$$(M_1 - M_0) = 23 \text{ MeV}, \quad \Gamma > \Gamma_\ell = 40 \text{ MeV}.$$

Thus, the proposed multicurrent model of weak interactions, including neutral currents, is of physical interest.

In conclusion, we note briefly still another alternate possibility, also peculiar to the multicurrent theory, which may turn out to be of interest in connection with searches for intermediate bosons. It is easy to verify that with increasing number of the parameters of the bare masses of the intermediate bosons it is possible, at will, to violate the universality of the nondiagonal interactions, by greatly suppressing some single "violating" group compared with others. If at the same time the levels of the masses of the intermediate bosons do not overlap, then, in view of the absence of interference phenomena, this suppression will generally not take place in decays of real intermediate bosons. Then, one cannot exclude in these decays considerable violations of the known weak-interaction selection rules, the conservation laws of certain charges, etc. One cannot exclude, for example, the possibility that channels of W-boson decays with single strange particles, with violation of the conservation of the lepton charge, of the rule $\Delta S = \Delta Q$, or others, will turn out to be not suppressed. In spite of the apparent artificiality of the latter possibilities, they should not be rejected a priori, since suprises can be expected at the threshold of W-boson production.

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GIANT RESONANCE IN THE FERMI-LIQUID DROP MODEL

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Collective excitations of nuclei can be connected, as is well known, both with changes in the shape of the surface of the nucleus, and with vibrations of all the nuclear particles, i.e., they can have a volume character. If the nucleus is sufficiently heavy, then surface effects can be disregarded in the analysis of its volume oscillations, and these oscillations can be treated as oscillations of the nuclear matter [1 - 3]. The giant resonance in nuclear reactions is connected with excitation of such vibrations.

To interpret the giant resonance in concrete nuclei and to compare the results of the theory with the experimental data, it does not suffice, of course, to consider the nucleus as an infinite system and it is necessary to take into account the finite dimensions of the nucleus.

The present communication is devoted to allowance for the finite dimensions of the nucleus in the Fermi-liquid model and to a comparison of the conclusions of the theory with the experimental data concerning the position of the giant dipole resonance in photonuclear reactions. We regard the nucleus as a spherical drop of a Fermi liquid[1], and take into account both purely nuclear and electric forces acting between the nucleons of the nucleus [3].

The Fermi liquid can be described [5] by a distribution function of the quasiparticles with respect to the momenta and coordinates $n(\vec{p}, \vec{r}, t)$, which is the density matrix with respect to the spin and isotopic variables. The equilibrium state corresponds to the Fermi distribution function $n_0(\vec{p}) = \theta(\zeta - \varepsilon_p)$ (ζ is the end-point energy, $\theta(x) = (1 + \operatorname{sign} x)/2$. At not too large deviations from equilibrium, the distribution function satisfies the kinetic equation

$$\left(\frac{\partial}{\partial t} + \frac{\partial \epsilon}{\partial \mathbf{p}} \frac{\partial}{\partial \mathbf{r}}\right)\delta n - \frac{\partial n_0}{\partial \mathbf{p}} \frac{\partial}{\partial \mathbf{r}}\left\{ \mathrm{Sp}_{\vec{\sigma}'\vec{\tau}'} \int \mathcal{F}(\mathbf{p}, \mathbf{p}')\delta n(\mathbf{p}', \mathbf{r}, t) \times \frac{d^3 p}{(2\pi)^3} + e\frac{1 + \tau_3}{2} \phi(\mathbf{r}, t)\right\} = 0, \tag{1}$$

where $\delta n = n - n_0$,

$$\mathcal{F}(\mathbf{p}, \mathbf{p}') = \mathcal{F}^{(0)} + \mathcal{F}^{(s)}\vec{\sigma}\vec{\sigma}' + \mathcal{F}^{(i)}\vec{\tau}\vec{\tau}' + \mathcal{F}^{(si)}\vec{\sigma}\vec{\sigma}'\vec{\tau}\vec{\tau}'$$

is a function describing the short-range nuclear interaction of the quasinucleons, ($\vec{\sigma}/2$ and $\vec{\tau}/2$ are the spin and isospin operators), and $\phi(\vec{r}, t)$ is the potential of the alternating electric field, connected with the distribution function of the quasinucleons by the Poisson equation

$$\Delta\phi(\mathbf{r}, t) = - 4\pi e \mathrm{Sp}_{\vec{\sigma}\vec{\tau}} \int \frac{1 + \tau_3}{2} \delta n(\mathbf{p}, \mathbf{r}, t) \frac{d^3 p}{(2\pi)^3}. \tag{2}$$

Equation (1) is a generalization of the well-known Landau-Silin equation [5, 6].

For a bounded Fermi liquid it is necessary to add to Eq. (1) (which holds inside the Fermi liquid) also a condition describing the behavior of the distribution functions on the surface of the nucleus. In the case of vibrations with a free boundary, we have the condition[2]

$$\frac{\partial}{\partial r} \delta n(\mathbf{p}, \mathbf{r}, t) = 0, \quad r = R \tag{3}$$

(R is the radius of the nucleus).

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[1]An attempt was made recently [4] to interpret giant resonance in inelastic scattering of electrons by the O^{16} nucleus by regarding the nucleus as a drop of ordinary liquid (described by the equation of hydrodynamics).

[2]We note that the boundary conditions were imposed in [4], rather inconsistently, not on the density of the nuclear matter itself, but on the coefficients of its multipole expansion.

By solving Eq. (1) jointly with the condition (3), we can determine the spectrum of the natural oscillations of a drop of Fermi liquid. The oscillations that are possible in the drop are of the same types as in an infinite Fermi liquid [3], namely oscillations of the spin density (s), of the isospin density (si), of the transverse component of the isospin density ($i_\perp$), and coupled oscillations of the density and of the charge density (two branches of oi_3 oscillations). The wave vector $\vec{k}_\ell^j$ of the oscillation of multipolarity with serial number j is connected in this case by the relation

$$k_\ell^j = x_\ell^j / R \tag{4}$$

with the j-th positive root x_ℓ^j of the expression

$$x J'_{\ell+1/2}(x) - (1/2) J_{\ell+1/2}(x) . \tag{5}$$

The frequency of the same oscillation ω_ℓ^j is connected with the wave vector by the same relation as for an infinite Fermi liquid [3]. In particular, in the case of oi_3-oscillations, this connection is

$$1 + F_{1,2}\, w(\omega / k v_F) = 0, \tag{6}$$

where

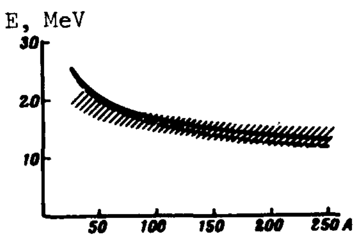
$$w(x) = 1 - \frac{x}{2} \ln \left| \frac{x+1}{x-1} \right| , \quad F_{1,2} = F^{(+)} + F^{(c)} \pm \sqrt{F^{(-)2} + F^{(c)2}},$$

$$F^{(a)} = \mathcal{F}^{(a)} \Big|_{p=p'=p_F} \frac{2 p_F m^*}{\pi^2}, \quad F^{(\pm)} = \frac{1}{2} (F^{(o)} \pm F^{(i)}), \tag{7}$$

$$F^{(c)} = \frac{e^2}{k^2} \frac{2 p_F m^*}{\pi}$$

p_F and v_F are the limiting Fermi momentum and velocity, $m^* = p_F / v_F$ is the effective mass.

The formulas given above and in [3] make it possible, by specifying first the values of m^* and $\mathcal{F}$, which are characteristics of the nuclear matter and therefore are the same for all medium and heavy nuclei, to calculate the frequencies of the collective excitations of these nuclei, and consequently the position of the giant resonance in photonuclear reactions. We note that since the nucleons in the nucleus are nonrelativistic ($p_F \ll M$), these reactions are connected mainly with oscillations of the density and of the charge density. There should be excited here, mainly, oscillations of the upper oi_3 branch (which go over into i_3 oscillations when A decreases), since the contribution of the lower branch to the cross section of the reaction at values $F^{(0)}$, $F^{(i)}$, obtained in [7], are much smaller than in [1].



In the figure, the position of the first dipole oscillations of this type (continuous curve) is compared with the experimental data of [8] (shaded region), which fit the well-known empirical relation

$$E_{dip} = (40{,}7 \pm 1{,}8) A^{-20 \pm 0{,}01} \text{ MeV} \qquad (8)$$

For $F^{(0)}$ and $F^{(i)}$ we used the values obtained by Migdal and Larkin [7] on the basis of an analysis of data on the compressibility of nuclear matter and its concentration

$$F^{(0)} = 0{,}5, \quad F^{(i)} = 1{,}5, \qquad (9)$$

and for v_F we used $v_F = 0.2c$. The dashed curve is the function $\omega(A) \sim A^{-1/3}$, which is obtained by neglecting the Coulomb interaction.

We see thus that the model of the Fermi-liquid drop with free boundary, which takes into account in addition to the pure nuclear interaction also the electric interaction of the nucleons, describes well the position of the giant dipole resonance for a large number of nuclei. In particular, it is possible to explain why the energy of the giant dipole resonance decreases more slowly than the usual $A^{-1/3}$ law for liquids. We emphasize that the parameters $F^{(0)}$ and $F^{(i)}$ which enter in the theory are obtained in this case for an analysis of data that do not pertain to giant resonance [7].

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EXCITATION OF SOUND IN A FERMI-BOSE LIQUID

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As is well known, weak solutions of He^3 and He^4 constitute at $T \ll T_F$ (T_F is the Fermi temperature for He^3 in solution) a peculiar mixture of Fermi and Bose liquids. The phenomenological theory of Fermi-Bose liquids was constructed by Khalatnikov [1]. In such a liquid, there exist two types of acoustic modes. Following [1], we call them first and second sound. When the He^3 concentration in the solution tends to zero, the first sound goes over into first sound in He II. The second sound propagates through the Fermi component of the liquid and has much in common with first sound in a Fermi liquid.