the corresponding equation in the selfconsistent field approximation by the presence of terms containing Φ. If, in the equilibrium state $f^{(+)} = f^{(-)}$, then upon linearization of Eq. (4) the terms containing Φ contribute nothing whatever. Therefore the vibration spectrum in this case coincides with that obtained in the selfconsistent field approximation. In the case where $f^{(-)} = 0$, the results of paper 1 are obtained.

However, in addition to density fluctuations, for particles with spin, new excitations arise, characterized by the function Φ and similar to a spin wave. The equation for the function Φ, which is gotten from Eq. (3), is:

$$\frac{\partial \Phi}{\partial t} + \frac{\mathbf{p}}{m}\frac{\partial \Phi}{\partial \mathbf{q}} + \frac{i}{\hbar}\frac{1}{(2\pi)^3}\int dq' d\vec{\tau} dp' dp'' \left[U\left(\left|\mathbf{q}-\mathbf{q}'+\frac{\hbar\vec{\tau}}{2}\right|\right) - U\left(\left|\mathbf{q}-\mathbf{q}'-\frac{\hbar\vec{\tau}}{2}\right|\right)\right] \times \left\{e^{i\vec{\tau}(\mathbf{p}'-\mathbf{p})}\Phi(\mathbf{q},\mathbf{p}'')f(\mathbf{q}',\mathbf{p}') - \Phi\left(\frac{\mathbf{q}+\mathbf{q}'}{2}+\frac{\hbar\vec{\tau}}{4},\mathbf{p}''\right)f\left(\frac{\mathbf{q}+\mathbf{q}'}{2}-\frac{\hbar\vec{\tau}}{4},\mathbf{p}'\right) \times \exp\left[i\vec{\tau}\left(\frac{\mathbf{p}'+\mathbf{p}''}{2}-\mathbf{p}\right)-\frac{i(\mathbf{q}'-\mathbf{q})(\mathbf{p}'-\mathbf{p}'')}{\hbar}\right]\right\} = 0. \quad (5)$$

Note that for particles with spin one, one should write the opposite sign in front of the curly brackets in Eqs. (3), (4) and (5). If $\Phi = 0$ in the equilibrium state, then upon linearizing Eq. (5)

$$f = f_0 + \varphi_{\mathbf{k}} e^{i\mathbf{k}\mathbf{q}}, \quad \Phi = \Phi_{\mathbf{k}} e^{i\mathbf{k}\mathbf{q}}$$

we obtain the following equation, describing the spin fluctuation**,

$$\frac{\partial \Phi_{\mathbf{k}}}{\partial t} + \frac{i\mathbf{k}\mathbf{p}}{m}\Phi_{\mathbf{k}} \pm \frac{i}{\hbar}\Phi_{\mathbf{k}}\int dp'\nu\left(\left|\frac{\mathbf{p}-\mathbf{p}'}{\hbar}\right|\right) f_0\left(\mathbf{p}'-\frac{\hbar\mathbf{k}}{2}\right) \mp \frac{i}{\hbar} f_0\left(\mathbf{p}-\frac{\hbar\mathbf{k}}{2}\right)\int dp'\nu\left(\left|\frac{\mathbf{p}-\mathbf{p}'}{\hbar}\right|\right)\Phi_{\mathbf{k}}(\mathbf{p}') = 0. \quad (6)$$

The upper sign goes with spin ½, the lower with spin 1. For the case of spin 1 and the temperature equal to zero, $f_0(p) = n_0\delta(p)$. In this case the solution to Eq. (6) is

$$\Phi_{\mathbf{k}}(\mathbf{p}) = e^{-i\omega t}\delta\left(\mathbf{p}-\frac{\hbar\mathbf{k}}{2}\right)c(\mathbf{k}),$$

where

$$\hbar\omega = \hbar^2 k^2/2m.$$

Thus the spin excitation spectrum of a degenerate Bose gas of spin one particles looks like the spectrum of noninteracting particles. Consequently one can say that (insofar as it is possible to consider liquid helium as a weakly ideal gas) the superfluidity of helium is explained, apparently, not only by the Bose statistics, which the He atoms obey, but also by their lack of spin.

In conclusion, I wish to thank Professor V. L. Ginzburg for a discussion of the results.

* For spin one particles, one should take the sum in Eq. (1) rather than the difference; and in Eq. (2) the difference rather than the sum.

** Such an equation is gotten for $f^{(-)}$ in the case where $f_0^{(-)} = 0$, which corresponds to the case of a system of particles whose spins in the ground state are oriented in one direction. In contrast to the ordinary theory of spin waves, Eq. (6) permits the calculation of the interaction not only with nearby particles, but also with those distantly situated.

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Detection of the Polarization of Beams of Fast Particles by Means of Nuclear Photoemulsions

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THE experiments of scattering of high energy particles point to the presence of non-central forces in the interactions between nucleons. The presence of such forces results in polarization of beams of the scattered particles. The magnitude of this polarization is experimentally determined by means of the measurement of the asymmetry in double scattering. The value of asymmetry is generally determined from the equation:

$$\varepsilon(\theta) = \frac{I(\theta, \varphi = 0°) - I(\theta, \varphi = 180°)}{I(\theta, \varphi = 0°) + I(\theta, \varphi = 180°)},$$

where $I(\theta, \phi = 0)$ and $I(\theta, \phi = 180°)$ are the numbers of particles scattered in second scattering at angle θ to the left or right of the direction of motion of the polarized particles.

At the present time a large number of experiments is devoted to the observation of polarization of beams of fast particles[1-4]. In all similar experiments the direction of particles undergoing second scattering was done by means of scintillation counters. In the present work it was attempted to determine the polarization of beams of protons and neutrons by photographic means from the observation of quasi-elastic scattering of protons from the nucleons of the nuclei of elements that make up the emulsion. The proton beam was obtained by scattering, at an angle of 18°, the internal beam of energy 670 mev in the synchrocyclotron. The scatterer-polarizer was Be target of thickness 4 cm. The medium energy of protons in the partly polarized beam was 570 mev[5]. In this beam were placed photographic plates with emulsions 200μ thick, capable of recording relativistic particles. In one of the experiments the plane of the emulsion was the same as the plane of the first scattering, in other experiments the plane of emulsion was perpendicular to the plane of the first scattering. The placing of the plates was thus selected to correspond to the planes of azimuthal angles 0 - 180° and 90° - 270°.

The stars generated by the protons in the emulsion contained gray tracks whose projections were in the interval of scattering angles $0° \leq \theta \leq 50°$ to the right and to the left depending on the direction of motion of the initial proton beam. Only those tracks were counted whose length exceeded 400 μ and whose density of grains corresponded to proton energies above 200 mev. In plates placed in the 0°- 180° plane, there were recorded 735 such tracks to the right while 922 tracks were recorded to the left. The corresponding value of the asymmetry is $\epsilon(\theta) = 0.11 \pm 0.03$. In plates placed in the 90°- 270° plane similarly 203 and 215 tracks were found to the right and left respectively. These values give $\epsilon(\theta) = 0.03 \pm 0.05$ which shows the presence of asymmetry in the 90°- 270° plane, as should be expected.

Under the same conditions of selection of tracks, measurements of asymmetry were made from gray tracks in stars produced by neutrons. A beam of neutrons with a broad energy spectrum was produced by charge exchange of protons in a Be target. Neutrons that were scattered from the target at angle 20° to the direction of motion of the proton beam in synchrocyclotron were incident on a photographic plate placed in the plane of the first scattering. In this case the following tracks were registered: to the right 667, to the left 747, yielding the asymmetry 0.06 ± 0.03.

The asymmetry of emerging fast particles after quasi-elastic collisions, found in the described experiments, shows that beams of protons and neutrons originating from interactions of protons of energy 670 mev with Be nuclei are partially polarized.

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The Excitation of Ultrasonic Vibrations by Ponderomotive Forces

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DURING the work with apparatus intended for investigation of nuclear magnetic resonance[1], an interfering resonance effect was observed at frequencies of the order of several megacycles. It was found that this effect was produced by excitation of ultrasonic vibrations by ponderomotive forces in the copper conductor of which the spectrometer coil was constructed. With each of the coils used a series of resonance peaks was observed during a change of the working frequency. The amplitudes of the peaks exceeded considerably the noise level of the instrument. The relative width of the peaks was of the order of magnitude 1:100. The amplitude of the peaks increased linearly with the increase in depth of modulation of the field. The instantaneous values of the other losses present in the circuit depend on the field quadratically. In field of 10^4 oersteds with doubled amplitude of the modulation field (15 oersteds) the strongest resonant lines correspond to modulation of autodyne radiofrequency spectrometer of $\Delta U/U \sim 10^{-6}$. Since the spectrometer was used in a region far from the threshold of self-excitation, this is the change in the Q of the coil as well. The full change in the Q of the coil on application of the field of 10^4 oersteds is $\Delta Q/Q \sim 10^{-3}$. This ratio gives the fraction of energy which was dissipated in generation of the ultrasonic waves.