tion of the reaction $p + \tilde{V} \rightarrow n + e^+$ equal to 6×10^{-42} cm^2, corresponding to an antineutrino energy ~10 MeV, approximately 50 antineutrinos will react in 1000 t of a compound of the $(CH_2)_n^-$ type. The energy of each of the reacting antineutrinos can be determined from the magnitude of the flash produced by the fast positron. It is thus possible, in principle, to determine separately the average arrival times of the neutrinos of lower and higher energies.

Observation of neutrinos from supernovas of neighboring galaxies would greatly shorten the expectation time of the flash, and would make it possible to decrease still further the upper limit of the neutrino mass (owing to the increase of T).

The amount of hydrogen containing matter needed to observe extragalactic neutrino flashes is tremendous (more than 10^6 t). Such an experiment is probably better performed by using not the scintillations of an organic liquid, but the Cerenkov radiation of water deep in the ocean, for which, however, photomultipliers with very large cathode surfaces are needed (with total area $>10^3$ m^2).

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THEORETICAL ANALYSIS OF REACTIONS OF THE (p, pd) TYPE

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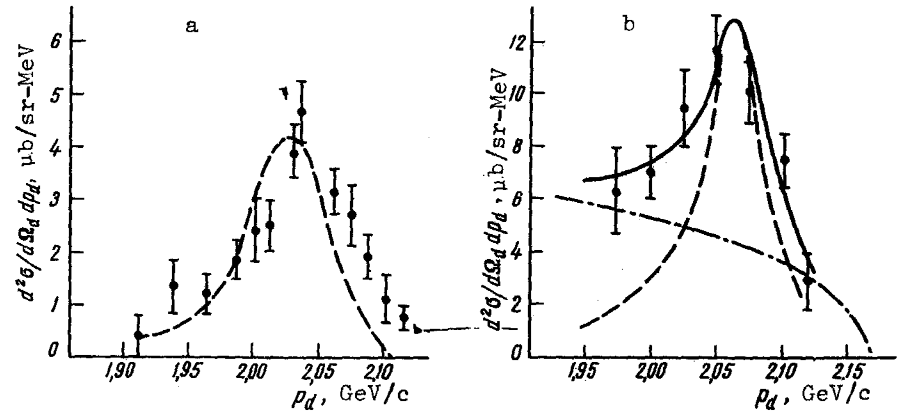
The present paper is devoted to a theoretical analysis of new data obtained by the Palevsky group [1] on the momentum spectra of deuterons emitted at a fixed angle to the initial beam in the reactions $He^4(p, pd)H^2$ and $O^{16}(p, pd)N^{14}$ at proton energies 1 GeV. An experiment of this type was first performed at the Joint Institute for Nuclear Research at 675 MeV [2], and showed that a reaction of the (p, pd) type has a quasielastic character. An analysis presented in [3] has made it possible to establish a qualitative agreement between the data of [2] with the pole mechanism. It was also indicated there that the theoretical momentum spectra turn out to be narrower than the experimental ones when account is taken of the finite dimensions of the nucleus.

A similar situation takes place at 1 GeV energy - the pole mechanism predicts a momentum spectrum half as wide as the experimental one (see below) for the deuterons from the reaction $O^{16}(p, pd)N^{14}$, emitted at an angle 4.38° to the direction of the incident protons. Allowance for the excited states of the residual N^{14} nucleus at the given kinematics barely changes the shape of the curve and does not improve the agreement between theory and experiment.

However, contributions to the amplitude of the (p, pd) process are made not only by the pole diagram but also by more complicated diagrams that vary slowly as functions of the mo-



Momentum spectrum of deuterons emitted in the reactions: a - $He^4(p, pd)H^2$ at an angle 10.1°, b - $O^{16}(p, pd)N^{14}$ at an angle 4.38°.

mentum transfer. Their contribution can be replaced approximately by a constant. Thus, we arrive at the representation of the amplitude of the (p, pd) reaction in the form of a pole term and a constant C, the magnitude of which is determined from the condition of best agreement between the theory and the experimental data. The constant was chosen to be pure imaginary, i.e., the interference term was eliminated. For the square of the matrix element of the reaction, averaged over the spin states of the initial and final particles,

$$\overline{|M|^2} = \overline{|M_{pol}|^2} + |C|^2, \tag{1}$$

where $|M_{pol}|^2$ corresponds to the pole diagram. For the differential cross section we get the expression

$$\frac{d^2\sigma}{dp_d\,d\Omega_d} = \frac{m_p p_d^2}{2\pi p_p\sqrt{p_d^2+m_d^2}\sqrt{p_p^2+p_d^2-2p_p p_d\cos\theta_{pd}}} \left\{\frac{27\theta^2}{R}\left(\frac{d\sigma_0}{d\Omega}\right)\int_{q_{min}}^{q_{max}}\frac{|f(q)|^2}{(q^2+\kappa^2)^2}\,q\,dq + \frac{m_p^2|C|^2}{(2\pi)^3}\left[q_{max}^2 - q_{min}^2\right]\right\}. \tag{2}$$

Here p_p, m_p, and p_d, m_d - momenta and masses of the incoming proton and emitted deuteron, q - modulus of the momentum of the residual nucleus in the laboratory frame, $\kappa^2 = 2m_B m_d \epsilon/(m_B + m_d)$, the indices A and B pertain throughout to the initial and final nucleus, ϵ - binding energy of the deuteron in nucleus A, $d\sigma_0/d\Omega$ - differential cross section of elastic pd scattering [4], θ^2 - reduced deuteron width of nucleus A, R - radius of channel A → B + d,

$$f(q) = \cos qR + \frac{\kappa}{q}\sin qR, \tag{3}$$

θ_{pd} - angle between the direction of the incident protons and the produced deuterons, q_{min} and q_{max} - minimum and maximum values that can be assumed by the momentum of the residual nucleus at specified θ_{pd} and p_d (expressions for them are given in [3]).

We note that q_{max} is much larger than κ - the characteristic momentum of the deuterons in nucleus A. Therefore the second term in (2) can make an appreciable contribution even in the case when pole mechanism predominates (i.e., when the first term of (1) is much larger than the second).

The figure shows the results of the calculation of the momentum spectra of the deuterons from the reactions $He^4(p, pd)H^2$ at $\theta_{pd} = 10.1°$ (Fig. a) and $O^{16}(p, pd)N^{14}$ at $\theta_{pd} = 4.38°$ (Fig. b). The dashed curves represent calculation in accordance with the pole diagram (i.e., at C = 0). Figure a shows that the dashed curve agrees well with the experimental data of [1]. The deep minimum in the experimental data in the left side of the spectrum offers evidence that the contribution of the remaining diagrams is small in this case. The dash-dot line in Fig. b represents the contribution of the second term of formula (2), and the solid line the result of calculation with both terms of (2) taken into account. From the condition of best agreement between the solid curve and the experimental results, the value obtained for the constant C is such that at low momentum transfers its modulus is ~1/15th of the entire amplitude.

In determining the values of the reduced deuteron widths, it must be borne in mind that we do not know what fraction of the fast deuterons produced in the reaction $He^4(p, pd)$ is accompanied by emission of a slow deuteron, and what part is accompanied by emission of a neutron and a proton. We can therefore only estimate for He^4 a certain total deuteron width. It is found to be 9.0 ± 2.0. In the case of the $O^{16}(p, pd)N^{14}$ reaction we do not know the fractions of the cases in which the N^{14} nucleus is produced in the ground state and in the excited states. We do know, however, that in ~40% of the cases of the $C^{12}(p, pd)B^{10}$ reaction the residual nucleus remains in states with excitation energy ≤ 5 MeV [1]. If it is assumed that the same situation obtains for the $O^{16}(p, pd)N^{14}$ reaction, then for oxygen $\sum_i \theta_i^2 = 4.7 \pm 1.0$, the summation being carried out over the states of the N^{14} nucleus with excitation energy ≤ 5 MeV. In view of the lack of the necessary experimental data, it is impossible at present to compare these values of the reduced widths with analogous quantities obtained from other experiments.

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