with $\mathrm{Im}\, k > 0$. Here ν_n is the kinematic viscosity of the normal component, ω_0 is the angular velocity of rotation, and β_n and β_s are the coefficients for the mutual friction between the superfluid and normal components (cf. reference 1).

As was to be expected, Eqs. (1) and (2) show that the dependence of M upon the rotational velocity vanishes for $\beta_n = \beta_s = 0$. Consequently, the influence of rotation upon the damping of the oscillations of a cylinder is characteristic only of helium II. Measurements[5,6] have confirmed the absence of such an effect in a classical fluid.

Using Eq. (2) it is not difficult to show that over a broad range of frequencies ω_0 and Ω and for $R \approx 1$ cm the penetration depth of the cylindrical waves excited by the oscillations of a cylinder in rotating helium II is appreciably less than the radius of the cylinder. This makes it possible to use an asymptotic expansion of the cylindrical functions for large values of the argument.

As a result, the damping γ' at the surface of a unit length of the cylinder is

$$\gamma' = \frac{\pi R^3 \sqrt{2\eta_n \rho_n \Omega}}{I_1}\left(1 - \frac{\omega_0}{\Omega}\beta_s\right)\left(1 - \frac{3\delta_0}{R}\right), \tag{3}$$

Where I_1 is the moment of inertia of the cylinder (per unit length), $\delta_0 = \sqrt{2\nu_n/\Omega}$ is the penetration depth in the absence of rotation, and ρ_n is the normal component density. Equation (3) is written in the linear approximation to the product of $2\omega_0/\Omega$ and the mutual friction coefficients.

To eliminate boundary effects it is convenient to measure the quantity $(\gamma_2 - \gamma_1)/(l_2 - l_1)$, which is equivalent to γ'; here γ_2 and γ_1 are the values of the damping for immersion of the cylinder to depths l_2 and l_1, respectively. (In addition, I_1 should be replaced in Eq. (3) by the moment of inertia of the suspended system I, which is presumed to be sufficiently great that the period of the oscillations is the same in both stationary and rotating helium, and for various depths of immersion.)

It can readily be seen that the ratio of the quantities $\gamma_2 - \gamma_1$ as measured in rotating and in stationary helium II is

$$(\gamma_2 - \gamma_1)/(\gamma_2 - \gamma_1)_{\omega_0 = 0} = 1 + \omega_0 \rho_s B/2\Omega\rho, \tag{4}$$

where ρ_s/ρ is the relative density of the superfluid component, and B is the coefficient of Hall and Vinen[7,8] ($\beta_s = -\rho_s B/2\rho$). Equations (3) and (4) are also confirmed by experiment.[6]

The authors regard it their pleasant duty to thank É. L. Andronikashvili and his colleagues in the cryogenic laboratory of the Tbilisi State University for their constant interest in this work.

*In solving this problem the necessity of using additional boundary conditions for the velocity of the superfluid liquid does not arise (cf. references 1 and 4), since its components turn out to be proportional to the corresponding components of the normal fluid velocity.

[1] Yu. G. Mamaladze, S. G. Matinyan, JETP **38**, 184 (1960), Soviet Phys. JETP **11**, 134 (1960).

[2] Andronikashvili, Tsakadze, Mamaladze, and Matinyan, Fifth All-Union Conference on Low Temperature Physics, Tbilisi, 1958.

[3] É. L. Andronikashvili and D. S. Tsakadze, JETP **37**, 562 (1959), Soviet Phys. JETP **10**, 397 (1960).

[4] H. E. Hall, Proc. Roy. Soc. **A245**, 546 (1958).

[5] Andronikashvili, Tsadkadze, Chkheidze, Тр. Института физики АН ГрузССР (Trans. Inst. Phys. Acad. Sci. Georgian SSR), in press.

[6] D. S. Tsakadze and I. M. Chkheidze, JETP, this issue, p. 637, Soviet Phys. JETP this issue, p. 457.

[7] H. E. Hall and W. F. Vinen, Proc. Roy. Soc. **A238**, 204, 215 (1956).

[8] E. M. Lifshitz and L. P. Pitaevskiĭ, JETP **33**, 535 (1957), Soviet Phys. JETP **2**, 418 (1958).

Translated by S. D. Elliott
130

ON THE POSSIBILITY OF MEASURING A GRAVITATIONAL FREQUENCY SHIFT IN THE SUN'S FIELD

B. D. OSIPOV

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor November 20, 1959

J. Exptl. Theoret. Phys. (U.S.S.R.) **38**, 657-658 (February, 1960)

SEVERAL authors[1,2] have discussed the possibility of using artificial earth satellites to measure the gravitational frequency shift. However, they have considered only the shift due to the earth's field. We wish to present a calculation which shows that the frequency shift due to the sun's field can also be measured with earth satellites.

The frequency shift due to the sun is

$$\Delta\nu/\nu = -kM_\odot/c^2 r, \tag{1}$$

where k is the gravitational constant, $M_\odot = 2.0 \times 10^{33}$ g is the mass of the sun and r is the distance from the satellite to the sun. If the satellite travels on a circular orbit lying in the plane of the earth's orbit, then the distance r can be written in the form $r = r_0 + \Delta r \cos \Omega t$, where Δr is the radius of the satellite's orbit, Ω is its frequency and r_0 is the distance between the earth and sun. The time-dependent part of (1) is then

$$\Delta\nu / \nu = (kM_{\odot} / c^2 r_0^2)\, \Delta r \cdot \cos \Omega t. \qquad (2)$$

This experiment could be done by putting a stable oscillator on either an artificial satellite or on the moon.

For a generator on the moon ($\Delta r = 3.8 \times 10^{10}$ cm) the fractional frequency change amounts to 5×10^{-11} (which can be compared with a maximum change of 7×10^{-10} in the earth's field). Although the effect due to the sun is smaller than that due to the earth, the experiment using the sun's field has the advantages that the frequency of the oscillator need not be unaffected by the rocket flight to put the satellite in orbit, and the effect is periodic with the period of the satellite.

[1] V. L. Ginzburg, JETP **30**, 213 (1956), Soviet Phys. JETP **3**, 136 (1956).

[2] S. F. Singer, Phys. Rev. **104**, 11 (1956).

Translated by R. Krotkov
131

ON THE APPLICABILITY OF THE FERMI-TELLER "Z-LAW" TO A PHOTOEMULSION CONTAINING URANIUM

G. E. BELOVITSKIĬ

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor July 30, 1959

J. Exptl. Theoret. Phys. (U.S.S.R.) **38**, 658-660 (February, 1960)

It has been shown recently[1,2] that the relative probability of capture of slow μ^- mesons by various atoms in chemical compounds, (such as Al_2O_3, AgCl, UF_4, etc) does not follow the expected law (proportionality to Z) obtained by Fermi and Teller,[3] but is proportional to the number of atoms of the given element in the molecule.

This unexpected result dictates a cautious approach to the conclusions previously drawn in many investigations, particularly those devoted to the investigation of fission of uranium by slow π^- mesons. In these works it has been assumed in the calculation of the fission probability P_f that the probability of capture of a π^- meson by various atoms contained in the photoemulsion gelatine obeys the Fermi-Teller "Z-law." In this connection it becomes advisable to clarify the applicability of the Fermi-Teller "Z-law" to an emulsion to which some other substance (uranium) has been added.

To make the experimental data more precise (the previously obtained values of P_f range from 0.18 to 0.5), the experiments on the fission of uranium by slow π^- mesons were repeated in this investigation. The value of P_f was calculated under several assumptions, and it has been demonstrated by comparison with electronically-performed experiments that the capture of π^- mesons by various atoms in a medium comprising gelatine + uranium obeys the Fermi-Teller Law.

NIKFI-R emulsions 200 μ thick and impregnated with uranyl acetate were used in the experiments. The number of uranium nuclei introduced into the emulsions was determined by counting the alpha particles from the natural radioactivity of the uranium. The plates were irradiated in the slow π^--meson beam of the synchrocyclotron of the Joint Institute for Nuclear Research. The μ^--meson admixture was found to be 20%. Since P_f of uranium is very low for μ^- mesons (0.07),[4] the fissions due to the μ^- mesons did not exceed 3% of the total and were taken into account in the final result. The experimental data are listed in the table.

Number of experiments		1	2
Number of fissions		20	61
Number of stopped π- mesons		1445	5560
Number of uranium nuclei per cm³ of emulsion		$1.8 \cdot 10^{20}$	$1.5 \cdot 10^{20}$
Probability of capture of π- mesons in uranium	"Z-law"	$7.3 \cdot 10^{-2}$	$6.3 \cdot 10^{-2}$
	number of atoms	$5.9 \cdot 10^{-3}$	$5.0 \cdot 10^{-3}$
Fission probability	"Z-law"	0.45 ± 0.11	0.42 ± 0.07
	number of atoms	~ 6	~ 6

The probability of uranium fission by π^- mesons was calculated on the following assumptions: 1) the uranium is completely adsorbed in the gelatine, as established experimentally by Lozhkin and Shamov;[5] 2) the probability of capture of the π^- meson by the various elements in the gelatine (with the exception of hydrogen) was calculated under two assumptions: a) the capture of π^- mesons is proportional to Z, and b) the capture of the π^- meson is proportional to the number of atoms of the