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Solar pulsation 1974–2003: the evidence for a fast rotating core

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Abstract. The measurements of the Doppler effect of the photosphere showed the presence of the persistent periodicity 159.9655(5) min. It is interpreted as by-product of the fast-rotating central solar core.

Roxburgh (1974) assumed that the core of the Sun rotates with period ~ 1 h. One of consequences of such a "rapid-core" hypothesis could be periodic radial shifts of the photosphere.

In the CrAO experiment, a Babcock-type magnetograph registers Doppler effect difference between the central, circular, and limb, annular, portions of the solar disk (using the Fe I 512.4 nm absorption line). Over last three decades the measurements were carried out during 1807 days (11117 h; Kotov *et al.* 2004). The most significant peak in the power spectrum of the photospheric velocity corresponds to period $P_1 = 159.9655(5)$ min, with the mean harmonic amplitude $A = 0.22$ m/s (3.5σ C.L.). It agrees well with the value 159.9663(8) min inferred earlier from the like Stanford measurements 1977–1994 (Kotov *et al.* 1997).

The O–C plot showed the initial phase of this oscillation was nearly constant over total 30 yr span. The average velocity profile obtained for the folding period P_1 is shown in figure 1.

The mean P_1 profile of the solar radius perturbations, with relative amplitude $A(\delta R/R) \approx 3\times10^{-6}$ (about 2 km), as deduced for the case of radial pulsation and shown in figure 2, occurs to be highly asymmetric, – like those of typical δ Sct stars and cepheids. The Sun however is not giant/supergiant, and the theory of pulsations of cepheids thus cannot be applied, – simply owing to the absence of a specific zone of "second ionization of helium" or that of "ionization of hydrogen".

Assuming $L_\odot \sim R^2$, we get simple relation between changes of radial velocity V_R (km/s) and bolometric magnitude M: $A(V_R) = k \times A(M)$. The parameter $k = 40(10)$ agrees well with that for cepheids, RR Lyr stars and δ Sct variables (Frolov 1970). This lends support to the conclusion of many variable star observers about plausible common nature of all these pulsators.

But nonlinear and non-adiabatic effects in the Sun are negligible (for radial oscillations, e.g., non-adiabatic corrections $\sim P/T_K$, with period $P \approx 10^4$ s and Kelvin time $T_K \approx 6 \times 10^{14}$ s; Cox 1980). The prominent non-harmonic R profile therefore brings to a head the old problem of pulsating stars... now including the Sun. We advance the hypothesis that P_1 pulsation has nothing to do with normal modes: a certain nonlinear mechanism, of unknown physical origin, must be responsible for its excitation. The latter can be associated with the superfast spinning central core of the Sun (Roxburgh 1974). The work was supported by INTAS (N 2000–840).

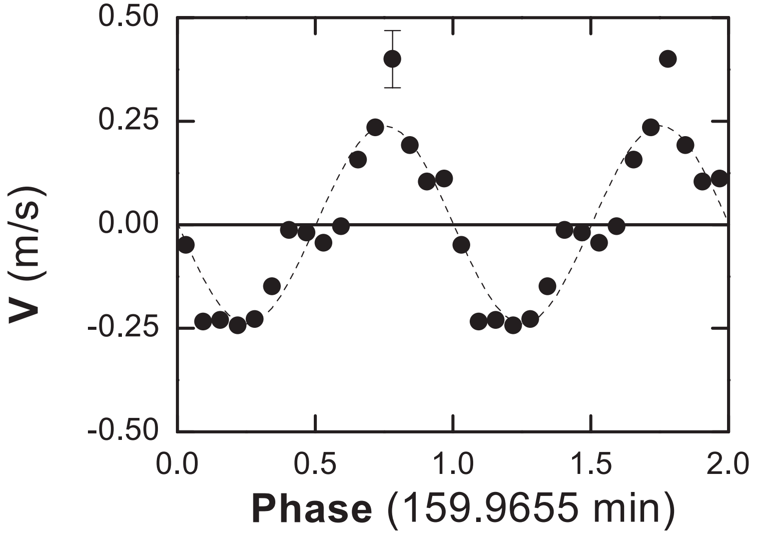

Figure 1. The mean velocity curve plotted for the folding period P_1 (dots, with a typical $\pm 1\sigma$ error shown by the vertical bar; the CrAO data 1974–2003). The dashed line is the best-fitted sinusoid. Zero phase corresponds to 0 UT on 1 January, 1974. Positive velocity corresponds to "expansion" of the Sun.

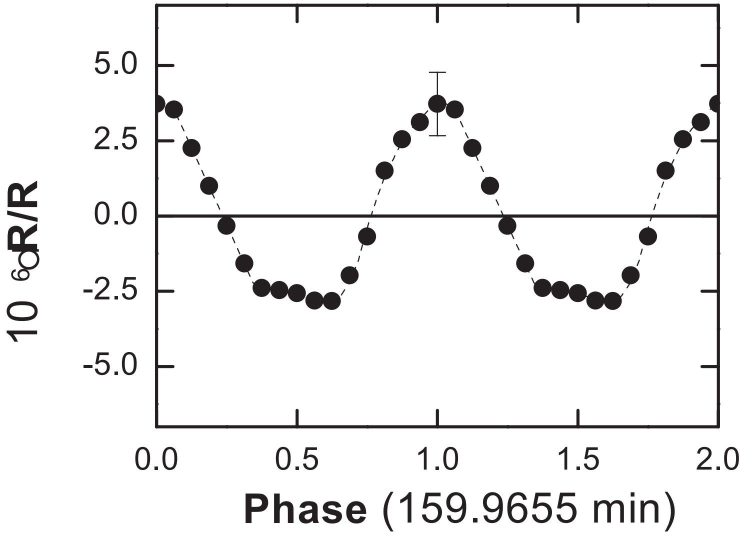

Figure 2. Same as figure 1 but for relative changes of solar radius R (dots; the dashed line approximates smoothly the radius variation). The curve is a result of numerical integration of the differential velocity curve plotted in figure 1.

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