The Impact of Large-Scale Surveys on Pulsating Star Research
ASP Conference Series, Vol. 203, 2000
L. Szabados & D. W. Kurtz, eds.

Light Curve Analysis of Tycho Variable Stars

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Abstract. A variety of methods has been applied to the Tycho suspected variable stars to find reliable periods.

1. Objective and Preparation of the Data

Our aim was to study the Tycho suspected variable stars of the list of Piquard et al. (2000). For that purpose, a large variety of period analysis methods was applied, and a sample of 320 stars with known periods was used to evaluate their efficiencies. First and foremost, the Tycho observations were prepared in order to improve their reliability: the data were corrected for systematic errors (Halbwachs 1997), and they were averaged when the time interval was shorter than 1 min. The merged observations received weights depending on their accuracy estimates.

2. Period Search: Approach I

We adapted the PDM method (Stellingwerf 1978) taking into account the unequal weights of the data. The periodograms have been computed separately for the B_T, V_T and T bands using the (5×5) bin structure (10×2 for eclipsing variables). A frequency was added to the list of possible candidates, if its "false alarm" probability due to noise was less than 0.002. The phase diagrams corresponding to candidate periods were fitted by a trigonometric polynomial. The "best" periods correspond to the true period, or a multiple for one or more colors, for about 60% of the known periodic variable stars.

3. Period Search: Approach II

To increase the signal to noise ratio, the periodograms have been computed separately for the B_T and V_T bands with a final periodogram depending on both test functions. The main periodogram was computed based on a *trigonometric polynomial fit* of order 2 (TP2), of which the statistical response to noise is identical to the 5-bin PDM method. It allowed the recovery of periods of stars

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with smooth variations. For the stars with abrupt changes (e.g. EA, RR) we have used the weighted differences of the magnitudes in the methods of Lafler & Kinman (1965) and Deeming (1970). Statistical properties of test functions of these and other *non-parametric* methods were recently studied by Andronov & Chinarova (1997).

Among the 320 known periodic variables, the true periods were detected in the TP2 periodogram for 206 stars. In 38% of these cases it was the first or the second most significant peak. This indicates that the variations are often pronounced mainly in one color.

4. Newly Developed Methods (Variable-Order Splines)

The *"RR-catcher"* was used to find periods of stars with asymmetric one-wave light curves. We applied here a 5-parameter fit: the descending branch is fitted by a parabola, and the ascending branch by a cubic polynomial, keeping the smoothing curve and its first derivative continuous (see Andronov 1999, Marsakova & Andronov 1996). For the *"EA-catcher"*, the phase diagram is split into two minima of equal duration opposite in phase with an unknown depth, and a constant level outside minima. Both these methods need nonlinear 3D optimization for each candidate period. A comparison of the TP2, "RR-" and "EA-catcher" fits leads to changes in ranking the candidate periods, increasing reliability of the best period. For example, the residuals of the data from the best "EA-catcher" curve were smaller than those of the TP2 fit in 30% of stars.

5. Conclusion

We failed to find a single method able to derive reliable periods from the Tycho measurements. However, the most probable periods may be extracted by using *several* complementary period analysis methods.

A quick examination of the light curves of the possible new variable stars of our list revealed some good candidates of different types of variability, such as δ Scuti stars, RR Lyrae stars, and eclipsing binaries. However, additional observations are needed to confirm these results.

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