

1972JAVSO.....1.....9C

THE CLASSICAL CEPHEID PROGRAM  
J.D. 2,440,000 - 2,441,000

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This paper represents a progress report on the AAVSO Classical Cepheid Program covering the period JD 2,440,000-JD 2,441,000. It is to be remembered that the primary purpose of this program is to investigate classical Cepheids with periods greater than 10.0 days for the possibility of slow period changes which might be associated with evolutionary changes in these stars. Originally it was suggested that observations be acquired around the maxima of the stars, and that these could be used for the determination of the "O-C" (observed minus calculated maximum) for each of the objects, but it was quickly learned that some of these stars were deviating sufficiently from their predicted maxima to render it necessary to find when the maxima were actually occurring at the present time. This entailed observing each star over most of its cycle, and in doing so, other rather interesting details were brought forth. An additional problem was that we were not getting a sufficient number of observations around the maxima to make decent determinations of the O-C's. It was finally concluded that we would introduce less prejudice in determining the maxima if we just asked all the observers to make magnitude estimates of the stars randomly as they saw fit and to use an interval longer than one year to combine into one mean curve. As this report indicates, this was probably the proper method of attack. Until it can be demonstrated to the contrary, we will continue this method at least until we have a better idea as to whether or not the program has a chance to yield results.

For the sake of convenience it is strongly suggested that anyone who is interested in taking part in this program should contact me for details. The observers should send all estimates of the classical Cepheids to me as well as to Headquarters since it places an additional burden on the Director to separate out all the estimates, assemble them, and send them on to me. It would be helpful if the data were sent to me in long interval lots, all the estimates of a star during a given apparition being sent at the end of each apparition.

INDIVIDUAL STARS

020057 VX Per: An insufficient number of estimates were available for meaningful data analysis. The range of about one magnitude indicates that the star should be useful for the program. More observations are needed to make sense of the current data set.

021959 SZ Cas: This star is located rather close to 021558 S Per, and should be one of our more frequently observed stars, but the contrary is true. Only six estimates are at hand. They indicate a range of at least one magnitude, with a sharp rise, and a possible O-C of + 5 days. This star should be followed as one of our better stars.

061606 SV Mon: 134 estimates were available for the current analysis. Daily means of the data were extracted, resulting in the light curve in Fig. 1. As noted, a rather sinusoidal curve resulted, with an M-m of about 7 days (0.5 Period) and an O-C of as close to zero as the reduction method would permit. Continued study of the star is recommended since the current data set forms a good basis for future studies for period changes.

061907 T Mon: This was one of the more frequently observed stars of the group, 180 estimates made by three observers being considered in this analysis. The individual daily means demonstrate the "observer constant" problem, especially in the region around + 3 days. The range for the star according to each of the three observers was: 6.6-7.6, 5.9-6.9, and 5.7-7.0. Despite these differences, means of the data can yield a date for maximum with little difficulty. It must be remembered, however, that these differences tend to flatten the mean curve. Because of this, a five-day running mean of the data was plotted which shows a well-defined maximum with an O-C of + 2 1/2 days (Fig. 2). Since the minimum is so much harder to define from the curve, an M-m would not be very meaningful. It is clear that this is one of the best stars on the program, and since it is easily observed with binoculars it should be observed frequently enough to provide sufficient data for the future of the project.

065820 Zeta Gem: 101 estimates made by two observers were available for the study of this star during the covered period. One observer's data show the star essentially constant during this time, while the other observer's data show essentially what would be expected from the General Catalog of Variable Stars data. The latter's data alone show an O-C of about 1 day, a sharp minimum with a broad maximum, and an M-m of about 4 1/2 days. This is rather similar to what was obtained in a preliminary survey of this star in the mid-1960's. Despite the rather small range, it would be advisable for more observers to work on this star, as it is quite easy to observe with the unaided eye and many good sequence stars are available. Other observers may be able to resolve the differences between the two sets of data currently available.

071069 RU Cam: Sixty-nine estimates were used in the analysis of this star. The 1000-day coverage occurred shortly after the star emerged from a long period of constancy, so little variation was to be expected, and the daily plot certainly verified this. However, a distinct pair of minima in the plot shows that the 22-day period is still found in the data at + 11 and - 11 days.

072820a X Pup: This star was observed only a total of 13 times during the period in question. Despite this the curve shows the large range, but since no data were available at the maxima little can be said about O-C and M-m. The large range, bright sharp maxima, long period, and good sequence make this one of the best stars in the sky for the program. It is sincerely hoped that more observers will make estimates of this star, as more data are urgently needed.

132002 W Vir: This star is the prototype for the halo population Cepheids and has a light curve generally denoted by a hump on the descending branch of the curve. It is this hump, occurring near maximum, which usually causes problems in accurately determining maximum. Such a blend has the effect of broadening the maximum and making it necessarily harder to determine accurately. The minimum frequently is sharper, and is perhaps better for phasing purposes than the maximum. The resulting mean curve from the 33 estimates obtained during this time interval demonstrates nicely just such an effect. Using the ill-defined maximum from the mean curve we could assign an O-C of any value from +6 1/2 to +11 1/2 days, while the minimum is defined nicely by one point. Of course, the data are far too meager to justify such conclusions, and this demonstrates the need for more observations of this star to yield useful results.

140512b AL Vir: The 38 estimates considered indicate a curve not typical of the W Vir type. The indicated O-C is essentially zero. It is interesting to note that the previous data set made to investigate the properties of this star yielded an O-C of about - 3 days. Since the present set yields a value of essentially zero, it remains to be seen if the next 1000 day set will give a value of + 3 days. This star has been known to be one of the more irregular of its class, so such differences are not out of the likelihood of normalcy.

153620b RX Lib: Only 12 estimates of this W Vir type star were available, so little could be concluded from these data. The long period indicates that this star should be a good one for the program, but it is difficult to make a decision if no observations are made of the star.

175822 AV Sgr: Only 23 estimates were available for this study, which is far too few to define the period adequately. However, we can say that the basic 15 1/2 day period seems to be confirmed. What was rather surprising was the indication of a double curve, each part with identical periods but quite different amplitudes. If we could obtain more observations we might be able to settle some of the questions raised by what few observations we do have on hand.

183604 RU Sct: 151 estimates were available for the current analysis. The combined individual plots show considerable scatter, almost certainly due to the variable being some 2° from the comparison sequence. An ill-defined flat maximum with an O-C of the order of + 5 days is indicated. Clearly a nearby sequence is required to improve our situation with this star.

183705 Z Sct: 191 estimates were combined for the mean curve (Fig. 3). An O-C of the order of - 5 1/2 days is indicated. This is of special interest since the preliminary investigation of this star during the mid 1960's showed an O-C of virtually zero. Since the evidence is so strong that there is a large variation in the period, this star should be on the top of our list for coverage. Current data indicate an M-m of about 4 days (about 0.3 P), which is rather standard for many Cepheids.

185600 V336 Aql: This star was considered only because of its proximity to two other stars on the program. Its range and period are out of the normal considered for this program, but since the observations were available it seemed worthwhile to see what they indicated. 87 estimates were plotted for the mean curve, which appears quite normal with an O-C of essentially zero. Since normal visual estimates are accurate to about 1/3 magnitude, they are too coarse to establish the light curve of this star. This object is discussed as a curiosity rather than as a normal program star.

185901 SZ Aql: Although 87 estimates were obtained for this star, the scatter was rather surprising. The small range encountered was almost surely a contributing factor. The O-C indicated by the data is around + 1/2 day, with an M-m of about 5 days (about 0.3P). More observations would be useful to determine the curve of this star more precisely, to see if we should continue it on the program.

190301 TT Aql: The 88 estimates considered here indicate a rather typical Cepheid curve with an M-m of about 5 days (0.3P) and an O-C of - 2 1/2 days (Fig. 4). This is clearly a very good star for the program and it is hoped that we will receive more observations of it. In a very good sky it can be observed throughout its cycle with binoculars.

194727 SV Vul: Although 311 estimates were available for this analysis, the daily means did not define the curve as well as might have been expected. A five-day running mean was prepared which would normally be expected to smooth the variations to such an extent that the maximum would be well defined. Instead, a double peak was found (O-C's of -3 and + 5 days being indicated), which could possibly reflect a rather strong Blazko effect. (Fig. 5) Another possible cause of the difficulty could be a large error in the point at + 6 1/2 days, since that point would affect the two on either side of it in a five-day running mean. If these five points were lowered only 0.1 magnitude the curve would look very good indeed. The resulting curve shows a very short steep rise to maximum - almost too steep. Since this star is the longest period Cepheid on our list in the Northern Hemisphere, it should be our best candidate for the program. It is unfortunate indeed that this difficulty arose, and many more observations are needed over the next 1000 days to resolve the problem and determine whether or not the double peak is real.

202946 SZ Cyg: Since only six estimates were available, little of value can be concluded at this time. The Star is so far away from the existing comparison sequence that any estimates made are hardly more than a wild guess. This star appears to have a range of at least a full magnitude, with a flat minimum, steep rise to maximum, and a sharp maximum which lends itself very well to our program. A comparison sequence rather near the star is needed if any further work is to be done.

203935 X Cyg: This excellent binocular object was observed 59 times during the interval under consideration. Despite the scatter, the mean curve is rather well defined (Fig. 6).

An O-C of as near zero as the reduction method will permit, and an M-m of the order of about 7 days (about  $0.4P$ ) are indicated. More observations of this star are needed to reduce the scatter.

204244, BZ Cyg: The published light curve of this star indicates that it would be a very good object for the program. However, the 22 estimates received show nothing but wild scatter. More observations are needed to resolve the chaos in the current data set. It is not an easy star to observe since it is quite far from the existing comparison sequence.

The following stars were not included in this study for the reasons cited:

174706, Y Oph:

The small range and poor comparison sequence for the visual estimates render this star useless to the program.

194029, SU Cyg:

Too few estimates are available, and the period is too short for the program.

200814, TW Cap:

A useful star, but too few estimates are available for any definitive work at this time.

222557, Delta Cep:

Many obviously bad estimates are available, and the period is too short for the program.

Observations by the following persons have made this report possible: Curtis Anderson, John Bortle, Thomas Cragg, Rainer Lukas, Edward Oravec.

#### REFERENCE

Cragg, Thomas A., AAVSO Abstracts, May 1971, 5.





