where θ_1, φ_1, θ_2, φ_2 are the angles of the vectors n_1 and n_2 in a system of spherical coordinates, when the z-axis is along the magnetic field.

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[2] K. Adler, Phys. Rev. 84, 369(1951).

Translated by E. S. Troubetzkoy
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Nonlinear Theory of Longitudinal Plasma Oscillations

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IN Refs. 1 and 2 there was considered the one dimensional oscillations of the electronic plasma, without taking into account the temperature effects, on the assumption that the electron density n, the electrical field E and the electron speed v are linear functions of the combination $x - Vt$, where V is the velocity of the wave, propagating along the x-axis. In the present note we obtain a fundamental result of this work —a relation between the frequency of the longitudinal wave and the amplitude for a more general assumption, namely, for an arbitrary relation between the quanttities n, E and v and x and t. The entire derivation is very much simplified if the basic equations are transformed from the Eulerian to the Lagrangian form.

We write the equation of motion of the electron and Maxwell's equations

$$dp/dt = eE, \tag{1}$$
$$dE/\partial x = 4\pi e(n - n_0), \tag{2}$$
$$0 = (1/c)(\partial E/dt) + (4\pi/c)\, env, \tag{3}$$

where n_0 is the ion density, which is assumed to be fixed; e, m and p are the charge, mass and momentum of the electron. From (2) and (3) follow

$$dE/dt = \partial E/\partial t + v\partial E/\partial x = -4\pi e n_0 v. \tag{4}$$

Differentiating Eq. (1) with respect to time and comparing with (4), we obtain

$$d^2p/dt^2 + \omega_0^2 mv = 0, \quad \omega_0^2 = 4\pi^2 n_0/m. \tag{5}$$

In the non-relativistic case $p = mv$ and, consequently $(d^2 v/dt^2) + \omega_0^2 v = 0$, i.e., the frequency of the plasma oscillation does not depend on the amplitude.[1]

In the relativistic case we express the velocity in terms of the momentum,

$$\frac{d^2p}{dt^2} + \frac{\omega_0^2}{\sqrt{1 + p^2/m^2c^2}}\, p = 0,$$

from which the dependence of the frequency on amplitude follows directly, as was obtained in Ref. 2.

In conclusion the author wishes to thank Ia. B. Fainberg for valuable suggestions and Prof. A. I. Akhiezer and G. Ia. Luibarskii for discussions.

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A Note on Mixed Meson Theory

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FEYNMAN[1] has made the statement that in a mixed theory of scalar and vector mesons with vector coupling, nonrenormalizable infinities cancel if the coupling constants are equal. Reference 2 is devoted to the application of this theory. Such a statement also occurs in Ref. 3. Actually, however, the cancellation of nonrenormalizable infinities is equivalent in this case to the fact that the equation for the vector meson

$$(p^2\delta_{\nu\mu} - p_\nu p_\mu)\varphi_\mu = -s_\nu$$

is transformed into

$$p^2\varphi_\nu = -s_\nu.$$

In this case the field φ_ν describes particles with spin one and zero, where components with spin zero correspond to a negative energy (see Ref. 4). This circumstance is also noted in Ref. 1.

Starting from a Hermitian Lagrangian for two fields with spin zero and one, interacting with the nuclear field, one finds that the nonrenormalizable divergences do not cancel, but, on the contrary, are additive. For each vector meson line (included in the vertex) one must write

$$f_1^2(\gamma_\nu \cdots \gamma_\mu)\,(\delta_{\nu\mu} - k_\nu k_\mu \mu_1^{-2})/(k^2 - \mu_1^2), \qquad (1)$$

where the dots denote an arbitrary part of the diagram, and for each scalar meson line, one must write

$$-(f_2^2/\mu_2^2)\,(\mathbf{k} \ldots \mathbf{k})\,(k^2 - \mu_2^2)^{-1}. \qquad (2)$$

The minus sign in the last expression is due to the fact that one of the factors **k** describes the creation of a meson, while the other describes annihilation (this sign also follows from Feynman's rule[1]: k is the difference between the initial and final momentum of the nucleon).

It follows from (1) and (2) that the divergences connected with the factor **k** in the numerator, will only cancel if $f_1^2/\mu_1^2 = -f_2^2/\mu_2^2$, i.e., if one of the charges is imaginary.

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Relative Cross Sections for $n-p$ Reactions Involving Nuclei with Several Stable Isotopes

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WHILE examining the literature on nuclear reactions the author noticed a regular variance in the $n-p$ and $n-\alpha$ reaction cross sections (for 14 mev neutrons) in the stable isotope series of individual elements. It follows from the data of Clarke and others[1] that the $n-p$ and $n-\alpha$ reaction cross sections for the various isotopes of an element decrease with increasing isotopic mass number as a rule (in seven of the nine investigated cases); moreover, in six of the seven cases, they decrease almost exactly by a factor of two or four*. In order to verify this regularity and define it more precisely, a program was initiated for the experimental determination of $n-p$ reaction cross sections of nuclei with several stable isotopes (Zr, Cd, Ti, Sr and Ca).

Specimens of salts of the elements under investigation were bombarded with 14 mev neutrons and dissolved; radioactive isotopes of Y, Ag, Sc, Rb and K produced by the $n-p$ reactions were then separated from the solution and their activity was measured with a standard cylindrical geiger counter. An analysis of the decay curves then yielded the activity of each isotope from the time the bombardment ended. Absolute activities were computed by correcting for decay during bombardment time and for absorption of radiation by the walls of the counter. The latter correction was determined in each case by means of special absorption measurements. This correction is not very large inasmuch as the reaction products of all investigated reactions [except for the reaction Ti(n, p)Sc] emit hard β-rays; therefore, even a large error in the determination of this correction cannot seriously affect the final result.

In this fashion relative cross sections were obtained for four isotopes of Zr, four of Cd, two of Sr, two of Ca; only rough preliminary results were obtained for Ti:

$$\sigma\,\mathrm{Zr}^{90} : \sigma\,\mathrm{Zr}^{91} : \sigma\,\mathrm{Zr}^{92} : \mathrm{Zr}^{94} = 1 : 0.74 : 0.46 : 0.20;$$

$$\sigma\,\mathrm{Cd}^{106} : \sigma\,\mathrm{Cd}^{111} : \sigma\,\mathrm{Cd}^{112} : \sigma\,\mathrm{Cd}^{113} = 5.00 : 1 : 0.71 : 0.52;$$

$$\sigma\,\mathrm{Sr}^{86} : \sigma\,\mathrm{Sr}^{88} = 1 : 0.46;$$

$$\sigma\,\mathrm{Ca}^{42} : \sigma\,\mathrm{Ca}^{44} = 1 : 0.24;$$

$$\sigma\,\mathrm{Ti}^{47} : \sigma\,\mathrm{Ti}^{48} : \sigma\,\mathrm{Ti}^{49} = (1) : (0.25) : (0.06)$$

Similar relations are presented below for five pairs of other isotopes computed from Clarke's data.

$$\sigma\,\mathrm{Mg}^{24} : \sigma\,\mathrm{Mg}^{25} = 1 : 0.23;\quad \sigma\,\mathrm{Si}^{28} : \sigma\,\mathrm{Si}^{29} = 1 : 0.46;$$

$$\sigma\,\mathrm{S}^{32} : \sigma\,\mathrm{S}^{34} = 1 : 0.23;\quad \sigma\,\mathrm{Zn}^{64} : \sigma\,\mathrm{Zn}^{66} = 1 : 0.26;$$

$$\sigma\,\mathrm{Ge}^{70} : \sigma\,\mathrm{Ge}^{72} = 1 : 0.50.$$

The following deductions can be made from the adduced data:

1) the $n-p$ reaction cross section for nuclei with several isotopes decreases considerably as