[1]According to the data possessed by us, a remarkable correlation is observed between the mean hourly values of f and $|\cos\psi|$. It is obvious, however, that more detailed information on the interplanetary magnetic field is necessary to verify the hypothesis.

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VELOCITY OSCILLATIONS OF A FREELY ROTATING VESSEL WITH HELIUM II

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Submitted 14 September 1973
ZhETF Pis. Red. 18, No. 10, 605 – 608 (20 November 1973)

Experiments with free rotation of vessels with helium-II show that the perturbations of the vortex lattice lead to oscillations of the rotation velocity. These data serve as a certain confirmation of the premise that Tkachenko oscillations of the vortex lattice play a role in the behavior of pulsars.

A detailed analysis of the behavior of gradually-decelerating freely-rotating helium II shows that the damping of its rotation is an oscillating function of the time, unlike that of a classical liquid, the motion of which should be damped gradually in a similar situation.

There are several causes of the oscillations of the angular velocity of freely-rotating helium II [1], but principal among them is apparently the action exerted on the walls of the rotating vessel by the oscillating lattice of Onsager-Feynman vortices [2]. These oscillations were theoretically studied by Tkachenko [3].

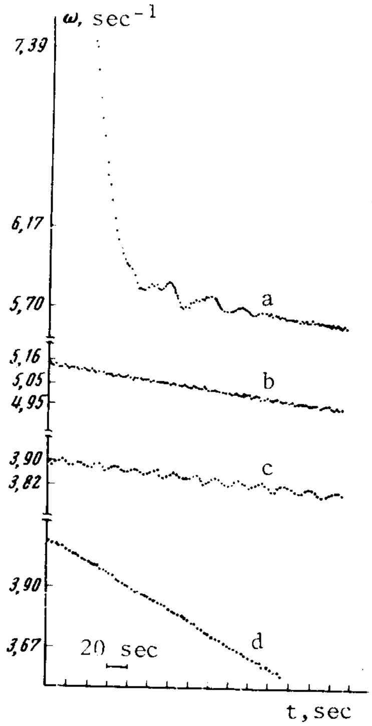
Naturally, experimental observation of this effect calls for a very sensitive instrument with a vessel having a small moment of inertia and with low damping of the rotation.

We used a magnetic bearingless suspension[1] having minimal friction. The vessels used for the helium were: 1) An organic-glass beaker of diameter 64 ± 0.05 mm, height 50.0 mm, and wall thickness 0.2 mm, with smooth inner surfaces; 2) The same beaker but with rough bottom and cover. The roughness was produced with sand particles of 0.01 mm linear dimensions; 3) A glass sphere with smooth inner surface and with diameter 68 ± 1.5 mm. The ratio of the moments of inertia of the superfluid component of the helium II (at $T = 1.46^\circ K$) to that of the vessel was 0.89, 2.38, and 2.0 for vessels 1, 2, and 3, respectively.

The rotating vessels were placed inside a copper screen in contact with a liquid-helium bath. The instrument was filled with liquid from a special beaker and a device that made it possible to move this beaker up and down. Just as in the previous experiments [1, 4], the procedure was the following: The instrument was set to revolve and the driving force was removed after a definite velocity was reached. We measured the dependence of the rotation velocity on time.

The setup was connected on line to an M-1000 computer and the experimental results were reduced automatically[2].

The figure shows preliminary results obtained in the experiment with the beaker with the smooth surfaces. It is clearly seen from an examination of curve a that immediately after acceleration of the initially immobile instrument its damping drops sharply (owing to the transfer of



Time variation of the angular velocity ω_0. Curves a, b, and c pertain to helium II, b is a continuation of a, and c is a continuation of b; a — start of rotation, b — relatively smooth damping approximately 12 minutes after the start of rotation, c — rotation with oscillations of the instrument, d — helium I subject to oscillations of the instrument (ω_0 is in logarithmic scale).

the torque to the liquid), and then varies periodically, with a period $\theta \sim 30''$. The rotation becomes more and more uniform with time, although there are always traces of definite perturbations of the rotation. The same figure shows the time dependence of the rotation $\sim$ 12 minutes after the start of the rotation (curve b).

If the rotating instrument is set to oscillate radially with amplitude $\sim 10^{-2}$ rad (the period of the radial oscillations of the instrument is $\sim$ 1.7 sec), then oscillations of the rotary speed of the instrument set in with increasing oscillation amplitude (curve c).

Similar results were obtained also when a beaker with rough end faces was used as the rotating vessel.

Control experiments performed on helium I, as well as with the instrument empty (without a liquid) have shown that the radial oscillations of the suspension system, with amplitudes $\phi \lesssim 10^{-2}$ rad, do not cause oscillations in its rotation (see curve d of the figure).

The experiments with the spherical vessel also reveal similar velocity oscillations, but less pronounced than in the case of a cylindrical vessel.

As is well known, the angular velocity of the pulsar NP0532 (in the Crab nebula), which consists in accordance with the two-component model [5] (as do also most other pulsars) of a solid shell filled with a superfluid neutron liquid, started to oscillate after acceleration, with an approximate period of three months [6]. Ruderman [7] suggests that this phenomenon can be connected with a perturbation of the vortex lattice of the superfluid neutron liquid in which oscillations can propagate, in analogy with the vortex lattice of helium II.

According to Ruderman [7], if we disregard the moment of inertia of a cylindrical vessel of infinite length, then the period of the fundamental mode of the Tkachenko oscillations and of the vortex lattice [3] (i.e., the maximum period) can be calculated from the formula

$$\theta \sim \frac{4\pi}{5}\left(\frac{m}{\hbar\omega_0}\right)^{1/2} R \,,$$

where m is the mass of the boson (of two neutrons in the case of a pulsar, and of a helium atom in our case), ω_0 is the angular velocity of the rotation, and R is the radius of the vessel. For the period of the oscillations in our instrument, this formula yields $\sim$ 250 sec as ω_0 ranges from 4 to 7 sec^{-1}. For the ratio of the periods of the pulsar in Crab ($\omega_0 = 190\ \text{sec}^{-1}$, $R \sim 10^6$ cm) and of our instrument the same formula yields $\theta_{cr}/\theta_{inst} \sim 4\times10^4$, whereas the actual ratio is $\sim 2\times10^5$.

In view of the rough nature of these estimates, one must admit of the possibility that the oscillations of the instrument generate Tkachenko oscillations of the vortices, and these cause the observed oscillations of the angular velocity. The finite dimensions of the instrument and the presence of a vessel with a relatively large moment of inertia can noticeably alter the parameters of the fundamental mode of the vortex-lattice vibrations. To verify this assumption, we shall undertake in the nearest future a more detailed analysis. It is clear in any case that the oscillations of the angular velocity of the rotation are the result of the presence of a vortex lattice, for no such oscillations are observed in helium I either at the start of the rotation or after the instrument is made to oscillate radially.

The authors are deeply grateful to E. L. Andronikashvili for stimulating interest in the work and to Yu. G. Mamaladze for systematic discussions.

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1)The transistorized circuit for the magneic suspension was developed and constructed at the Institute of Semiconductor Physics of the USSR Academy of Sciences, in the Laboratory of A. N. Vetchin-in under the direction of K. A. Zhdanov, to whom the authors are sincerely grateful.

2)This system and the corresponding mathematical program were developed by D. I. Garibashvili, S. M. Shrabshtein, G. I. Chitashvili, L. M. Sikharulidze, and L. V. Teplyashina, to whom the authors are sincerely grateful.

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MUONIUM SPIN RELAXATION IN ICE OF ORDINARY AND HEAVY WATER

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Submitted 25 September 1973
ZhETF Pis. Red. 18, No. 10, 608 – 611 (20 November 1973)

We measured the relaxation rate λ of the muonium spin in frozen H_2O and D_2O at 77°K. The values obtained for λ of ordinary and heavy water are 5.7 ± 0.9 and 2.0 ± 0.2 μsec, respectively.

In [1] we proposed a method for the investigation of magnetic dipole interaction and the diffusion of μ^+ mesons in a solid. The method is based on determining the damping rate λ of the precession amplitude a of the μ^+ meson in the given substance, which is placed in a magnetic field that is transverse relative to the μ^+-meson spin. The precession damping or the spin relaxation of the μ^+ meson is the result of the action exerted on the μ^+ meson by local magnetic fields produced by the magnetic moments of the lattice nuclei. Owing to the action of these magnetic fields, the muons in different crystal cells precess with different frequencies, and this causes damping of the observed muon spin precession. As the muon diffuses over the lattice, the local magnetic fields at the muon become alternating in time, and their influence on the muon precession decreases, and it is this which decreases the damping rate λ. The damping of the precession amplitude of the diffusing muon can be described by the formula [2]:

$$a = a_0 \exp\left\{-2\sigma^2\tau^2\left[\exp\left(-\frac{t}{\tau}\right) - 1 + \frac{t}{\tau}\right]\right\}. \quad (1)$$

Here a_0 is the precession amplitude at the initial instant t = 0, τ is the average time spent by the diffusing muon in one crystal cell, and σ characterizes the damping rate of the amplitude a in the absence of diffusion (τ = ∞). It can be shown that for the given crystal lattice

$$\sigma \sim \mu \sqrt{\frac{I+1}{I}}\,, \quad (2)$$

where I and μ are the spin and magnetic moment of the lattice nuclei. It follows from (1) that in the absence of diffusion we have

$$a = a_0 \exp(-\sigma^2 t^2), \quad (3)$$

and in the case of fast diffusion, when the observation time is t >> τ,