

and expand into a more and more diffuse coma. On December 10 its trace could no longer be found on a plate showing stars down to magnitude 17. Further watch is to be kept of this object which, according to previous experience, might flare up again unexpectedly, but it is moving rapidly into the evening sky and soon the observational season will be over for it.

On November 22 I succeeded in locating the faint image of COMET 1933 IV (PERIODIC WHIPPLE) which now comes again in opposition in the constellation of Monoceros. It appeared then as a round coma hardly more than $10''$ in diameter and the brightness was not more than that of a 17th magnitude star. This will extend by a year the arc covered by the observations at this apparition. But few further observations can be expected of this inconspicuous object.

Williams Bay, Wisconsin, December 11, 1941.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Predicting Dates of Maxima and Minima for Long-Period Variables: The variations from uniformity in the arrival at maximum and minimum for long-period variables, especially those of the Mira-type, have long been a subject for much discussion. Paul Ahnert, of Sonnenberg, Germany, has recently published a paper in which he raises the question as to which is more expedient, to predict dates of maximum and minimum from an assumed constant period for the star under consideration, or to make use of sine or quadratic terms which would seem to best represent sudden or gradual changes in period. His conclusions more or less agree with those recent investigators, that is, that secondary terms for Mira-type stars have little value for predictions, especially over long intervals. Sine terms may well represent what has taken place in the past, but they serve little purpose for predicting what the star will do in the future.

Ahnert has investigated 15 Mira-type stars which were common to his and Nijland's programs covering an unbroken series of observations of 35 years (1905-1940). For 80 dates of maximum, he finds the mean differences between his own dates and those determined from Nijland's observations to be of the order of 5 days, with a difference of $12\frac{1}{2}$ days for the 10 largest deviations. If we assume a mean value of the period as 300 days, this indicates a mean difference for all 80 maxima of 1.7 percent, or 4.1 percent for the largest deviations.

Of the 15 stars discussed by Ahnert, only two—W Andromedae and R Lyncis—were found for which linear elements represented the entire series of observations between 1905 and 1940. R Aquilae, as is well known, showed a gradual change in period, as does R Hydrae.

Ahnert concludes that if only moderate accuracy in predictions is required, say within 5 percent of the period, simple elements are adequate for the majority of the stars, provided these elements depend on a sufficiently long series of observational data. The use of sine terms only makes matters worse, for the changes are more often abrupt or irregular, rather than cyclical. He suggests the use of "instantaneous" elements, which are assumed to be those elements which are the most up-to-date, and which take into account the recent behavior of the star in

question. He also points out that changes in period as derived from maxima are not found to prevail for the immediate related minima. Accordingly, the intervals from minimum to maximum ($M - m$) must vary, although not to such a large extent. No specific rule can be applied for the stars in general; the conditions differ from star to star.

It was recognized at Harvard many years ago that the predictions of dates of maxima and minima from linear or sine term elements was futile. On occasion, the differences between observed and predicted dates exceeded a month, and the average value was nearly 25 days. For this reason, predictions were made there which are based on the use of mean light curves for the individual stars, referred to the preceding, best observed maximum or minimum. Immediately a marked improvement was noted. For the year 1921, the average difference between observed and predicted dates was 12.5 days for the maxima and 15 days for the minima. Expressed in another manner, 33 percent of the predictions were within five days, 56 percent within 10 days, and only 12 percent exceeded 25 days. In 10 years these differences were appreciably improved; 9^d.4 for maxima, and 10^d.5 for minima, or 42 percent of the maxima within five days, 67 percent within 10 days, and 6 percent greater than 25 days. When it is recalled that an average difference of at least five days can be accounted for by intrinsic irregularities in the variables themselves, as shown by Ahnert's discussion, this value indicates that the dates predicted by the Harvard method are really almost as good as can be expected. The maxima and minima for stars with long protracted and irregular maxima and minima naturally are more difficult to predict.

An extensive discussion of changes in period of long-period variables was made by Sterne and Campbell in 1936, and the results appear in a paper published in the Harvard Tercentenary Papers.

Variations in Brightness of Maxima of Long-Period Variables: The fact that many of the Mira-type stars attain markedly different magnitudes at maximum and at minimum for the same star has been recognized almost since the beginning of variable star observing. This feature is particularly noticeable in such stars as α Ceti and χ Cygni, in spite of the fact that the Mira stars are considered, in general, as "regular" variables. The elements of the light curves can be said to represent only mean values.

Paul Ahnert has recently discussed the variation in the brightness of the maxima of Mira stars, and his results more or less confirm earlier and contemporaneous conclusions. Joy has discussed the spectra of these stars, which show a variation in intensity of emission lines which depends on the height of maximum, and that for the fainter maxima, new emission lines, not otherwise observed, appear, as do some unknown absorption lines. Also, Merrill finds that the radial velocities appear to be unchanged for different maxima of the same variable.

Ahnert attempts to find a possible relation between intervals between consecutive maxima, and the brightness at the time of the second maximum. He has shown in an earlier paper that, for a given star, faint maxima were, in general, retarded, while bright maxima occurred earlier. In his recent paper, he concludes, from a statistical standpoint only, that the differences between higher and lower maxima are correlated with lengths of the intervals between the maxima: greater range in brightness at maximum being related to the greatest differences in length of the intervals between maxima.

Ahnert's conclusion is of interest in view of the discussion made at Harvard a few years ago of Mira itself. There it was shown that when the interval in time

between two successive rises to a median magnitude (magnitude 6.0) was short, the star rose to a brighter maximum, and conversely that long intervals indicated faint maxima. This discussion is now being extended by C. B. Ford to a large number of Mira stars, and the results of the discussion will be looked forward to with anticipation. The Harvard discussion appeared to give more uniform results when the intervals between successive attainments of sixth magnitude for α Ceti were correlated with the brightness of the following maximum, than when the intervals between consecutive maxima were used.

Dates of Maxima of Long-Period Variables, 1942: The following list contains predicted dates of maxima during 1942 for those long-period variables which attain a mean magnitude brighter than 8.0. Since it is well known that most long-period variables are subject to variations in brightness at maxima, one can expect the actual observed magnitude at this phase to differ somewhat from that cited in the table. Dates of predicted maxima can be relied upon to within 10 days, judging by results of previous years.

Design.	Name	Date of Max.	Mean Max. Mag.	Design.	Name	Date of Max.	Mean Max. Mag.
0010 ₃₂	S Scl	12 16	6.9	123307	R Vir	{ 5 10 }	6.9
001838	R And	4 7	6.9			{ 10 12 }	
021143a	W And	4 22	7.3	123961	S UMa	{ 2 21 }	
02140 ₃	α Cet	5 15	3.4			{ 10 14 }	7.9
02281 ₃	U Cet	{ 2 19 }	7.5	1324 ₂₂	R Hya	2 20	4.2
		{ 10 12 }		13270 ₆	S Vir	1 2	7.0
023133	R Tri	7 15	6.0	13315 ₅	RV Cen	11 30	7.0
02505 ₀	R Hor	5 22	6.4	134440	R CVn	{ 1 24 }	7.6
04326 ₃	R Ret	7 30	7.6			{ 12 16 }	
04356 ₂	R Dor	11 21	5.3	Design	Name	of Max.	Mag.
04434 ₉	R Pic	{ 1 2 }	6.7	Design	Name	of Max.	Mag.
		{ 6 24 }		14095 ₉	R Cen	7 15	6.0
		{ 12 14 }		14253 _{9a}	V Boo	{ 1 10 }	7.5
04551 ₄	R Lep	1 1	7.3			{ 9 26 }	
05153 ₃	T Col	{ 2 11 }	7.5	143227	R Boo	{ 4 8 }	7.1
		{ 9 24 }				{ 11 17 }	
05240 ₄	S Ori	11 17	7.9	151731	S CrB	9 8	7.0
06170 ₂	V Mon	7 7	7.2	15182 ₂	RS Lib	{ 1 24 }	7.6
06520 ₈	X Mon	{ 3 24 }	7.3			{ 8 30 }	
		{ 8 27 }		15284 ₉	R Nor	{ 1 6 }	7.3
070122a	R Gem	1 25	7.1			{ 12 4 }	
070310	R CMi	7 16	7.9	15365 ₄	T Nor	7 3	7.0
072708	S CMi	7 12	7.5	154615	R Ser	8 31	6.9
072820b	Z Pup	1 8	7.5	154639	V CrB	7 17	7.8
081112	R Cnc	5 17	6.8	160625	RU Her	1 6	7.9
081617	V Cnc	{ 3 4 }	7.7	16211 ₂	V Oph	5 26	7.4
		{ 12 2 }		163266	R Dra	6 3	7.6
08240 ₅	RT Hya	7 7	7.1	164715	S Her	7 20	7.5
084803	S Hya	{ 3 27 }	7.9	16484 ₄	RS Sco	8 14	6.0
		{ 12 8 }		17021 ₅	R Oph	10 5	7.6
08500 ₈	T Hya	9 30	7.9	171723	RS Her	{ 4 12 }	7.9
09296 ₂	R Car	8 3	4.4			{ 11 17 }	
093934	R LMi	8 6	7.0	180531	T Her	{ 4 25 }	7.8
094211	R Leo	4 22	5.9			{ 10 7 }	
10066 ₁	S Car	{ 3 22 }	5.3	181136	W Lyr	{ 6 18 }	7.7
		{ 8 18 }				{ 12 31 }	
103769	R UMa	4 15	7.5	18213 ₃	RV Sgr	10 7	7.8
11444 ₇	X Cen	9 8	7.4	183308	X Oph	4 16	6.8
12141 ₈	R Crv	3 1	7.4	190108	R Aql	7 2	6.0
122001	SS Vir	5 3	6.6	19101 ₉	R Sgr	4 13	7.3