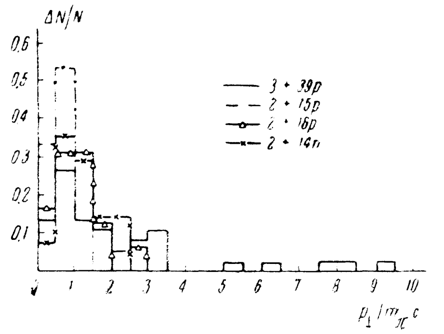

FIG. 1

It seems to us that a discussion of the interesting relation between the degree of anisotropy of shower particles and the character of the distribution of their transverse momenta is not without value. In Fig. 1 is shown the distribution in transverse momenta of particles produced in four showers: the showers 2 + 16p and 2 + 14n described by Edwards et al.,[1] the shower 2 + 15p described by Shein et al.,[5] and the shower 3 + 39p described by Debenedetti et al.[6] It is reasonably clear from this figure that the distribution of $p_\perp$ in the showers 2 + 16p, 2 + 14n and 3 + 39p corresponds to a significant number of particles with transverse momenta in excess of $m_\pi c$, whereas in the shower 2 + 15p the values of transverse momenta of the particles do not exceed $1.5\, m_\pi c$. When this fact is related to the character of the angular distributions of the indicated showers, them it becomes possible to reach an interesting conclusion. In Fig. 2 are shown integral angular distributions of

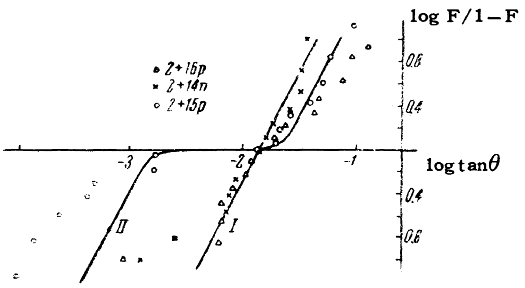

FIG. 2

the particles in the showers 2 + 16p, 2 + 14n, and 2 + 15p. The angular distribution of the particles in the shower 3 + 39p is nearly identical to that of the showers 2 + 16p and 2 + 14n. The straight line I corresponds to a particle distribution in the center of mass system that is isotropic in angle and monoenergetic, curve II corresponds to one anisotropic in angle (of the type $\cos^{2n}\theta^*$) and monoenergetic. We see upon comparison of the data shown in Figs. 1 and 2 that when the angular distribution is anisotropic the values of transverse momenta are essentially of order $m_\pi c$, whereas for a smaller degree of anisotropy (showers 2 + 16p, 2 + 14n, and 3 + 39p) values of transverse momenta in excess of $m_\pi c$ occur frequently. (Let us note that in the case of collisions between a nucleon and a complex nucleus large values of $p_\perp$ may appear as a consequence of scattering.) We propose that in the case of smaller anisotropy (which corresponds approximately to small values of the impact parameter) the production of heavier mesons is more probable, whereas in the case of a strongly anisotropic distribution (which corresponds to larger values of the impact parameter) essentially only π mesons are produced. From this point of view the relation between the degree of angular anisotropy and the character of distribution in transverse momenta of particles produced in the high energy region becomes comprehensible. At the present time we are engaged in an attempt to establish this relation between the degree of angular anisotropy and the distribution in transverse momenta for particles in showers produced by 10-Bev protons from the proton synchrotron of the Joint Institute for Nuclear Research.

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118

POLARIZATION OF HYDROGEN NUCLEI IN A FREE RADICAL

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BELJERS et al.[1] have shown that Overhauser's[2] method can be used to polarize hydrogen nuclei in the free radical of diphenyl picryl hydrazyl (DPPH).

When the $\Delta M = \pm 1$ and $\Delta m = 0$ transitions (where M and m are the projections of the electron and nuclear spins respectively in the direction of the magnetic field) are saturated, on account of the electron-nucleus interaction, an increase occurs in the difference in population of the nuclear levels of hydrogen. When the quantity $2(\mu_n + s|\mu_e|)H/kT$ is small, it is easy to show that this difference increases by a factor of $(\mu_n + \mu_e)/\mu_n$ [μ_n and μ_e are the magnetic moments of the proton and electron respectively, and s is the coefficient of saturation of paramagnetic resonance (p.r.)].

We investigated the possibility of polarizing hydrogen nuclei in DPPH at liquid-helium temperatures. We cooled a sample of DPPH down to 4° K and then applied three mutually perpendicular magnetic fields to it: a constant field with $H \approx 3300$ oe, an ultrahigh-frequency (UHF) field of frequency $\nu_e = 9419$ Mcs for the purpose of saturating the p.r., and a high-frequency field with $\nu_n = 14$ Mcs for the purpose of observing the nuclear resonance (n.r.) of the protons.

The frequency and power of the UHF field remained constant in the course of the experiment. We plotted the dependence of the amplitude of the n.r. signal on the constant field. Theory leads one to expect that the n.r. signal will increase by a factor of $(\mu_n + s|\mu_e|)/\mu_n$ at a value of the field $H_0 = h\nu_e/2.003\mu_e$. However, the effect was not observed at the H_0 point. An increase of the n.r. signal was observed for the two values of the field, $H_0 \pm \Delta H$. We gave an incorrect interpretation of this phenomenon earlier.[3]

At the $H_0 + \Delta H$ point the polarity of the n.r. signal indicates that $n_+ > n_-$, while in the case of $H_0 - \Delta H$ we get $n_- > n_+$ (n_- and n_+ are the number of hydrogen nuclei with spins against and along the field respectively). The accompanying figure shows the dependence of the amplitude of the n.r. signal on the constant field.

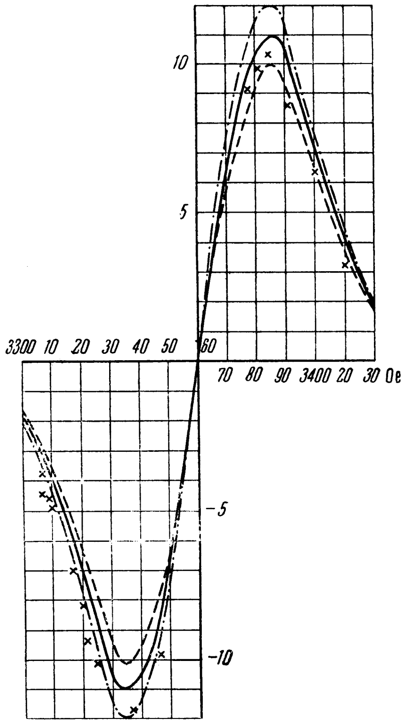
Uebersfeld et al.[4] observed a similar effect in the case of protons in benzene absorbed by carbon. Abragam et al.[5] have explained this phenomenon.

The UHF field causes $\Delta M = \Delta m = \pm 1$ and $\Delta M = -\Delta M = \pm 1$ transitions. If the probabilities of such transitions are much greater than those of nuclear transitions due to other processes, we obtain in equilibrium

$$n_+/n_- = \exp\{\pm 2|\mu_e|H/kT\},$$

the plus sign in the exponent is taken in the first case. Correspondingly, the magnetic field will be $H = H_0(1 \pm \mu_n/\mu_e)$, which in our case will yield $H = (3360 \pm 5)$ oe. On this basis, when the frequency and power of the UHF field remain constant, one would expect the field dependence of the amplitude of the n.r. signal to have the shape of two Gaussian distributions with maxima of $\pm|\mu_e|/\mu_n$ situated at $H = (H_0 \pm 5)$ oe respectively and half-widths equal to the sum of the half-widths of the p.r. and n.r. lines. If the distributions are so wide that they overlap, these lines of opposite sign will interfere with each other.

We observed a strong temperature dependence of the p.r. line width. At 4° K the half-width of the p.r. line is ~ 40 oe, while that of the n.r. line is ~ 15 oe. We therefore observed the total picture.



Dependence of the magnitude of the n.r. signal on the field at constant frequency and constant UHF power (the n.r. signal in the absence of the UHF field is taken as the unit of signal magnitude). The crosses designate the experimental points. The lines were obtained by a summation of Gaussian distributions with maxima taken to equal 42 units (solid line), 38 units (broken line), and 46 units (dot-dash line).

For the purpose of comparison with experiment, the figure shows the curves resulting from the summation of two Gaussian distributions of opposite sign with centers at $(H_0 \pm 5)$ oe and half-widths equal to 55 oe. The maximum was selected to obtain the best agreement with the experiment. As can be seen from the figure, it is possible to state, with an accuracy within 10%, that the n.r. signal should have increased by a factor of 42 instead of 660.

At fixed values of ν_e and H the amplitude of the n.r. signal versus the power of the UHF field is given by the following values:

UHF power, mw	0.26	0.85	1.6	18
amplitude of n.r. signal	7.3	10.7	11.1	13.7

From this it can be seen that we were close to saturation.

It is interesting to note that the unpaired electron of the DPPH molecule can cause the polarization of not only the protons of its own molecule but also those of distant molecules.

Before the experiment the sample was subjected to vacuum melting (1 to 0.1 mm Hg) and kept in that condition for several hours. This led to a decrease in the number of unpaired electrons and a consequent increase in the number of protons per unpaired electron. The accompanying data correspond to a sample in which the number of protons per unpaired electron is of the order of 10^3. As the experiment shows, we had too weak a concentration of unpaired electrons.

Borghini and Abragam[6] have carried out similar experiments.

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119

MEASUREMENT OF THE LOGARITHMIC DAMPING DECREMENT OF A HOLLOW CYLINDER IN ROTATING HELIUM II

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As is well known, the fundamentals of the theory of the rotation of a superfluid liquid have been set forth in the publications of Feynman, based on Onsager's concept of the existence in rotating helium II of vortex lines. According to these papers, the number of vortex lines grows as the rotational velocity increases, while each such line has a definite energy per unit length. Investigation of the properties of vortex lines in rotating helium II has been carried out both by the stack-of-disks method,[1-3] and by the method of a single disk oscillating about its axis, with the latter parallel to the vortex lines (references 4 and 5, as well as private communication by Hall).

In one of these papers[4] Andronikashvili and Tsakadze have shown that with increasing rotational velocity the logarithmic damping decrement of the disk passes through a maximum, which must be explained (cf. reference 6) by a corresponding change in the elastic-plastic properties of rotating helium II. In accordance with this hypothesis the superfluid component of helium II should, at small velocities of rotation, be regarded as a system of relatively few vortex lines not interacting among themselves, while at large velocities, these lines form a single elastic-plastic tangle. In the two cases, of both low and high velocities, the vortex lines may be considered to be bound at their ends, to a greater or lesser degree, to the surface of the oscillating disk. It was natural to assume that rotating helium II should show different viscous properties in experiments in which the surface of the solid body subjected to retardation moves perpendicular to the direction of the vortex lines and in which it moves parallel to them.

With the object of verifying this hypothesis, the single disk in the previously-described[4,5,7] apparatus was replaced by a hollow cylinder, machined from organic glass and having circular graduations ruled on its cylindrical surface to facilitate its immersion to various depths in the rotating helium II, suspended upside down on an elastic fiber. As in the work with the single disk, the hollow cylinder took part simultaneously in both rotational and oscillatory motion. The cylinder had a diameter of 24.06 mm, a height of 49.80 mm, and a thickness of 0.49 mm. The distance between the rulings was 5.0 mm. The number of rulings was 9. The outer container, which rotated uniformly together with the helium II with which it was filled, had a diameter of 44 mm and a height of 62 mm.

The solution of the hydrodynamic problem of a cylinder immersed in a rotating classical liquid and performing axial-rotational oscillations of small amplitude superimposed upon rotation leads to the formula

$$(\delta_2 - \delta_1)/(l_2 - l_1) = (2\pi^2 r^3/J)\sqrt{2\eta\rho/\Omega}, \qquad (1)$$

where $\delta_1 (\delta_2)$ is the logarithmic damping decrement for the oscillations of the cylinder when it is immersed in the liquid to a depth $l_1 (l_2)$, r is the radius of the cylinder, η and ρ are the viscosity