COMPLICATED PERIOD CHANGES IN HQ LYRAE AND DF CYGNI

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Abstract

The O-C diagrams of HQ Lyrae and DF Cygni cannot be described by equations of reasonably simple form. The sine curves which had satisfied limited stretches of data have failed to maintain their usefulness. A new linear ephemeris is given for HQ Lyrae.

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Long-term O-C diagrams for various classes of pulsating stars include some cases where a line, representing a perfectly constant period, is entirely satisfactory. Sometimes a parabola, representing a uniformly increasing or decreasing period, gives a satisfactory representation. A sine curve may work if the period is alternately increasing and decreasing. Typically, however, the O-C diagram of a well-observed star is so complex that it defies all attempts to write an equation to summarize the relation of O-C to time. It is as though the stars are reminding us that they have not studied analytic geometry.

Recent work at the Maria Mitchell Observatory provides two instructive examples. A sine curve had satisfied forty-eight years of observed maxima of HQ Lyrae, a Mira star (Hoffleit 1974). Table I gives the dates of eight later maxima, along with their deviations from two sets of computed maxima, a linear ephemeris,

$$A = \text{JD } 2424770 + 289\overset{d}{.}5\ n, \qquad (1)$$

and the sinusoidal form which had successfully represented the behavior for n = 0 to 60,

$$B = \text{JD } 2424770 + 289\overset{d}{.}5\ n + 30^{d}\sin(8^{o}n). \qquad (2)$$

In these formulae n stands for the number of cycles since JD 2424770. The column headed O-B in Table I shows that the sinusoidal form predicted the 63rd and 64th maxima remarkably well, but since then it has failed. Future maxima are likely to be better predicted by this revised linear ephemeris:

$$JD_{(max)} = 2445925 + 289\overset{d}{.}7\ n, \qquad (3)$$

where n now stands for the number of cycles since JD 2445925.

In the case of the RVb variable, DF Cygni, a new analysis (Silverwood 1984) shows that neither the previously suggested sine curve (Koval 1953) nor an alternative suggestion of a parabola (Hoffleit 1970) can satisfy the later minima of the short-period variation (P~50 days). It was already clear that the sine term was, at best, useful only for a limited interval, and was probably based on a miscount of the number of cycles or half-cycles between isolated groups of observations. The latter suspicion is now confirmed. The newly derived curve can be approximated, but only roughly, by a different parabola.

It is the slope of the O-C curve that gives the correction to the assumed period. Very slightly different O-C curves may have significantly different slopes along parts of their length and still represent the data equally well. This would not be true, of course, if we had a perfectly precise value of O-C for every cycle, but that is impossible. There are always more ways than one to draw an O-C curve through any real data set. Unless theory demands that the curve have a certain form, there is no solution to the dilemma except to watch the star closely for a very long time and to use extreme care to derive values of O-C that are as precise as they can possibly be. For statistical purposes it may be useful to force a curve of some analytic form through the data points. Unless the data define the curve very closely, however, it is unwise to draw conclusions about detailed behavior of the period of an individual star from the slope of the computed curve.

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TABLE I

Maxima of HQ Lyrae

JD	n	O-A	O-B
2443032	63	+16^{d}5	+ 5^{d}9
3312	64	+12	- 0.1
4215	67	+58.5	+46.4
4488	68	+29	+34.1
4772	69	+34.5	+32.7
5040	70	+15	+15.3
5648	72	+36	+51.6
5925	73	+21.5	+42.3