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Astroinformatics: Periodogram Analysis of Astronomical Signals

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"Different algorithms for periodogram analysis are reviewed. The mathematically strong definition is that, for a periodical signal $x(t) = x(t + m * P)$, for each moment of Time t. The period is the minimal value, for which this equation is satisfied for all integer values of m.
For regularly distributed discrete moments of time $t_k = t_0 + k * \delta$, with a time step (=time resolution) δ, the number of observation k, the period may be $P = n * \delta/m$, where n is the number of observations, and $m = 1..\mathrm{int(n/2)}$. Such simplest case allows using very popular methods like a Fourier Transform (FT) (originating from the famous work of Jean Baptiste Joseph Fourier published in 1822), an Auto-Correlation Analysis (ACF) and their numerous modifications. Astronomical Time Series (TS) are generally not regular in time. Even special space missions like KEPLER or TESS, with an excellent accuracy, produce TS with some gaps. Other photometric surveys often contain sparse data. In this case, other methods are needed beyond these oversimplified ones. One of group of methods uses only "moments of characteristic events"(e.g. times of maxima or minima (ToM)), For statistically optimal determination of ToMs, the software MAVKA (http://uavso.org.ua/mavka) is used, where 11 types of functions (21 functions totally) may be realized. The review of methods to determine a period is in 1988AN….309..121A .
For using all the (sparse) data, there is a large group of methods based on a determination of a maximum (or minimum) of some test function $\Theta(t_k, x_k, k = 1..n; P, T_0)$, which characterizes a "goodness"of the phase curve $x_k(\phi_k)$, where the phase $\phi_k = \mathrm{TRUNC}((t_k - T_0)/P)$.
These methods may be divided into two large subgroups. The first one is the so-called "Non-parametric"or "point-point"methods. The test function characterizes the "effective distance between the points, which are subsequent in phase (see a review 1997KFNT…13f..67A) or at least a group of points close in phase. No approximation is made, no parameters are determined. The second group of the methods, alternately, are called "parametric"or "point-curve"methods and are based on (generally, weighted) least squares approximation (LSQ). The approximations proposed range from a usual cosine to polynomial (or non-polynomial) splines (special functions/shapes/patterns).
We argue for using complete mathematical models, instead of over-simplified ("step-by-step) ones (like "mean/trend removal"(="detrending"), "pre-whitening"etc.), to avoid possible large bias of the parameters.An effective tool for an analysis of (multi-periodic) (multi-) harmonic signals is the program MCV ("Multi-Column Viewer) at http://uavso.org.ua/mcv/MCV.zip .
Such approximations are called the "phenomenological"ones, as the number of determined parameters may be significantly larger than that needed for the "physical"modeling (which may need models of unstable stellar atmospheres with a huge number of physical parameters). They are effective for photometric data, especially, of a newly discovered variables, A recent review is in 2020kdbd.book..191A .
We illustrate these methods with applications to variable stars of different types - pulsating (of types M, SR, RV, δ Cep, RR) and binary (eclipsing, cataclysmic, symbiotic)."

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