for hydrogen, however, are in satisfactory agreement with the results of Ball[6], who, unlike[4], took account of the contribution of the D wave.

The comparison of the theory with the experimental data for deuterium is simplified in many respects if the latter data are represented in the form of a ratio of the cross sections for the photoproduction of neutral pions on deuterium and on hydrogen. In Table II these data for the angles $\theta_\pi \sim 0°$ are compared with the ratios of the cross sections calculated in the impulse approximation. In Table II are given only the statistical errors, while all other possible experimental errors arising in the calculation of the ratio cancel out.

Table II. Ratio of cross sections for the photoproduction of neutral pions on deuterium and on hydrogen

$\bar{\varkappa}$, MeV	$\left(\frac{d\sigma_d}{d\sigma_p}\right)_{\text{exp}}$	$\left(\frac{d\sigma_d}{d\sigma_p}\right)_{\text{theor}}$	$\overline{\cos\theta_\pi}$
190	3.12 ± 0.40	2.28	0.938
224	2.43 ± 0.13	2.50	0.966
250[7]	2.34 ± 0.33	2.58	0.999

The theoretical ratios of the cross sections of the elastic photoproduction process on deuterium to the photoproduction cross section on hydrogen are calculated with greater rigor than in [1]. At angles $\theta_\pi \sim 0°$ the principal role is apparently played by the elastic photoproduction on deuterium. If we take into consideration the fact that the spin-independent part of the matrix element for photoproduction on a nucleon $|L|^2$ is proportional to $4\sin^2\theta_\pi$ and the spin-dependent part is $|K|^2 \sim (1+\cos^2\theta_\pi)$, and if we assume that $K_n = K_p$ and $L_n = L_p$, then we get in the impulse approximation

$$\frac{d\sigma_d^{\text{el}}}{d\sigma_p} = a\,\frac{8}{3}\,F^2(q)\,\frac{2+5\sin^2\theta_\pi}{2+3\sin^2\theta_\pi},$$

where a is a coefficient that depends on the momentum of the photon and the meson, and on the mass of the target nucleus in each of the processes, while $F(q)$ is the form factor of the deuteron.

It follows from Table II that for angles $\theta_\pi \sim 0°$ the experimental results are in good agreement with the theoretically calculated ratios for energies from approximately 200 to 250 MeV. This means that in these conditions the contribution of the inelastic process and of multiple scattering[8] lies within the experimental error. At energies below 200 MeV, the experimental result exceeds the theoretical value by more than two standard deviations. Taking into account the foregoing remark, we can assume that the existing discrepancy is connected with the contribution of the neutral pions produced by scattering with charge exchange of the π^0 mesons, inasmuch as it is known that at small energies $\sigma_\pm \gg \sigma_0$.

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SENSITIVITY OF LIQUID TO RADIATION

Yu. A. ALEKSANDROV, G. S. VORONOV, and N. B. DELONE

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

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A sensitivity of liquids to radiation was observed by Glaser, who showed that vapor bubbles can be produced in a liquid along the path of a charged particle. For this purpose the liquid must have a definite temperature and must be superheated in suitable fashion.

From the experiments described below, it follows that the liquid can be sensitive to radiation also in the nonsuperheated state, if at the instant of passage of the charged particles in the liquid the pressure is reduced with sufficient speed.

The experiments were made with a bubble chamber filled with propane. Commercial propane was used, containing light and heavy impurities. By distilling off the light impurities the commercial propane was brought to a state in which the saturated vapor curve corresponded to the tabulated values for pure propane. The experiments were carried out at a propane temperature 68°C (saturated vapor pressure 23 atm), and the initial pressure was 34 atm; the pressure was decreased within a time of about 20 milliseconds to a value between 13 and 19 atm. The liquid was irradiated during the time that the pressure was reduced with the aid of a pulsed source of gamma quanta from radioactive Co^{60}.[1] The duration of the radiation pulse was about 2.0 milliseconds, that is, much shorter than the duration of the period during which the pressure was decreased. The instant of irradiation could be varied, so that the liquid could be irradiated at different pressures. The change in pressure in the liquid was registered by a membrane capacitive pressure transducer. The pressure irradiation, and chamber illumination were observed on an oscilloscope and photographed.

Experiments aimed at studying the sensitivity of the liquid to radiation as the pressure in it was decreased yielded the following basic results: 1) the vapor bubbles are initiated by the radiation in a nonsuperheated liquid; 2) the vapor bubbles grow in the nonsuperheated liquid to a dimension at which they can be observed ($\sim 10^{-2}$ cm); 3) the sensitivity (the number of bubbles observed per unit liquid volume, the track density) is determined by the rate at which the pressure is decreased and by the absolute value of the pressure in the liquid at the instant of irradiation. The sensitivity is the larger, the larger dP/dt and the smaller P. A sensitivity was observed at dP/dt from 0.3 to 2.0 atm/sec.

A set of control experiments was also carried out.

The correctness of the measurement of the pressure by a membrane capacitive transducer was checked with the aid of a non-inertial piezoelectric pressure transducer. The readings of both transducers were identical.

The sensitivity of the piezoelectric transducer to high frequency pressure oscillations was checked. Such oscillations can arise in the form of shock waves during the time that the pressure is reduced, and might superheat the liquid. The sensitivity was checked by exciting high frequency oscillations in the liquid simultaneously with the usual pressure-reduction process. It was established that the piezoelectric transducer is sensitive to high frequency oscillations in that part of the period of pressure reduction during which the main measurements were made.

A sharp short-duration decrease in the rate of pressure reduction was produced during the instant of irradiation[2] (without appreciable change in the total duration of the time of pressure reduction). In this case the liquid ceased to be sensitive to radiation.

The control experiments confirmed that the sensitivity of nonsuperheated liquid to radiation is observed when the pressure is reduced in it.

The corresponding theoretical notions concerning the mechanism of the sensitivity (both the ionic[3] and the thermal[4] models) have been developed for the case of a superheated liquid at constant pressure. To explain the mechanism whereby nonsuperheated liquid becomes sensitive to radiation when the pressure in it is decreased we can advance for the time being only the following qualitative considerations.

When the charged particle moves through the liquid it loses part of its energy to local heating of the liquid, producing at the same time the nucleation bubbles of various dimensions. The formation of nucleation bubbles occurs in both superheated and nonsuperheated liquid. If it is assumed that the reduction in pressure contributes to the growth of the bubbles, then the greater the rate at which the pressure is decreased, the smaller the dimensions of those nucleation bubbles which can grow, and consequently the larger the sensitivity.

It must also be borne in mind that propane is a contaminated liquid. Consequently, any experimental results, both affirmative and negative, obtained with mixtures with different contents of components and particularly in liquid known to be pure (for example hydrogen) will be quite valuable.

The results of this work point to a new way of producing an ultrasonic bubble chamber[2]. In addition, operation in this mode makes it possible to decrease appreciably the expansion coefficient, an important factor for large chambers.

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POSSIBILITY OF OBSERVING NEUTRAL CURRENTS IN NEUTRINO EXPERIMENTS

S. S. GERSHTEĬN, NGUYEN VAN HIEU, and R. A. ÉRAMZHYAN [1)]

Joint Institute for Nuclear Research

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A weak interaction scheme, which contains along with the product of the charged currents [1,2] also the product of neutral currents, was proposed and discussed by several authors [3-6]. Schemes of this type, for example the Bludman scheme, have the same degree of beauty as the Feynman–Gell-Mann scheme, and do not lead to the appearance of experimentally unobservable decays of the type $\mu \to 3e$, $K \to \pi + 2e(2\nu)$, etc, since they contain "symmetrical" neutral currents of the type $(\nu\nu)$ and (ee), and do not contain "asymmetrical" ones such as (μe) and $(K\pi)$ (see [6]). The experimental detection of neutral currents in weak interactions is very important both from the point of view of checking the correctness of the weak-interaction scheme, and from the point of view of applications to astrophysical phenomena (inasmuch as the existence of neutral currents can lead to very effective mechanisms of emission of $\nu\bar{\nu}$ pairs by stars [6]). However, experiments proposed for the observation of neutral currents on the basis of effects of parity non-conservation and scattering of electrons by nuclei [4] or in electron-electron scattering [5] are quite difficult.

We wish to remark that possibly a more realistic method of observing neutral currents are neutrino experiments. The existence in the weak-interaction Lagrangian of terms in the form

$$L' = \frac{G}{\sqrt{2}}(\bar{\nu}\,\hat{O}\,\nu)(\bar{N}\,\hat{O}\tau_3 N), \qquad \hat{O} = \gamma_\mu(1+\gamma_5), \tag{1}$$

which was proposed in the papers of Bludman [3] and Zel'dovich [4], should lead, in the case of the scattering of high-energy neutrinos by nuclei, to the appearance of lepton-free stars due to the interaction

$$\nu + N \to \nu + N. \tag{2}$$

At neutrino energies near 1 BeV, the cross section of this process should be on the order of 10^{-38} cm^2 and consequently this process can undoubtedly be noted in the presently performed neutrino experiments at high energies.

On the other hand, apparently, there is a possibility of verifying the existence of interaction (2) in experiments with low-energy anti-neutrinos (from a reactor). Indeed, interaction (2) should lead to the excitation of the nuclear levels

$$\bar{\nu} + Z \to \bar{\nu} + Z^*, \tag{3}$$

which can be detected by the characteristic radiation $Z^* \to Z + \gamma$. The differential cross section for the scattering of a neutrino by an angle θ with excitation of a nucleus, in the case of interaction (1), has the form

$$d\sigma/d\Omega = (2\pi)^{-2} G^2 \Big[a_0(1+\cos\theta) + b_0\Big(1 - \tfrac{1}{3}\cos\theta\Big)\Big](E_\nu - \Delta E)^2, \tag{4}$$

where

$$a_0 = \Big|\int d\tau \langle Z^* \Big| \sum_A \tau_3 e^{i\mathbf{kr}} | Z\rangle\Big|^2,$$

$$b_0 = \Big|\int d\tau \langle Z^* \Big| \sum_A \tau_3 \sigma e^{i\mathbf{kr}} | Z\rangle\Big|^2, \tag{5}$$

ΔE is the excitation energy of the nucleus, E_ν is the anti-neutrino energy. From formulas (5) we see that for the antineutrino in reactor experiments the vector variant does not make a contribution to the cross section, since $a_0 = 0$ owing to the orthogonality of the wave functions Z and Z*. The total excitation cross section is

$$\sigma = \frac{G^2}{\pi} b_0 (E_\nu - \Delta E)^2. \tag{6}$$

The value of the cross section (6) is of the same order as the cross section of the process $\bar{\nu} + p \to e^+ + n$ in the experiments of Reines and Cowan [7].

By way of an example we have considered the excitation of the Li^7 nucleus. The ground state of Li^7 has the characteristics $J = 3/2^-$, $T = 1/2$; the first excited level has $J = 1/2^-$ and $T = 1/2$; the excitation energy is $\Delta E = 480$ keV. In the calculation of b_0 the wave functions of the ground and excited states were obtained by mixing the configurations with the pair potential in the form of a Rosenfeld exchange variant with parameters $\xi = -2.1$ MeV,