FISHING FOR PERIOD CHANGES: A NANTUCKET INDUSTRY

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Abstract

First results are presented from a project in which pulsating variable stars are being examined on the Maria Mitchell plate collection with a view to determining the behavior of their periods.

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On the island of Nantucket an important local industry is the harvesting of food from the sea. There is a little observatory on the island, the Maria Mitchell Observatory, well known to many members of the AAVSO. This observatory, with its considerable collection of astronomical photographs, engages in another sort of fishing: for information about variable stars. In the summer of 1979 the principal catch was data about period changes.

The crew consisted of the author and her summer assistants. Those engaged in the period-change project are identified by name in Table 1. The net we used is a device called an O-C diagram. This

TABLE 1

Type	Designation	Inconstancy Index	Sign of Period Change(s)	Observers**
Cepheid I	V377 Sgr	.041	both	MM
	V741 Sgr	<.00006	none	MM
Cepheid II	TY Sct	.0003	+	CB
	CN Sct	<.0002	none	CB
	EP Cyg	<.0001	none	AL
RR Lyrae	CK Com	.002	both	DG
	IM Aql	.0007	-	EL
	V957 Aql	.000024	+	ES
	V783 Cyg	.000015	+	AL
	CD Com	<.000013	none	DG
	DV Com	<.000008	none	DG

* Average annual percentage charge.

**CB=Christian Bailey, DG=Diane Gilmore, EL=Elizabeth Lada, AL=Allen Loser, MM=Melanie Mitchell, ES=Elisabeth Street

is a graph showing errors in the predictions based on an assumed constant period. It shows, as a function of date, the difference between "O," the observed time of some feature of the light curve (maximum, say), and "C," the computed or predicted time. A point on the horizontal axis means that the prediction turned out to be correct. A higher point indicates that the observed time was later than the prediction. If all of the observed points define a horizontal line, the period used for the predictions must have been correct. A sloping line means that the period needs correcting. Most interesting is the case where the slope is not constant, for this means that the period has not been constant.

An example of an O-C diagram is shown in Figure 1. It is clear that on the average TY Scuti was behaving very much as predicted, for the points cluster around the line defined by O-C = 0. The best line calculated by the method of least squares, however, shows that a sloping line is slightly better. Observations that come increasingly early compared with the predictions mean that the true period has been shorter than the one used for the predictions. The best parabola through the points turned out to be somewhat better still, judging by the scatter of the points around the line and the curve. From the curvature of the parabola, one can calculate the rate of change of the period on the assumption that this rate has been constant. It appears that TY Scuti may have been increasing its period at the rate of .0003% per year. A constant period is certainly not excluded, however.

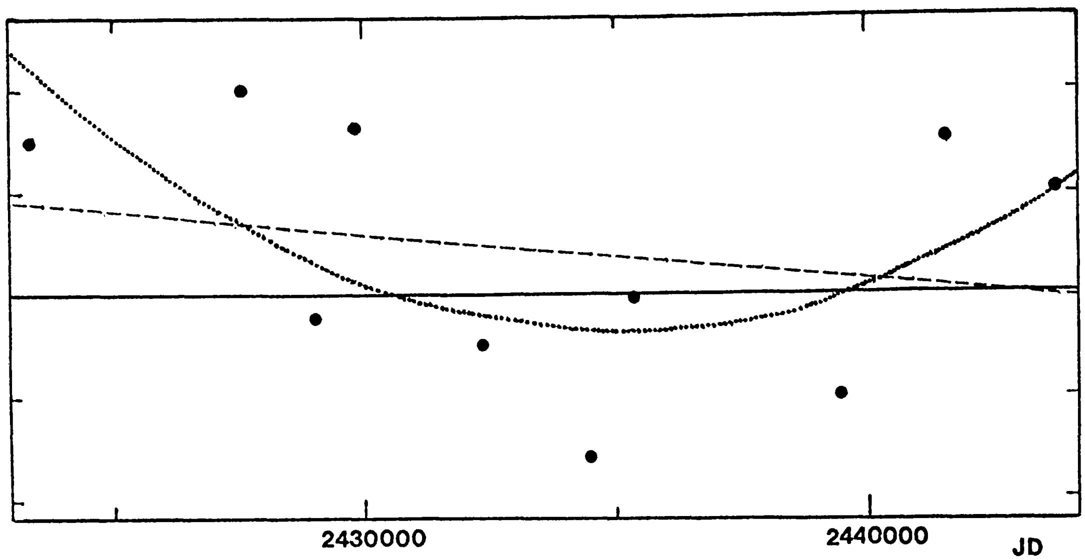

Figure 1. O-C diagram for TY Sct. The least-squares line and parabola are indicated. Marks on the vertical axis are two one-hundredths of a cycle apart. According to the least-squares line the average period has been 11.05291 days, with a mean error of .00016 day. The parabola implies an increase at the rate of .000033 day/yr.

O-C analysis was performed for eleven stars, in all, during the summer project. All have been photographed at Maria Mitchell for at least twelve years, some for more than fifty. For five of the stars there was no suggestion of a change in period. The researchers working on these stars either calculated or estimated the uncertainty in the best constant period implied by the Maria Mitchell observations. One of the periods has decreased, either gradually or, perhaps, in several more or less abrupt steps. There were three period increases, if one can count TY Scuti. The other two stars have changed their periods in both directions. It is not easy to think of a simple way to summarize this behavior. Tentatively an Inconstancy Index is defined. For a smoothly varying period it is simply the percentage change per year. If one change was observed during N years the Inconstancy Index is the size of that change divided by N. For more than one change the average of the absolute values is used and is divided by N over the number of changes. The aim is to have a measure of the average annual percentage change. An upper limit can be calculated for apparently constant periods as the uncertainty in the period divided by the number of years. Our results, in some cases provisional pending further investigation, are collected in Table 1, where the stars, all pulsating variables, are classified according to their type. It is no surprise that the largest Inconstancy Index is for a Type II Cepheid. These stars, also known as W Virginis variables, are notorious for their erratic behavior. That the smallest well-determined values are for RR Lyrae stars perhaps only reflects the fact that periods can be more accurately determined for these short period variables. When more cycles can be observed in the same length of time the uncertainty in the cycle length is correspondingly less.

The least-squares computer program used in the analysis of TY Scuti was developed for the Observatory's TRS-80 computer by Virginia deWolf and Robert DeBenedictus, who joined the staff after the regular summer season in a program sponsored by Earthwatch, of Belmont, MA. Elizabeth Lada's participation in the summer program was made possible by a scholarship from the same organization. The other summer researchers were supported by the National Science Foundation under Grant AST78-07405 A01. For this support of the variable project, I am deeply grateful.