δ SCUTI STAR GX PEGASI: ADDITIONAL ANALYSIS

S.V. Repin[1], E. Michel[2], M. Auvergne[2], A. Baglin[2],
M.J. Goupil[2], L.S. Gurin[1], Yu.O. Samoilova[1]
[1] Space Research Institute, 84/32, Profsoyuznaya st.,
Moscow, 117810, Russia
[2] Observatoire de Paris-Meudon, DASGAL, URA CNRS,
F-92195 Meudon, France

ABSTRACT. Three criteria of the periodicity are discussed in the paper and their properties are investigated. These criteria are applied to investigate the periodicity properties of a variable star GX Pegasi. A number of periodic components are extracted.

Key words: variable star, periodicity, δ Scuti

Criteria of periodicity

Criterion of periodicity is a function of a sequence of "measurements" and a trial period T. This function reaches its maximum when the "measurements" have a periodic component with a period P and, inverse, it takes a "low" values for other trial periods.

Three criteria of periodicity were used in our investigation. First of them represents the simplest case of a periodogram and is known as Rayleigh criterion

$$K_1(T) = \frac{1}{\left(\sum_{j=1}^{M} x_j\right)^2} \times$$

$$\times \left[\left(\sum_{i=1}^{M} x_i \sin \frac{2\pi t_i}{T} \right)^2 + \left(\sum_{i=1}^{M} x_i \cos \frac{2\pi t_i}{T} \right)^2 \right],$$

where x_i are the measurements, t_i – the appropriate time moments, T – the trial period.

Two other criteria are some kind of epoch superposition method and analyse the structure of light curves

$$K_2(T) = \frac{m}{M} \sum_{j=1}^{m} \left(n_j - \frac{M}{m} \right)^2,$$

$$K_3(T) = 1 - \frac{max\ (1,\ min\ n_j)}{max\ n_j},$$

where m is the number of bins in a light curve, n_j – the array of bins values, M – the sum of all the "measurements", so that M/m is the mean value of the bin in a light curve.

The criteria properties have been investigated in (Gurin et.al., 1992).

freq. (μHz)	ampl. (mmag)	conf. (%)
187.2	1.62	$\geq$ 99
197.0	0.58	$\leq$ 20
221.9	0.56	$\leq$ 20
224.0	0.76	$\leq$ 20
227.6	1.78	$\geq$ 99
230.4	2.08	$\geq$ 99
237.5	1.80	$\geq$ 99
240.5	2.18	$\geq$ 99

Table 1: Periodic components, extracted by CLEAN technique (Belmonte et al. 1991)

GX Pegasi data analysis

The variable star GX Pegasi (HR8584, HD213534, $\alpha = 22^h\!.5$, $\delta = 29^\circ\!.5$, spectrum A8V) was discovered to be a δ Scuti star by Breger (1969). The ground based observations were organized in August–September 1989. The detailes of observations, instruments and data reduction are presented in (E.Michel, 1992, see Table 2, Fig. 2 and also references there).

A number of periodic component were extracted. We reproduce here these results, Tables 1 and 2 to have a possibility for comparison.

Three criteria, described above, were applied to extract the periodic components. The results are shown in Table 3.

As one can see, we have a good agreement in all three tables. But one detail should be payed attention. The amplitudes, presented in Table 3, are slightly higher for all the frequencies than ones in Tables 1 and 2. It depends on the details of the data processing technique and cannot be explained by simple reasons. The amplitude was evaluated here as a half a difference between maximum and minimum values in light curve. The light curve can be smoothed and after smoothing this quantity may become slightly lower, but these changes are quite neglidgble.

freq. (μHz)	ampl. (mmag)	conf. (%)
187.3	1.7	$\geq$ 99
223.6	0.8	$\geq$ 20
227.5	2.1	$\geq$ 99
230.4	2.3	$\geq$ 99
237.5	1.9	$\geq$ 99
240.5	2.2	$\geq$ 99

Table 2: Periodic components, extracted by ISWF technique

No.	freq. μHz	ampl. (mmag)	Conf. level 1	2	3
1	187.2	2.12	99	99	99
2	196.8	0.91	97	86	90
3	227.6	2.11	94	80	82
4	230.4	2.48	98	96	92
5	237.5	2.23	98	96	81
6	240.5	2.55	97	93	78
7	277.2	0.50	99	97	95

Table 3: Periodic components, extracted by three criteria, described here

To decrease the influence of the noise the additional investigation was made. The intervals with obvious sinusoidal curves only were selected. They are the following intervals in days since the base date: 0.7–1.0, 7.68–7.85, 8.35–9.0, 10.37–10.85, 11.6–11.95, 17.35–17.75, 18.45–18.68. After that the combined time series was tested by the described criteria. The results are shown in Table 4 (only frequencies and amplitudes, the confidence levels were not evaluated, but we are sure they are high).

No.	freq. μHz	ampl. (mmag)
1	187.2	2.3
2	227.6	3.8
3	230.2	5.2
4	237.2	4.2
5	240.6	5.2

Table 4: Periodic components, extracted in the intervals with good sinusoidal structure

As we see, all the main five frequencies are presented, the amplitudes are rather higher than in full observations series and the frequencies values are quite close to that was obtained by processing the full data series.

The situation looks like the amplitudes are not the constants, but depend on the time. That dependence can be defined, but it is a very difficult and cumbersome variation problem, it takes extremely large amount of processor time. May be we turn back to this problem after the observations on the board of Mars-96 space probe, experiment EVRIS.

References

Belmonte J.A. et al.: 1991, *As. Ap.*, **246**, 71.

Breger M. et al.: 1989, *As. Ap.*, **214**, 209.

Gurin L.S., Repin S.V., Samoilova Yu.O.: 1992, The investigation of the statistical characteristics of some criteria, which are used to detect and extract the weak periodic signals. *Preprint IKI RAS*, **1846** (issued in Russian).

Michel E. et al.: 1992, *As. Ap.*, **255**, 139.

Roberts D.H., Lehar J., Dreher J.W.: 1987, *AJ*, **93**, 968.