the Larmor precession correspond to different parts of a single branch of the excitation spectrum. We note that the presence of a term proportional to $j \times Q$ in the friction force would lead to the appearance in ω of a coefficient different from unity.

If the waves are propagated perpendicular to the vortices, then it is necessary to take into account the condition div $j = 0$ and the following expansion is used for $j \times Q$:

$$\overline{[j_0 Q_1]} = \left[\overline{(j_0 x)}, \frac{\partial Q_1}{\partial x} \right] + \frac{1}{2} \left[\overline{(j_0 x^2)}, \frac{\partial^2 Q_1}{\partial x^2} \right] + \ldots$$

The expression for j_0 is taken from [2]. If the centers of the vortices form a quadratic lattice in the perpendicular cross section, we then get

$$\omega_1 = -i\Omega_0 [Ck^4 d^4 \sin 4\varphi + \alpha k^2 \delta^2 / (1 + k^2 \delta^2)],$$

$$\omega_2 = -i\Omega_0 [Ck^4 d^4 \sin 4\varphi + \beta k^2 \delta^2 / (1 + k^2 \delta^2)], \qquad (6)$$

where C is a constant of the order of unity. For a trigonal lattice, in place of the term $k^4 d^4$, there is a term $k^6 d^6$. The first of these solutions refers to a plane polarized wave with f_y and Q_z, while the second, to a plane wave with f_z and Q_y. Thus, in contrast with the conclusion of De Gennes and Matricon,[1] the propagation of transverse undamped waves is not possible. It also follows from (6) that the lattice of the vortices is unstable in the absence of dissipation ($\alpha, \beta = 0$). In view of the strong dependence of the coefficients α and β on k for a small number of macroscopic defects (see below), this can lead to shortwave "jitter" of the lattice.

In the recently published work of Vinen and coworkers,[4] the motion of vortices was studied by the relaxation of the magnetization of a cylindrical specimen upon change in the external field. From Eq. (4) for the relaxation time, we get

$$\tau = R^2 / 5.8 \alpha \delta^2 \Omega_0, \qquad (7)$$

where R is the radius of the cylinder. Comparison with the results of the given research shows that $\alpha \sim 1000$. At first glance, it then follows that the frequency of oscillation (5) is essentially an imaginary quantity, i.e., the oscillations do not exist. However, it is necessary here to take it into consideration that the fundamental mechanism of dissipation at low temperature is the interaction with macroscopic inhomogeneities. If the number of such inhomogeneities is not large, so that the distance between them $l \gg d$, then one can consider the wavelength $\lambda \ll l$. For such oscillations, α will be small. If one is concerned with the motion of the filaments as a whole, which is the case in the work of Vinen et al., then one must naturally expect large values of α. In other words, on the basis of the data of Vinen and coworkers, one must not expect the absence of oscillations, but only a strong dependence of α on the wave vector.

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*rot = curl.

†[jQ] = j × Q.

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METHOD OF INVESTIGATING ELASTIC pp SCATTERING AT HIGH ENERGIES BY MEANS OF SEMICONDUCTOR COUNTERS

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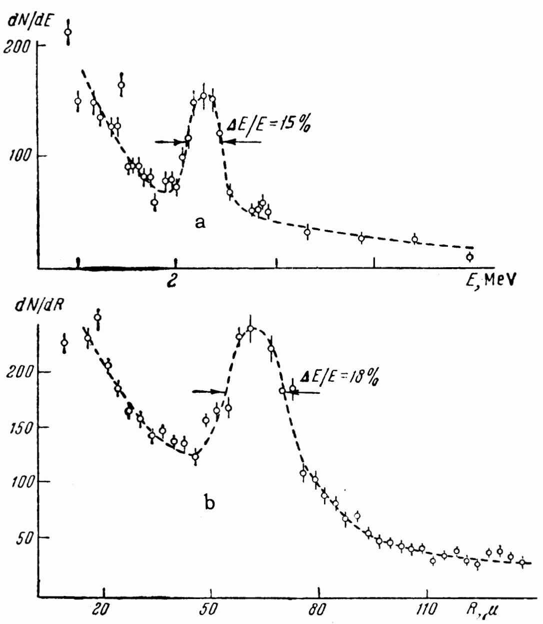
In the present work we have experimentally demonstrated the possibility of studying elastic scattering of high energy protons in the small-momentum-transfer region

$$1.5 \cdot 10^{-3}\, \mathrm{GeV}^2/c^2 \leqslant -t \leqslant 1.5 \cdot 10^{-1}\, \mathrm{GeV}^2/c^2$$

by means of semiconductor nuclear particle detectors. The nuclear emulsion method [1] which has previously been used for this purpose has the disadvantage of a low rate of collecting statistics. Semiconductor counters are free from this difficulty, possess good energy resolution ($\sim 1\%$), are compact, and are insensitive to magnetic fields. The fact that the sensitive layer in the semiconductor detector can begin immediately at the surface permits counting protons of very low energies, down to several tens of keV.[2] This means that it is possible to study scattering in



Spectra of particles emitted at an angle of 87.7° from a $(CH_2)_n$ target bombarded by 10 BeV protons: a — energy distribution measured by a semiconductor counter; b — range distribution in photographic gelatin emulsion diluted by a factor of four.

the region of angles where the Coulomb scattering is many times larger than the nuclear scattering.

Below we report the systematic results of an experiment carried out on the proton synchrotron at the Joint Institute for Nuclear Research.

The semiconductor counters were placed in an evacuated channel at an angle of 87.7° to the proton beam at a distance of 3 m from a target placed in the internal 10 BeV proton beam. The target was prepared from a hydrogen-containing polymer film of the type $(CH_2)_n$ of thickness 0.7 μ. The counters and the preamplifiers located near them were thoroughly shielded from external electromagnetic pickup and no difficulty from this source was observed during the experiment. The pulses from the counters were amplified and fed to a pulse-height analyzer.

Section a of the figure shows the results obtained with a surface-barrier counter of dimensions $3 \times 4 \times 0.09$ mm. The measurement time was 10 min. The peak corresponding to recoil protons of 2.2 MeV is clearly visible above a background due to the carbon in the target. The weight of the peak at half-height, which amounts to 330 keV (15%), was determined on the basis of the Coulomb scattering of the recoil protons in the target and the experimental geometry. The "instrumental" width, according to measurements on monochromatic α particles, was 50 keV. For comparison, section b shows the distribution of particles, emitted from the same target under identical conditions, with respect to the range in gelatin emulsion diluted by a factor of four. A peak corresponding to recoil protons from elastic scattering has a half-width $\Delta E/E \approx 18\%$, i.e., somewhat wider than the distribution obtained with the semiconductor counters.

In the course of measurements with thicker counters it was established that if the thickness of the sensitive layer does not exceed a fraction of a millimeter, the background from the target direction predominates over the background not connected with the target. It follows from this that protons with energies tentatively up to 10 MeV, whose range is confined to a silicon layer of thickness 0.7 mm, can be identified by a single counter. For thicker detectors it becomes necessary to introduce an additional counter in order to select particles emitted from the target, by the coincidence method.

Finally we will mention that the method described is applicable to study in the small-momentum-transfer region of any reaction of the form $a + b \rightarrow c + d$ (for example, scattering by nuclei, scattering with production of excited nucleon states, etc).

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