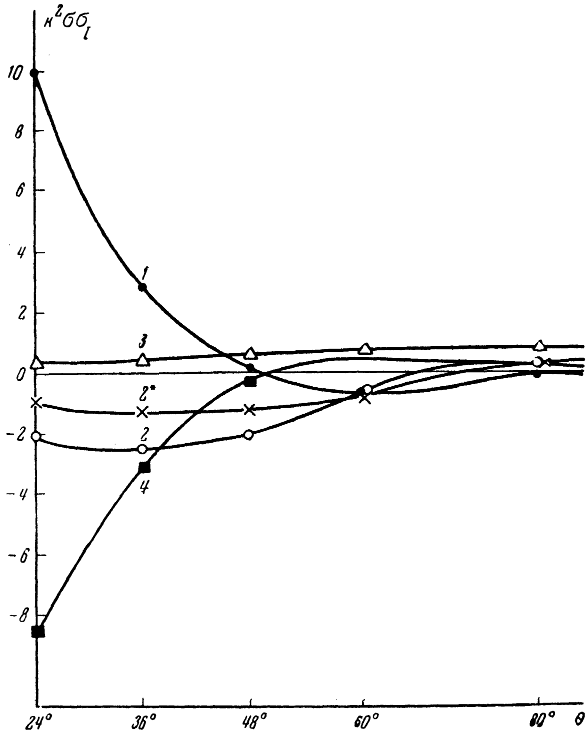

into account the large deviations from the phase values in a given group).

As is shown by phase analysis which takes into account only phases of isotropic states[5] (first approximation), the *S*-phase, for the energy under consideration should have a large negative value. Groups 2 and 2* show agreement with this statement, besides yielding only minor mean square deviations. Groups 1 and 4, whose phases differ greatly from those of 2 and 2*, show a sharply different behavior of σ_I for small angles. This circumstance permits sorting them out by measuring σ_I.

This work has been carried out on the suggestion of Professor Ia. A. Smorodinskii, to whom I wish to express my appreciation. I also wish to thank Professor O. Chamberlain (USA) for furnishing data on phase analysis.

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Translated by D. A. Kellog
248

Polarization of Deuterons in Elastic Scattering

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WE CONSIDER IN THIS WORK several questions concerning the polarization of deuterons during their elastic scattering by nuclei. Lakin[1] and the author[2] made calculations on the polarization of deuterons, but these were based only on general considerations of invariance and did not yield concrete results with regard to polarization. For the interaction potential of the deuteron and the nucleus we shall take (in analogy to the interaction potential of a nucleon with a nucleus[3])

$$V_{dA}(\mathbf{r}) = \int \psi_d^*(|\mathbf{r}_n - \mathbf{r}_p|)[V_{nA}(\mathbf{r}_n) + V_{pA}(\mathbf{r}_p)]\psi_d(|\mathbf{r}_n - \mathbf{r}_p|)\,d(\mathbf{r}_n - \mathbf{r}_p). \quad (1)$$

The interaction potentials for neutrons and protons with nuclei are taken as

$$V_{nA}(\mathbf{r}) = V_0\rho(r) + V_1 \frac{1}{r}\frac{\partial\rho(r)}{\partial r}(\boldsymbol{\sigma}_n\mathbf{L}), \quad (2)$$

$$V_{pA}(\mathbf{r}) = V_0\rho(r) + V_1 \frac{1}{r}\frac{\partial\rho(r)}{\partial r}(\boldsymbol{\sigma}_p\mathbf{L}) + V_c(r). \quad (3)$$

The Coulomb interaction potential of the proton with a nucleus is taken as

$$V_c(r) = \begin{cases} (3R^2 - r^2)Ze^2/2R^3, & \text{for } r < R \\ Ze^2/r, & \text{for } r > R \end{cases} \quad (4)$$

where R is the nuclear radius and Z is the nuclear charge. The spin-orbital Coulomb interaction is not taken into consideration, since it is small compared with the spin-orbital nuclear interaction.

The calculation is carried out by the Born approximation; it is assumed that the deuteron is in the

s-state. The differential scattering cross section of the polarized deuteron beam in this case takes the form

$$I(\vartheta, \varphi) = \left(\frac{2M}{\hbar^2}\right)^2 \left(\frac{4\alpha}{q}\right)^2 \left(\tan^{-1}\frac{q}{4\alpha}\right)^2 \Big\{ |A|^2 + \frac{2}{3}|B|^2 +$$
$$+ 2\sqrt{\frac{2}{3}}\sqrt{\frac{4\pi}{3}}\, \mathrm{Im}\,(AB^+) \sum_M \langle T_{1M} \rangle Y^*_{1M}(\mathrm{n}) + \frac{\sqrt{2}}{3}\sqrt{\frac{4\pi}{5}}\,|B|^2 \sum_M \langle T_{2M} \rangle Y^*_{2M}(\mathrm{n}) \Big\},$$
$$A(\vartheta) = \frac{2V_0}{q}\int_0^\infty j_1(qr)\frac{\partial\rho(r)}{\partial r} r^2 dr + \frac{Ze^2}{R}\Big\{\frac{3}{2}\frac{1}{q^3}\sin qR - \tag{5}$$
$$-\frac{3}{2}\frac{R}{q^2}\cos qR + \frac{3R^2}{2q}\left(1+\frac{2}{(qR)^2}\right) j_1(qR)\Big\},$$
$$B(\vartheta) = \frac{2V_1}{q} k^2 \sin\vartheta \int_0^\infty j_1(qr)\frac{\partial\rho(r)}{\partial r} r^2 dr, \quad q = 2k\sin\frac{\vartheta}{2}, \qquad \mathrm{n} = \frac{[\mathbf{k}, \mathbf{k}_0]}{k^2\sin\vartheta},$$

where M is the mass of the deuteron, $\mathbf{k}_0$ and $\mathbf{k}$ the wave vectors of the deuteron before and after scattering, $j_1(qr)$ the first-order spherical Bessel function, Y_{jM} the associated Legendre polynomials, and T_{jM} the tensor operator of the deuteron spin[1]. Equation (5) can be considered as the formula for double elastic scattering of unpolarized deuterons by nuclei, provided $< T_{1M} >$ and $< T_{2M} >$ are replaced by the value of the deuteron polarization after the first scattering.

If after the first scattering the deuteron travels in the direction of the z axis, while the y axis is perpendicular to the plane of the first scattering, then

$$I(\vartheta, \varphi) = I_0(\vartheta)\{1 + P_{20}(\vartheta) P_{20}(\vartheta_1) + 2P_{11}(\vartheta) P_{11}(\vartheta_1)\cos\varphi + 2P_{22}(\vartheta)P_{22}(\vartheta_1)\cos 2\varphi\}, \tag{6}$$

where

$$P_{20}(\vartheta) = -\frac{1}{3\sqrt{2}}\frac{|B|^2}{|A|^2 + {}^2/_3|B|^2} = \langle T_{20}\rangle,$$
$$iP_{11}(\vartheta) = -\frac{2i}{\sqrt{3}}\frac{\mathrm{Im}\,(AB^+)}{|A|^2 + {}^2/_3|B|^2} = \langle T_{11}\rangle,$$
$$P_{22}(\vartheta) = -\frac{1}{2\sqrt{3}}\frac{|B|^2}{|A|^2 + {}^2/_3|B|^2} = \langle T_{22}\rangle.$$

The differential cross section for the unpolarized deuterons is

$$I_0(\vartheta) = \left(\frac{2M}{\hbar^2}\right)^2\left(\frac{4\alpha}{q}\right)^2\left(\tan^{-1}\frac{q}{4\alpha}\right)^2\Big\{|A|^2 + \frac{2}{3}|B|^2\Big\}, \tag{7}$$

where ϑ_1 and ϑ are the angles of the first scattering and of the corresponding second scattering. Equation (6) contains those quantities which characterize the interactions of nucleons with nuclei.

Assuming that each nucleon of the moving deuteron has half the energy of the deuteron (the experiment was carried out[5] with deuterons of high energy – 167 Mev), and calculating the interaction potential by using the optical model of the nucleus[6], we obtain for the central part of the potential

$$V_0\rho(r) = \begin{cases} -(28 + i16)\ \text{Mev}, & \text{for } r < R \\ 0, & \text{for } r > R \end{cases}$$

If we take the spin-orbital part of the potential to be 15 times larger than the Thomas expression for the real part of the central potential[7], then

$$V_1 = 9 \times 10^{-26}\ \text{Mev cm}^2.$$

If both scatterings occur in carbon, and the scattering angles ϑ_1 and ϑ are both 20°, Eq. (6) takes the form

$$I(20°, \varphi)$$
$$= (p + q\cos\varphi + r\cos 2\varphi) \times 10^{-27}\ \text{cm}^2/\text{steradian}$$

where $p = 18.1$, $q = 5.5$, $r = 2.4$. The following results were obtained experimentally: $p = 50.3 \pm 2.2$, $q = 15.3 \pm 1.9$, $r = -1.8 \pm 3.6$. The experimental statistical errors are correct only as concerns the relative values of p, q, and r, and not as regards absolute values.

The $p : q$ ratio obtained above agrees with experiment, but the $p : r$ ratio is somewhat low.

Reference 8 gives the results of double scattering of deuterons into various scattering angles by various scattering materials. We have made a comparison for the case where both scattering targets are carbon and the deuteron energy is 156 Mev.

For this experiment the first scattering angle was 16°. The second scattering angle was varied in the interval 11° to 28°. For a second scattering angle greater than 16°, there is satisfactory agreement with the experimental results in the $p : q$ ratio. For smaller angles the agreement breaks down, and our calculation of the coefficient r of the term $r \cos 2\varphi$ comes out to be several times larger than the experimental value.

As is proposed in Ref. 1, it is necessary to consider that the state of the deuteron makes a major contribution, and leads to the diminuation of the coefficient r in front of $\cos 2\varphi$.

I wish to express my thanks to Professor G. P. Khutsishvili for his never-failing interest in the work and for his valuable discussions.

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Translated by D. A. Kellog
249

Some New Possibilities of Ionic Phenomena in Metastable Liquids

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IONIZING PARTICLE TRACKS are produced in the usual bubble chambers[1] through the budding of nucleation voids directly accompanying the passage of ionizing particles, and are generated as the result of ponderomotive micro-entrainment among the accumulated mutually repelling ions or else as the result of micro-explosions due to local heating. The short lifetime of these phase nuclei does not permit their use for delayed track production, which to a certain extent limits the usefulness of the usual bubble chambers, assuming only semiautomatic registration of particles in preliminary saturation. (This condition increases interest in the investigation of the density, lifetime and dynamic growth of these *primary* phase centers, and in attempts at very high speed photographic registration of the tracks, such as could be done by using pulses from highly sensitive electro-optical tubes[2] or by other optical recorders, activated by the scattering or the emission of light by these optical inhomogeneities. Such inhomogeneities arise virtually along the entire particle track, not only under metastable conditions, but even without pressure drops, in stable heated or aerated liquids, for example, near the boiling point, and especially strongly near the critical point).

A series of suggested methods for the proposed accomplishment of the automatic operation of bubble chambers employs the possibility of formation of *secondary* centers for the initiation of the action on the remaining ions. Among such methods are, for example, the proposal[3] to use the local energy liberated upon the recombination of ions, the formation of phase nuclei through dissipative drifting of ions in an external electric field or else in the field of an approaching ion of opposite charge, attempts at influencing the ions by high frequency electromagnetic waves[4], *etc.*, using various ways of changing the dynamics of recombination of the ions by the application of an external electric field.

Without stopping to evaluate the effectiveness of these methods for various working liquids in bubble chambers, let us examine possible new methods of revealing the presence of single ions, based on the stratification of a working liquid composed of heterogeneous components in ion fields.

Let us assume that the molecules of a profusely dissolved substance (for example, a gas, vapor or liquid) possess a dipole moment markedly exceeding the dipole moment of the solvent liquid. Then the strong inhomogeneous electric field due to ion formation leads to a sharp change in the concentration of the solution in the vicinity of the ions (local enrichment or quasi-liquid complex formation). If the lifetime of the ion exceeds the time needed to establish localized statistical diffusion equilibrium (and it is indeed these relatively long-lived ions, for which this condition is known to be fulfilled, that we are interested in), then in accord with the Boltzmann formula the local concentration of the solution at a distance r from the center of