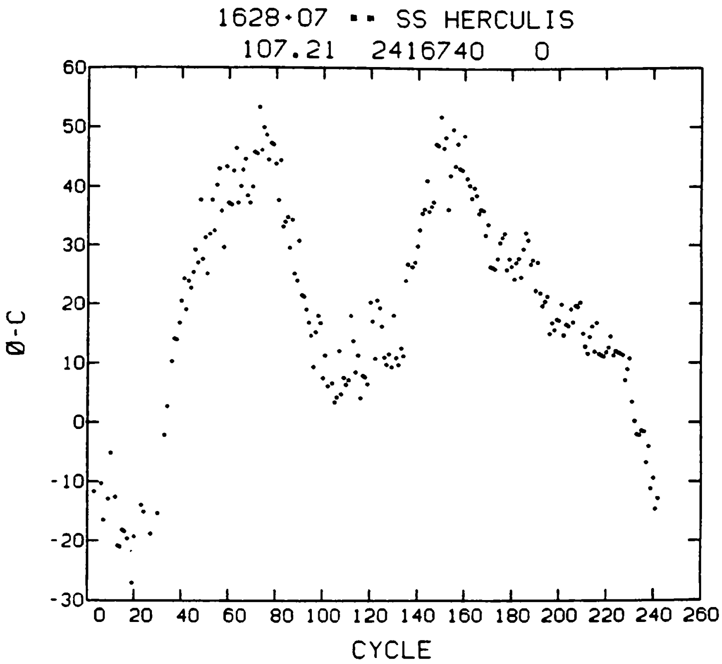


Figure 1. O-C diagram for Z Aurigae. The heading provides information regarding the star's designation number, name, mean period, initial Julian date (in this data set) and the corresponding cycle number. From cycle 0 to 120, the actual period is fairly constant and shorter than the mean period, resulting in a straight line with negative slope. After cycle 120, the period of the star seems to increase suddenly by ~23 days, with the actual period now being larger than the mean period, yet still constant. This results in a line with positive slope.



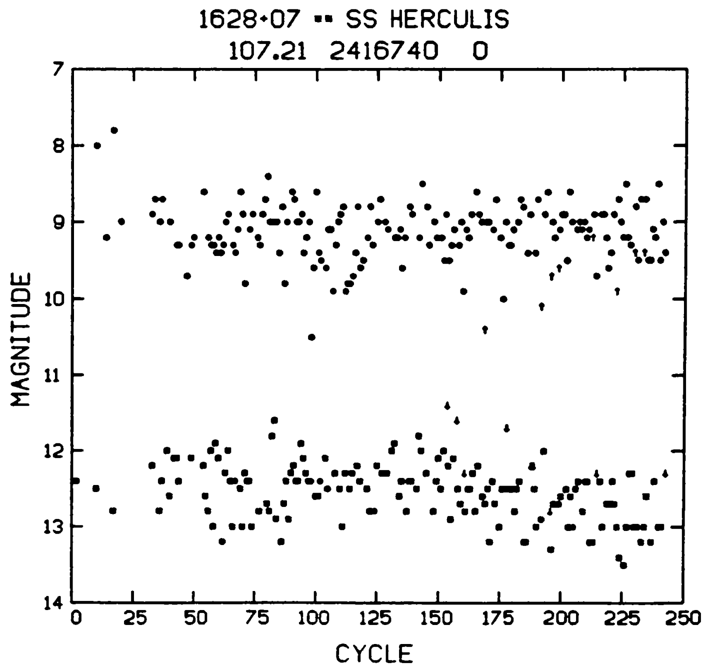


Figure 2. O-C diagram (top) and plot of magnitudes at maximum and minimum brightness versus cycle number (bottom) for SS Herculis. In the bottom diagram, magnitude estimates are represented by arrows: ↑(brighter than) and ↓(fainter than).

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