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Antarctica photometric survey using PDM13

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Abstract. PDM13 is a new graphic interface program dedicated to frequency domain analysis based on the Phase Dispersion Minimization technique (PDM, Stellingwerf 2012). In this paper, we will present the different algorithms running in PDM13, including the Auto-Segmentation, the Gauss-Newton and the PDM algorithms. More details on this triptych are available in our recent paper (Zalian *et al.*, submitted). Their aim is to offer a simple and powerful way to extract frequency. Amongst the numerous improvements offered by the program, we will particularly focus on the reduction of aliases and the ability to look directly for multiple-period phenomena and the Blazhko effect. After that, we will show the first results from PDM13 using the Antarctica photometric survey.

Keywords. Frequency analysis, phase dispersion minimization, graphical interface, Antarctica photometric survey

1. Introduction

Frequency analysis of light curves is one of the many tools provided by asteroseismology to understand the underlying mechanisms of pulsating stars. Several extraction algorithms exist based on Fourier transform (Lenz & Breger 2005), minimisation of standard deviation (Stellingwerf 1978), entropy (Ulrych & Bishop 1975). Among these methods, phase dispersion minimization is a well-known method, particularly efficient in poor-time coverage data and large gaps. Unfortunately, like many other powerful algorithms, the lack of intuitive, user-friendly interface prevent their use within a large community of researchers. PDM13 tries to overcome this problem by including a graphical interface as well as complementary algorithms, resulting in a simple and powerful program.

2. Interface and algorithms

2.1. *PDM algorithm*

For a given frequency, the PDM algorithm folds the data to obtain a phase plot and divides the obtained diagram into 10 or 100 bins depending on the number of data. For each bin, a mean value is calculated and an interpolated curve is computed. Finally the program calculates the corresponding variance and divides it by the initial variance according to equation (2.1). Thus, good guesses are characterized by low values of Θ:

$$\Theta = \frac{s^2}{\theta^2}, \tag{2.1}$$

where s^2 is the variance for a trial period and θ^2 the overall variance.

Different significance algorithms are also available (Schwarzenberg-Czerny 1997, Linnell Nemec & Nemec 1985) and can be included using the option menu.

2.2. *Gauss-Newton algorithm*

Unfortunately, PDM does not provide the amplitude of an extracted frequency as a Fourier transform analysis would do. Hence, we have added an amplitude fitting algorithm based on the Gauss-Newton algorithm (Björck 1996).

2.3. *Auto-segmentation*

Another feature added to program is the auto-segmentation algorithm. Previous versions of PDM included the possibility to divide the data into segments which were studied independently so that aliases caused by gaps become less prominent. Still, the segmentation method was trivial and not optimised. Based on the Lee and Heghinian method implemented (Lee & Heghinian 1977), we are able to detect gaps accurately.

2.4. *Graphical interface and process*

After each PDM run, the residuals are calculated following Stobie's method (Stobie 1970) enabling another run to determine multiple periods. The process is shortened and harmonic amplitudes are obtained directly with the Gauss-Newton fit. Moreover, exploiting the co-cyclarity of the modulated signal, PDM13 is able to look directly for Blazhko modulation.

3. S Arae: Case study using PDM13

S Arae was observed during 700 h using PAIX – Photometer AntarctIca eXtinction – attached to a 40-cm Ritchey-Chrétien optical telescope located at Dome Charlie in Antarctica, designed and built by PaixTeam at Université Nice Sophia-Antipolis (Chadid *et al.* 2010). It is a RR Lyrae Blazhko star with a main frequency of $f_1 = 2.2129$ d^{-1} and modulation frequency of $f_{\rm m} = 0.02$ d^{-1}.

We have been able, using our program, to extract up to 10th-order harmonics with Blazhko multiplet structure. Auto-segmentation combined with the Gauss-Newton algorithm simplifies the analysis giving us quick and accurate results.

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