PERIODS OF SMALL-AMPLITUDE CEPHEID Y OPH.

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ABSTRACT. Fourier analysis of all 299 *RV* data for Y Oph collected during last century displayed its mean pulsational period of 17.123024 days with two equidistanted ones, - 17.965158 and 16.355637 days, respectively. The ratio of these periods is near 0.92 with corresponding beat one near 370 days assumes nonradial pulsation of this Cepheid. Furthermore the analysis results provide an availability of one or more companions with orbital periods of 8424.1, 3361.3 days and more. Pulsational period and its amplitude undergo periodical changes, connected, probably with orbital periods, mentioned above.

Key words: Stars: radial velocities; Cepheids: nonradial pulsations; Cepheids: companions; Cepheids: Y Oph

1. Introduction

Classical Cepheid Y Oph is one of most attractive variable stars for investigations. At first, belonging to small-amplitude Cepheids group (DCEPS) it shows the phenomenon of pulsational amplitude decrease during almost one century, like the famous one α UMi (Polaris) (Fernie et al., 1995). At second, its pulsational period undergoes some changes, increased and decreased periodically (Szabados, 1989). At third, Y Oph belongs to spectroscopic binaries, having, probably a companion with orbital period from $1222.^d5$ (Szabados, 1989) to 2612^d (Abt & Levy, 1978), respectively. Y Oph come the second rank among the classical Cepheids by the number of their measured *RV* data. Unfortutunately, these data have been obtained during last century very irregularly: in the first decade (Albrech, 1907), in the thirties (Sanford, 1935), in the fifties (Abt, 1954), in the end of sixties, during the seventies and half of the eighties (Abt & Levy, 1978; Barnes et al., 1987; Beavers & Eittter, 1986; Coulson & Caldwell, 1985; Evans & Lyons, 1986; Lloyd Evans, 1980; Wilson et al., 1989). And for the nineties there are Berdnikov's set of 1995-1997 (Berdnikov, 2000), in which has been added the author's *RV* values (14 ones), based on McDonald spectra, obtained in the same time lag. So, totally there are 299 *RV* values covered almost one century.

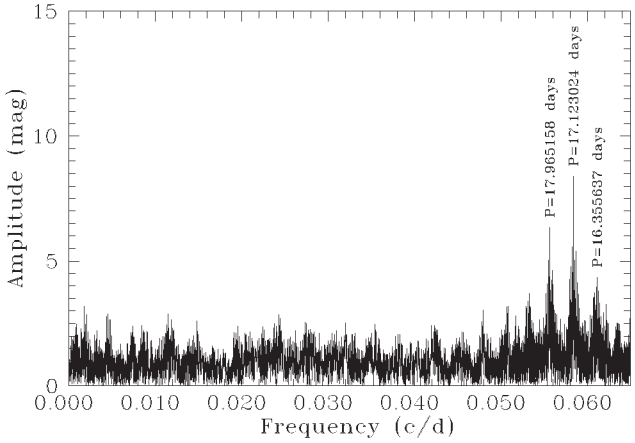

Figure 1: Fourier amplitude spectrum of Y Oph for pulsational period

The author's task consisted in the specification of pulsational and orbital periods using the Fourier analysis, and analyzing of pulsational period and amplitude changes during the last century.

2. Results

For analysis has been used PERIOD 98 program (Sperl, 1998) which allows to search for and fit sinusoidal patterns within a time series of data containing huge gaps. PERIOD 98 used tecniques Fourier and Fast Fourier analysis with minimization of residuals of sinusoidal fits to the data.

2.1. Pulsational periods

A Fourier amplitude spectrum was obtained over the frequency range 0-1 d^{-1} at a resolution of 0.00002 d^{-1} (see Figure 1). At that, the highest amplitude 8.419 corresponds to frequence of 0.058401 d^{-1}, or 17.123024 days, respectively. At that the zero-point (γ - velocity) is equal to -7.094 km/s. It is very noticeable that there is two frequences with high amplitudes (6.364 and 5.059) equidistanted from the main one by 0.0028 d^{-1}, - 0.0556633 d^{-1} and 0.061141 d^{-1}, or 17.965158 and 16.355637 days, respectively.

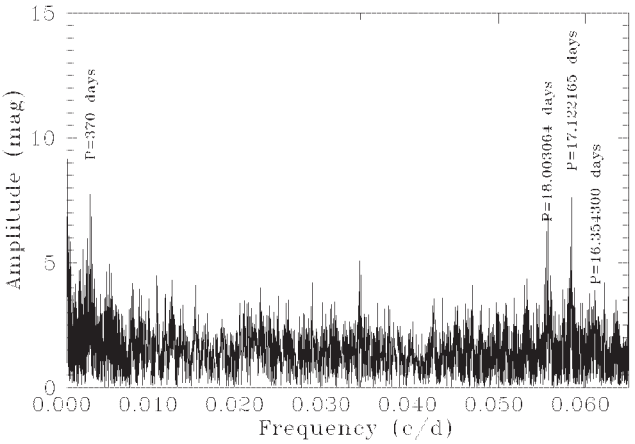

Figure 2: Fourier amplitude spectrum for residual velocities of Y Oph for pulsational period

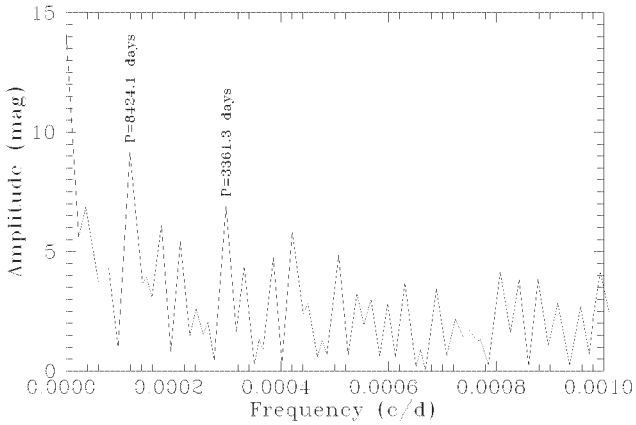

Figure 3: Fourier amplitude spectrum for residual velocities of Y Oph for orbital periods

Since the dominant period of Y Oph has been obtained, a Fourier search for additional periods was performed on the residual velocities. As seen in Figure 2 there are the same frequences of 0.05840383 d^{-1} (amplitude 8.29059), 0.0555461 d^{-1} (amplitude 6.25873) and 0.061146 d^{-1} (amplitude 3.7445), that correspond well to periods mentioned above. But it is interesting that the period ratio is about 0.92, whould result in a beat period near 370 days. Nevertheless a such peak is present (see Figure 2). Therefore, if these observed periods correspond to the different modes then Y Oph is a nonradial pulsator.

2.2 Orbital periods

As seen in Figure 1 it is difficult to indify any frequences that could be correspond to the orbital period values, mentioned above. But in Figure 3, presenting the results of Fourier amplitude spectrum for residual velocities, are evident two values for 8424.1 and 3361.3 days, although the highest peak get to zero value. This fact could be explain by the presence of possible one more companion with longer orbital period.

2.3. Changes in the pulsational period and amplitude

Fourier search has been made for *RV* data, obtained by Albrecht (1907), Sanford (1935) and fresh data corresponded for the set of 1995-1997, to determine the pulsational period and amplitude values. These results, combined into Szabados (1989) and Fernie et al.(1995) ones, are given in Table 1. As seen, the periodic changes of the pulsational period and amplitude are evident.

Table 1: Changes of the pulsational period of Y Oph

HJD Interval	Period, days	Ref.	RV_{amp}, km^{-1}	Ref.
2416977 - 2417445	17.978836	1	18.4	3
2421768 - 2427553	17.126137	1	19.2	3
2432781 - 2433106	17.113288	2	16.1	3
2434733 - 2435281	17.126813	2	16.8	3
2435281 - 2435691	17.111255	2	17.5	3
2439014 - 2439682	17.127643	2	21.8	3
2440778 - 2446601	17.126908	2	14.7	3
2450245 - 2451095	17.120887	1	16.5	1

1 - this work; 2 - Szabados (1989); 3 - Fernie et al. (1995).

3. Conclusions

1. Fourier analysis of all *RV* data displayed the mean pulsational period of 17.123024 days and two equidistanted ones, - 17.965158 and 16.355637 days, respectively.

2. The ratio of these pulsational periods is near 0.92 and the corresponding beat period near 370 days is presented in Fourier amplitude spectrum. This ratio value assumes nonradial pulsation of Y Oph.

3. These Fourier analysis data provide an availability of one or more companions with orbital periods of 8424.1 and 3361.3 days. The presence of companion with longer period do not except.

4. Pulsational period and its amplitude undergo periodical changes connected, probably with orbital motions of one or more companions.

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