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Paraconic Pendulum: Proposal to Detect the Gravity Screening Effect During the Full Solar Eclipse.

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Summary. — The possibility to detect Allais effect by the paraconic pendulum with the needle and ball suspension is considered. Foucalt force and friction force are estimated with the conclusion to use the ball suspension system for pendulum.

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Allais used first the paraconic pendulum to detect the gravity effects during the solar eclipse in 1954 (1). He observed the change of direction of the oscillation plane of pendulum during the phase of eclipse. Yet such deviations of the same order occurred before and after eclipse, and the day-change of plane was irregular. The construction of the instrument had a lot of defects: the pendulum was not isolated from the atmosphere so one needed to restart it each 14 min because of damping, the deformation of suspension system was too big, the direction of oscillation plane was calculated visually with precision 0.1° only, and so on. That is why the deviation of oscillation plane on 15° as the result of eclipse is doubted.

The author of this article took part in the gravimetric expedition of State Sternberg Astronomical Institute and tried to detect the gravity effects during the full solar eclipse in 1961 by paraconic pendulum of his own construction (2).

(1) M. ALLAIS: *Compt. Rend.*, 13 Mai; 4, 13, 18, 25 Nov., 4 Dec. 1957.
(2) N. P. GROUSHINSKY and M. U. SAGITOV: *Observation of gravity force during the full solar eclipse*, Viestnik MGU, series 3: *Physic, Astronomy*, 5, 46 (1962).

The usual gravimetric pendulum of period $T = \frac{1}{2}$s was modified with the needle suspension (fig. 1). The pendulum was placed inside of a vacuum camera, the starting and stopping were realized by a mechanic remote control, the deviation of oscillation plane was photoregistered. I failed then, but one can see from the below analysis that the idea of the experiment is correct, and it could be done today.

Fig. 1.

The principal acting forces on the pendulum of free suspension are the Foucalt force, the force of rolling and pivoting friction, and the force of atmospheric resistance. The last could be minimum in vacuum. The horizontal component of the Coriolis acceleration which causes the Focault effect is, for this case (3),

$$w_c = 2\Omega\, v_r \sin\varphi\,,$$

where Ω is the angular Earth velocity, v_r is the relative velocity of pendulum, φ the latitude of the point of observation. The Foucault force is of course $F_F = mw_c$, where m is the mass of the pendulum. The force of rolling friction causes the damping of the amplitude of pendular oscillation, and the force of pivoting friction counteracts the Focault force. For the considered pendulum the coefficient of pivoting friction could be equal to the coefficient of rolling friction (4) in dimension of length. The friction force is inversely proportional to the radius of the curvature of the needle, and directly proportional to the normal component of the force of the specific pressure mg, and to the coefficient of friction μ, *i.e.*

$$F_f = \mu\, mg/\rho\,.$$

(3) G. K. Souslov: *Teoreticheskaya Mekhanika* (OGIS, Moscow, 1932).
(4) Ch.-J. de la Vallée Poussin: *Leçons de mechanique analytique*, tome 1, Université de Louvain (1926).

Since $m = 611.5\,g$, $\mu = 0.001\,cm$, $\rho = 0.005\,cm$, $\Omega = 729 \cdot 10^{-7}\,1/s$, $\varphi = 47.233°$, $v_r = 2\pi R \cos\varphi/24$ hours, where $R = 637 \cdot 10^6\,cm$ as Earth radius, I estimated $F_F \sim 2 \cdot 10^3\,g\,cm/s^2$ and $F_f \sim 1.2 \cdot 10^5\,g\,cm/s^2$. Thus the friction forces between the support and the needle end exceed the Foucault force by two orders, and the pendulum cannot feel the Foucault effect, as it was in reality. By Allais's estimation his effect is about one half of Foucault effect, and the pendulum could not react to other effects of the same order all the more so.

The calculation shows that the change of the needle suspension by ball suspension with the diameter about 4 mm decreases the friction forces, and they could be compared with the Foucault force ($F_f \sim 3 \cdot 10^3\,g\,cm/s^2$). I reached such a conclusion in the time of the experience during eclipse, and changing the needle with the ball of 5 mm diameter I observed Foucault effect, but it was already too late.

Today one can experiment on a modern device. Taking part of the international project E-8 under the direction of World Laboratory the group of scientists of the department of gravity measurement of Moscow State Sternberg Astronomical Institute suppose to modify the high-precision pendulum «AGAT» using CCD system of registration and to try to observe the gravity effects by paraconic pendulum during the full solar eclipse in 1990.