A permalloy screen served as the source of the arionic field. A volume with mercury vapor and a coil for creating an auxiliary magnetic field of $H_0 \sim 0.1$ Oe, in which the initial measurement of the ratio γ_1/γ_2 of the precession frequencies of the nuclei was performed, were placed inside the screen. Then the screen was magnetized with an external field $H_\alpha \| H_0 (H_\alpha \sim 100$ Oe). In this case, the arionic field of polarized electron spins in the screen acted on the mercury nuclei, while the magnetic field of these spins and of the external inductor compensated one another with an accuracy up to the small quantity H_α/k, where $k \gg 1$ is the screening factor. Thus, the precession frequencies of the nuclei varied insignificantly due to the penetration of the magnetic field H_α/k through the screen, and this facilitated the precision measurement of their ratio.

The arionic interaction was not observed in the experiment. The accuracy achieved permits asserting that the magnetic interaction of mercury 199 nuclei with electron spins is at least a factor of $10^{11}\lambda$ times stronger than the hypothetical arionic interaction. Here, λ is the parameter calculated with the known wave function of the nuclei:

$$\lambda = \frac{\gamma_2}{\gamma_1} \frac{\langle {}^{201}\mathrm{Hg} | \hat{\Sigma} | {}^{201}\mathrm{Hg} \rangle}{\langle {}^{199}\mathrm{Hg} | \hat{\Sigma} | {}^{199}\mathrm{Hg} \rangle}, \quad \hat{\Sigma} = \sum_p \sigma_p - \sum_n \sigma_n.$$

The summation in the operator $\hat{\Sigma}$ extends over the protons and neutrons of the corresponding nucleus. The use of a rough model for the mercury nucleus gives $\lambda = 0.1$. In terms of the parameters x_i introduced above, the upper limit obtained on the product $x_e x_q$ has the following form for electrons and quarks:

$$x_e x_q < 2.5 \cdot 10^{-8}.$$

In the future, we propose to repeat the experiment with a different pair of fermions, which would permit a more reliable calculation of the parameter λ.

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D. A. Kirzhnits and F. M. Pen'kov, *Coulomb interaction of composite particles.* The interaction of bound complexes consisting of charged particles at distances $r \gg R$ (R is the radius of the complex) is described with the help of the well-known expressions for the polarization potential (PP), which includes the potential of the van der Waals forces. In particular, the PP

$$V(r) = -\frac{e^2\alpha(0)}{2r^4} \qquad (1)$$

describes the simplest case, namely, the interaction of a structureless particle of mass m and charge e with a complex particle with polarizability $\alpha(\omega)$. This PP is usually applied to electron-atomic systems, for which the mass m coincides with the mass of the "valence" particles of the complex M, which determines its size.

In recent years, there has been great interest in problems concerning the interaction of a *light* particle with $m \ll M$ with a compound particle ("pion or lepton + nucleus", "electron + mesoatom", "muon + molecule", "lepton + hadron as the bound state of quarks" systems). It turns out that in this case the (1) is valid only at large distances $r \gg R\sqrt{M/m}$, while in the range

$$R \ll r \ll R\sqrt{M/m}$$

a PP with a different form arises:

$$V(r) = -\frac{me^2\langle d^2\rangle}{(3\hbar^2 r^2)}, \qquad (2)$$

acting only in the s-state of the orbital motion of the particle (d is the dipole moment of the complex and the brackets indicate averaging over its ground state).[1]

The PP (1) arises as a result of the excitation of internal motion in the complex (its polarization) by the particle, while PP (2) appears as a result of the excitation of the orbital motion of the particles by zero-point vibrations of the dipole moment of the complex. The proportionality of PP (2) to the mass of the particle, showing that gravitational forces are not the only forces satisfying the principle of equivalence, is remarkable.

Expression (2) was obtained in the nonrelativistic approximation, which requires that the condition

$$\left(\frac{\hbar}{McR}\right)^2 \ll \frac{m}{M} \ll 1$$

be satisfied. For this reason, PP (2) does not describe the interaction of a very light particle with a complex particle (for example, electron with a hadron). Another assumption that lies at the basis of the result (2) is the "rigidity" of the complex

$$g = \frac{m^2e^2\langle d^2\rangle}{\hbar^4} \ll 1.$$

However, the $1/r^2$ dependence remains in the case $g \gtrsim 1$ as well and, for this reason, when some value of g of the order of unity is reached, a situation of "falling toward the center" appears. This leads to the appearance of a series of bound states, whose properties are similar to the well-known Efimov levels in the nuclear three-body problem.

With the help of Eqs. (1) and (2), it is easy to calculate the polarization contribution to the phase of the particle scattered by the complex and to the energy of their bound state. This contribution is determined by the moment $\sigma_{-3/2}$ of the density of oscillator strengths, which is an intermediate quantity relative to the moments σ_{-2} and σ_{-1} entering, respectively, into (1) and (2), where $\sigma_n = \int_0^\infty d\omega\omega^{n+1}$ Im $\alpha(\omega)$. This fact was previously encountered in the direct calculation of the polarization shift of the levels.[2] The simple equations for the system "pion or muon + deuteron" can serve as an illustration of the foregoing.[1]

In conclusion, we note that a modification of the van der Waals forces (interaction "complex + complex"), similar to that examined above, is possible only when very rigid conditions are satisfied.

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M. M. Makarov, G. Z. Obrant, and V. V. Sarantsev, *Splitting of the deuteron by π-mesons with intermediate energies*. The interest in interactions of intermediate-energy π-mesons with deuterons stems from several factors.

a) possibility of making progress in understanding the mechanism of the process in the region where the Glauber-Sitenko diffraction theory is inapplicable[1];

b) solution of the problem of dibaryon resonances[2] and observation of quarks in nuclei[3];

c) clarification of the role played by π-mesons in the formation of cumulative nucleons accompanying the interaction of high-energy hadrons with nuclei.

The mechanism of the process of splitting of the deuteron by pions with energies of several hundred MeV is determined primarily by single scattering of a π-meson by nucleons in the deuteron, by interaction of two nucleons in the final state, and by double rescattering of the pion.[4] Amplitudes with rescattering multiplicity exceeding two make a small contribution due to the fact that the conditions for the impact approximation are satisfied[5] ($U\tau \ll 1$, U is the characteristic nuclear potential in the deuteron) and due to the smallness of the parameter $\sigma_{\pi N}/4\pi R^2$ ($\sigma_{\pi N}$ is the pion-nucleon scattering cross section, R is the radius of the deuteron). Each of the three contributions mentioned above has distinguishing features, according to which it can be identified in the experiment. The single-scattering amplitude has a characteristic peak at 45 MeV/c in the momentum distribution of the nucleon, not participating in πN scattering (the nucleon is a "spectator"). The interaction of two nucleons in the final state has a peak at low relative proton-neutron energies and rapidly "dies away" with increasing momentum q transferred to the pion. The double scattering amplitude of π-mesons has a sharp singularity with respect to the energy variable ΔE, corresponding to nonconservation of energy with the transition from the initial state into the intermediate state at a distance of the nucleon at rest in the deuteron (peak with $\Delta E = 0$).[4] A general feature of the physics of the interaction of pions with energies of several hundred MeV with a compound system is the presence of a Δ (3,3) resonance in the πN amplitude, which greatly increases the contribution of double scattering.

Figures 1 and 2 show some results of an experiment on studying the process $\pi^- d \to \pi^- pn$, performed at the Leningrad Institute of Nuclear Physics of the USSR Academy of Sciences using the 35-cm deuteron bubble chamber,[6-9] as well as their description by a theory that includes multiple and double interaction of particles, as well as the Fermi motion of the nucleons. The momentum spectra (see Fig. 1) of the neutrons (on the left) and protons (on the right) with an initial pion momentum of 438 MeV/c in different parts of the phase volume with respect to the transferred momentum q (the entire range of q (a); $q > 0.3$ GeV/c (b); $q > 0.4$ GeV/c (c); $q > 0.5$ GeV/c (d); and, $q > 0.6$ GeV/c (e)) demonstrate the contribution of different amplitudes to the process. The initial neutron spectrum (see Fig. 1) shows that the regions dominating the different amplitudes strongly overlap and the peak at the momentum $\approx$45 MeV/c from the "spectator" neutron is manifested very weakly against an intense background of other processes. After the small transferred momenta q are excluded (in this case, recoil neutrons in the amplitude with the "spectator" proton are excluded in the soft part of the spectrum), this peak begins to dominate for small momenta and a single amplitude with the "spectator" neutron is thus singled out. It is evident from a comparison of the theoretical curves in Fig. 1c and the experimental dis-