*Stars and their variability observed from space*
*C. Neiner, W. W. Weiss, D. Baade, R. E. Griffin, C. C. Lovekin, A. F. J. Moffat (eds)*

# ANALYSIS OF PHOTOMETRY OF STARS FROM SPACE AND GROUND-BASED SURVEYS

D. E. Tvardovskyi[1,2,3], I. L. Andronov[2], K. D. Andrych[1,2] and L. L. Chinarova[1,2]

**Abstract.** Methods for extended analysis of signals with irregularly spaced times are discussed with an application to variable stars of different types: eclipsing, cataclysmic, symbiotic, short- and long- periodic pulsating variables. Some of the methods are realized in the "Multi-Column Viewer" (MCV, Andronov & Baklanov 2004) and in a newly developed program MAVKA (Andrych & Andronov 2019). This code realizes 9 methods for approximations of the near-extremum parts of the light curve. We made tests of all of these methods with artificial data sets (both symmetric and asymmetric). Then we chose best methods for each shape of minimum and obtained moments of extrema for 16 randomly chosen stars from sector 11, observed by TESS. Totally, we got 262 extrema. As well, MAVKA was used in several other of our researches and there we got 1030 minima using AAVSO observations.

Keywords: variable stars - photometric observations - visual observations - brightness extrema

## 1 Introduction

MAVKA is the software for extrema approximation of stellar light curves developed by Andrych & Andronov (2019). MAVKA is used at the "near-extremum" parts of the light curve. The main aim is to determine the moment of extremum with best accuracy. Currently there are 11 methods included in MAVKA, i.e.: algebraic polynomial in general form, "Symmetrical" algebraic polynomial, "New Algol Variable" (NAV) (Andronov et al. 2016), the modified function of Mikulášek (2015), "Asymptotic Parabola" (AP) (Andrych et al. 2015), "Wall-Supported Parabola" (WSP), "Wall-Supported Line" (WSL), "Wall-Supported Asymptotic Parabola" (WSAP) (Andrych et al. 2017), and "Parabolic Spline of defect" (spline). In previous research (Andrych et al., in press) we made analysis of approximation accuracy of methods for generated signals with various parameters and shapes. In this research, we present a practical part of our calculations.

## 2 AAVSO observations

MAVKA was used in several articles: Savastru et al. (2017) - 1 star, 4 extrema; Tvardovskyi et al. (2017) - 6 stars, 235 extrema; Tvardovskyi et al. (2018) - 2 stars, 20 extrema; Tvardovskyi et al. (in press)- 7 stars, 549 extrema; Tvardovskyi (in press) - 5 stars, 222 extrema and Andrych et al. (in prep.). We used our own and the AAVSO observations of different observers. All these data were used for further O-C analysis.

## 3 TESS observations

We randomly chose 16 stars from the 11th sector of the TESS observation fields. 15 of them are pulsating variables of different types and one is an eclipsing binary. We split the data into separate near-extrema (both maxima and minima). After that, we processed all of them with 9 methods. We plot a histogram to investigate which method is the best for pulsating variables.

[1] Odessa I. I. Mechnikov National University, Odessa, Ukraine
[2] Department Mathematics, Physics and Astronomy, Odessa National Maritime University, Odessa, Ukraine
[3] Université de Mocton, Moncton, New Brunswick, Canada

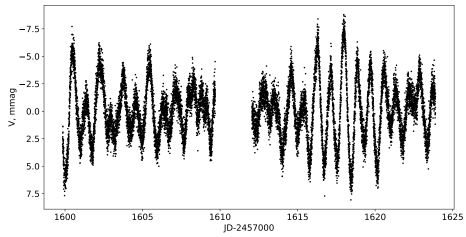


**Fig. 1.** Light curve of TIC 340176098 observed by TESS in sector 11.

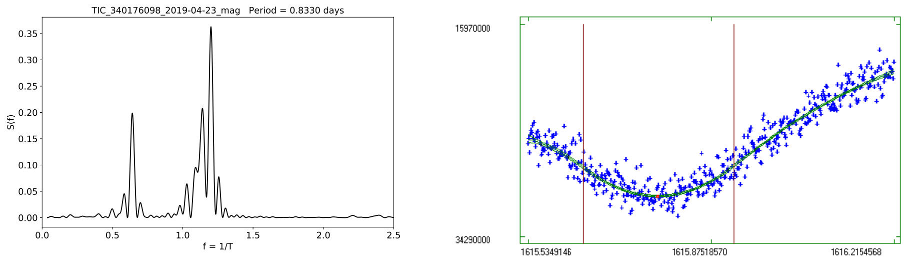


**Fig. 2.** Left: the periodogram $S(f)$ of TIC 340176098 obtained with the software MCV. Right: an example of extremum approximation made by using MAVKA.

## 4 Conclusions

As a result of the testing, we determined the best methods for several general shapes of extrema:

- symmetric (not total eclipse/transit) - polynomial, symmetric polynomial, NAV, Mikulášek;
- pulsating in general case - polynomial, parabolic spline, asymptotic parabola;
- asymmetric - asymptotic parabola, parabolic spline, polynomial;
- extremely sharp - asymptotic parabola;
- eclipsing or transit - WSP, WSL, WSAP;

Not recommended to use:

- for pulsating stars - WSP, WSL, WSAP;
- clearly asymmetric and insufficient number of points on one of the branches - polynomial.

We sincerely thank the organizers of this conference "Stars and their variability observed from space" (Vienna, Austria, 19-23 August 2019) for the possibility to present and publish the results of this research. In addition, we are grateful to the AAVSO observers and TESS mission for providing the data.

## References

Andronov, I. L. & Baklanov, A. V. 2004, Astronomical School's Report, 5, 264

Andronov, I. L., Chinarova, L. L., Kudashkina, L. S., Marsakova, V. I., & Tkachenko, M. G. 2016, ASPCS, Vol. 505, Statistically Optimal Approximations of Astronomical Signals: Implications to Classification and Advanced Study of Variable Stars (ASP), 101

Andrych, K. D. & Andronov, I. L. 2019, Open European Journal on Variable Stars, 197, 65

Andrych, K. D., Andronov, I. L., & Chinarova, L. L. 2017, Odessa Astronomical Publications, 30, 57

Andrych, K. D., Andronov, I. L., Chinarova, L. L., & Marsakova, V. I. 2015, Odessa Astronomical Publications, 28, 158

Mikulášek, Z. 2015, A&A, 584, A8

Savastru, S. V., Marsakova, V. I., Andrych, K. D., & Dubovsky, P. 2017, Odessa Astronomical Publications, 30, 126

Tvardovskyi, D. E., Marsakova, V. I., & Andronov, I. L. 2017, Odessa Astronomical Publications, 30, 135

Tvardovskyi, D. E., Marsakova, V. I., Andronov, I. L., & Shakun, L. S. 2018, Odessa Astronomical Publications, 30, 103