from our value $N_{eff} = 0.32 \pm 0.03$ amounts to $\theta^2 = 0.59 \pm 0.06$.

We obtained the following data: the dependence of the differential cross section on the invariant mass of the $\pi^- p$ system, the spectrum of the π^- mesons scattered at a fixed angle, the distribution with respect to the angle between the π^--meson and proton paths, and the angular distribution of the recoil nuclei. They agree qualitatively with the theoretical calculations both in region I and in region II.

It can thus be assumed that the pole mechanism dominates in the region of momenta $\lesssim$ 100 MeV/c transferred to the nucleus.

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SEARCHES FOR THE GRAVITATIONAL MOMENT OF THE PROTON

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1. If it is assumed that violation of C and P invariance, each separately, occurs in weak interaction because the latter is weak, then we can attempt to extend the loss of left-right symmetry to interactions of the microworld with a gravitational field. The Hamiltonian of a proton located in a gravitational field will then include a pseudoscalar term $\Delta U = (\vec{\xi}\cdot\vec{G})$, where $\vec{G}$ is the intensity of this field (polar vector, and we shall call $\vec{\xi}$ the gravitational moment of the proton (axial vector). Its dimension is erg/Gal in the cgs system.

The distinguished direction for the proton is that of the spin, and consequently $\vec{\xi} = \xi_0\vec{\sigma}$ (ξ_0 - projection of $\vec{\xi}$ on the Z axis, $\vec{\sigma}$ - Pauli matrix).

It is easy to show that a proton with ξ_0 in a field G will precess with a frequency $\omega' = \pm\xi_0 G/(h/2)$, forming a right-hand (Fig. 1a) and a left-hand system of coordinates (Fig. 1b). A consistent analysis shows that the frequencies of the nuclear magnetic resonance (NMR) remain unchanged when $H_0 \downarrow\downarrow G$ and $H_0 \uparrow\downarrow G$, but when $H_0 \perp G$ the position of the NMR relative to the first two cases shifts either towards higher or lower frequencies. This makes it possible to determine the value of ξ_0 and its sign for the corresponding coordinate system:

$$\Delta\nu = \nu_{\parallel} - \nu_{\perp} = \frac{\pm \xi_0 G}{\pi \hbar}, \quad \text{or} \quad \xi_0 = \pm \frac{\Delta\nu\pi\hbar}{G}.$$

When $\Delta\nu > 0$ it is necessary to assume $\xi_0 > 0$ in the right-hand system and $\xi_0 < 0$ in the left-hand system of coordinates. If $\Delta\nu < 0$, then $\xi_0 < 0$ in the right-hand system and $\xi_0 > 0$ in the left-hand system.

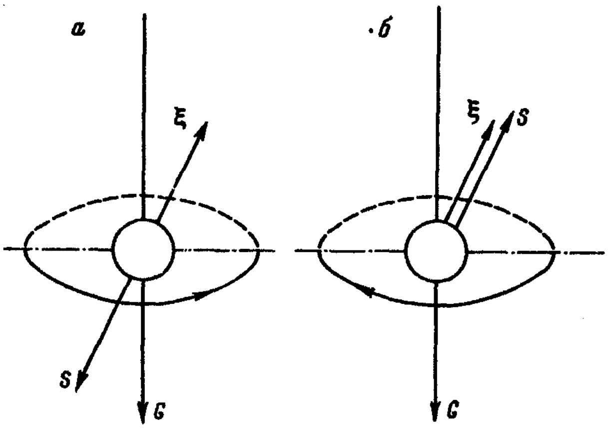

Fig. 1. a) The spin precession (circular arrows) and the vector G form a left-hand frame; b)right-hand frame.

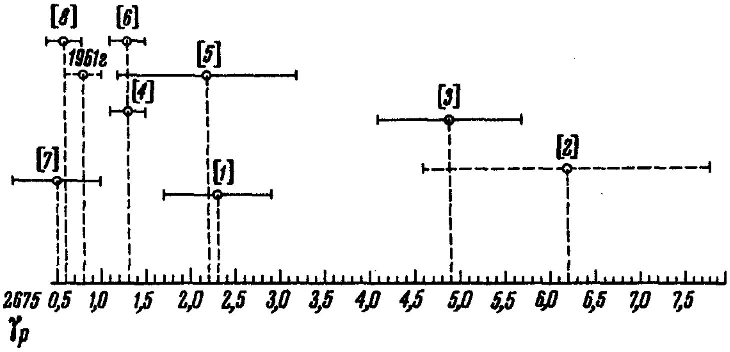

Fig. 2. Summary of metrological work done on the measurement of the proton gyromagnetic ratio.

2. In Fig. 2 are gathered all the measurement data known to the author on the gyromagnetic ratio of the proton $\gamma_p = \omega/H_0$ [1-8]. The results of two investigations [2, 3] are patently too high. It turns out that all other measurements were made at $H_0 \perp G$, whereas in [2, 3] the field H_0 (~100 Oe) was oriented along H_E (the earth's magnetic field) and the influence of the latter was eliminated by reversing the current in the solenoid. These measurements were made in Cologne (W. Germany), where the angle between H_E and G is approximately 20°. If a correction for the field G is introduced in the calculation of γ_p of [3], then $\gamma_p^W = \gamma_p + \Delta\gamma_p$, where

$$\Delta\gamma_p = \frac{2\xi_0 G}{\hbar H_0} \cos 20° = \gamma_p^w - \gamma_p^T = 2{,}6 \pm 1$$

(γ_p^W - result of [3], γ_p^T - result of [1]). In the calculation we assumed $\xi_0 > 0$ in the right-hand frame and $\xi_0 < 0$ in the left-hand frame. It follows from the obtained relation that

$$\xi_0 = \pm(1{,}4 \pm 0{,}7) \cdot 10^{-28} \text{ erg/Gal.}$$

3. Our measurement setup consisted of two pairs of Helmholtz coils (120 and 140 cm dia) which compensated the field H_E to within 10^{-3} Oe. This was determined with a magnetometer (ferromagnetic probe) and by a ballistic method. An iron-free setup producing the field H_0 was located at the center of the system and could be oriented vertically and horizontally. The NMR detector circuit was taken from [3]. A cell (24 cm dia) with a solution of $CuCl_2$ in water was placed in the generator coil. The $CuCl_2$ concentration was chosen such as to produce no "capture" and minimize the absorption-line width. The signal to noise ratio was 1:50. The total line width at 1/3 height was $\Delta\nu/\nu = 4 \times 10^{-4}$, making it possible to determine the NMR at the vertex with accuracy $\Delta\nu/\nu = 3 \times 10^{-5}$. Numerous measurements in a vertical field H_0, when switching of the current producing H_0 yielded the conditions $H_0 \downarrow\downarrow G$ and $H_0 \uparrow\downarrow G$, have shown that the NMR position remains unchanged with accuracy $\Delta\nu/\nu = 4 \times 10^{-5}$.

Figure 3 shows the differences between the resonance frequencies ν_v and ν_h for horizontal and vertical H_0, respectively. The mean value is $\Delta\nu = \nu_v - \nu_h = 31 \pm 10$ Hz. Most measurements were madeunder conditions requiring no exact compensation of H_E. To this end, the resonance was measured twice, with currents in opposite directions, for both vertical and horizontal H_0. The results obtained for each case were added and $\Delta\nu$ was determined from the two sums. To exclude the possible systematic error, the measurements were made with three different arrangements. The light circles of Fig. 3 were obtained with forced air cooling of the solenoid, the triangular points were obtained with the Helmholtz system, and the black point was obtained with a water-cooled solenoid. The dashed point was obtained from an analysis of the metrological investigations (see Fig. 2). There is no noticeable dependence of $\Delta\nu$ on H_0 in the interval from 64 to 170 Oe.

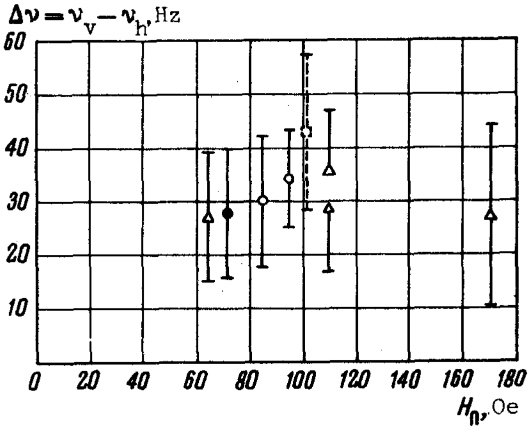

Fig. 3. Observed effect of relative shift of NMR frequencies of protons at vertical and horizontal orientations of the field H_0.

The measurements thus yield $\xi_0 = \pm(1\ \ 0.4) \times 10^{-28}$ erg/gal, where $\xi_0 > 0$ in a right-hand frame and $\xi_0 < 0$ in a left-hand frame.

In conclusion, the author thanks Yu. I. Neronov for discussions of the NMR procedure.

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CONCERNING DISCRETE SATURATION IN INHOMOGENEOUSLY BROADENED EPR LINES

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In. [1, 2] there was described the discrete saturation (DS) observed when a short-time saturating pulse of microwave power acts on an EPR line whose width is governed by the nuclei surrounding the paramagnetic center. It was proposed that a possible mechanism causing the DS is one in which the quantum of the microwave field causes simultaneous reorientation of the spin of the electron and of the nucleus located in the environment of the neighboring paramagnetic center. Such a process should depend strongly on the concentration of the magnetic centers. By investigating DS in samples in which the concentration was varied in a wide range, we have established that the DS picture hardly varies with the concentration. It follows therefore that the DS mechanism should be local. A similar statement was made recently in [3].

The Hamiltonian of the paramagnetic center and the nuclei surrounding it can be written in the form

$$\mathcal{H} = g\beta H_0 \mathbf{S}\mathbf{n} + \sum_i \mathcal{H}_i ,$$
$$\mathcal{H}_i = \hbar\gamma H_0 \mathbf{I}^i \mathbf{n} + \mathbf{S}A^i\mathbf{I}^i ,$$

where the index i labels the nuclei, $\vec{n}$ is a unit vector along the external field H_0, $\vec{S}$ is the electron spin operator, $\vec{I}^i$ is the spin operator of the i-th nucleus, and A^i is the tensor of hyperfine interaction of the i-th nucleus with the electron spin.

It was shown in [4] that in the case when the energy of the hyperfine interaction A is of the order of the Zeeman energy of the nucleus in the external field, $\hbar\gamma H_0$, the EPR spectrum may become complicated by the presence of "forbidden" transitions with simultaneous reorientation of the spins of the electron and of the nuclei. This occurs in the electronic transition because of the change of the orientation of the effective magnetic field $\vec{H}_m^i = H_0\vec{n} + (m/\hbar\gamma)A^i\vec{n}$ in which the nuclear spin is quantized. The problem of a complex super-hfs was solved completely, in principle, for any number of non-equivalent nuclei with spin 1/2 in the environment of the paramagnetic center.

In the general case the number of components of the complex super-hfs is 4^ℓ, where ℓ is the number of nuclei in the environment of the paramagnetic center. For ℓ equivalent nuclei, the number of observed lines decreases to $(\ell + 1)^2$. We recall that for a simple spectrum this number equals $\ell + 1$. Individual lines in the complex super-hfs may overlap, and in this case each line in the observed EPR spectrum represents an aggregate of different transitions. When this component is saturated by a short-duration powerful microwave pulse, the neighboring hfs components are also saturated. In the case of an unresolved super-hfs spectrum this will present the appearance of resolution of the structure.

We shall illustrate the foregoing using a simple example of four equivalent nuclei in