capillary was rotated with the vessel.

Upon immersing the apparatus in liquid helium, a beam of light was directed on the rouge plug. As a result, a difference in level was established between the liquid in the capillary and in the container. This difference was measured by a cathetometer. Then the container was rotated. Under these conditions there was a lowering of the level of He II in the capillary by an amount which, in the limits of error of the experiment, did not differ from the displacement of the central part of the meniscus which was brought about by the rotation. This experiment covered the velocity range from 0.25 to 22 rev/sec and was repeated at different temperatures. The light intensity (which supplied the heat) was chosen separately in each case. As is evident from the table, the dependence of the thermomechanical effect on the rotational velocity is not observed up to velocities of 16 rev/sec, which corresponds to tangential speeds of 136 cm/sec.

In another experiment, this same capillary, rigidly fixed independently of the vessel, was displaced along its radius, thus playing the role of a stirrer. However, even in this case, the total rise of He II in the capillary changed insignificantly for a velocity change of 160 cm/sec.

From these experiments it follows that, in the transition through the critical velocity, the superfluid phenomenon not only does not disappear but that the quantitative characteristics, such as the thermomechanical effect and the quantity ρ_n/ρ connected with it, remain unchanged, and independent of the velocity of rotation, within the limits of error of measurement, up to very large velocities. It is thus possible to confirm that in the region of critical velocity the superfluid component maintains motion for which curl v_s differs from zero.

Translated by R. T. Beyer
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Collisions of Fast Nucleons with Nuclei

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In the investigations of collisions of nucleons and mesons (with energies of the order $10^{10} \div 10^{12}$ ev) with nuclei one occasionally finds the entire process with its attendant generation of new mesons (and possibly new nucleon pairs) represented as a cascade process within the nucleus or, in any case, as a process of successive collisions of the incident particle within the nucleus; the emission of new formed particles and nucleons being produced by the nucleons situated along the collision path. Occasionally, detailed calculations are exhibited which are based on the fact that after the collision, the primary particle and its products move through small angles relative to the initial direction of motion of the particle[1].

Nevertheless one cannot forget that, because of the wave properties of the particles, this view may be internally inconsistent. Let us consider, for example, the collision of two nucleons which produces in one event ν mesons, each with a mass μ and energy ϵ. If the collision cross section is of the order of π/μ^2 (where $\hbar = c = 1$, in the following) then the mean impact parameter is $1/\mu$, the momentum $q_\perp$ in the perpendicular direction, which is transferred to the nucleon by emission, has the order of μ and the energy carried away by these nucleons should be, on the average, comparatively small. Consequently, if we consider the momentum $q_\parallel$ in the longitudinal direction, which is transferred to the nucleon by emission, we can write

$$q_\parallel \approx \sqrt{E^2 - M^2} - \sqrt{(E-\varepsilon\nu)^2 - M^2}\cos\theta_M - \nu\sqrt{\varepsilon^2-\mu^2}\cos\theta_\mu \quad (1)$$

$$\approx \frac{M^2\nu\varepsilon}{2E(E-\nu\varepsilon)} + \frac{\nu\mu^2}{2\varepsilon} + \frac{1}{2}\left(\theta_M^2(E-\nu\varepsilon) + \theta_\mu^2\nu\varepsilon\right).$$

Here θ_M and θ_μ are the emergent angles of the nucleon and the mesons, and are considered small; in addition, all particles are assumed relativistic. Further considerations depend upon the emergent angles of the particles. Thus for example,

a) one occasionally assumes that

$$\theta_M \sim \theta_\mu \sim M/E. \quad (2)$$

It is easily seen that in this case, with sufficiently high energies, the quantity $q_\parallel$ can become quite small. Thus the effective extent of space within which the process occurs equals, according to the uncertainty relation, $1/q_\parallel$, and can become substantially greater than the extent of the core of one nucleon. More precisely, it is sufficient that

$$q_{||}(1/\mu) \ll 1. \quad (3)$$

Furthermore, if $q_{||}(A^{1/3}/\mu) \ll 1,$ (4)

then this effective region elongates to a distance greater than the dimension of the entire nucleus. In these cases one cannot consider the collision of the incident nucleon and the generation of products as a collision with one nucleon in the nucleus It is necessary to treat it as a process of simultaneous interaction within a "tube" or "channel" which has a cross section of π/μ^2 and which is cut out in the nucleus by the incident nucleon.

From Eqs. (1) - (4) one can easily obtain the conditions for the existence of such a collective interaction. Two cases are possible: 1) $\nu\epsilon \ll E$ and 2) $\nu\epsilon \sim E \sim E - \nu\epsilon$. For both cases, condition (3) has the form, after substitution of Eq. (2) into Eq. (1) and then Eq. (1) into Eq. (3):

$$\frac{M^2}{2E}\frac{1}{\mu} \ll 1, \quad E \gg M\frac{M}{2\mu} \sim 5\cdot 10^9\,\text{eV} \quad (3')$$

[here one requires].
For condition (4), the threshold energy is multiplied by $A^{1/3}$. If the emergent angles are smaller than M/E, then the picture of successive collisions becomes inapplicable even earlier. If

b) the nucleons scatter with angles greater than $\theta_M \sim \sqrt{M/E}$ (isotropic in the center of mass system of both nucleons) then one finds

$$q_{||} \sim M, \quad q_{||}(A^{1/3}/\mu) \gg 1, \quad (5)$$

and the picture of successive collisions can be retained.

c) To the degree to which the impact parameter equals, in the mean, $1/\mu$ and $q_\perp \sim \mu$, then there is greater probability that the scattering angle of the nucleon is $\theta_M \sim \mu/M$. Then the decisive role is played by the emergent angle of the meson, θ_μ. If it equals $\sqrt{M/E}$ (this occurs, for example, in the case of isotropic emission of mesons in the center of mass system), then, as is plausible, the main role is played by the last term in Eq. (1):

$$q_{||} \sim {}^1/_2(M\nu\varepsilon/E).$$

The picture of successive collisions is useful if the meson energy is not very small, that is, if

$$\nu\varepsilon > 2(\mu/M)E. \quad (6)$$

If the mesons are emitted isotropically in the system of rest of the incident nucleon then $\theta_\mu \sim M/E$ and we again revert to case (a) and condition (3).

In this sense, only with a special mechanism of meson emission can we say that, in the realm of energies $E > 5 \times 10^9$ ev, successive collisions of a nucleon with different nucleons occur. The preceding considerations lose their force when $E \gtrsim 10^{12} \div 10^{13}$ ev[3], where the Fermi-Landau process[2] becomes operative.

Translated by A. Skumanich
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[1] See, for example, *Cosmic Rays*, (edited by W. Heisenberg, Dover publications, 1948)

[2] E. Fermi, Progr. Theor. Phys. 5, 570 (1950); Izv. Akad. Nauk SSSR, Ser. Fiz. 17, 51 (1953)

[3] I. L. Rosental and D. S. Chernavskii, Usp. Fiz. Nauk 52, 185 (1954)

Improvement of the Quality of a Cavity Resonator By Means of Regeneration

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N connection with the possibility of constructing a molecular oscillator[1,2] there arises the question of substantially improving the quality of cavity resonators. One possibility which can be utilized for this purpose is the construction of a superconducting type of cavity resonator[3]. Another is the adoption of the well known low frequency radio method of regeneration[4].

In experiments performed by us, a cavity resonator with a Q value of 4×10^4 was employed. This resonator was connected in a positive feedback loop with a microwave amplifier. By gradually increasing the gain modulus, the effective Q of the resonator increased and reached the value 3×10^6. This value was maintained for several hours; while a Q of 5×10^6 could be maintained for only 10 - 20 minutes. The Q values were measured with the help of a quartz frequency standard.

Further increase in the quality is restricted by the lack of stability in the amplifier system, which results from fluctuations in the gain modulus and, in particular, the phase shift.