total intensity of emission for the transition of the current through the boundary is found as $J_{em} = -W_{\varepsilon} - W_0 - \Delta\varepsilon$ (18). Further calculations show that in the case of a strong magnetic field the intensity of the radiation is less than when no field is present at all. When the boundary is extended, i. e., when an intermediate region of the thickness l_0 exists, the relation $\omega^2\varepsilon = \omega^2 - \omega_0^2 \frac{z}{l_0}$ (24) holds, where ω_0 is the Langmuir frequency of the medium at $z > l_0$. The following is obtained for the Fourier components of the electric field in the intermediate region:

$$\frac{d^2E}{d\zeta^2} + \zeta E = F e^{ih\zeta}, \tag{25}$$

$$\zeta = \zeta_0 - \frac{z}{N}; \quad \zeta_0 = N^2\lambda^2; \quad \lambda^2 = \frac{\omega^2}{c^2} - k^2,$$

$$\left.\begin{aligned} N &= \sqrt[3]{\frac{l_0 c^2}{\omega_0^2}}; \quad h = -\frac{\omega}{v} N, \\ F &= -\frac{i\omega I}{\pi c^2}\frac{N^2}{v} e^{i\frac{\omega}{v}N\zeta_0}. \end{aligned}\right\} \tag{26}$$

By solving Eq. (25) one finds the work performed during the transition from the vacuum to the medium:

$$w = \frac{I}{v}\int E_y(x,\ z,\ t)\Big|_{\substack{x=0\\ t=\frac{z}{v}}} dz = \frac{I^2}{c^2}\int w_{k,\omega}\, dk\, d\omega \qquad (37)$$

a) in the vacuum:

$$w^c_{k,\omega} = \frac{\Phi_0}{\pi v}\,\frac{\frac{\omega}{v}}{\lambda - \frac{\omega}{v}}, \qquad (38)$$

b) in the intermediate region:

$$w_{k,\omega}=\frac{N^3 I\omega}{v^2\pi}\int\limits_{-ih}^{\infty}\frac{1}{(s+ih)}\left[e^{-\zeta_0 s+ih\zeta_0}-e^{-\zeta_0 s-ih\zeta_0}\right]e^{-\frac{s^2}{3}+\frac{ih^2}{3}}\,ds+$$
$$+\frac{NI\omega}{v^2\pi}\Phi_1 e^{ih\zeta_0}\int\limits_{\Gamma_1}\frac{1}{(s+ih)}e^{-\frac{s^2}{3}}\left(e^{-\zeta_0 s-ih\zeta_0}-e^{-\zeta_0 s-ih\zeta_0}\right)ds+$$
$$+\frac{NI\omega}{v^2\pi}\Phi_2 e^{ih\zeta_0}\int\limits_{\Gamma_2}\frac{1}{(s+ih)}e^{-\frac{s^2}{3}}\left(e^{-\zeta_0 s-ih\zeta_0}-e^{-\zeta_0 s-ih\zeta_0}\right)ds, \tag{39}$$

c) in the medium:

$$w^{\varepsilon}_{k,\omega}=-\frac{\Phi_l}{\pi}\frac{\frac{\omega}{v^2}}{\left(\lambda_\varepsilon-\frac{\omega}{v}\right)}e^{i\left(\lambda_\varepsilon-\frac{\omega}{v}\right)l}. \tag{40}$$

When l_0 tends towards infinity, the work in vacuo, w^0, and that in the medium, w^{ε}, vanish. Finally, the author thanks V. I. Veksler, V. L. Ginzburg, M. S. Rabinovich, and B. M. Bolotovskiy for discussions. I. M.

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Transient radiation of a current ... S/057/61/031/007/002/021
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Frank is mentioned. There are 7 Soviet references.

ASSOCIATION: Fizicheskiy institut AN SSSR im. P. N. Lebedeva Moskva (Institute of Physics AS USSR imeni P. N. Lebedev, Moscow)

SUBMITTED: September 1, 1960

Card 9/9

TSYTOVICH, V.N.

Coherent transition radiation from current-carrying and charged clusters. Zhur.tekh.fiz. 31 no.8:923-935 Ag '61. (MIRA 14:8)
(Radiation) (Particles (Nuclear physics))

LEVIN, M.L.; TSYTOVICH, V.N.

Taking inertia into account in current interaction. Zhur.tekh.fiz. 31 no.8:936-938 Ag '61. (MIRA 14:8)

1. Fizicheskiy institut imeni P.N.Lebedeva AN SSSR, Moskva.
(Electric currents)

24706
S/056/61/040/005/006/019
B111/B205

24.6713

AUTHOR: Tsytovich, V. N.

TITLE: Some problems in relativistic gas dynamics of charged particles

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 5, 1961, 1325-1332

TEXT: In the first section of the present paper the results of V. I. Veksler (DAN SSSR, 118, 63, 1958) and I. M. Khalatnikov (ZhETF, 27, 529, 1954) for self-consistent and external electromagnetic fields are generalized, and it is shown that in all cases where the ion portion of the current is small, the theorem of conservation of the magnetic flux along a fluid contour can be generalized to relativistic motions of an electron-ion plasma. The second part is devoted to the study of the one-dimensional relativistic expansion of a charged gas layer into the empty space, the inertial terms being predominant, and also to the problem of electric fields generated during expansion of a quasi-neutral plasma into

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the empty space. Furthermore, the problem of relativistic collision of the charged layer with constant external fields is treated. The investigation is limited to isentropic motion in an electromagnetic field, for which the relation $W^{(s)}u_{\mu}^{(s)} = -eA_{\mu} + \partial\varphi^{(s)}/\partial x_{\mu}$ is derived; $W^{(s)} = w^{(s)}/n^{(s)}$, with $w^{(s)}$ being the heat function per unit volume, $n^{(s)}$ the proper density of the particles, $u_{\mu}^{(s)}$ the four-velocity, A_{μ} the four-potential of the electromagnetic field, and φ the flow potential. This relation is found to be the desired generalization. In the following, it is shown that the above equation will always be fulfilled for one-dimensional non-steady events. This is illustrated by the one-dimensional motion of an electron fluid with a current perpendicular to the direction of motion. The theorem of conservation deduced therefrom reads

$$\left(u_1 \frac{\partial}{\partial x_1} + u_4 \frac{\partial}{\partial x_4}\right)(W^{(e)}u_3^{(e)} + eA_3) = \frac{d}{ds}(W^{(e)}u_3^{(e)} + eA_3) = 0. \quad (8)$$

If the inertial term $W^{(e)}u_3^{(e)}$ is negligible, then Eq. (8) will take the form of the theorem of conservation of the flux through a fluid contour. It is shown that the one-dimensional non-steady motion is here a potential flow. A generalization of Thomson's theorem of conservation of the velocity circulation is derived also for a three-dimensional motion: $\partial F_{\nu\mu}/\partial x_\alpha + \partial F_{\alpha\nu}/\partial x_\mu + \partial F_{\mu\alpha}/\partial x_\nu = 0$. Some one-dimensional problems are discussed next: 1) relativistic expansion of a charged layer into the empty space. For $-1 < x_1 < 1$ (1 - layer thickness) one obtains

$$\psi = u/n_0r_0x_0 + (x_0/u)(\sqrt{u^2+1} - 1), \qquad (19)$$
$$u = v\gamma = v/\sqrt{1-v^2},$$

where v indicates the hydrodynamic velocity, and n_0 the initial density; $r_0 = 4\pi e^2/m$. The particle density is given by

$$\frac{n}{n_0} = \left\{\sqrt{1+u^2} + n_0r_0x_0^2\left[1 - \frac{(u^2+1)(\sqrt{1+u^2}-1)}{u^2\sqrt{1+u^2}}\right]\right\}^{-1}. \qquad (21)$$

which holds for $T_0/m \ll n_0 r_0 l$. 2) Expansion of a neutral plasma layer into the empty space. It is assumed that the ions and electrons have the same density at the instant t = 0. The fundamental waves are expressed by

$$\frac{\Delta n}{n} = \frac{m^{(l)}}{9\pi e^2 n_0 x_0^2}\left(1 - \frac{1}{5}\frac{x_1}{x_0}\frac{m^{(l)}}{T^{(e)}}\right)^3, \qquad (24)$$

$$\frac{\Delta v}{v} = \frac{m^{(l)}}{27\pi e^2 n_0 x_0^2}\left(1 + \frac{3}{5}\frac{x_1}{x_0}\frac{m^{(l)}}{T^{(e)}}\right)\left(1 - \frac{1}{5}\frac{x_1}{x_0}\frac{m^{(l)}}{T^{(e)}}\right)^{-2}. \qquad (25)$$

3) Motion of a charged plasma layer toward a region with a constant electric field. Thermal effects are neglected, and using the gauge invariance one obtains

$$\chi + \chi_{\text{H}} = \frac{\partial u}{\partial x_0} + \frac{\partial}{\partial x_1}\sqrt{1 + u^2}, \qquad (26)$$

$$\frac{\partial \chi}{\partial x_0} + \frac{u}{\sqrt{1 + u^2}}\frac{\partial \chi}{\partial x_1} = 0. \qquad (27)$$

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where $\chi_H(x_1)=eE_H/m$ (electric field in the direction of the x-axis). The solution is given in the form of elliptic integrals. 4) Motion of a charged layer toward a region with a constant magnetic field. For an external field growing linearly with the distance, the calculation again leads to elliptical integrals. I. M. Khalatnikov and L. D. Landau are mentioned. The author thanks V. I. Veksler, M. S. Rabinovich and A. A. Rukhadze for discussions. He also thanks M. A. Leontovich for valuable comments. There are 4 Soviet-bloc references.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva, Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: August 23, 1960

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B108/B209

AUTHOR: Tsytovich, V. N.

TITLE: Spatial dispersion in a relativistic plasma

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1775 - 1787

TEXT: The author examined the dielectric constant of an isotropic relativistic plasma, taking into account pair-production effects. In this case, the dielectric constant is a three-dimensional tensor:

$$\varepsilon_{ij} = \delta_{ij} + 4\pi\omega^{-1}\sigma_{ij} = \varepsilon^{t}(\delta_{ij}\mathrm{k} - \mathrm{k}^{-2}k_ik_j) + \varepsilon^{l}\mathrm{k}^{-2}k_ik_j, \qquad (1),$$

$$j_i = \sigma_{ij}(\omega,\mathrm{k})E_j, \quad \sigma_{ij}(\omega,\mathrm{k}) = \sigma^{t}(\delta_{ij} - \mathrm{k}^{-2}k_ik_j) + \sigma^{l}\mathrm{k}^{-2}k_ik_j, \qquad (2),$$

where j_i are the four-dimensional Fourier components of the current; E_j is the Fourier components of the electric field strength; σ^l, σ^t, ε^l, ε^t are the longitudinal and the transverse electric conductivity and dielectric constant, respectively. This may also be written in four-dimensional notation:

$$j_\mu = \Pi_{\mu\nu}(\omega,\mathrm{k})A_\nu, \quad \Pi_{ik} = i\omega\sigma_{ik}, \quad \Pi_{i4} = \Pi_{4i} = -ik_i\sigma^{l},$$

$$\Pi_{44} = -i(\mathrm{k}^2/\omega)\sigma^{l}, \qquad (3)$$

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with the Fourier components A_y of the potential. The expression

$$\varepsilon^{l,t} = 1 - \frac{4\pi e^2}{\omega^2}\int f(\varepsilon_p)\,dp\,\left\{\frac{\varepsilon_p - \varepsilon_{p-k}}{(\varepsilon_p - \varepsilon_{p-k})^2 - \omega^2}\Lambda_-^{l,t} + \right. \qquad (10)$$

$$\left. + \frac{\varepsilon_p + \varepsilon_{p-k}}{(\varepsilon_p + \varepsilon_{p-k})^2 - \omega^2}\Lambda_+^{l,t}\right\} + \delta\varepsilon_B^{l,t},$$

$$(10)$$

$$\Lambda_\mp^l = 1 \mp \frac{\varepsilon_p^2 + (pk) - 2(pk)^2/k^2}{\varepsilon_p\varepsilon_{p-k}}, \qquad \Lambda_\mp^t = 1 \mp \frac{m^2 - (pk) + (pk)^2/k^2}{\varepsilon_p\varepsilon_{p-k}},$$

$$f(\varepsilon_p) = 2(2\pi)^{-3}(n_p^- + n_p^+),$$

$$\delta\varepsilon_B^t\omega^2 = (\omega^2 - k^2)\,\delta\varepsilon_B^l = \Pi_B = \frac{c^2}{\pi^2}\int\Lambda_+^l\,\frac{\varepsilon_p + \varepsilon_{p-k}}{(\varepsilon_p + \varepsilon_{p-k})^2 - \omega^2}\,dp;$$

is obtained for the dielectric constant, where $\varepsilon_{\vec{p}} = \sqrt{\vec{p}^2 + m^2}$ is the energy modulus, $n_{\vec{p}}^+$ and $n_{\vec{p}}^-$ are the mean numbers of positrons and electrons, respectively, with the density matrix ϱ; $\delta\varepsilon^{l,t}$ is the vacuum polarization. In the classical ($\vec{k} \ll \vec{p}$) ultrarelativistic $p \gg m$ case, in which the positron contribution vanishes, Eq. (10) leads to the result obtained by V. P. Silin,

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(Ref. 1: ZhETF, 38, 1577, 1960) with the help of the equation of motion. The spatial dispersion may be neglected in the case of small wave vectors, so that the real part of the dielectric constant assumes the form

$$\mathrm{Re}\,\varepsilon(\omega) = 1 - \frac{4\pi e^2}{\omega^2}\int f(\varepsilon_p)\,\frac{4\varepsilon_p\,(1 - p^2/3\varepsilon_p^2)\,dp}{4\varepsilon_p^2 - \omega^2}. \qquad (12)$$

which, for low frequencies $\omega \ll 2\varepsilon_{\vec{p}}$, leads to the known formula

$$\mathrm{Re}\,\varepsilon(\omega) = 1 - \frac{\omega_0^2}{\omega^2}, \qquad \omega_0^2 = 4\pi e^2 \int \frac{f(\varepsilon_p)}{\varepsilon_p}\left(1 - \frac{1}{3}\frac{p^2}{\varepsilon_p^2}\right)dp. \qquad (13)$$

The expression for the natural frequency ω_0 of the plasma goes over into the expression obtained by Silin (Ref. 1) for the ultrarelativistic case with $n^{+}_{\vec{p}} = 0$. When the system is in equilibrium at ultrarelativistic temperatures, the chemical potential μ vanishes at sufficiently high temperatures, $n^{+}_{\vec{p}} \approx n^{-}_{\vec{p}} \approx \left[\exp(p\beta) + 1\right]^{-1}$ and $\omega_0^2 = 2\zeta(2)e^2/3\pi\beta^2$ (14), where ζ is Riemann's zeta-function. At high frequencies,

$$\mathrm{Re}\,\varepsilon(\omega) = 1 + Z/\omega^4, \qquad (15)$$

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Spatial dispersion in...

$$Z \simeq 16\pi e^2 \int f(\varepsilon_p)\, \varepsilon_p \left(1 - \frac{1}{3}\frac{p^2}{\varepsilon_p^2}\right) dp. \qquad (15)$$

holds. For equilibrium and ultrarelativistic temperatures, $Z = 120e^2\zeta(4)/\pi\beta^4$ (16). In order to obtain the imaginary part of $\varepsilon^{l,t}$, the energy denominators must be replaced by δ-functions expressing the laws of conservation of energy and momentum. The general expressions for the imaginary parts of ε^{l} and ε^{t}, describing the Cherenkov absorption of the longitudinal and the transverse wave, respectively, are calculated from (10) by integration over p_z with the help of the δ-function:

$$\operatorname{Im} \varepsilon^{l}_{u} = \frac{8\pi^3 e^2}{k^3} \int_{\varkappa_0}^{\infty} \left(\varepsilon^2 - \frac{k^2}{4}\right)\left[f\left(\varepsilon - \frac{\omega}{2}\right) - f\left(\varepsilon + \frac{\omega}{2}\right)\right] d\varepsilon, \qquad (21),$$

$$\operatorname{Im} \varepsilon^{t}_{u} = \frac{4\pi^3 e^2}{\omega^2 k}\left(1 - \frac{\omega^2}{k^2}\right) \int_{\varkappa_0}^{\infty} \left(\varepsilon^2 + \frac{k^2}{2} - \varkappa_0^2\right)\left[f\left(\varepsilon - \frac{\omega}{2}\right) - f\left(\varepsilon + \frac{\omega}{2}\right)\right] d\varepsilon. \qquad (23).$$

The author examines the spectra of longitudinal and transverse plasma oscillations at high densities and temperatures, taking into account both the Cherenkov absorption and absorption due to pair production.

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Spatial dispersion in...

V. P. Silin and A. A. Rukhadze are thanked for their help, as well as V. L. Ginzburg, Ye. L. Feynberg, and Ye. S. Fradkin for their interest in the work. Mention is made of L. D. Landau, G. S. Saakyan, Sh. M. Kogan, and V. L. Bonch-Bruyevich. There are 2 figures and 11 Soviet-bloc references.

ASSOCIATION: Fizicheskiy institut im P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: January 4, 1961

Card 5/5

ALEKSEYEVA, K. I., ZHDANOV, G. B., TRETYAKOVA, M. I. TSYTOVICH, V. N., and SHCHERBAKOVA, M. N.

"Ionization momentum dependence for electrons in the ultra-relativistic region"

Fourth International Colloquium on Photography (Corpuscular) - Munich, West Germany, 3-8 Sep 62

TSYTOVICH, V.N.

Passage of fast particles trhough a magnetoactive plasma. Izv.vys. ucheb.zav.; radiofiz. 5 no.6:1078-1092 '62. (MIRA 16:2)

1. Fizicheskiy institut imeni P.N. Lebedeva AN SSSR.
(Plasma (Ionized gases))

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B125/B186

26.2331 /7

AUTHOR: Tsytovich, V. N.

TITLE: Structure of nonlinear waves in plasma

PERIODICAL: Zhurnal tekhnicheskoy fiziki, v. 32, no. 9, 1962, 1042 - 1049

TEXT: The propagation of strong, steady, nonlinear waves perpendicular to a magnetic field is studied. The condition $r_e \gg 1$ is assumed to hold for the electron radius. There are no limitations as to the ion radius. The four-dimensional velocities V_e, v_e of the electrons and V_i, v_i of the ions are calculated from the system

$$\gamma_0 r_e \frac{dh}{d\xi} = \frac{V_0}{\gamma_0}\left(\frac{v_e}{V_e} - \frac{v_i}{V_i}\right),$$
$$r_e = \frac{d\mathcal{E}}{d\xi} = -\frac{V_0}{\gamma_0}\left(\frac{\sqrt{1+V_e^2+v_e^2}}{V_e} - \frac{\sqrt{1+V_i^2+v_i^2}}{V_i}\right) \quad (5),$$

$$\left.\begin{aligned} -V_e \frac{dV_e}{d\xi} &= \mathcal{E}\frac{\sqrt{1+V_e^2+v_e^2}}{\gamma_0} + h v_e, \\ \frac{dv_e}{d\xi} &= h - \frac{V_0}{\gamma_0}\frac{\sqrt{1+V_e^2+v_e^2}}{V_e}, \end{aligned}\right\} \quad (6)$$

$$r_e = \frac{H_0^2}{4\pi n_0 m_e}; \quad r_i = \frac{H_0^2}{4\pi n_0 m_i}$$

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of two Maxwell equations, and two equations for the velocity components of the electron gas. V are the four-dimensional velocity components in the system of the wave in the x-direction; v is perpendicular to the wave and to the magnetic field. Here, $\xi = x/x_o$; $x_o = m_e/eH_o\gamma_o$. $\equiv E_x/H_o$ is the electric field strength, $h = H_z/H_o\gamma_o$ is the magnetic field strength, k is the wave number in the laboratory system, and $v_o = \omega/k$, $\lambda = kx_o/\gamma_o$. $\gamma_o = \sqrt{1-V_o^2}$, $V_o = v_o/\sqrt{1-v_o^2}$; H_o is the external magnetic field in the plasma rest system and $H_o\gamma_o$ that in a system in which the wave front is at rest. From an approximate solution of the above linearized system, assuming $V_e = V_o + \delta V_e$ and $V_i = V_o + \delta V_i$, $\lambda^2 \approx (V_o^2 - r_e)/V_o^2 r_e \gamma_o^2$ is obtained which holds for electron waves if $V_o^2 \gg 1$. The same result is obtained by linearizing the initial system if the ion velocities are put equal to zero. Therefore, the ion velocities in the wave are low. The wave becomes nonlinear for high $|\xi|$ values. The approximate solution

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corresponding to the root $-\sqrt{\lambda^2}$ describes the magnetosonic branch. $\lambda^2 = (V_o^2 - r_e)/V_o^2 r\gamma_o^2$ and $\lambda^2 = -(1+r)/V_o^2 r\gamma_o^2$ hold for an electron-positron plasma. The waves of the second type are always periodic, those of the first type may be aperiodic. Nonlinear electron waves are ultrarelativistic at $r_e \gg 1$. For these waves, v_e becomes zero at $\delta V_e^{\pm} = -2(1+r_e)V_o \pm 2\gamma_o \sqrt{r_e(1+r_e)}$, and no solution exists in the range $\delta V_e^- < \delta V < \delta V_e^+$. Flows with several velocities may exist at $r_e < V_o/2$.

$$\delta V_e = -\frac{2(V_0^2 - r_e)}{V_0 + \gamma_0 \sqrt{\frac{r_e}{r_e+1}}\,\mathrm{ch}\,\eta}; \quad \eta = \xi \frac{\sqrt{r_e+1}}{r_e\gamma_0}\frac{\sqrt{V_0^2 - r_e}}{V_0} \qquad (17)$$

holds for weak waves, and

$$\delta V_e = \delta V_e^+ + \frac{\xi^2}{4r_e\gamma_0}\frac{1}{\left(\frac{r_e}{V_0^2} - \frac{1}{4r_e}\right)^2}; \quad V_0^2 \gg r_e. \qquad (18)$$

for strong ones. The structure of nonlinear magnetosonic waves is

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described by

$$\frac{m_i}{m_e}\frac{dy}{d\xi} = \pm\frac{1}{V_0}\sqrt{1+\frac{1}{r_i}}\, y \sqrt{\frac{y^2}{16V_0^2\gamma_0^2\left(1+\frac{1}{r_i}\right)} + \frac{y}{2\gamma_0^2} + \frac{\frac{V_0^2}{r_i}-1}{\gamma_0^2}}$$

$$y = y_0 = -4V_0^2\left(1+\frac{1}{r_i}\right) + 4V_0^2\gamma_0\sqrt{1+\frac{1}{r_i}} \quad \text{при} \quad \frac{dy}{d\xi}=0.$$

$$\frac{m_e}{m_i\gamma_0 V_0}\sqrt{1+\frac{1}{r_i}}\,\xi = -\frac{1}{\sqrt{\frac{V_0^2}{r_i}-1}} \times$$

$$\times \ln\left\{\frac{2\left(\frac{V_0^2}{r_i}-1\right)+\frac{1}{2}y+2\sqrt{\frac{V_0^2}{r_i}-1}\sqrt{\left(\frac{y}{1V_0\sqrt{1+\frac{1}{r_i}}}+V_0\sqrt{1+\frac{1}{r_i}}\right)^2-\gamma_0^2}}{y} \times \frac{y_0}{\left[2\left(\frac{V_0^2}{r_i}-1\right)+\frac{1}{2}y_0\right]}\right\} + \frac{r_i}{V_0}\sqrt{1+\frac{1}{r_i}} \times \quad (30).$$

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Structure of nonlinear...

$$\times \ln \left\{ \frac{1 + \frac{y}{4V_0^2\left(1+\frac{1}{r_i}\right)^2} + \frac{\gamma_0}{V_0}\sqrt{\left(\frac{y}{4V_0\sqrt{1+\frac{1}{r_i}}} + V_0\sqrt{1+\frac{1}{r_i}}\right)^2 - \gamma_0^2}}{1 + \frac{y}{4V_0^2\left(1+\frac{1}{r_i}\right)^2} - \frac{\gamma_0}{V_0}\sqrt{\left(\frac{y}{4V_0\sqrt{1+\frac{1}{r_i}}} + V_0\sqrt{1+\frac{1}{r_i}}\right)^2 - \gamma_0^2}} \right\}$$

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR (Physics Institute imeni P. N. Lebedev AS USSR)

SUBMITTED: October 12, 1961

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1001/

ACCESSION NR: AP4010753 S/0020/64/154/0076/0079

AUTHOR: Tsy*tovich, V. N.

TITLE: On stimulated resonance scattering and radiation in a medium

SOURCE: AN SSSR. Doklady*, v. 154, no. 1, 1964, 76-79

TOPIC TAGS: resonance scattering, stimulated resonance, Cerenkov radiation, nonlinear wave interaction, photon emission, perturbation theory, plasma, particle energy

ABSTRACT: In a number of papers (e.g., Astr. zhur., no. 4, 1963), the author has treated stimulated Cerenkov radiation and absorption of waves in a medium and reduced them to the effects of wave acceleration of charged particles and diffusion of particles in a plasma energy space. The stimulated scattering and radiation of two photons which follow from the next approximation of the perturbation theory are nonlinear effects, since they depend on the second power of the number of photons. In the present paper, the author

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ACCESSION NR: AP4010753

points out that the perturbation theory cannot be applied if the frequency and the angle of incident radiation are close to those of the Cerenkov cone, because resonance scattering takes place. It is necessary then to make the summation of the series of the perturbation theory. A theory of the stimulated scattering, radiation, and absorption is developed which takes into account the radiation corrections for the spontaneous Cerenkov radiation. The results indicate that the average change of the particle energy owing to the stimulated processes is not of the resonance type. Thus, the distribution of photons may be affected, but not the average characteristics of the plasma particles. "The author is grateful to Acad. I. Ye. Tamm for his interest." Orig. art. has: 9 formulas.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR (Lebedev Physical Institute, AN SSSR)

SUBMITTED: 09Jul63 DATE ACQ: 10Feb64 ENCL: 00

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ATD PRESS: 3043

ACCESSION NR: AP4028969 S/0057/64/034/004/0764/0767

AUTHOR: Tsy*tovich, V.N.; Shapiro, V.D.

TITLE: On the interaction of an electron beam with an optically active medium

SOURCE: Zhurnal tekhnicheskoy fiziki, v.34, no.4, 1964, 764-767

TOPIC TAGS: electron beam plasma interaction, electron beam laser pumping, laser

ABSTRACT: The interaction of an electron beam with an optically active gas is discussed. It is found that considerable power can be generated in the visible and ultraviolet regions even when the density of the beam is small compared with that of the medium and the Langmuir frequency is small compared with the optical resonance frequency. It is suggested that electron beams might be useful for laser pumping. Powers of the order of 10^2 kW/cm^3 at a frequency of 6×10^{16} cycles/sec can be developed by a beam of 10^{14} electrons/cm^3 having velocities of 3×10^9 cm/sec in a medium of density 10^{19} cm^{-3}. The medium is treated as an ensemble of oscillators, and expressions are derived for the power developed and the velocity disperions required of the exciting beam. The condition for the applicability of the quasi-linear approximation employed is given, and a future treatment of the non-linear terms is

ACCESSION NR: AP4028969

promised. The equation for the (negative) damping constant of the oscillations, on which all the calculations are based, is simply written without derivation or reference. "In conclusion, the authors express their gratitude to Ya.B.Faynberg and M.S.Rabinovich for valuable advice." Orig.art.has: 9 formulas.

ASSOCIATION: Fizicheskiy institut im.P.N.Lebedeva, Moscow (Physical Institute)

SUBMITTED: 10Nov63 DATE ACQ: 28Apr64 ENCL: 00

SUB CODE: PH NR REF SOV: 001 OTHER: 001

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ACCESSION NR: AP4037586 S/0056/64/046/005/1726/1740

AUTHOR: Gaylitis, A.; Tsy*tovich, V. N.

TITLE: Radiation of transverse electromagnetic waves due to scattering of charged particles by plasma waves

SOURCE: Zh. eksper. i teor. fiz., v. 46, no. 5, 1964, 1726-1740

TOPIC TAGS: plasma, plasma waves, dipole radiation, particle scattering, electron scattering, plasma wave scattering, synchrotron radiation

ABSTRACT: It is shown that in the classical limit, emission of transverse waves by electrons with energies exceeding those of thermal electrons occurs in the field of a plasma wave as a result of dipole radiation due to oscillations of the electron in the wave (Compton effect on plasma waves) and by passage of electrons through density inhomogenieties produced by the plasma wave. In the non-relativistic case, emission of transverse waves by electrons is forbidden, due to interference of the two effects. This forbiddenness

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ACCESSION NR: AP4037586

does not hold for particles with masses differing from that of the electron. The radiation spectrum of electrons and ions is calculated for a broad energy range from nonrelativistic to relativistic energies. The graph technique is used for calculating quantum effects which become significant for secondary quantum energies close to the energy of the charged particles. Possible astrophysical applications are discussed as well as the possibility of determining the particle energy and mean energy density of the plasma waves on basis of the intensity of radiation. It is also shown that the frequencies of transverse waves produced in scattering of cosmic ray electrons by plasma waves may considerably exceed the frequency of waves produced by the synchrotron mechanism. Orig. art. has: 65 formulas and 7 figures.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute, Academy of Sciences SSSR)

SUBMITTED: 11Oct63 DATE ACQ: 09Jun64 ENCL: 00

SUB CODE: ME NO REF SOV: 017 OTHER: 000

Card 2/2

GAYLITIS, A.; TSYTOVICH, V.N.

Emission of transverse electromagnetic waves due to the scattering of charged particles on plasma waves. Zhur. eksp. i teor. fiz. 46 no.5:1726-1740 My '64. (MIRA 17:6)

1. Fizicheskiy institut imeni Lebedeva AN SSSR.

KOVRIZHNYKH, L.M.; TSYTOVICH, V.N.

Interaction between an intense high-frequency radiation and a plasma. Dokl. AN SSSR 158 no.6:1306-1309 O '64. (MIRA 17:12)

1. Fizicheskiy institut im. P.N. Lebedeva AN SSSR. Predstavleno akademikom V.I. Vekslerom.

TSYTOVICH, V.N.

Generation and acceleration of neutrinos in a turbulent plasma.
Dokl. AN SSSR 159 no.6:1268-1271 D '64 (MIRA 18:1)

1. Fizicheskiy institut im[illegible] P.N. [illegible] AN SSSR. [illegible]
akademikom V.I. Vekslerom.

ACCESSION NR: AP4042920 S/0057/64/034/008/1365/1373

AUTHOR: Danilkin, I.S.; Tsy*tovich, V.N.

SOURCE: Zhurnal tekhnicheskoy fiziki, v.34, no.8, 1964, 1365-1373

TOPIC TAGS: plasma, plasma oscillation, noise, fast particle

ABSTRACT: The authors discuss the effect of random oscillations of a plasma (noise) on the average motion of a fast charged particle. The average rate of change of the particle momentum is given by the velocity divergence of the tensor

$$\Pi_{ij}=\frac{\hbar^2}{m}\int k_i k_j w_p N_{\omega,k}\,d\omega d\mathbf{k},$$

where $N_{\omega,k}$ is the quantum density of the noise field and $w_p(\omega,k)$ is the transition probability for the particle from a state of momentum p to p-ħk. w_p is given by

$$w_p=\frac{e^2}{\pi^3\hbar}\frac{\delta(\omega-\mathbf{kv})}{k^2}\,\mathrm{Im}\,\frac{1}{\varepsilon^l(\omega,\mathbf{k})},$$

where v is the velocity of the particle and ε^l is the longitudinal part of the dielectric tensor. The effects of the acoustic and the high frequency plasma wave components of the noise field are discussed separately in the absence of an external field. An isotropic noise field has no average effect, but it is found that an

ACCESSION NR: AP4042920

anisotropic field can either accelerate the charged particle or decelerate it. Noise fields with cylindrical symmetry are treated in some detail, and it is found that waves propagating preferentially parallel to the motion of the particle tend to decerlate it, while waves propagating mainly transversely to the particle motion accelerate it. The effect of noise on the acquisition of energy by a charged particle from an external electric field is discussed in terms of the theory developed by V.D.Shapiro [no reference given]. According to this theory the velocity of the particle is limited by the decelerating action of waves that its own motion generates. It is found that the effect of the noise field is much less than that of the decelerating waves generated by the particle unless the noise field is so intense that neither the present theory nor that of Shapiro is valid. The effect of the noise field on the characteristic time required for the particle to generate and interact with the decelerating wave is found to be particularly weak, and it is suggested that large currents of "runaway" particles may be obtainable in a spatially limited plasma in which the free flight time of the electrons is smaller than this characteristic time. Orig.art. has: 52 formulas.

ACCESSION NR: AP4042920

ASSOCIATION: Fizicheskiy institut im. I.P.Lebedeva AN SSSR, Moscow (Physics Institute, AN SSSR)

SUBMITTED: 20Nov63 ENCL: 00

SUB CODE: ME NR REF SOV: 004 OTHER: 000

34641
S/056/62/042/002/024/055
B108/B104

24,7700 (1160,1164,1385)

AUTHOR: Tsytovich, V. N.

TITLE: Macroscopic renormalization of mass and energy loss of charged particles in a medium

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 2, 457 - 466, 1962

TEXT: In first-order perturbation theory, macroscopic mass renormalization (mmr) of an electron is due to emission and absorption of a virtual photon in a medium. The magnitude of the mmr depends on the velocity of the electron. The mmr and energy losses in a strongly absorbing medium are calculated by the method of the Green's function with consideration of spatial dispersion. For a particle with spin 1/2, energy E, and momentum $\vec{p}$, the energy is a complex quantity owing to the losses which are to be considered in this paper: $E = E' + iE''$ where $E'' = -\gamma/2$. The rate of energy loss γ is equal to that obtained with the aid of phenomenological quantum electrodynamics (V. L. Ginzburg, ZhETF, 10, 589, 1940; A. A. Sokolov. DAN SSSR, 28, 415, 1940). The real part of E is related with $\vec{p}$ through the mmr

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Macroscopic renormalization of... S/056/62/042/002/024/055
B108/B104

and is different from the energy of the free particle $\varepsilon_{\vec{p}} = \sqrt{\vec{p}^{\,2} + m^2}$. $\Delta E = E' - \varepsilon_{\vec{p}}$; $\Delta m = \sqrt{E'^2 - p^2} - m$. The difference between the activation energies of a particle in a vacuum and in a medium is found as

$$\Delta U = \Delta E - \frac{i\gamma}{2} = \frac{e^2}{4\pi^2 v} \int_0^\infty d\omega \int_0^\infty \varkappa \, d\varkappa \left[D^l_{ret}\left(\omega, \sqrt{\omega^2/v^2 + \varkappa^2}\right) - \frac{-\varkappa^2 v^2}{\varkappa^2 + \omega^2/v^2} D^t_{ret}\left(\omega, \sqrt{\omega^2/v^2 + \varkappa^2}\right) \right]. \qquad (37)$$

The first-order quantum corrections to this expression which was derived in the classical limit are calculated. Moreover, the quantum corrections [illegible] characteristic losses of electrons in a thin film are calculated. [illegible] shown that the quantum corrections to the longitudinal losses may be [illegible]erable near the boundary which is not the case with the quantum

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Macroscopic renormalization of...

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corrections to the transverse losses. The author thanks V. L. Ginzburg, V. P. Silin, and B. M. Bolotovskiy for their interest and discussions. Mention is made of V. M. Agranovich, A. A. Rukhadze (ZhETF, 35, 1171, 1958), I. Ye. Tamm, and I. M. Frank (DAN SSSR, 14, 107, 1937). There are 18 references: 15 Soviet and 3 non-Soviet. The references to the English-language publications read as follows: K. M. Watson, J. H. Jauch. Phys. Rev., 74, 950, 1485, 1948; 75, 1247, 1949; E. Fermi. Phys. Rev., 57, 485, 1940.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: June 20, 1961

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35568

24 6713

S/056/62/042/003/026/049
B102/B138

AUTHOR: Tsytovich, V. N.

TITLE: Energy losses of charged particles in a plasma

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 3, 1962, 803 - 811

TEXT: The differential probabilities of emission and absorption of longitudinal and transverse quanta by charged particles in media with spatial dispersion are calculated. The results obtained are more general than in previous papers (e. g. A. I. Akhiyezer, A. G. Sitenko, ZhETF, 23, 161, 1952; A. I. Larkin, ZhETF, 37, 264, 1959; V. P. Silin, ZhETF, 37, 273, 1959; UFN, 74, 223, 1961), since relativistic particles are also considered. The probability calculations are carried out to an accuracy $\sim e^2$, i. e. the effect of macroscopic mass renormalization on the energy losses is neglected and only the statistical mean of quantum numbers enters the expressions. The denotations used are the same as in Ref. 12 (V. N. Tsytovich, ZhETF, 42, 457, 1961). The emission probability $\gamma = -2\mathrm{Im}E(p) = 2(\delta E'' - p\delta p''/\varepsilon_p - m\delta m''/\varepsilon_p)$, $\delta E''$, $\delta p''$ and $\delta m''$ are the components of the

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antihermitian part of the mass operator, which is calculated by using the Green photon function

$$D^c_{\mu\nu}(\omega, k) = \frac{1}{\pi}\int\limits_0^\infty D^{R''}_{\mu\nu}(\omega', k)\left\{P\frac{1}{\omega'-\omega} - P\frac{1}{\omega'+\omega} + i\pi \operatorname{cth}\frac{\omega'\beta}{2}[\delta(\omega-\omega') - \delta(\omega+\omega')]\right\} d\omega', \quad (4)$$

proposed by I. Ye. Dzyaloshinskiy and L. P. Pitayevskiy (ZhETF, 36, 1797, 1959); ε_p is the particle energy, β is the reciprocal temperature. The differential probabilities are obtained as

$$\gamma_l^{\pm}(\omega, \theta) = \frac{e_1^2}{\pi^2}\sqrt{p^2+\omega^2\mp 2\varepsilon_p\omega}\left[\frac{p^2}{\varepsilon_p} + \omega - \frac{p}{\varepsilon_p}\sqrt{p^2+\omega^2\mp 2\varepsilon_p\omega}\cos\theta + \frac{p^2\sin^2\theta}{k_\pm^2\varepsilon_p}(p^2+\omega^2\mp 2\varepsilon_p\omega)\right]\operatorname{Im}\frac{1}{k_\pm^2 - \omega^2\varepsilon^t(\omega, k_\pm)}\begin{cases}N_{\omega,k}+1 & \text{для } \gamma^+\\ N_{\omega,k} & \text{для } \gamma^-\end{cases}, \quad (8)$$

$$\gamma_l^{\pm}(\omega, \theta) = -\frac{e_1^2}{2\pi^2}\sqrt{p^2+\omega^2\mp 2\varepsilon_p\omega}\left[\varepsilon_p \mp \omega + \frac{p^2}{\varepsilon_p} + \frac{p}{\varepsilon_p}\sqrt{p^2+\omega^2\mp 2\varepsilon_p\omega}\cos\theta\right]\times \operatorname{Im}\frac{1}{k_\pm^2\,\varepsilon^l(\omega, k_\pm)}\begin{cases}N_{\omega,k}+1 & \text{для } \gamma^+\\ N_{\omega,k} & \text{для } \gamma^-\end{cases}; \quad (9)$$

$$k_\pm^2 = (p^2+\omega^2\mp 2\varepsilon_p\omega) - 2p\sqrt{p^2+\omega^2\mp 2\varepsilon_p\omega}\cos\theta + p^2. \quad (10)$$

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B102/B138

Energy losses ...

$$\cos\psi\pm = \pm[p - \sqrt{p^2 + \omega^2 \mp 2\varepsilon_p\omega\cos\theta}]/k_\pm. \qquad (11)$$

$\theta = (\vec{p}\vec{p}')/pp'$, $\vec{p}'$ - momentum after scattering, $N_\omega = (e^{\omega\beta}-1)^{-1}$ is the number of equilibrium quanta of the frequency ω; absorption is proportional to $2N_\omega = \mathrm{cth}(\omega\beta/2)-1$; ψ is the angle between quantum emission and initial particle momentum. For induced Cerenkov radiation, when $\varepsilon^t(\omega, k_\pm) \approx \varepsilon(\omega) = n^2(\omega)$ and $\mathrm{Im}\,\varepsilon^t = 0$,

$$\gamma_i^+ = \int_{\cos\psi_+<1} e_1^2 v\left[1 - \frac{1}{n^2v^2} - \frac{\omega}{vp}\left(1-\frac{1}{n^2}\right) + \frac{\omega^2n^2}{4p^2}\left(1-\frac{1}{n^4}\right)\right](N_\omega^+ + 1)d\omega, \qquad (13)$$

$$\gamma_i^- = \int_{\cos\psi_-<1} e_1^2 v\left[1 - \frac{1}{n^2v^2} + \frac{\omega}{vp}\left(1-\frac{1}{n^2}\right) + \frac{\omega^2n^2}{4p^2}\left(1-\frac{1}{n^4}\right)\right]N_\omega^-\, d\omega;$$

$$\cos\psi_\pm = 1/nv \pm \omega(n^2-1)/2pn, \qquad (14)$$

is obtained and the losses are given by

$\Delta W = -\frac{2e_1^2}{p}\int N_\omega\omega^3 d\omega(1-1/n^2)$; $v = p/\varepsilon_p$, the particle velocity and $N_\omega = N(\omega, \psi_\pm)$.

For induced plasmon emission with $\omega_s/vp \ll 1$, ω_s being the zeros of $\varepsilon(\omega)$,

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Energy losses ...

$$\Delta W = -e_1^2 \sum_s \frac{2N_{\omega_s}\omega_s^2}{v\varepsilon_p} \left| \frac{\partial \varepsilon(\omega)}{\partial \omega} \right|^{-1}_{\omega=\omega_s} \left[\ln \frac{v^2 k_{max}^2}{\omega_s^2} - 2 + \frac{1}{v^2} \right]. \qquad (20).$$

The energy losses of charged particles in an isotropic equilibrium plasma are obtained as $W^l = \int_0^\infty dk \int_{-1}^{+1} dx W^l(k, x)$ with

$$W^l(kx) = -\frac{e^2}{2\pi}\left(1 + \mathrm{cth}\,\frac{kvx\beta}{2}\right) kvx\,\mathrm{Im}\,\frac{1}{\varepsilon^l(kvx, k)}.$$

if $\omega \approx kvx$; $x = \cos\psi = (\vec{k}\vec{p})/kp$. The longitudinal and transverse losses of relativistic particles (m_1, e_1) in a non-relativistic plasma are

$$W^l = \frac{e_1^2 \omega_{0e}^2}{v}\left\{\ln \frac{2m_e \varepsilon_p v^2}{(\varepsilon_p + m_e)\,\omega_{0e}\hbar} - \frac{1}{2}\left[1 - \left(1 + \frac{m_e}{\varepsilon_p}\right)^2\right] \ln\left[1 - \frac{\varepsilon_p^2 v^2}{(\varepsilon_p + m_e)^2}\right]\right\}; \qquad (29)$$

$$\varepsilon_p = \sqrt{p^2 + m_1^2}, \quad W^t = \frac{1}{2} e_1^2 \omega_{0e}^2 v \left\{\frac{(\varepsilon_p + m_e)^2}{v^2 \varepsilon_p^2} \ln \frac{(\varepsilon_p + m_e)^2}{(\varepsilon_p + m_e)^2 - v^2\varepsilon_p^2} - 1 + \frac{m_e^2 \varepsilon_p^2 v^2}{[(\varepsilon_p + m_e)^2 - \varepsilon_p^2 v^2]^2}\right\}$$

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B102/B138

Energy losses ...

For an ultrarelativistic plasma

$$W = W^{l} + W^{t} = \frac{3}{4} e_1^2 \omega_{0e}^2 (\ln (2 d_e^2 m_1 / \beta^2 \varepsilon_p) - 0{,}82). \qquad (37).$$

V. I. Veksler, V. P. Silin and V. L. Ginzburg are thanked for discussions.
There are 13 references: 12 Soviet and 1 non-Soviet.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences, USSR)

SUBMITTED: July 31, 1961 (initially) February 10, 1962 (after revision)

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39674
S/056/62/043/001/044/056
B102/B104

24.6716

AUTHOR: Tsytovich, V. N.

TITLE: Effect of radiation on a charged particle penetrating a magnetically active plasma

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 1(7), 1962, 327-329

TEXT: The author considers a magnetically active plasma which is hit by an outer radiation of high density. This radiation is supposed to interact weakly with the plasma but strongly with the particles penetrating it (induced Cherenkov emission and absorption). If spatial dispersion is neglected, the induced changes in energy and angle ($\theta = v_{\perp}/v_z \ll 1$) can be given by

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B102/B104

Effect of radiation on a charged ...

$$\frac{dE}{dz} = \frac{e^2\omega_{0e}^3}{2mv_z^4}\int u\,du\left\{\frac{|\varepsilon_z|}{\varepsilon^2}\left(\frac{m_e}{m}h + \frac{m}{m_e}\frac{u^2}{h}\right)(\overline{N}_- - \overline{N}_+) - \right. \quad (1)$$

$$\left. - \frac{|\varepsilon_z|}{\varepsilon^2}2u(\overline{N}_- + \overline{N}_+) - \frac{2u}{|\varepsilon|}\left(\overline{N}_0 + \frac{u\omega_{0e}}{2v_z}\frac{\partial\overline{N}_0}{\partial k_z}\right)\right\},$$

$$\overline{N}_\nu = \overline{N}(\omega, k_z, k_\perp) \quad \text{при } k_\perp = \sqrt{-\frac{\varepsilon_z}{\varepsilon}}k_z, \quad k_z = \frac{\omega + \nu\omega_H}{v_z}, \quad \nu = 0, \pm 1;$$

$$\frac{d\theta^2}{dt} = \frac{e^2\omega_{0e}^3}{2m^2v_z^6}\int\frac{du\,|\varepsilon_z|}{\varepsilon^2}\left\{\left(u - \frac{m_e}{m}h\right)^2\overline{N}_- + \left(u + \frac{m_e}{m}h\right)^2\overline{N}_+\right\}. \quad (2).$$

$\overline{N}(\omega, k_z, k_\perp)$ is the number of quanta of frequency ω and of the momentum $\vec{k}$, averaged over the angle $\varphi = \arctan(k_x/k_y)$; $k_\perp^2 = k_x^2+k_y^2$; v_z, $v_\perp$ are the particle velocity components in and perpendicular to $\vec{H}$; $\varepsilon_z = 1-u^{-2}$, $\varepsilon = 1-(u^2-h^2)^{-1}$ are the diagonal components of the ε-tensor. $u=\omega/\omega_{oe}$,
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$h = \omega_{He}/\omega_{oe}$; $\omega_H = m_e\omega_{He}/m = eH/m$; m is the particle mass, m_e is the electron mass; $\hbar = c = 1$; the domain of integration over the frequencies corresponds to the conditions for spontaneous Cherenkov radiation:

$$0 < u < h, \quad 1 < u < \sqrt{h^2+1} \quad \text{при } h < 1;$$
$$0 < u < 1, \quad h < u < \sqrt{h^2+1} \quad \text{при } h > 1.$$

the lower limit of the domain of integration is given by

$$\theta\left|\frac{\omega+\omega_H\nu}{\omega_H}\right|\sqrt{\frac{-\varepsilon_z}{\varepsilon}} \ll 1,$$

Results: The effect of radiation always leads to an increase in θ. The particles are accelerated by radiation if the wave number in the medium decreases with increasing refractive index. As to the order of magnitude, the critical radiation density ρ_{cr}, beyond which acceleration exceeds spontaneous deceleration, is determined by $\rho_{max} \sim (\lambda/r_0)\rho_{cr}$; where λ is the wavelength of radiation, r_0 is the particle radius. Estimates of λ and ρ_{cr} show that e. g. fast electrons of the radiation belt can be

Effect of radiation on a charged ... S/056/62/043/001/044/056
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accelerated by solar radio radiation. The effect of radiation on particles emitted during outbursts of supernovae is likely to be a factor which has to be considered in astrophysics.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: March 20, 1962

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S/056/62/043/001/051/056
B102/B104

AUTHORS: Zhdanov, G. B., Tret'yakova, M. I., Tsytovich, V. N., Shcherbakova, M. N.

TITLE: The ionization losses of ultrarelativistic electrons

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 1(7), 1962, 342-345

TEXT: Up to now the ionization losses of fast charged particles have been considered in first perturbation-theoretical approximation only. The contribution of the next order, i. e. that of the radiation corrections, is comparable with the effect of a relativistic increase of the ionization losses. Theoretical estimates of these corrections are here compared with experimental results. It is shown that in real cases, if $1 \ll \Delta^{1/2} \ll (\pi\hbar c/e^2)^{1/2}$, the correction may be given approximately by $\Delta_\infty = 2\ln^2\zeta$, where ζ is a function of the total electron concentration in the medium and the corresponding frequencies; $\Delta = \Delta_\infty$. For a photo-

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The ionization losses of ...

emulsion (AgBr) ξ^{-1} is between 100 and 200 and the radiation correction reaches 8-10%. The relative track densities, measured in НИКФИ-Р (NIKFI-R) emulsions and for 8.7-Bev protons (OIYaI) and Ilford G-5 and 19-Bev protons (CERN) as dependent on $\varepsilon_p/mc^2 \gg 1/\xi$, are compared with theoretical curves both with and without radiation correction. The uncorrected agrees satisfactorily with the experimental data. There are 2 figures.

SUBMITTED: May 12, 1962

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43371

S/056/62/043/005/032/058
B102/B104

24.6700

AUTHOR: Tsytovich, V. N.

TITLE: Radiative corrections to the energy losses of particles in a medium

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 5(11), 1962, 1782 - 1794

TEXT: The radiative corrections to particle energy losses in a medium are divided into a microscopic and a macroscopic part. The latter, which is due to the presence of a medium, i.e. to the fact that the mass of a particle in vacuo differs from that in a medium by Δm, is much greater than the former and is investigated here. At high energies, i.e. for $\varepsilon_p/m \gg \omega_s/\omega_0$, Δm tends to its upper limit $-e^2\omega_0$; ω_0 is the plasma frequency and ω_s the natural frequency of the medium. In first ($\sim e^2$) and second ($\sim e^4$) perturbation-theoretical approximations the macroscopic part is studied in detail and from various standpoints. It is shown that this part of energy losses may reach 7% of the total losses. From energy loss

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Radiative corrections to the...

calculations carried out in the e^2-approximation a density effect is to be expected, which is studied on the basis of the oscillator model. This effect is found to occur at energies higher than those where such an effect arises in the main part of the energy losses. Multiple scattering is found not to contribute to the radiative corrections. It is predicted that the energy losses due to ionization decrease by about 7 - 10% on the Fermi level. This drop of the losses was experimentally observed for ultra-relativistic electrons by G. B. Zhdanov et al. (Trudy soveshchaniya po yadernoy fotoemul'sii, Moscow, 1960). The theory presented here agrees with experimental observations within the limits of error. The course of the ionization-versus-momentum curve as predicted by theory for the electrons will be valid also for heavier particles, e.g. mesons. Since the microscopic part is of the order of $e^2\omega_{max}/2\pi m_e$ it may be kept always small if only such events are considered in which the energy transferred (ω_{max}) is small with respect to the electron rest mass (m_e). Among others it is also shown that the radiative corrections to the Cherenkov radiation may reach a magnitude allowing them to be observed experimentally. There is 1 figure.

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B102/B104

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: May 23, 1962

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S/020/62/142/001/010/021
B104/B102

24.6716

AUTHOR: Tsytovich, V. N.

TITLE: Structure of relativistic nonlinear waves in plasma

PERIODICAL: Akademiya nauk SSSR. Doklady, v. 142, no. 1, 1962, 63-66

TEXT: The plasma and the beam of charged particles generating nonlinear waves in it are described in hydrodynamic approximation for T = 0 and the energy losses of the beam in the plasma are calculated. The ions compensating for the volume charges of the plasma at the beginning are assumed to be immobile, and the plasma is assumed to move linearly along the x-axis. The motion of electrons can then be described by

$$\chi = \frac{\partial u_l}{\partial x_0} + \frac{\partial}{\partial x}\sqrt{1+u_l^2}; \quad \frac{\partial}{\partial x} n_l u_l + \frac{\partial}{\partial x_0} n_l \sqrt{1+u_l^2} = 0;$$

$$\frac{\partial \chi}{\partial x_0} = r_0 \sum_l (n_l u_l - n_l^{(0)} u_l^{(0)}); \qquad (1)-(2)$$

$$\frac{\partial \chi}{\partial x} = - r_0 \sum_l \left(n_l \sqrt{1+u_l^2} - n_l^{(0)} \sqrt{1+u_l^{(0)2}}\right),$$

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(V. N. Tsytovich, ZhETF, no. 5 (1951)), where $\chi = eE_x/m$, E_x = electric field strength, u_i are the components of the four-velocity, n_i are the densities ($i = 1,2$), $r_0 = 4\pi e^2/mc^2$ (the subscript 0 indicates the initial value), and $\gamma_i = \sqrt{1 + u_i^2}$. For a frame of reference, in which all quantities are independent of time, a nonlinear potential equation is set up, the first integral of which is given as

$$\frac{1}{2}\left(\frac{d\gamma_1}{dx}\right)^2 = r_0 \sum_i \left(n_{i0} u_{i0} \sqrt{\gamma_i^2 - 1}\, \mathrm{sign}\, u_i - n_i^{(0)} \gamma_i^{(0)} \gamma_i\right) + \mathrm{const}, \quad (4).$$

For the structure of nonlinear relativistic waves in a plasma without particle beam,

$$\pm \frac{\xi}{\sqrt{2}} = \frac{1}{\sqrt[4]{1-k^2}} \frac{\alpha^2 - 1}{\alpha} E(k, \theta) + \frac{k^2}{2\sqrt[4]{1-k^2}} \frac{1}{\alpha} \frac{\sin 2\theta}{\sqrt{1 - k^2 \sin^2 \theta}};$$
$$\theta = \frac{1}{2} \arccos \frac{\gamma_1 + \sqrt{\gamma_1^2 - 1} - \lambda\alpha}{\sqrt{\lambda^2 - 1}\,\alpha}, \quad (7)$$

32814

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B104/B102

Structure of relativistic ...

is obtained, where $E(k)$ is a total elliptic integral, $k^2 = 2\sqrt{\lambda^2 - 1}\,(\lambda + \sqrt{\lambda^2 - 1})^{-1}$, $k^2 < 1$ corresponds to a nonrelativistic approximation, and the constant λ characterizes the wave amplitude; $\lambda^2 = \lambda + \beta^2 u_{10}^2$.

$$\overline{W}_E = \frac{2}{\xi_0}\int_0^{\xi_0/2} \frac{E^2}{8\pi}\, d\xi = \frac{1}{6}\, m n_{10} \frac{k^2}{\sqrt{1-k^2}}\left[\frac{2}{k^2} - 1 + 2\left(1 - \frac{1}{k^2}\right)\frac{K(k)}{E(k)}\right] \quad (9)$$

is obtained for the energy density of the electric field, averaged over one period. In the nonrelativistic case, W_E agrees with the result of a linear approximation. Also derived are the density of kinetic energy and the momentum density, averaged over one period, as well as the velocity of the frame of reference, in which the mean momentum density is zero. Finally, the nonlinear waves in a system of two plasmas of the same kind penetrating each other are investigated, and the nonlinear problem of energy loss of a beam of charged particles in the plasma is solved. V. I. Veksler, M. S. Rabinovich, and A. A. Rukhadze are thanked for discussions. There are 5 Soviet references.

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32814
S/020/62/142/001/010/021
B104/B102

Structure of relativistic ...

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

PRESENTED: July 12, 1961, by V. I. Veksler, Academician

SUBMITTED: June 13, 1961

Card 4/4

APPROVED FOR RELEASE: 08/31/2001 CIA-RDP86-00513R001757320017-8"

32838

S/020/62/142/002/013/029
B104/B138

24.6720

AUTHOR: Tsytovich, V. N.

TITLE: Particle acceleration by irradiation in a medium

PERIODICAL: Akademiya nauk SSSR. Doklady, v. 142, no. 2, 1962, 319-321

TEXT: The particle acceleration by a radiation flux in vacuo is low due to the small cross section of Thompson scattering. At a pressure of 10 atm, acceleration is about 10^{-7} ev per cm of path. If the radiation density attains a critical value, Čerenkov radiation and absorption are possible. The probability of these effects is proportional not to e^4, as in the case of scattering, but to e^2. The acceleration of a particle is found from the difference between absorbed and emitted energy. In a previous paper (ZhETF, 32, no. 3 (1962)), the author solved the problem of allowing for the quantum effect of recoil when calculating the probability of Čerenkov radiation. In the work, only on quantization of microfields was performed using the many-body theory and the method of Green functions. Acceleration and slowing down of a particle in a medium are found from the imaginary part of the effective energy spectrum. The

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S/020/62/142/002/013/029
B104/B138

Particle acceleration by ...

emission and the absorption probability for a medium with spatial dispersion is correct for the region in which the medium is highly absorptive. Neglecting spatial dispersion, the following relation is obtained for the acceleration of a particle with spin 1/2 in a transparent region of the medium:

$$\frac{dW}{dx} = e^2 v \int\limits_{\cos\theta_- < 1} \omega\, d\omega\, N(\omega, \theta_-)\left[1 - \frac{1}{n^2 v^2} + \frac{\omega}{vp}\left(1 - \frac{1}{n^2}\right) + \frac{\omega^2}{4p^2} n^2 \left(1 - \frac{1}{n^4}\right)\right] - e^2 v \int\limits_{\cos\theta_+ < 1} \omega\, d\omega\, (N_+(\omega, \theta_+) + 1)\left[1 - \frac{1}{n^2 v^2} - \frac{\omega}{vp}\left(1 - \frac{1}{n^2}\right) + \frac{\omega^2}{4p^2} n^2 \left(1 - \frac{1}{n^4}\right)\right], \quad (1)$$

where

$$\cos\theta_\pm = \frac{1}{nv} \pm \frac{\omega(n^2 - 1)}{2pn}; \quad N(\omega, \theta) = \frac{1}{2\pi}\int\limits_0^{2\pi} N(\omega, \theta, \varphi)\, d\varphi \quad (2)$$

is the number of quanta with the frequency ω and the momentum $k = \omega n/c$, $n^2(\omega) = \varepsilon(\omega)$, v is the velocity, and p the particle momentum. The Čerenkov slowing-down obtained for N = 0 fits the phenomenological quantum electrodynamics. A nearly monochromatic radiation, for which the conditions of Čerenkov radiation and absorption are satisfied, is examined. The somewhat different conditions for the absorption and emission of Čerenkov radiation are finally examined. V. I. Veksler and

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32834
S/020/62/142/002/013/029
B104/B138

Particle acceleration by ...

N. G. Basov are thanked for discussions. There are 5 Soviet references.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

PRESENTED: August 1, 1961, by V. I. Veksler, Academician

SUBMITTED: August 1, 1961

Card 3/3

38102
S/020/62/144/002/009/028
B104/B102

24.6720

AUTHOR: Tsytovich, V. N.

TITLE: Radiative corrections to the intensity of the Cherenkov radiation of charged particles

PERIODICAL: Akademiya nauk SSSR. Doklady, v. 144, no. 2, 1962, 310-313

TEXT: Radiative corrections to the energy losses of charged particles were examined by taking account of the terms e^4 and $e^4 \ln e^2$. The energy losses can be determined by using Green's function to determine the poles and continuing Green's particle function analytically. The calculation is notably simplified by considering only the terms of first order of ω/ε_p in all orders of e^2 (e^2, e^4, $e^4 \ln e^2$). ε_p denotes the energy of a free particle ($\hbar = c = 1$), and ω is the frequency of the emitted quantum. The dispersion equation $E - \varepsilon_p - \Sigma(E,\vec{p}) = 0$ is solved in successive approximation. E is the energy of a particle, and Σ is the mass operator. The value $E = \varepsilon_p$, obtained in zero-th approximation, is

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S/020/62/144/002/009/028
Radiative corrections to the intensity ... B104/B102

substituted in Σ_1 which is the mass operator obtained in first approximation with respect to e^2. Hence one obtains: $E = \varepsilon_p + \lambda_0 - i\gamma_0$. This value is substituted in $\Sigma_1 - \Sigma_1|_{E=\varepsilon_p} + \Sigma_2$. The terms of the order of $e^{2\nu}\psi_\nu(\ln e^2)$ obtained in this way decrease with increasing ν if ν is small. There are 2 figures.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

PRESENTED: December 27, 1961, by V. I. Veksler, Academician

SUBMITTED: November 23, 1961

Card 2/2

ASSOCIATION: ...
of Physics, AN SSSR)

SUBMITTED: 20Jun62

DATE ACQ: 07Aug63

ENCL: 00

OTHER: 000

ESD-3/

discussion (on the basis of 40 equations) of the problem for arbitrary particle

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APPROVED FOR RELEASE: 08/31/2001 CIA-RDP86-00513R001757320017-8"

DANILKIN, I.S.; TSYTOVICH, V.N.

Effect of weak stationary turbulence on fast plasma particles.
Zhur. tekh. fiz. 34 no.8:1365-1373 Ag '64. (MIRA 17:9)

1. Fizicheskiy institut imeni I.P. Lebedeva AN SSSR, Moskva.

APPROVED FOR RELEASE: 08/31/2001 CIA-RDP86-00513R001757320017-8"

APPROVED FOR RELEASE: 08/31/2001 CIA-RDP86-00513R001757320017-8"

TSYTOVICH, V.N.

Possibilities of detecting high-frequency turbulence of cosmic plasma. Astron.zhur. 41 no.5:992-995 S-O '64.

1. Fizicheskiy institut im. P.N.Lebedeva AN SSSR.

(MIRA 17:10)

APPROVED FOR RELEASE: 08/31/2001 CIA-RDP86-00513R001757320017-8"

APPROVED FOR RELEASE: 08/31/2001 CIA-RDP86-00513R001757320017-8"

ACC NR: AP5028305

SOURCE CODE: UR/0057/65/035/011/1925/1932

AUTHOR: Tsytovich, V.N.; Shapiro, V.D.
44,55 44,55

ORG: none

57
B

TITLE: On the theory of a charged particle beam traversing a plasma

SOURCE: Zhurnal tekhnicheskoy fiziki, v. 35, no. 11, 1965, 1925-1932
21,44,55

TOPIC TAGS: plasma oscillation, plasma beam interaction, particle beam, plasma wave
16,44,55

ABSTRACT: An analytic solution is obtained in the quasi-linear approximation for the spectral energy density of the oscillations excited in a semi-infinite plasma by a charged particle beam having a narrow velocity distribution incident normally on the plasma surface with a velocity exceeding the phase velocity of the plasma waves. Some results previously obtained from qualitative considerations (Ya.B.Feynberg and V.D.Shapiro, ZhETF, 47, 1389, 1964) are confirmed; in particular, the energy of the excited plasma oscillations is confined largely to a thin layer near the surface, the thickness of which decreases exponentially with time. The case of an incident pulse of charged particles of finite duration is also treated, and expressions are derived for the pulse shape and the energy density of the plasma oscillations after the particles have penetrated deeply into the plasma. The authors thank Ya.B.Feynberg 44,55 and M.S.Rabinovich 44,55 for their interest in the work and discussion of the results. Orig. art. has: 28 formulas and 2 figures.

SUB CODE: 20 SUBM DATE: 08Mar65/ ORIG.REF: 005 OTH REF: 000

Card 1/1

ACC NR: AP5024701 SOURCE CODE: UR/0056/65/049/003/0797/0806

AUTHORS: Tsytovich, V. N.; Shvartsburg, A. B.

ORG: Physics Institute im. P. N. Lebedev, Academy of Sciences SSSR (Fizicheskiy institut Akademii nauk SSSR)

TITLE: Contribution to the theory of nonlinear interaction of waves in a magnetoactive anisotropic plasma

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 49, no. 3, 1965, 797-806

TOPIC TAGS: magnetoactive plasma, anisotropic plasma, plasma interaction, plasma wave propagation, plasma oscillation, plasma decay

ABSTRACT: A procedure previously used by one of the authors (Tsytovich, with A. Gaylitis, ZhETF v. 46, 1726, 1964 and v. 47, 1469, 1964; also with L. M. Kovrizhnykh, ZhETF v. 46, 1455, 1964) is used to obtain general equations describing nonlinear interaction of waves in an anisotropic plasma both in the presence and in the absence of external magnetic fields. Unlike in earlier papers, the results are not confined to the assumption that the plasma is isotropic even in the case of zero magnetic field, and are therefore suitable for a description of the

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ACC NR: AP5024701

interaction of waves in a system of interpenetrating plasmas. The results can be used for an analysis of the interaction and nonlinear conversion of non-potential oscillations and waves in a plasma, such as interaction between a plasma and intense high-frequency radiation in the radio and optical bands. Damping is neglected and a procedure for analyzing the interaction of waves having random phases is used. Explicit expressions are derived for the probabilities of scattering of normal waves by plasma electrons and ions and for the probabilities of the decay processes. The equations obtained are limited to a weakly turbulent plasma, and in this approximation the nonlinear effects describe the interaction between waves that satisfy the dispersion relations of the linear theory. Orig. art. has: 31 formulas

SUB CODE: 20/ SUBM DATE: 12Feb65/ NR REF SOV: 018/ OTH REF: 002

Card 2/2

L 20540-66 EWT(d)/EWT(1)/EEC(k)-2/EWC(f)/EPF(n)-2/EWG(m)/FCC/EWA(h) IJP(c)
ACC NR: AP6008733 RB/AT/GW SOURCE CODE: UR/0386/66/003/003/0105/0110

AUTHOR: Tsytovich, V. N.; Shvartsburg, A. B.

ORG: Physics Institute im. P. N. Lebedev, Academy of Sciences SSSR (Institut fiziki Akademii nauk SSSR)

TITLE: Nonlinear polarization of radiation passing through a plasma

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki. Pis'ma v redaktsiyu. Prilozheniye, v. 3, no. 3, 1966, 105-110

TOPIC TAGS: nonlinear plasma, plasma interaction, radio wave propagation, cosmic radiation, cosmic radio source

ABSTRACT: The authors show that nonlinear interaction effects can noticeably alter the polarization of radiation passing through a plasma, if the radiation has sufficient intensity or if its path in the plasma is sufficiently long. The results can be used in investigations of the polarization properties of cosmic radiation, propagation of radio waves, etc. This is done by assuming that the nonlinear effects are weak, expanding the current produced by the wave in the plasma in powers of the wave amplitude, and solving the wave propagation equation by the method of Bogolyubov and Van der Pol, as demonstrated elsewhere (Izv. VUZov, Radiofizika v. 8, 3, 1965). The results are used to analyze the interaction between different polariza-

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ACC NR: AP6008733

tion components of a single monochromatic wave, and the relative rotation of the polarization ellipse and the electric vector. They apply also to the interaction of two waves having different frequencies, where it can be shown that the sum of the energies of the two components of each of the polarizations is conserved. Equations for the mean value of the polarization components are obtained for random interacting waves. It is shown that the interaction of any one wave with any other wave can lead only to a change in the ratio of the intensities of the different polarization components, without changing the total energy of the wave. This characteristic property of the nonlinear interaction in question sharply distinguishes it from other known nonlinear interactions (decay processes and induced scattering) that lead to a change in the spectral composition of the radiation. Another consequence of the calculation is the conservation of entropy (which follows from the conservation of the number of quanta), and consequently reversibility of the nonlinear interactions for random waves. A rough estimate is presented to illustrate the role of the interaction under consideration for the most unfavorable case, when the ellipticity is quite small. For the Crab nebula, for example, with energy densities of 5 ev/cm^3 at a wavelength ~100 m, the ellipticity is found to be $\sim 10^{-3}$. An account of this effect becomes even more important for other radio sources with larger emission density, and also in the case of radio wave propagation in the ionosphere, etc. Orig. art. has: 9 formulas.

SUB CODE: 20/ SUBM DATE: 25Nov65/ ORIG REF: 007/
Card 2/2

L 41750-66 FBD/EWT(1)/FCC IJP(c) AT/GW/WS-2

ACC NR: AP6017865 SOURCE CODE: UR/0053/66/089/001/0089/0146

79
78
B

AUTHOR: Tsytovich, V. N.

ORG: Physics Institute im. P. N. Lebedev, AN SSSR (Fizicheskiy institut AN SSSR)

TITLE: Statistical acceleration of particles in a turbulent plasma

SOURCE: Uspekhi fizicheskikh nauk, v. 89, no. 1, 1966, 89-146

TOPIC TAGS: plasma charged particle, plasma instability, plasma acceleration, statistics, turbulent plasma, plasma oscillation, radio astronomy, interplanetary space

ABSTRACT: This is a review article dealing with recent progress in the theory of plasma instability, especially under outer-space conditions, and the initiation of such instability by statistical acceleration mechanisms. Various applications of the statistical theory, which is an extension of the theory of weakly-turbulent plasma and which includes the Fermi acceleration mechansim as a special case, are discussed both for astrophysical problems and for the possible interpretation of numerous laboratory experiments. The general characteristics of statistical acceleration are discussed and information is presented on plasma turbulence and on mechanisms of plasma generation, statistical changes in the states of the particles in a plasma, acceleration of plasma particles by Langmuir oscillations and by high-frequency transverse waves, the spectra and average energies of the accelerated particles, and the efficiencies of various acceleration mechanisms. This is followed by the theory of

Card 1/2 UDC: 533.9

L 41750-66

ACC NR: AP6017865

statistical acceleration, with emphasis on the relative role of high-frequency and low-frequency turbulent pulsations, the limitations imposed on the oscillation intensity, the limiting transition of the statistical acceleration to the particular case of Fermi acceleration, and the role of nonstationary turbulent pulsations. The article concludes with a section dealing with applications of acceleration mechanisms, including applications connected with acceleration of particles under laboratory conditions and astrophysical applications in connection with radio emission from quasars, acceleration of electrons and ions in the radiation belts, and acceleration of cosmic rays. Orig. art. has: 6 figures and 185 formulas.

SUB CODE: 20/ 03/ SUBM DATE: 00/ ORIG REF: 154/ OTH REF: 012

Card 2/2

L 25-1-66

ACC NR: AP6013931 SOURCE CODE: UR/0207/66/000/002/0116/0119

AUTHOR: Liperovskiy, V. A. (Moscow); Tsytovich, V. N. (Moscow)

ORG: none

TITLE: Nonlinear conversion of electromagnetic waves to ion-acoustic plasma oscillation

SOURCE: Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki, no. 2, 1966, 116-119

TOPIC TAGS: plasma oscillation, electromagnetic wave phenomenon, acoustic wave, acoustic absorption

ABSTRACT: The authors consider the self-consistant problem of conversion of electromagnetic waves with a frequency much higher than the critical frequency to ion-acoustic oscillations in a plasma assuming that a Langmiur wave is generated as the transverse electromagnetic wave decays and that the ion-acoustic wave is then generated by the Langmiur wave. The problem is solved with regard to ion-acoustic wave absorption as well as in the one-dimensional approximation. Examples of two-stage decay are given to illustrate application of the expressions derived in the paper. One-dimensional quasistationary boundary problems are also considered and solutions are given for nonlinear equations which determine the spatial distribution for the number of waves in the spectrum during the decay process. Orig. art. has: 13 formulas.

SUB CODE: 20/ SUBM DATE: 03Aug65/ ORIG REF: 005/ OTH REF: 000

Card 1/1

L 45919-66 EWT(1) IJP(c) AT

ACC NR: AP6028604 SOURCE CODE: UR/0057/66/036/008/1339/1350

AUTHOR: Kovrizhnykh, L.M.; Liperovskiy, V.A.; Tsytovich, V.N.

ORG: Physics Institute im. P.N.Lebedev, AN SSSR, Moscow (Fizicheskiy institut AN SSSR)

TITLE: Nonlinear production of plasma waves by a beam of transverse waves. 2.

SOURCE: Zhurnal tekhnicheskoy fiziki, v. 36, no. 8, 1966, 1339-1350

TOPIC TAGS: mathematic physics, nonlinear effect, nonlinear plasma, plasma wave, plasma wave absorption, transverse wave, longitudinal wave

ABSTRACT: One of the authors has previously discussed the passage through an isothermal plasma of a parallel monochromatic beam of transverse waves whose frequency f is much higher than the Langmuir frequency f_o of the plasma and the accompanying decay of the transverse waves into longitudinal plasma waves V.N.Tsytovich, ZhTF, 35, No.5, 773, 1965). In the present paper these calculations are extended to the case when the transverse wave beam is not strictly parallel, but has a small angular divergence. The present calculations are based on the results of the earlier ones, and notation employed in the earlier paper is sometimes used in the present discussion without definition. It is found that there is a critical angular spread of the beam given by $\theta_c = (f_o/f)^{3/2}$. When the angular spread of the beam is small compared with θ_c the results previously obtained for a strictly parallel beam are valid. When the

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L 45919-66

ACC NR: AP6028604

angular spread exceeds θ_c the rate of decay to longitudinal waves decreases with increasing beam spread and eventually becomes smaller by a factor of f_0/f than the rate of decay in the case of a strictly parallel beam. Formulas are derived for the rate of decay and for the directions with respect to the beam in which the longitudinal waves propagate, and the passage to the limiting case of zero beam divergence is carried through in an appendix. The effect of a longitudinal magnetic field is discussed. The magnetic field has little effect on the critical beam divergence, but there appear new decay modes into waves having the Larmor frequency. The decay into longitudinal waves of the Larmor frequency is always slower than the decay into Langmuir waves, however, and does not contribute significantly to the absorption of transverse waves in the plasma. Orig. art. has: 56 formulas.

SUB CODE: 20 SUBM DATE: 04Sep65 ORIG. REF: 014 OTH REF: 002

Card 2/2 rjs

L 00908-67 EWT(1)/FCC IJP(c) AT, JW

ACC NR: AP6019668 SOURCE CODE: UR/0033/66/043/003/0528/0542

AUTHOR: Tsytovich, V. N.

ORG: Institute of Physics imeni P. N. Lebedev, Academy of Sciences SSSR (Fizicheskiy in-t Akademii nauk SSSR)

TITLE: On isotropization of cosmic rays

SOURCE: Astronomicheskiy zhurnal, v. 43, no. 3, 1966, 528-542

TOPIC TAGS: cosmic rays, galactic radiation, plasma wave, nonlinear plasma, plasma instability

ABSTRACT: The role of various plasma effects is discussed in the isotropization of cosmic rays. Two mechanisms are considered to explain the isotropization process: a) the beam instabilities in the cosmic rays that lead to a build-up of plasma oscillations; b) the scattering of cosmic rays on turbulent plasma oscillations. The conditions that lead to isotropy in cosmic rays due to beam instability are analyzed in some detail. To this end, the instability of relativistic distribution of cosmic rays f is considered where f = f(p,x), x = cos θ. It is shown that extremely large increments arise at the initial stages of development of beam instability. The anisotropic component of this increment is given by

$$\gamma_k{}^A \simeq \frac{n_1}{n_0}\frac{m_e}{m}\frac{v_{Te}{}^2}{c^2}\omega_{0e}\left(\frac{1}{f}\frac{\partial f}{\partial x}\right).$$

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L 00908-67

ACC NR: AP6019668

It is also shown that nonlinear plasma effects at low energies, such as near Maxwellian distribution of ions, eliminate instabilities and destroy the isotropization of the relativistic cosmic particles. This is shown by the oscillation energy transfer expression corresponding to the above increment, or

$$\frac{\Delta W_0}{W_0} \simeq \frac{m_e}{m_i} \frac{v_{Te}^2}{c^2} \overline{\left(\frac{1}{f} \frac{\partial f}{\partial x}\right)}.$$

Next, the effect of low frequency turbulence is analyzed on the isotropization process of the cosmic rays. The anisotropic increment in this case is given by

$$\gamma_k{}^A \simeq \frac{m_e}{m} \omega_{0e} (v_\phi{}^s)^3 \overline{\left(\frac{1}{f} \frac{\partial f}{\partial x}\right)} \frac{n_i}{n_0} \frac{m_i}{m_e} \frac{k_\parallel}{\omega_{0e}}$$

which is somewhat less than the case of beam instability. Isotropization effects due to the scattering of cosmic rays on high frequency turbulence and also hydrodynamics oscillations are considered. It is concluded that the above discussed isotropization mechanisms are local and are not necessarily connected with magnetic fields. The author is grateful to V. L. Ginzburg for detailed evaluation of the work. Orig. art. has: 56 formulas.

SUB CODE: 20, 03, 04/ SUBM DATE: 05May65/ ORIG REF: 014/ OTH REF: 001

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Card 2/2