is obtained. The necessary and sufficient condition of stability of the distribution function $f_0(u)$ is given by the fact that the roots of (13) must not lie in the upper semiplane. If s is real, the real and the imaginary part of the function $G_H(s)$ is given by

$$\operatorname{Re} G_H(s) = \cos^2\theta \int_{-\infty}^{\infty} \frac{f_0'(u)\,du}{u-s} + \frac{\sin^2\theta}{2s_H}\int_{-\infty}^{\infty} f_0'(u)\ln\left|\frac{u-s+s_H}{u-s-s_H}\right| du,$$

(α)

$$\operatorname{Im} G_H(s) = \pi\cos^2\theta f_0'(s) + \pi\frac{\sin^2\theta}{2s_H}\int_{s-s_H}^{s+s_H} f_0'(u)\,du.$$

In this case the distribution function is stable if for all values s for which $\operatorname{Im} G_H(s) = 0$ the real part $G_H(s)$ is negative. An even distribution function is stable if it has a single maximum (for n=0).

$$\int_{-\infty}^{\infty} \frac{f_0'(u)\,du}{u-s} + \frac{ieE_0}{mk}\cos\theta\int_{-\infty}^{\infty}\frac{du}{u-s}\frac{d}{du}\left[\frac{f_0'(u)}{u-s}\right] = \frac{k^2}{\omega_0^2}, \qquad (17)$$

is obtained for the dispersion equation for high-frequency plasma oscillations where $f_0(u)$ is the initial function of the electron distribu-

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22147

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B113/B202

Stability conditions of...

tion and θ the angle between $\vec{k}$ and $\vec{E}_0$. The stability condition of the distribution function $f_0'(u)$ is obtained in the form

$$\int_{-\infty}^{\infty} \frac{f_0'(u)\,du}{u-u_l} - \frac{\pi e E_0}{4mk}\cos\theta f_0'''(u_l) < 0, \qquad (18)$$

where u_i are the roots of equation

$$f_0'(u_l) + \frac{eE_0}{2\pi mk}\cos\theta \int_{-\infty}^{\infty} \frac{f_0'''(u)}{u-u_l}\,du = 0; \quad e<0. \qquad (b)$$

The authors thank K. N. Stepanov and A. B. Kitsenko for valuable advice and assistance, L. D. Landau and M. A. Leontovich for discussion. Ya. Faynberg and B. Ya. Levin are mentioned. There are 10 references: 6 Soviet-bloc and 4 non-Soviet-bloc. The four references to English-language publications read as follows: F.Berz.Proc.Phys.Soc.,B69, 939, 1956; P. D. Noerdlinger. Phys.Rev.,118,879,1960; O.Penrose.Phys.Fluids, 3,258,1960; P.L.Auer.Phys.Rev.Lett.,1,411,1958.

Phys-Tech Inst. Acad. Sci UkrSSR

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25206
S/056/61/040/006/027/031
B125/B202

24.6714

AUTHORS: Akhiyezer, A. I., Kitsenko, A. B., Stepanov, K. N.

TITLE: Interaction between charged particle currents and low-frequency plasma oscillations

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1866-1870

TEXT: The authors deal with the interaction between a compensated beam of charged particles and the low-frequency oscillations of a plasma (mainly with the magneto-acoustic waves and the Alfvèn waves) in a constant field in parallel direction to the beam and in the absence of collisions. If the plasma is rarefied to such an extent that the frequency ω of the oscillations is much higher than the frequency $1/\tau$ of the collisions, the plasma oscillations must be described on the basis of the kinetic equation. With $\omega\tau \ll 1$ the plasma can be described hydrodynamically. The authors studied the case $\omega\tau \gg 1$. The general dispersion equation for plasma oscillations in an external magnetic field with random distribution function of the particles with respect to the velocities

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reads as follows: $An^4 + Bn^2 + C = 0$ (1) where $n = kc/\omega$. The wave vector $\vec{k}$ and the quantities A, B, and C are determined by the components of the tensor of the dielectric constant ε_{ij}. Furthermore, it is assumed that $\omega \ll \omega_{Hi}$, $kv_0 \ll \omega_{Hi}$ where ω_{Hi} is the gyrofrequency of the ions, $v_i = (T_i/M)^{1/2}$ the mean thermal velocity of the ions (T_i denotes the temperature and M the mass of the ions) and v_0 the velocity of the beam. Under these conditions (1) falls into the equations $(kc/\omega)^2\cos^2\theta - \varepsilon_{11} = 0$ (3) and $(kc/\omega)^2 - \varepsilon_{22} - \varepsilon_{23}^2/\varepsilon_{33} = 0$ (4) describing the Alfvèn wave and the sound wave, respectively. If the velocity distribution of the particles in the beam has the form $f_{e,i} = n_0' \left(\frac{m_{e,i}}{2\pi T_{e,i}'}\right)^{3/2} \exp\left\{-\frac{m_{e,i}(v - v_0)^2}{2T_{e,i}'}\right\}$ (5) (n_0' density of the particles in the beam, T_e', T_i' temperatures of the electrons and ions of the beam, $m_e = m$, $m_i = M$)

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$$\varepsilon_{11} = 1 + \sum_{\alpha} \frac{\Omega_{\alpha}^{2} (\omega - k_{\parallel} v_{0\alpha})^{2}}{\omega_{H\alpha}^{2} \omega^{2}}, \qquad \varepsilon_{22} = \varepsilon_{11} + \sum_{\alpha} \frac{\Omega_{\alpha}^{2} k^{2} v_{\alpha}^{2}}{\omega_{H\alpha}^{2} \omega^{2}} 2i \sqrt{\pi} \sin^{2} \theta z_{\alpha} w(z_{\alpha}),$$

$$\varepsilon_{33} = 1 + \sum_{\alpha} \frac{\Omega_{\alpha}^{2}}{k_{\parallel}^{2} v_{\alpha}^{2}} (1 + i \sqrt{\pi} z_{\alpha} w(z_{\alpha})),$$

$$\varepsilon_{23} = - \sum_{\alpha} \frac{\Omega_{\alpha}^{2}}{\omega \omega_{H\alpha}} \sqrt{\pi} \operatorname{tg} \theta z_{\alpha} w(z_{\alpha}), \tag{6}$$

где

$$w(z_{\alpha}) = e^{-z_{\alpha}^{2}} \left(\pm 1 + \frac{2i}{\sqrt{\pi}} \int_{0}^{z_{\alpha}} e^{t^{2}} dt \right), \qquad z_{\alpha} = \frac{\omega - k_{\parallel} v_{0\alpha}}{\sqrt{2} k_{\parallel} v_{\alpha}},$$

$$\Omega_{\alpha}^{2} = 4\pi e^{2} n_{0\alpha}/m_{\alpha}, \quad v_{\alpha}^{2} = T_{\alpha}/m_{\alpha}, \quad \omega_{H\alpha} = e_{\alpha} H_{0}/m_{\alpha} c, \quad k_{\parallel} = k \cos\theta$$

holds with Maxwellian equilibrium velocity distribution of the electrons and ions of the plasma. The upper and lower signs in $\omega(z_{\alpha})$ hold with $k_{\parallel} > 0$ and $k_{\parallel} < 0$, respectively; the index α denotes the types of all particles of the plasma and the beam. With the aid of (6) expression

$$\omega = k_{\parallel} \frac{v_{0} \Omega_{i}'^{2} \pm [(\Omega_{i}^{2} + \Omega_{i}'^{2}) c^{2} \omega_{Hi}^{2} - \Omega_{i}^{2} \Omega_{i}'^{2} v_{0}^{2}]^{1/2}}{\Omega_{i}^{2} + \Omega_{i}'^{2}}, \tag{7}$$

for the frequency of the Alfvèn wave modified by the existence of the beam is obtained from (3). Due to the excitation of the Alfvèn waves the state of the system plasma - beam is unstable if condition

$$v_0^2 > V_A^2 + V_A'^2,$$

$$\text{где} \quad V_A = H_0 / \sqrt{4\pi n_0 M}, \quad V_A' = H_0 / \sqrt{4\pi n_0' M}, \tag{8}$$

is fulfilled. With sufficiently low densities of the beam the excitation of the Alfvèn waves is impossible as long as the coupling between the Alfvèn waves and the magneto-acoustic waves is neglected. When considering this coupling an instability is observed also with those densities at which (8) is not valid. In the following study of the beam by means of the magneto-acoustic waves the density of the beam is assumed to be small as compared to the plasma density. With $kv_i \ll \omega \ll kv_e$ the solution of the dispersion equation (4) has the form

$$\omega_\pm = kV_\pm, \quad V_\pm^2 = \frac{1}{2}\left(V_A^2 + s^2 \pm \left[(V_A^2 + s^2)^2 - 4V_A^2 s^2 \cos^2\theta\right]^{1/2}\right), \tag{9}$$

with lacking beam, where $s = (T_e/M)^{1/2}$. With $V_A \sim s$ the quantities $V_\pm$ are also of the order of magnitude s. In this case the condition $\omega \gg kv_i$

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holds only for a strongly nonisothermal plasma ($T_e \gg T_i$) while the magneto-acoustic waves with $T_e \lesssim T_i$ are strongly attenuated. Besides, also $|\omega - k_{\parallel} v_0| \gg kv'_e$ holds. The dispersion equation (4) then reads as follows: $\omega = k_{\parallel} v_0 + \varepsilon$ (10) with $|\varepsilon| \ll |k_{\parallel} v_0|$. Under the conditions studied, the state of the system plasma-beam is unstable due to the excitation of the magneto-acoustic waves. If v_0 does not lie in the interval $s < v_0 < V_A$ this instability occurs even with neglection of η ($|\eta| \ll 1$). With $v_0 \cos\theta \to V_{\pm}$, (13) holds. With the maximum (resonance) interaction (with $V_{\pm} = v_0 \cos\theta$) the increment of increase of the oscillations is not proportional to $(n'_0/n_0)^{1/2}$ but to $(n'_0/n_0)^{1/3}$. The solutions (10) to (13) of the dispersion equation (4) hold for a strongly non-isothermal plasma. With $T_e \lesssim T_i$,

$$\varepsilon = \left(\frac{M}{m}\right)^{1/3} \varepsilon_0 = \pm \frac{\Omega'_i \left[n^2 - \varepsilon_{22}^{(0)}\right]^{1/2}}{\left[\varepsilon_{33}^{(0)} \left(n^2 - \varepsilon_{22}^{(0)}\right) - \varepsilon_{23}^{(0)2}\right]^{1/2}}, \qquad (14)$$

is obtained with neglection of the thermal motion of the electrons of the beam. ε^{o}_{ij} is the component of the tensor of the dielectric constant of the plasma without beam with $\omega = k_{\parallel}v_o$. An instability also occurs with $T_e \lesssim T_i$ if the plasma oscillations are weakly attenuated. With $kv_i' \ll |\omega - k_{\parallel}v_o| \ll kv_e'$ the thermal motion of the electrons in the beam has to be taken into account. (4) then has the solution $\omega = k_{\parallel}v_o + \varepsilon_o$, $|\varepsilon_o| \ll k_{\parallel}v_o|$ (15) where ε_o is obtained from (14). If $k_{\parallel}v_o$ lies near the eigenfrequency $kV_{\pm}$ of the magneto-acoustic wave in the nonisothermal plasma $\omega = kV_{\pm} + \varepsilon_o$, $|k(v_o\cos\theta - V_{\pm})| \ll |\varepsilon_o|$ (16) holds where ε_o is to be determined from (13). These formulas hold for sufficiently low temperatures of the beam $|\omega - k_{\parallel}v_o| \gg kv_i'$. With sufficiently small n_o'/n, $\omega = \omega_{\pm} + i\gamma_{\pm}$ holds with

$$\gamma_{\pm} = -\frac{\sqrt{\pi}\,\omega_{\pm}\sin^2\theta\,(\xi_e + \xi_e' + \xi_i')}{4\zeta_{\pm}\,|\cos^2\theta - \zeta_{\pm}|\,(\zeta_+ - \zeta_-)}, \qquad \zeta_{\pm} = \left(\frac{V_{\pm}}{s}\right)^2.$$

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25206
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B125/B202

Interaction between charged ...

A beam with low density and high energy spread of the electrons and ions generally does not cause a magneto-acoustic wave in the plasma. There are 9 references: 7 Soviet-bloc and 2 non-Soviet-bloc. The two most recent references to English-language publications read as follows: D. Bohm, E. Gross. Phys.Rev., 75, 1851, 1864, 1949. I.B. Bernstein, R.M. Kulsrud. Phys.Fl., 3, 937, 1960.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Institute of Physics and Technology of the Academy of Sciences of the Ukrainskaya SSR)

SUBMITTED: January 27, 1961

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27204

26.2311

S/056/61/041/002/026/028
B125/B138

AUTHORS: Akhiyezer, A. I., Akhiyezer, I. A., Sitenko, A. G.

TITLE: Contribution to the theory of plasma fluctuations

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 2(8), 1961, 644-654

TEXT: This article deals with the theoretical determination of the spectral distributions and correlation functions of various fluctuating quantities, including the distribution function of particles, and also with the determination of the scattering cross sections of electromagnetic waves by plasma fluctuations without collisions. The authors study a free plasma and a plasma located in a constant homogeneous magnetic field. The possible difference between the electron and ion temperatures is taken into account. In accordance with the general theory (H. B. Callen, T. A. Welton, L. D. Landau, and Ye. M. Lifshits), fluctuations in a plasma that is in perfect statistical equilibrium can be investigated if the tensor of its dielectric constant is known. V. V. Tolmachev, S. V. Tyablikov, and Yu. L. Klimontovich determined equations for the spatial correlation

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X

functions of particle systems undergoing electromagnetic interaction. V. D. Shafranov calculated the correlation functions of microcurrents from the equations of motion. F. G. Bass, M. I. Kaganov, and V. P. Silin investigated plasma fluctuations, taking spatial dispersion into consideration. The Fourier components of the correlators of charge transverse current density in a plasma read

$$\langle \rho^2 \rangle_{k\omega} = \frac{T}{2\pi}\frac{k^2}{\omega}\frac{\operatorname{Im}\varepsilon_l}{|\varepsilon_l|^2} = \frac{T(ak)^2}{4\sqrt{\pi}as}\frac{e^{-z^2}+\mu e^{-\mu^2z^2}}{[1+(ak)^2-\varphi(z)-\varphi(\mu z)]^2+(\pi/4)z^2(e^{-z^2}+\mu e^{-\mu^2z^2})^2},$$

$$\langle j_t^2 \rangle_{k\omega} = \frac{T}{2\pi}\omega(\eta^2-1)^2\frac{\operatorname{Im}\varepsilon_t}{|\eta^2-\varepsilon_t|^2} = \frac{T\omega}{\sqrt{\pi}}\left(\frac{\omega}{\Omega}\right)^2\frac{(1-\eta^2)^2 z e^{-z^2}}{[\omega^2(1-\eta^2)/\Omega^2-2\varphi(z)]^2+\pi z^2 e^{-2z^2}}. \qquad (4)$$

This indicates that at ka $\gtrsim$ 1 low-frequency oscillations are the most important factor in fluctuation spectra of ρ and $\vec{j}$. The correlation

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function of the charge density reads

$$\langle \varrho(\vec{r}\,', t)\varrho(\vec{r}\,'', t)\rangle = 2e^2 n_0 \left[\delta(\vec{r}) - \frac{1}{4\pi a^2}\frac{e^{-r/a}}{r}\right], \quad \vec{r} = \vec{r}\,' - \vec{r}\,'' \qquad (7).$$

The spectral distributions of fluctuations of the electric and magnetic fields read:

$$\langle E^2\rangle_{k\omega} = \frac{8\pi T}{\omega}\left(\frac{\operatorname{Im}\varepsilon_l}{|\varepsilon_l|^2} + 2\frac{\operatorname{Im}\varepsilon_t}{|\eta^2 - \varepsilon_t|^2}\right),$$

$$\langle H^2\rangle_{k\omega} = \frac{16\pi T}{\omega}\eta^2\frac{\operatorname{Im}\varepsilon_t}{|\eta^2 - \varepsilon_t|^2}. \qquad (9)$$

respectively. The resulting correlation functions for the field strengths read:

$$\langle \vec{E}(\vec{r}\,', t)\,\vec{E}(\vec{r}\,'', t)\rangle = 8\pi T\left[\delta(\vec{r}) + \frac{1}{8\pi a^2}\frac{e^{-r/a}}{r}\right], \quad \langle \vec{H}(\vec{r}\,', t)\,\vec{H}(\vec{r}\,'', t)\rangle = 8\pi T\delta(\vec{r}) \qquad (10).$$

The spectral distribution of fluctuations in an electron gas for

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$T \ll mv_0^2/2$ (v_0 - limiting velocity) reads

$$\langle\rho^2\rangle_{k\omega} = \frac{3}{4}\frac{\hbar\zeta k^2}{1-e^{-\hbar\omega/T}}\left\{\frac{1}{2}z\theta(1-|z|)\left[\left(\zeta+1-\frac{z}{2}\ln\frac{1+z}{1-z}\right)^2+\left(\frac{\pi z}{2}\right)^2\right]^{-1}+\right.$$
$$\left.+\delta\left(\zeta+1-\frac{z}{2}\ln\left|\frac{z+1}{z-1}\right|\right)\operatorname{sign} z\right\}, \qquad (11)$$
$$\theta(z)=\begin{cases}0, & z<0\\ 1, & z>0\end{cases},$$

where $z = \omega/kv_0$ and $\zeta = \frac{(kv_0/\Omega)^2}{3}$. The spectral distribution of charge-density fluctuations in a plasma in the high-frequency range reads

$$\boxed{\begin{aligned}\langle\rho^2\rangle_{k\omega} &= \frac{T}{4}\left(\frac{k\omega}{\Omega}\right)^2\frac{(\omega^2-\omega_H^2)^2}{\omega^4\cos^2\vartheta+(\omega^2-\omega_H^2)^2\sin^2\vartheta}\times\\ &\times(\delta(\omega-\omega_+)+\delta(\omega+\omega_+)+\delta(\omega-\omega_-)+\delta(\omega+\omega_-)).\end{aligned}} \qquad (14).$$

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Then the authors determine the electron and ion density fluctuations separately. They also determine the fluctuations of the distribution functions for the plasma particles, the electron temperature T^e and the ion temperature T^i being assumed to differ. A non-isothermal plasma can be regarded as a quasi-equilibrium system, and the fluctuations occurring in it can be studied with the aid of fluctuation theory. The following expression is obtained for the Fourier components of electron and ion density fluctuations:

$$\begin{aligned} \delta n^e(\mathbf{k},\omega) &= i\frac{k}{\omega}\frac{1}{\varepsilon(k,\omega)}\left(Y^e_{k\omega}(1+4\pi\varkappa^i)+Y^i_{k\omega}4\pi\varkappa^e\right),\\ \delta n^i(\mathbf{k},\omega) &= i\frac{k}{\omega}\frac{1}{\varepsilon(k,\omega)}\left(Y^e_{k\omega}4\pi\varkappa^i+Y^i_{k\omega}(1+4\pi\varkappa^e)\right);\\ Y^a_{k\omega} &= \int\frac{\mathbf{k}\mathbf{v}}{k}\left(\omega-\mathbf{k}\mathbf{v}+\frac{i}{\tau^a}\right)^{-1}y^a(\mathbf{v},\mathbf{k},\omega)\,d\mathbf{v}, \end{aligned} \qquad (18),$$

where $\varepsilon = 1 + 4\pi(\varkappa^e + \varkappa^i)$; $\varkappa^e$ and $\varkappa^i$ denote the electrical susceptibilities of electrons and ions respectively. From this the following expression is obtained for the spectral distribution of charge density fluctuations:

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Contribution to the theory of...

$\langle \varrho^2 \rangle_{\vec{k}\omega} = e^2 < |\delta n^e - \delta n^i|^2 >_{\vec{k}\omega} = \frac{2k^2}{\omega |\varepsilon|^2} \operatorname{Im}\{T^e \varkappa^e + T^i \varkappa^i\}$. The correlators of the distribution functions are given by

$$\begin{gathered}\langle f^a(\mathbf{v}) f^b(\mathbf{v}') \rangle_{\mathbf{k}\omega} = 2\pi\delta_{ab} F_0^a(v)\,\delta(\mathbf{v}-\mathbf{v}')\,\delta(\omega-\mathbf{kv}) \pm \\ \pm 2\pi \cdot 4\pi e^2 k^{-2} F_0^a(v)\, F_0^b(v')\, S^{ab}(\mathbf{v},\mathbf{v}'), \end{gathered} \tag{22}$$

the upper (lower) sign indicates equal (different) particles. The authors then generalize the results obtained to the case where the plasma is located in a constant and homogeneous magnetic field $\vec{H}_0$. Then, the correlators of the fluctuations of electron density and magnetic field strength are given by

$$\begin{gathered} e^2 \langle |\delta n^e|^2 \rangle_{\mathbf{k}\omega} = \frac{k_i k_j}{\omega^2} \langle j_i^e j_j^e \rangle_{\mathbf{k}\omega}, \\ \langle \delta H_i \delta H_j \rangle_{\mathbf{k}\omega} = \left(\frac{4\pi}{\omega}\right)^2 \frac{\eta^4}{(\eta^2-1)^2} e_{ilm} e_{jl'm'} k^{-2} k_l k_{l'} \langle j_m j_{m'} \rangle_{\mathbf{k}\omega}, \\ e \langle \delta n^e \delta H_j \rangle_{\mathbf{k}\omega} = -\frac{4\pi i}{c\omega} \frac{\eta^2}{\eta^2-1} e_{jm'l} \frac{k_m k_{m'}}{k^2} (\langle j_m^e j_l^i \rangle_{\mathbf{k}\omega} + \langle j_m^e j_l^i \rangle_{\mathbf{k}\omega}). \end{gathered} \tag{27}$$

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where $e_{...}$ is a completely antisymmetric tensor of third rank. The scattering of electromagnetic waves by fluctuations in a free plasma is determined only by the electron density fluctuations. For a plasma located in a magnetic field $\vec{H}_0$, it is also necessary to take account of the fluctuations $\delta\vec{H}$ of the magnetic field. In the absence of a magnetic field, the differential scattering coefficient for an unpolarized wave reads

$$d\Sigma = \frac{1}{4\pi}\left(\frac{e^2}{mc^2}\right)^2\left(\frac{\omega}{\omega_0}\right)^2\sqrt{\frac{\varepsilon}{\varepsilon_0}}\,(1+\cos^2\theta)\,\langle|\delta n^e|^2\rangle_{q\Delta\omega}\,do\,d\omega, \qquad (28)$$

where θ is the scattering angle, do is the element of the solid angle $\vec{k}$, $\varepsilon \equiv \varepsilon(\omega) = 1 - \Omega^2/\omega^2$, $\varepsilon_0 = \varepsilon(\omega_0)$. In this formula, the frequency can be changed arbitrarily. In the presence of a magnetic field, the expression

$$d\Sigma = \frac{1}{2\pi}\left(\frac{e^2}{mc^2}\right)^2\left(\frac{\omega_0\omega}{\Omega^2}\right)^2 R\left\{|\xi|^2\langle|\delta n^e|^2\rangle_{q\Delta\omega} - \frac{en_0}{mc}\frac{\omega}{\Omega^2}\,\mathrm{Im}\,(\xi A_l\langle\delta n^e\delta H_l\rangle_{q\Delta\omega}) + \right.$$
$$\left. + \frac{n_0}{4\pi mc^2}\frac{\omega^2}{\Omega^2}A_l^* A_l\langle\delta H_l\delta H_l\rangle_{q\Delta\omega}\right\} do\, d\omega, \qquad (29)$$
$$R = \eta^2\left\{\eta_0\left(|e_0|^2 - \frac{|e_n k_n|^2}{k_0^2}\right)\varepsilon_{ij}e_i^* e_j^0\right\}^{-1}, \quad \xi = (\varepsilon_{ij}^0 - \delta_{ij})e_i^* e_j^0,$$
$$A_l = (\varepsilon_{kl} - \delta_{kl})e_k^* e_{lml}(\varepsilon_{mj}^0 - \delta_{mj})e_j^0,$$

holds instead of (28), where $\vec{e}$ is the polarization vector of the scattered wave. At equal temperatures of electrons and ions, the spectrum of scattered radiation, in the absence of a magnetic field, consists of a line broadened by the Doppler effect ($\Delta\omega \lesssim qs$) and sharp maxima at $\Delta\omega = \pm\Omega$, if $aq \ll 1$. For $\Delta\omega \gg qs_e$ there occurs only scattering by Langmuir oscillations. In the most interesting case $\Delta\omega/qs_i \gg \ln(T^e/T^i)$, the following equation holds for $\Delta\omega/qs_i \gg \ln(T^e/T^i)$ and $\Delta\omega \sim \omega_s(q)$:

$$d\Sigma = \frac{e^2 k_e^4 T^e(1+\cos^2\Theta)}{16\pi(mc^2)^2(k_e^2+q^2)}\left\{\delta\left(\Delta\omega - \omega_s(q)\right) + \delta\left(\Delta\omega + \omega_s(q)\right)\right\} \qquad (33).$$

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Contribution to the theory of...

For $\omega_0 \gg \omega_+$ and $T^e = T^i$ and $(\Delta\omega)_{eff} \ll \omega_0 \sin\Theta$, the integral scattering coefficient reads

$$d\sum = \frac{n_0}{4}\left(\frac{e^2}{mc^2}\right)^2 \left(\frac{\omega_0}{\Omega}\right)^4 (R|\xi|^2)_{\omega=\omega_0} \frac{1+2(aq)^2}{1+(aq)^2}\, do \qquad (35).$$

There are 25 references: 19 Soviet and 6 non-Soviet. The two most recent references to English-language publications read as follows: E. E. Salpeter. Phys. Rev., 120, 1528, 1960; J. P. Dougherty, D. T. Farley. Proc. Roy. Soc., A 259, 79, 1960.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physicotechnical Institute of the Academy of Sciences Ukrainskaya SSR). Khar'kovskiy gosudarstvennyy universitet (Khar'kov State University)

SUBMITTED: March 30, 1961

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S/861/62/000/000/001/022
B125/B102

AUTHORS: Akhiyezer, A. I., Faynberg, Ya. B.

TITLE: Linear acceleration of charged particles (introductory article)

SOURCE: Teoriya i raschet lineynykh uskoriteley; sbornik statey. Fiz.-tekhn. inst. AN USSR. Ed. by T. V. Kukoleva. Moscow, Gosatomizdat, 1962, 5 - 18

TEXT: The development of linear accelerators since 1946 has been promoted by the disadvantages of cyclic accelerators, viz., large magnets, large radiative losses in high-energy electron acceleration, low amperage of the particle beam. The magnetic systems of linear accelerators need not be large. Such accelerators ensure continuous operation and high phase stability; also they furnish much heavier currents than cyclic accelerators. They produce almost no radiation, and can be extended by adding on sections. Hitherto it has not been possible to combine radial stability with phase stability, but even without special focusing this will be rendered possible in plasma wave guides. The highest electron energies achieved using linear accelerators are ~660 Mev. Linear proton accelerators of ~50 to ~100 Mev

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and linear ion accelerators serve as injectors for cyclic accelerators. Linear acceleration up to several Bev is thought possible. Self-stabilization of phase allows of accelerating many injected particles. The following types of linear accelerators now exist: (1) Periodic structures of waveguide accelerators with perforated metal discs are at present the most effective accelerators where phase velocities are extremely high ($v_{ph} \to c$). These are ineffective for low phase velocities ($v_{ph}/c \sim 0.3$ to 0.5). (2) When filled with anisotropic dielectrics, waveguides can also be used for low phase velocities. (3) Periodic structures with drive tubes spaced along the axis are very efficient for $v_{ph} \sim 0.3$ to 0.4. Disadvantages become manifest if the length of these accelerators or the phase velocity is increased. Small local changes in the parameters of an individual element affect the field strength considerably, because of the strong coupling between the individual elements. (4) Slow waves can be produced using helical waveguides.

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S/861/62/000/000/003/022
B125/B102

24.6730

AUTHORS: Akhiyezer, A. I., Lyubarskiy, G. Ya., Pargamannik, L. E.

TITLE: Dynamics and stability of charged particle motion in a linear accelerator

SOURCE: Teoriya i raschet lineynykh uskoriteley; sbornik statey. Fiz.-tekhn. inst. AN USSR. Ed. by T. V. Kukoleva. Moscow, Gosatomizdat, 1962, 38 - 80

TEXT: The motions of a particle bunch in standing- or traveling-wave linear accelerators are considered. The theory is based on the following assumptions: A certain "fundamental particle" travels with the velocity $c\beta$ through all sections of the accelerator at strictly predetermined phases φ, designated as synchronous phase of the section. The initial conditions on injection can differ from the initial conditions of the fundamental particle in phase, radius, magnitude or direction of velocity. Studying the stabilities of the longitudinal and transverse motions of the accelerated particle leads to differential equations of the form $\ddot{q} + \Omega^2(t)q = 0$ (2.1), with $\Omega^2(t)$ positive or negative. From (2.1) the approximate equations

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Dynamics and stability of...

$$\left.\begin{aligned} q_{k+1} &= a_{11}(k)\, q_k + a_{12}(k)\, \dot{q}_k, \\ \dot{q}_{k+1} &= a_{21}(k)\, q_k + a_{22}(k)\, \dot{q}_k. \end{aligned}\right\} \qquad (2.6)$$

are derived. Formulating

$$\left.\begin{aligned} q_k &= A_k \exp\left\{ i \sum_{m=0}^{k-1} \gamma_m, \right. \\ \dot{q}_k &= B_k \exp\left\{ i \sum_{m=0}^{k-1} \gamma_m. \right. \end{aligned}\right\} \qquad (2.7)$$

yields the general solution of (2.1):

$$q_k = A_0 \left(\frac{\Omega_0}{\Omega_k} \right)^{1/2} \cos\left(\sum_{i=0}^{k-1} \tau_i \Omega_i + \theta \right). \qquad (2.11);$$

$A_0 = \sqrt{q_0^2 + (\dot{q}_0^2/\Omega_0^2)}$. The differential equation $\frac{d}{dt}(\dot{q}/\sqrt{1-\beta^2}) + \Omega^2(t)q = 0$ has the solution

$$q_k = A_k \cos(\varphi_k + 0) = A_0 \left(\frac{1-\beta_k^2}{1-\beta_0^2}\right)^{1/4} \times$$

$$\times \left(\frac{\hat{\Omega}_0}{\hat{\Omega}_k}\right)^{1/2} \cos\left(\sum_{l=1}^{k-1} \hat{\Omega}_l \tau_l + 0\right). \qquad (2.16),$$

where $\hat{\Omega}$ is the frequency of the oscillations. The longitudinal wave is stable in the synchronous phase range $0 < \varphi_s < \pi/2$. In this range the scattered particle does not escape from the acceleration process. The stability of the longitudinal oscillations decreases as the synchronous phase increases. The capture width $\Delta\varphi = \phi_m + \varphi_s = 2\pi K$; if $\varphi_s \ll 1$, $\Delta\varphi = 3\varphi_s$; φ_m is the maximum, φ_s the synchronous phase. In the case of transverse oscillations the non-relativistic frequency of the particles is $\Omega_r^2 = G - (1/2)(1-\beta^2)C\sin\varphi_s$, and their relativistic frequency is $\hat{\Omega}_r^2 = \sqrt{1-\beta^2}\,\{G - (1/2)(1-\beta^2)C\sin\varphi_s'\}$. G is the radial force exerted by the

Dynamics and stability of...

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radial focusing fields. When $G > 0$, a positive synchronous phase exists, and the longitudinal and transverse phases are stable simultaneously. The defocusing effect of the space charge can be neglected when the effective currents amount to a few hundred ma. Simultaneous longitudinal and transverse stability is simply achieved by focusing with foils. The focusing effect of a magnetron lens is described by $G = (\gamma/N)(eH/2mc)^2 m/m_0$; for protons, it is 1840 times greater than the focusing effect of a longitudinal magnetic field. There are 14 figures.

Card 4/4

S/781/62/000/000/016/036

AUTHORS: Akhiezer, A. I., Lyubarskiy, G. Ya., Polovin R. V.

TITLE: Evolutional discontinuities in magnetohydrodynamics

PERIODICAL: Fizika plazmy i problemy upravlyayemogo termoyadernogo sinteza; doklady konferentsii po fizike plazmy i probleme upravlyayemykh termoyadernykh reaktsiy. Fiz.-tekhn. inst. AN.Ukr.SSR. Kiev, Izd-vo AN Ukr. SSR, 1962, 76-79

TEXT: Evolutionality conditions of magnetohydrodynamic shock waves with respect to perturbations that propagate perpendicularly to the discontinuity surface were derived by Akhiezer, Lyubarskiy, and Polovin (ref. 2: ZhETF, 35, 731 (1958)) and their stability under small general perturbations (propagating at arbitrary angle to the discontinuity surface) was demonstrated by V. M. Kontorovich (ref. 3: ZhETF, 35, 1216, 1968). In the present article Kontorovich's re-results are derived in a simple manner, wherein the arbitrary disturbance is expanded in a Fourier integral in the transverse dimension and is assumed small over a sufficiently short time interval, so that the magnetohydrodynamic equations can be linearized. It is demonstrated that to determine the evolutionality con-

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ditions it is sufficient to consider plane waves propagating perpendicular to the discontinuity surface. In particular, in the region $U_{1x} < v_{1x} < U_{1+}$, $U_{2-} < v_{2x} < U_{2x}$ the shock wave is not evolutional. Here

$$U_{+} = \sqrt{\frac{U^2 + c^2 + \sqrt{(U^2 + c^2)^2 - 4c^2U_x^2}}{2}} \;;\; U = H/\sqrt{4\pi\rho}$$

and c is the velocity of sound. It follows therefore that there exist two types of shock waves, a slow one for which $U_{1-} < v_{1x} < U_{1x}$; $v_{2x} < U_{2-}$ and a fast one for which $U_{1+} < v_{1x}$; $U_{2x} < v_{2x} < U_{2+}$. It follows from the foregoing two inequalities that if the shock waves of the same type follow each other, the rear wave will overtake the front wave. As to waves of different types, an Alfven discontinuity will overtake a slow shock wave or a slow magnetic-sound weak discontinuity, while a fast shock wave will overtake all types of discontinuities. Nonevolutionary shock waves cannot result from either continuous or discontinuous solutions. They can exist only for an instant either upon collision of two evolutionary discontinuities, or as discontinuities in the initial conditions. The resultant nonevolutional discontinuity immediately splits into shock and self-similar waves, although all boundary conditions are satisfied on such a discontinuity and the entropy can increase. An example of such a splitting was considered by Lyubarskiy and Polovin (ref. 5: ZhETF 36, 1272, 1959).

44876

S/861/62/000/000/007/022
B125/B102

24.6730

AUTHORS: Akhiyezer, A. I., Lyubarskiy, G. Ya., Pargamanik, L. E., Faynberg, Ya. B.

TITLE: Prebunching and dynamics of a proton bunch in a linear accelerator

SOURCE: Teoriya i raschet lineynykh uskoriteley; sbornik statey. Fiz.-tekhn. inst. AN USSR. Ed. by T. V. Kukoleva. Moscow, Gosatomizdat, 1962, 114 - 130

TEXT: It is shown that a linear accelerator can have a low injection energy of ~0.5 Mev whilst furnishing large currents of ~10 to 50 ma. When the mean accelerating field strength is 20 kv/cm a focusing magnetic field of 15,000 oe is needed in the initial part of the accelerator. This focusing field becomes rapidly weaker with increasing particle energy. The efficiency of ion capture is increased by klystron bunching. When particles in a bunch that was originally homogeneous in velocity and density pass along a segment under an rf field, and immediately afterwards through a field-free drive segment, they are accelerated at different rates and form bunches of charge density. The preaccelerated particles must enter the accelerator at

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the focus $X_1 = v_0/\alpha\omega$. $\alpha = eU/mv_0^2$. $U \sin \omega\tau$ is the modulated voltage applied to the acceleration segment, τ the instant when the particle enters the segment, and v_0 the initial velocity of the particle in the bunch. The greater the angular width of the group of particles, the tighter the bunch is pinched on klystron bunching. If Δv_0 is the initial velocity spread, then the phase range covered after bunching by particles entering the buncher with a velocity of $v_0 + \Delta v_0$ in the phase range $2\psi_0$ is $\phi = 2\psi_0(1 - (\sin\psi_0/\psi_0)(1 - 3\Delta v/v_0))$. The effective accelerating field on the accelerator axis can be undesirably attenuated by unequal attenuations of the fields on the axis and on the periphery of the gaps and also by a shift of the field into the drive tube. Long narrow tubes screen considerably better than short wide tubes. According to experimental studies in the Institut khimicheskoy fiziki AN SSSR (Institute of Chemical Physics AS USSR), the mean value of the electric field strength on the axis remains constant when the gap between the drive tubes is varied, and it increases slightly when the outer diameter of the drive tubes is increased. The problem of multiple gaps cannot be solved from the data available at present. The decreases in the depth of the potential well and in the angle of incidence, induced by space charge, are calculated on the basis of the model of an ellipsoidal bunch with slowly changing dimensions. Stable equilibrium corresponds to the synchronous particle phase $\varphi = \varphi_s$. In that model the focusing magnetic field reads

$$\left(\frac{H}{E}\right)^2 = \frac{mc^2}{eE\lambda}\left\{\frac{mc^2}{eE\lambda}\left(4\pi\frac{\Omega}{\omega}\right)^2 + 4\pi\frac{\sqrt{1-\beta^2}}{\beta^2}\sin\varphi_s + \frac{6J}{cEl}\left(\frac{\lambda}{R}\right)^2(1-k)\right\}, \qquad (4.1).$$

$\omega = 2\pi c/\lambda$ is the frequency of the r-f field, 2l the length of the bunch and Ω the frequency of the radial oscillations. The magnetic fields needed for injection energies of 0.5, 18.75, 145 and 350 Mev are 14.5, 7.6, 6.2 and 5.9 koe. The values $\Delta\beta/\beta = 2\%$ for the initial relative velocity spread in the bunch, and $\alpha = 2.2\cdot10^{-2}$ for the modulation factor of the buncher are obtained. There are 9 figures.

44877

S/861/62/000/000/008/022
B125/B102

24.6730

AUTHORS: Akhiyezer, A. I., Lyubarskiy, G. Ya., Faynberg, Ya. B.

TITLE: Electron counterflow focusing in a proton accelerator

SOURCE: Teoriya i raschet lineynykh uskoriteley; sbornik statey. Fiz.-tekhn. inst. AN USSR. Ed. by T. V. Kukoleva. Moscow, Gosatomizdat, 1962, 131 - 146

TEXT: A theory is developed on counterflow focusing of a proton bunch (Nature, 168, 782, 1951). Radial focusing is achieved by the electrostatic field of the electron beam, which has to be stronger than the defocusing r-f field. Furthermore, the scattering of the electrons from the background gas is studied, taking space charge into account. The minimum amperage of the bunch is $j_{min} = (1/2)(vE/\beta\lambda)\sin\varphi_s$. v is the electron velocity averaged over the period of the r-f oscillations, φ_s the synchronous phase, $c\beta$ the proton velocity, and λ the wavelength of the r-f field. The h-f field of the accelerator is taken to be a traveling wave of amplitude E_0, frequency ω and wave vector k(z). The canonical variables Q and P are introduced:

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$Q = \frac{\partial f}{\partial P} = (\frac{2u}{\alpha v_0} - t)\omega$, $p = \frac{\partial f}{\partial z} = \frac{\omega P}{v_0 u}$, where $f = P\omega(\frac{2u}{\alpha v_0} - t)$. Then

$$\Delta H_1 = \frac{1}{\omega} \int_0^{2\pi} \frac{dH_1}{dt} \frac{dQ}{\frac{v_{\text{эл}}}{u v_0} - 1}, \qquad (1.15),$$

if $H_1 = H + \frac{\partial f}{\partial t}$ and $\frac{dH_1}{dt} = \frac{\partial H_1}{\partial t}$, ΔH_1 is the change of H_1 during a period during which Q changes by 2π. $u = (1 + \alpha z)^{1/2}$, $\alpha = 2eE\cos\varphi_s/Mv_0^2 > 0$, and v_0 is the injection velocity of the protons. When $E = 18$ kv/cm, $v_0 = 3.3\cdot 10^{-2}c$, $\varphi_s = 20°$ and $\lambda = 150$ cm, H_1 increases nearly linearly with H_0. The larger β, the larger H_1. $\Delta H_1/H_1 \simeq 10^{-2}$ holds in the initial stage of the motion of the electron. The greater the velocity of the electrons in the bunch, the greater must be the density of the electron bunch needed for focusing. The total amperages under the present conditions at injection energies $(mc^2(\varepsilon - 1))$ of 1, 10, 50, 70 and 90 kev are 3.5, 1.9, 1.2, 1.06 and 0.7 a. S. Chandrasekhar's methods give

$$\overline{\Delta x^2} = \frac{4\pi N Z^2 e^4}{m^2} \int_0^t \left[\psi_1^2(\tau - t) + \psi_2^2(\tau - t)\right] \frac{1}{v} \ln \frac{a_0 m v^2}{2Z^{4/3} e^2} d\tau. \quad (3.13)$$

for the mean square deviation of the electrons from the accelerator axis. N is the number of gas atoms per cm^3, Z the nuclear charge and $a_0 = 0.53 \cdot 10^{-3}$ cm. For $\sqrt{\overline{\Delta x^2}} < 10^{-2}$ cm, the magnetic field must be greater than 645 gauss. The effect of collisions on bunch broadening is completely compensated by increasing the magnetic field by 10 to 20 gauss. The significant divergence of the bunch as a result of space-charge repulsion is not impeded by this slight increase in field strength. This paper was written in 1953. There are 1 figure and 4 tables.

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44886

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B125/B108

24,6730

AUTHORS: Akhiyezer, A. I., Faynberg, Ya. B., Selivanov, N. P., Stepanov, K. N., Pakhomov, V. I., Kovalev, O. V., Khizhnyak, N. A., Gorbatenko, M. F., Bar'yakhtan, V. G., Shanshanov, A. A.

TITLE: Linear electron acceleratorsfor high energies

SOURCE: Teoriya i raschet lineynykh uskoriteley; sbornik statey. Fiz,-tekhn. inst. AN USSR. Ed. by T. V. Kukoleva. Moscow, Gosatomizdat, 1962, 243 - 309

TEXT: This paper, finished in 1955, is a voluminous report on the most important results obtained at the Fiziko-tekhnicheskiy institut AN USSR (Physicotechnical Institute AS UkrSSR) between 1948 and 1955 as to the proper choice of an accelerating system and its optimum parameters as well as on the dynamics of the electrons inside the accelerator. One of the most efficient systems is the $\pi/2$ traveling wave type accelerator segmented by annular metal disks (designed by V. V. Vladimirskiy). The calculation of such a waveguide with the Walkinshow-Brillouin method (J. Appl. Phys., 20, 634 (1949)) is demonstrated. The radial motion of the electrons in a Bev-accelerator under the action of terrestrial magnetism and gravity should be

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Linear electron accelerator... S/861/62/000/000/017/022
B125/B108

compensated by the combined magnetic fields of rectilinear currents and a small number of electromagnets. In such a case, detectors are necessary indicating the displacement of the beam by the fields of the correcting magnets. Owing to the great length of linear accelerators, an additional radial focusing on the principal section is necessary. In the first section and in the injector this will be achieved by strong longitudinal magnetic fields. In the principal section radial focusing can be achieved by short magnetic lenses (diameter 50 cm) producing a longitudinal magnetic field of ~1000 oe/cm, or by a system of four-pole lenses. Both systems can reduce the beam radius at the output of the accelerator to 0.5 cm. There are 1 figure and 18 tables.

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44889

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24.6730

AUTHORS: Akhiyezer, A. I., Faynberg, Ya. B.

TITLE: Theory of the interaction of charged particles with an electron beam in a magnetic field

SOURCE: Teoriya i raschet lineynykh uskoriteley, sbornik statey. Fiz.-tekhn. inst. AN USSR. Ed. by T. V. Kukoleva. Moscow, Gosatomizdat, 1962, 320 - 325

TEXT: This paper presents an estimation of the accelerating fields occurring as the result of the inverse Cherenkov effect and the inverse effect of polarization losses when a charged particle bunch moving in a longitudinal magnetic field $\vec{H}_0$ is entrained by an electron beam. The space charge of the beam is assumed to be compensated by positive ions. The field excited by the particles is described by Maxwell's equations and by the equations of motion of the plasma particles. The voluminous integral in the expression for the energy losses $\frac{d\mathcal{E}}{dx}$ of the particle is considerably simplified when the magnetic field is either very weak $(\nu \ll 1)$ or very strong $(\nu \gg 1)$:

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Theory of the interaction of...

$$\frac{d\varepsilon}{dx} = -\frac{q^2\Omega^2}{2V^2}\left\{\ln\left(1+\frac{V^2}{a^2\Omega^2}\right)-\frac{\omega_H^2(1-\beta^2)}{6\Omega^2}(9-4\beta^2)\right\}. \qquad (4)$$

and

$$\frac{d\varepsilon}{dx} = -\frac{q^2\Omega^2}{2V^2}\left\{(1-\beta^2)+\ln\left[1+\frac{V^2}{(1-\beta^2)\omega_H^2a^2}\right]-1\right\} \qquad (5),$$

respectively. q is the charge of the moving particle. The first term of these two formulas corresponds to the excitation of frequencies having the order of magnitude $\Omega = \sqrt{4\pi n_o e^2/m}$, whereas the second term corresponds to the excitation of frequencies whose order of magnitude is $\omega_H (\omega = \vec{k}\vec{V})$. $\nu = eH_o/mc\Omega$, $\beta = \frac{V}{c}$. For small values of V, (5) is not valid since the condition $V \gg a\Omega$ does not continue to apply. The quantity $a = 1/k_{\perp max}$ is determined by the minimum parameter for remote collisions between the particles and the electrons of the beam. The upper limit for the energy losses, obtained by inserting the minimum value of the particle velocity $V \sim a\Omega$ in (5),

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B108/B104

AUTHORS: Akhiyezer, A. I., Aleksin, V. F., Bar'yakhtar, V. G., Peletminskiy, S. V.

TITLE: Influence of radiative effects on relaxation of electrons and electric conductivity of a plasma in a strong magnetic field

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 2, 1962, 552 - 564

TEXT: This paper is to show that emission and absorption of electromagnetic waves by plasma electrons may have a considerable effect on the establishment of the thermal equilibrium of the electrons. Equilibrium of the absolute magnitude of the transverse electron momentum can be reached at nonrelativistic temperatures ($T \ll m_0 c^2$) and of the transverse as well as of the longitudinal components of the electron momentum at relativistic temperatures ($T \gg m_0 c^2$). The radiative relaxation time has the order of magnitude of the ratio of mean electron energy to mean intensity of electron emission in a magnetic field. If this relaxation time is less than the mean time

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between two Coulomb collisions then it will also determine relaxation with respect to the corresponding variable. This means it will determine the time of equilibrium distribution of the electrons with respect to their absolute transverse momentum in the nonrelativistic case. The radiative relaxation time is of the order of unity at $H = 2 \cdot 10^5$ gauss, $T = 10^{-2}\ m_0c^2$, and an electron density of $10^3\ \mathrm{cm}^{-3}$, and it decreases with increasing H and T and with decreasing electron density. The transverse component of the electric conductivity of a plasma is determined by the Coulomb collisions as well as by radiative effects. The longitudinal component on the other hand is determined by the Coulomb collisions only. Owing to this fact, electric conductivity of a plasma may be highly anisotropic. Beside the electron relaxation, also a relaxation of the photons occurs which manifests itself in a quasi-equilibrium distribution of the photons. This distribution which is determined by the instantaneous electron distribution reaches equilibrium, i.e., Rayleigh-Jeans distribution somewhat after electron relaxation. L. D. Landau, M. A. Leontovich, and K. N. Stepanov are thanked for discussions. Mention is made of B. A. Trubnikov, A. Ye. Bazhanova (Sb. Fizika plazmy i problema upravlyayemykh termoyadernykh reaktsiy (Plasma

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B108/B104

Influence of radiative ...

physics and problems of controlled thermonuclear reactions), 3, Izd. AN SSSR, p. 121), V. S. Kudryavtsev. (idem, p. 114) and L. E. Gurevich, S. T. Pavlov (ZhTФ, 30, 41, 1960). There are 7 Soviet references.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physicotechnical Institute of the Academy of Sciences of the Ukrainskaya SSR)

SUBMITTED: August 21, 1961

X

Card 3/3

AKHIYEZER, A.I.; BAR'YAKHTAR, V.G.; PELETMINSKIY, S.V.

Effect of radiation processes on transport phenomena in a plasma in a high magnetic field. Zhur. eksp. i teor. fiz. 43 no.5:1743-1749 N '62. (MIRA 15:12)

1. Khar'kovskiy gosudarstvennyy universitet.
(Plasma (Ionized gases))
(Magnetic fields)

S/056/62/043/006/042/067
B183/B102

AUTHORS: Akhiyezer, A. I., Akhiyezer, I. A.

TITLE: Coexistence of superconductivity and ferromagnetism

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 6(12), 1962, 2208 - 2216

TEXT: Contrary to the assumption that nonsuperconducting ferromagnetic regions separated by superconducting intermediate layers exist in solid solutions of ferromagnetic metals in superconductors (B. Matthias, H. Suhl, Phys. Rev. Lett., 4, 51, 1960), it is shown here from theoretical studies that superconductivity and ferromagnetism may, in principle, coexist in the same spatial regions. The Cooper problem (J. Bardeen, L. Cooper, J. Schrieffer, Phys. Rev., 106, 162, 1957) is investigated taking account of the interaction between the conduction electrons via phonon and spin wave exchange. The interaction energy due to emission and absorption of spin waves is calculated. This depends mainly on the orientation of the s-electron spin. Starting from the Schrödinger equation for the wave function of the Cooper problem the potentials for the exchange of spin waves and phonons between the electrons are derived. Then the relationship

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Coexistence of superconductivity...

between the forbidden-band width and the Curie temperature is formulated mathematically. The following was found for the spin wave exchange between the electrons: If pairing occurs in the singlet state the forbidden-band width decreases with increasing Curie temperature; but if it occurs in the triplet state with the spin projections ± 1 the forbidden-band width does not depend on the Curie temperature. In solid solutions of ferromagnetic metals, the Curie temperature increases with increasing concentration of the ferromagnetic component while the Debye temperature is almost independent of the concentration. Thus, with small concentrations of the ferromagnetic component, the critical temperature increases with increasing concentration whereas in the case of high concentrations it decreases with increasing concentration, irrespective of the spin state of the interacting electrons. There are 2 figures.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physicotechnical Institute of the Academy of Sciences Ukrainskaya SSR)

SUBMITTED: July 2, 1962

AKHIYEZER, A. I., BARYAKHTAR, V.G.

"Relaxation Processes in Ferro- and Antiferromagnets."

report submitted for the Conference on Solid State Theory, held in Moscow, December 2-12, 1963, sponsored by the Soviet Academy of Sciences.

ACCESSION NR: AT4036052 S/2781/63/000/003/0151/0161

AUTHORS: Akhiyezer, A. I.; Lyubarskiy, G. Ya.; Polovin, R. V.

TITLE: On the kinetic instability of a plasma

SOURCE: Konferentsiya po fizike plazmy* i problemam upravlyayemogo termoyadernogo sinteza. 3d, Kharkov, 1962. Fizika plazmy* i problemy* upravlyayemogo termoyadernogo sinteza (Plasma physics and problems of controlled thermonuclear synthesis); doklady* konferentsii, no. 3, Kiev, Izd-vo AN UkrSSR, 1963, 151-161.

TOPIC TAGS: plasma research, plasma instability, kinetic gas theory, distribution statistics, plasma stability, plasma magnetic field interaction, Laplace transformation

ABSTRACT: The article deals with the stability of the distribution function of particles in a plasma with respect to plasma oscillations. The general conditions for the stability of the electron distribution

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ACCESSION NR: AT4036052

function are derived by investigating the behavior of individual spatial Fourier components of the potential and the deviations of the electron distribution function from the initial distribution function. The first part of the analysis is devoted to a free plasma without external fields. The singular points of the Laplace transformations of the potential and of the distribution function (which determine the behavior of these functions in the steady state) are then determined. Stability criteria based on the locations of these roots in the complex plane are then established. It is shown that a distribution function which has only one maximum is stable; this confirms deductions made by others. Furthermore, an arbitrary spherically symmetrical distribution function which does not vanish anywhere is also stable, regardless of the number of maxima. The second part of the analysis is devoted to a plasma in a constant and homogeneous magnetic field, the stability being investigated only with respect to plasma waves for which the electric field is potential. The necessary and sufficient stability criteria are estab-

ACCESSION NR: AT4036052

lished and it is shown that an even distribution function with a single maximum is stable and that any anisotropic distribution function is stable. The stability conditions for a fixed value of the plasma frequency are also established. The stability condition of the distribution function in a plasma in a constant and homogeneous weak electric field is then determined and it is shown that a weak electric field does not change the stability conditions. "The authors are grateful to K. N. Stepanov and A. B. Kitsenko for valuable advice, and to L. D. Landau and M. A. Leontovich for a useful discussion." Orig. art. has: 29 formulas.

ASSOCIATION: None

SUBMITTED: 00 DATE ACQ: 21May64 ENCL: 00

SUB CODE: ME NR REF SOV: 013 OTHER: 014

Card 3/3

S/021/62/000/012/004/018
D251/D308

AUTHOR: Romanenko, V.M.

TITLE: A problem of control

PERIODICAL: Akademiya nauk Ukrayins'koyi RSR. Dopovidi, no. 12, 1962, 1549-1552

TEXT: The system of equations

$$\frac{dx}{dt} = Gx + F(t), \qquad x(0) = x_0 (0 \leqslant t \leqslant T) \qquad (1)$$

is considered. Here $x(t) = (y(t), u(t))$, where $y(t)$ is an m-dimensional vector function and $u(t)$ a scalar function; $F(t)$ is a piece-wise continuous $m + 1$ dimensional vector function of the disturbances, and the constant real matrix G is given by $G = \begin{Vmatrix} A & b \\ c & d \end{Vmatrix}$, where A is an $m \times m$ matrix, b and c are m-dimensional vectors, and d is a scalar. This equation may be use to describe a dynamic system of control $\{G\}$, in which $F(t)$ are fixed disturbances, A and b are fixed and charac-

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D251/D308

A problem of control

terize the controlled object, and c and d are variable and describe the regulator. The concepts of 'technically stable' and 'naturally stable' are defined in terms of the eigenvalues ν and $\varkappa$ of the matrices $H = \frac{A + A'}{2}$, $K = \frac{G + G'}{2}$ respectively (the prime indicates transposition) $\nu \neq \varkappa$. {G} is 'technically stable' in the time-interval [0, T] if for arbitrary $\varepsilon > 0$, it is possible to find $\delta(\varepsilon) > 0$ such that

$$(x_0, x_0) \leqslant \delta(\varepsilon) \tag{2}$$

implies

$$(x(t), x(t)) \leqslant \varepsilon \tag{3}$$

for any $t \in [0, T]$. It is 'naturally stable' if all eigenvalues ν_k of H satisfy $\nu_k < N$, when N is a real number, defined for given $\delta(\varepsilon)$. It is shown that if {A,b} is naturally stable, then the corresponding choice of {c,d} will always give a dynemic system of automatic control that is technically stable in {0,T}.

PRESENTED: by Yu.A. Mytropol's'kyy, Academician

SUBMITTED: May 10, 1962

Card 2/2

L 14279-63 EWT(1)/BDS/EEC(b)-2 AFFTC/ASD Pi-4 GG/IJP(C)

ACCESSION NR: AP3005289 S/0056/63/045/002/0337/0343

AUTHOR: Akhiyezer, A. I.; Bar'yakhtar, V. G.; Poletminskiy, S. V.

61
60

TITLE: On coherent amplification of spin waves

SOURCE: Zhur. eksper. i teoret. fiz., v. 45, no. 2, 1963, 337-343

TOPIC TAGS: spin wave, coherent amplification, spin-wave amplification, coherent spin wave, ferromagnetic spin wave, antiferromagnetic spin wave

ABSTRACT: The amplification of spin waves in ferromagnetic (I) and antiferromagnetic (II) samples was investigated analytically by using the principles of coherent interaction between the spin waves and charged particles (electrons) produced by external sources or by an electric field applied to the samples. Linear Maxwell equations for the Fourier components of the electric and magnetic field intensities were set up and, with certain simplifying assumptions, solved for the case of charged particle-spin wave interactions. The solutions were applied to samples of types (I) and (II). It was found that the amplification is quite satisfactory when the conditions $\omega_s(k) = kv$ and $\omega_s(k) = kv - \omega_B$ are

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ACCESSION NR: AP3005289

fulfilled, where ω_s (k) is the frequency of a spin wave of wave vector k, v is the particle velocity, and ω_B is the electron cyclotron frequency. At small particle densities and sufficient energy uniformity of the particles in the beam, the rate of growth is proportional to $n^{1/3}$ for $\omega_s = kv$ and to $n^{1/2}$ for $\omega_s = kv - \omega_B$. Orig. art. has: 20 formulas.

ASSOCIATION: Fiziko-tekhnicheskiy institut AN Ukrainskoy SSR (Physicotechnical Institute, AN Ukrainian SSR)

SUBMITTED: 11Feb63 DATE ACQ: 06Sep63 ENCL: 00

SUB CODE: PH NO REF SOV: 005 OTHER: 001

Card 2/2

L 1593-66 EWT(1)/EPF(n)-2/EWG(m)/EPA(w)-2 IJP(c) AT

AM5007590 BOOK EXPLOITATION UR/ 533.9 7U B+1

44,55 44,55 44,55 41 65 44,55

Akhiyezer, A. I.; Akhiyezer, I. A.; Polovin, R. V.; Sitenko, A. G.; Stepanov, K. N.

21,44,55

Collective oscillations in plasma (Kollektivnyye kolebaniya v plazme) Moscow, Atomizdat, 1964. 0162 p. illus., biblio. 3,700 copies printed.

TOPIC TAGS: plasma physics, plasma oscillation, charged particle, magnetic field plasma stability, ,particle distribution, particle scatter

PURPOSE AND COVERAGE: This book is a presentation of the theory of linear oscillations in "Collisiouless" plasma in which paired collisious do not exert significant influence on its oscillations properties. Three basic problems are presented in the book: natural oscillations spectra, stability and instability of various particle distributions, and fluctuations in homogeneous plasma. The book will be of interest to scientists working in the fields of physical and technological problems such as: diffusion of radio waves in the ionosphere and other plasmas, stellar radioemission, microradiowave amplification and generation with the aid of plasma, acceleration of charged particles in plasma, relaxation in plasma, plasma diagnosis, etc.

L 1593-66
AM5007590

0

TABLE OF CONTENTS (abridged):

SUB CODE: ME, NP SUBMITTED: 26Sep64

NR REF SOV: 100 OTHER: 045

Card 2/2

SHTOKALO, I.Z., akademik, red.; BOGOLYUBOV, N.N., akademik, red.; GLUSHKOV, V.M., akademik, red.; AKHIYEZER, A.I., akademik, red.; PARASYUK, O.S., akademik, red.; KOPNIN, P.V., doktor filosofskikh nauk, red.; VIL'NITSKIY, M.B., kand. fil. nauk, red.; DYSHLEVYY, P.S., kand. fil. nauk, red.; KUCHER, V.I., red.

[Philosophical questions of modern physics; materials] Filosofskie voprosy sovremennoi fiziki; materialy. Kiev, Naukova dumka, 1964. 325 p. (MIRA 17:10)

1. Respublikanskoye soveshchaniye po filosofskim voprosam fiziki elementarnykh chastits i poley. Kiev, 1962. 2. Vitse-prezident AN Ukr.SSR (for Glushkov). 3. Ukrainskiy fiziko-tekhnicheskiy institut (for Akhiyezer). 4. Institut matematiki AN Ukr.SSR (for Parasyuk). 5. Institut filosofii AN Ukr.SSR (for Dyshlevyy, Kopnin).

AKHIYEZER, I.A.

Interaction between charged particles and a turbulent plasma. Zhur. eksp. i teor. fiz. 47 no.2:667-677 Ag '64. (MIRA 17:10)

1. Fiziko-tekhnicheskiy institut AN UkrSSR.

AKHIYEZER, I.A.

Theory of nonlinear motions of a nonequilibrium plasma. Zhur. eksp. i teor. fiz. 47 no.3:952-957 S '64. (MIRA 17:11)

1. Fiziko-tekhnicheskiy institut AN SSSR.

L 10914-65 EWT(m)/T/EWA(m)-2 AFWL/AS(mp)-2/ASD(a)-5/SSD/ESD(t)

ACCESSION NR: AP4046441 S/0056/64/047/003/1169/1171

AUTHORS: Akhiyezer, A. I.; Rekalo, M. P.

TITLE: Electromagnetic properties of strong-interacting particles in the unitary model

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 47, no. 3, 1964, 1169-1171

TOPIC TAGS: [illegible] elementary particle [illegible]

[illegible] electromagnetic [illegible]

[illegible]

[illegible] unitary [illegible]

Card 1/2

breaks the unitary symmetry in first order of perturbation theory. It is shown that the mass splitting, and also various electromagnetic quantities (magnetic moments, form factors, Compton effect [illegible] others) satisfy [illegible] [illegible]. A deep analogy is seen [illegible] between the [illegible] magnetic interaction and the interaction that breaks the unitary symmetry within the framework of the SU transformation. [illegible]

[illegible] transitions [illegible]

[illegible]

[illegible] constitute [illegible]

AKHIYEZER, A.I., akademik; REKALO, M.P.

Relations between photoproduction amplitudes in a unitary symmetry model. Dokl. AN SSSR 159 no.2:298-299 N '64. (MIRA 17:12)

1. Fiziko-tekhnicheskiy institut AN SSSR. 2. AN UkrSSR (for Akhiyezer).

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] baryon, [illegible] symmetry, magnetic [illegible]

[illegible] The results show that [illegible]
[illegible] magnetic [illegible]
[illegible]
[illegible] of [illegible]
[illegible] moderate [illegible]
[illegible] of [illegible]
[illegible] derive a [illegible]
[illegible]

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ACCESSION NR: AP5013573

$\mu(p) = 3\mu_1 + 3\mu_2 + 6\mu_3,$ $\mu(\Sigma^0) = \mu_1$

$\mu(n) = -2\mu_1 - 2\mu_2 - 4\mu_3,$ $\mu(\Lambda) = -\mu_1 + 2\mu_2 - 2\mu_3,$

[illegible]

[illegible]

Card 2/4

[illegible]

[illegible] baryons from the octet, valid in [illegible] by a moderately [illegible]

$$M(N^{*+} \to p + \gamma) = M(N^{*} \to [illegible] + \gamma), \qquad (5a)$$

[illegible]

$$M(Y_1^{*-} \to \Sigma^- + \gamma) = M(\Xi^{*-} \to \Xi^- + \gamma),$$

$$M(N^{*0} \to n + \gamma) = M(\Xi^{*0} \to \Xi^0 + \gamma) = 2M(Y_1^{*0} \to \Sigma^0_u + \gamma), \qquad (5b)$$

ACCESSION NR: AP5013673

$$M(N^{*+} \to p + \gamma) + M(Y_1^{*-} \to \Sigma^- + \gamma) - M(\Xi^{*0} \to \Xi^0 + \gamma) + 2M(Y_1^{*+} \to \Sigma^+ + \gamma) = 0. \quad (5c)$$

Relation (5a) is satisfied at the level of isotropic invariance of strong interaction, relations (5b) hold in SU(3) symmetry, and relations (5c) are satisfied [illegible] symmetry. Orig. art. has: [illegible]

[illegible] Academy of [illegible]

[illegible]

SUB CODE: [illegible] OTHER: [illegible]

L 8294-66 EWT(1)/ETC/EPF(n)-2/EWG(m) IJP(c) AT

SOURCE CODE: UR/0185/65/010/011/1161/1167

ACC NR: AP5028919

67

B

44,55 44,55

AUTHOR: Akhiyezer, I. O. -- Akhiyezer, I. A.

44,55

ORG: Physicotechnical Institute, AN UkrSSR (Fizyko-tekhnichnyy instytut AN UkrSSR)

TITLE: The fluctuations and scattering of particles in a turbulent plasma

SOURCE: Ukrayins'kyy fizychnyy zhurnal, v. 10, no. 11, 1965, 1161-1167

21,44,55

TOPIC TAGS: turbulent plasma, electron plasma, ionized plasma, ion interaction, plasma interaction, particle interaction, particle scatter

ABSTRACT: An investigation was made of a stationary distribution of the turbulent fluctuations in a plasma consisting of cold ions and hot electrons moving with respect to the ions at a velocity u exceeding the velocity of sound s. The case of a low supercriticality 1 - s/u << 1 was considered. It was found that at some definite values of the wave vector almost all the turbulent waves propagate inside a narrow cone around the direction u, the angle of aperture of this cone being much smaller than the Cerenkov angle. At some other values of the wave vector almost all turbulent waves propagate along the surface of the Cerenkov cone. From an investigation of the interaction of charged particles with a turbulent plasma it was found that the intensity of interaction is determined by the level of fluctuations in the plasma. The dependence of the change in the energy of the particle per unit time on the magnitude

2

1/2

L 8294-66

ACC NR: AP5028919

8

and direction of its velocity is determined by the character of the spectral and angular distribution of fluctuations in the plasma. Thus, the scattering of particles in plasma can be used for experimental checking of the theory of plasma turbulence. [JA] Orig. art. has: 20 formulas.

SUB CODE: 20/ SUBM DATE: 20Jan65/ ORIG REF: 006/ OTH REF: 003/ ATD PRESS: 4149

80

Card 2/2

AKHIYEZER, A.I.; BAR'YAKHTAR, V.G.; PELETMINSKIY, S.V.

Theory of transfer phenomena in metals in strong magnetic fields. Zhur. eksp. i teor. fiz. 48 no.1:204-221 Ja '65. (MIRA 18:4)

1. Fiziko-tekhnicheskiy institut AN UkrSSR.

ACCESSION NR: AP5004394 [illegible]

AUTHOR: Akhiyezer, A. I.; Bar'yakhtar, V. [illegible] [illegible]

27

TITLE: Contribution to the theory of transfer [illegible] metals [illegible] magnetic fields

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 48, [illegible]

TOPIC TAGS: electron scattering, [illegible] kinetic coefficient [illegible]

[illegible]

[illegible] strong magnetic fields, and to a determination of the roles played by [illegible] in heat transfer [illegible]

τ_e -- mean free flight time of the electron in the absence of a magnetic field). In this case the electric field and the gradients of the temperature and of the chemical potential are at right angles to the magnetic field [illegible]

Card 1/3

[illegible]

ACCESSION NR: AP5004395

tions can be written for the electron and phonon distribution functions. An important feature of these equations is that they do not contain kinematic terms and that [illegible] density gradients [illegible] [illegible]. [illegible] tions are used to derive general formulas for the transport coefficients, with account of the phonon-electron drag. It is shown that solutions of the transport equations can be obtained for weak [illegible] small [illegible], and that in sufficiently pure metals the heat current transported by the phonons is appreciably larger than the heat current carried by the electrons. In the quantum [illegible] case the phonon heat [illegible] the same [illegible] as the electron transport coefficients [illegible] the position [illegible] maxima). The relative amplitude of the quantum [illegible] ations of all transport coefficients connected with electron-s [illegible] and lattice vibrations, [illegible] be of the order of unity. [illegible] drag is shown to affect the magnitude of the thermal [illegible] has [illegible] formulas

ASSOCIATION: Fiziko-tekhnicheskiy inst[illegible] SSR (Physico-technical Institute, Academy of Sciences [illegible]

[illegible]

ACCESSION NR: AP[illegible]

SUBMITTED: [illegible] ENCL: [illegible] SUB CODE: [illegible]

NR REF SOV: 007 OTHER: 002

Card 3/3

L 07407-67 EWT(1) IJP(c) GD/AT

ACC NR: AT6020575 (N) SOURCE CODE: UR/0000/65/000/000/0133/0139

49

B+1

AUTHOR: Akhiyezer, A. I.; Akhiyezer, I. A.; Polovin, R. V.

ORG: none

TITLE: On the damping of initial excitations and stop of growth of fluctuations in a collision-free plasma

SOURCE: AN UkrSSR. Vysokochastotnyye svoystva plazmy (High frequency properties of plasma). Kiev, Naukovo dumka, 1965, 133-139

TOPIC TAGS: plasma oscillation, plasma wave

ABSTRACT: The mechanism of the stopping of the growth of initial fluctuations of macroscopic quantities in nonequilibrium plasma is investigated for the case of an unbounded plasma. Following Landau's theory (*ZhETF*, 1946, 16, 574) a general Fourier component time development is obtained. The undisturbed equilibrium distribution functions which can be analytically continued into complex domain are chosen for this study. Two examples, where frequencies and damping coefficients are given by the initial excitation and do not depend on plasma property are closely examined. It is shown that Dirac δ-singularities lead to undamped excitations, in contradistinction to Landau's results. This result is generalized to singularities in higher derivatives and the asymptotic form of the potential components is derived. The behavior of the fluctuations is simi-

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L 07407-67

ACC NR: AT6020575

0

lar to that given by Rostoker (*Yadernyy sintez*, 1961, 1, 101) and provides an estimate of time when the growth of fluctuations in nonequilibrium plasmas stops. Orig. art. has: 12 formulas.

SUB CODE: 20/ SUBM DATE: 19Nov65/ ORIG REF: 003/ OTH REF: 001

Card 2/2

AKHIYEZER, A.I., akademik; REKALO, M.P.

Photoproduction of mesons on nucleons, and SU(6)-symmetry. Dokl. AN SSSR 166 no.1:60-62 Ja '66. (MIRA 19:1)

1. Fiziko-tekhnicheskiy institut AN UkrSSR. Submitted September 6, 1965.

L 07405-67 EWT(1) IJP(c) GD/AT

ACC NR: AT6020577 (N) SOURCE CODE: UR/0000/65/000/000/0142/0148

47
Bt/

AUTHOR: Akhiyezer, I. A.

ORG: none

TITLE: On a theory of the nonlinear motion of a nonequilibrium plasma

SOURCE: AN UkrSSR. Vysokochastotnyye svoystva plazmy (High frequency properties of plasma). Kiev, Naukovo dumka, 1965, 142-148

TOPIC TAGS: plasma oscillation, plasma wave propagation, ion noise

ABSTRACT: The kinetic equation for a nonequilibrium plasma is used to study wave dispersion in the collisionless regime. The equation is rewritten using distribution function moments; small charge separation in the sound waves considered here is assumed. This system of equations is used to follow the evolution of finite amplitude waves characterized by the density, phase velocity and distribution moments. The initial Maxwell distribution is studied in greater detail, where sound velocity and distribution momenta per unit density are density-independent, allowing use of isothermal hydrodynamics. In a two-temperature plasma which has a compressing boundary, a self-similar wave exists in the absence of any shock processes. This allows one to write a set of equations which connect all quantities characterizing the plasma behavior in terms of the compressing velocity which is analogous to piston velocity in the hydrodynamic case. Orig. art. has: 9 formulas.

SUB CODE: 20/ SUBM DATE: 19Nov65/ ORIG REF: 006/ OTH REF: 001

Card 1/1

ACC NR: AP7002956 (A, N) SOURCE CODE: UR/0413/66/000/024/0005/0005

INVENTOR: Akhiyezer, A. I.; Peletminskiy, S. V.; Ber'yakhtar, V. G.

ORG: none

TITLE: Certificate of discovery. Class 00, No. 46

SOURCE: Izobreteniya, promyshlennyye obraztsy, tovarnyye znaki, no. 24, 1966, 5

TOPIC TAGS: supersonic wave, magnetic wave, magnetoacoustic resonance, ferromagnetic material, antiferromagnetic material

ABSTRACT:
This Certificate registers the discovery of an interaction between supersonic and magnetic (spin frequency) waves in ferro-, ferri-, and antiferromagnetic materials, which are especially strongly exhibited as the excitation of magnetic waves by supersonic waves and supersonic waves by magnetic waves when the frequencies of their vibration coincide (magneto-acoustic resonance). [TD]

SUB CODE: 20/ SUBM DATE: 08Jan65/ ATD PRESS: 5115

Card 1/1 UDC: none

AKHIYEZER, A.N.

Interference power attenuator. Izm.tekh. no.1:24-28 Ja-F '56.
(MLRA 9:5)

(Wave guides) (Electric waves)

AKHIYEZER, A.N.

Measuring small attenuations by use of double T-pieces. Izm.tekh. no.4:34-37 Jl-Ag '56. (MLRA 9:11)
(Wave guides)

AKHIYEZER, A.N.; BRODSKIY, A.I.

Thermistor bridge circuits with coupled resistance boxes. Izm.tekh. no.5:44-45 S-O '56. (MLRA 10:2)

(Thermistors)

AKHIYEZER, A.N.

SUBJECT USSR / PHYSICS CARD 1 / 2 PA - 1465
AUTHOR ACHIEZER,N.I., ACHIEZER,A.N.
TITLE On the Problem of the Diffraction of Electromagnetic Waves at a Circular Opening in a Plane Screen.
PERIODICAL Dokl.Akad.Nauk, 109, fasc. 1, 53-56 (1956)
Issued: 9 / 1956 reviewed: 11 / 1956

The present work applies the results obtained by N.I.ACHIEZER, Dokl.Akad.Nauk, 98, No 3 (1954) to a diffraction problem. One of these results relates to the integral equations:

$$\int_0^\infty C(\lambda)J_m(\lambda r)\lambda^{m+1}d\lambda = 0\,(r>a),\quad \int_0^\infty C(\lambda)J_m(\lambda r)\lambda^{m+1}\frac{d\lambda}{\gamma} = F(r)r^m\,(0<r<a) \qquad (1)$$

Here $m(\geqslant 0)$ is a whole number, $k \geqslant 0$, the radical $\gamma = \sqrt{\lambda^2-k^2}$ is positive at $\lambda^2 > k^2$ and at $0 < \lambda^2 < k^2$ it has a negative imaginary part, $F(r)(0 \leqslant r \leqslant a)$ is an assumed smooth function. The required function $C(\lambda)$ must satisfy the condition (2) $\int_0^\infty |C(\lambda)\lambda^m|^p \lambda\, d\lambda < \infty$. The solution of the system of equations (1) has the form: $C(\lambda) = \sqrt{\frac{2}{\pi}}\int_0^a g(t)\cos(t\gamma)dt$, where $g(t)$ is determined from the following integral equation with real symmetrical kernel:

Dokl.Akad.Nauk, 109, faso.1, 53-56 (1956) CARD 2 / 2 PA - 1465

$$g(t)+\frac{i}{\pi}\int_0^a\left\{\frac{shk(t+x)}{t+x}+\frac{shk(t-x)}{t-x}\right\}g(x)dx=\sqrt{\frac{2}{\pi}}\frac{d}{dt}\int_0^t rf(r)\frac{ch(k\sqrt{t^2-r^2})}{\sqrt{t^2-r^2}}dr$$

Here $f(r)$ is determined by quadratures by means of the formula $\left(\frac{1}{r}\frac{d}{dr}\right)^m f(r)=(-1)^m F(r)$ and the arbitrary constant at $f(r)$ can and must be selected in such a manner that the function $C(\lambda)$ satisfies the condition (2). Now the problem of the diffraction of electromagnetic waves at a circular opening in an infinitely thin, ideally conductive, plane screen is investigated. Dependence of time is assumed to be characterized by the factor $e^{-i\omega t}$. The components of the electric and of the magnetic field occurring because of the opening in the screen are given. The components E^+ and H^+ at $z > 0$ can be expressed by the magnetic HERTZ vector. The equation for this HERTZ vector is then solved step by step. The computation of the construction of the approximation is here explained, but the problem of the convergence of the process is not mentioned.

In conclusion the expression for $H_z(x,y,0)$ in the opening $r < a$ is given.

INSTITUTION: Charkov State University A.M.GOR'KIJ.

AUTHOR AKHIYEZER, A., AKHIYEZER, N., LYBARSKIY, G., PA - 281o

TITLE Effective Boundary Condition on the Sueface of Multiplying and Slowing down Medium.
(Effektivnoye granichnoye usloviye na poverkhnosti razdela mul'tiplitsituyushchey i zamedlyayushchey sred - Russian)

PERIODICAL Zhurnal Tekhn. Fiz., 1957, Vol 27, Nr 4, pp 822-829, (U.S.S.R.)
Received 5/1957 Reviewed 6/1957

ABSTRACT The effectiv boundary condition at the boundary of the multiplicatory- and the slowing down medium are obtained for the case in which the slowing down characteristics of both media are the same. It is assumed that the multiplicatory medium fills the right half-space $(x > 0)$ whilst the left half-space is filled by the slower-down (x-great distances from the flat boundary). As the dimensions of the multiplicatory medium are infinite, whilst a steady problem is present, the multiplicatory factor of the neutrons is assumed to be equal to one in the case of the determination of the effective boundary conditions. The equation for the slowing-down process of the fast neutons is set up and is then taken as a diffusion equation and reduced to the form of an integral-differential equation with a difference as kernel. The problem consists in finding an asymptotic representation of $f(\xi)$ with $\xi \gg 1$. $\xi = \frac{x}{L_+}$, where L_+ is the diffusion length of the neutrons with $x > 0$. The problem is solved by applying a method resembling that of Viner-Gopf. In an appendix the exact computation is carried out. (With 3 citations from Slav publications)

Card 1/2

Effective Boundary Condition on the Surface of Multiplying PA- 2810
and Slowing Down Medium.

ASSOCIATION	FTI of the Academy of Science of the Ukrainian SSR, Charkow, (FTI AN USSR, Kharkov)
PRESENTED BY	
SUBMITTED	1.10.1956
AVAILABLE	Library of Congress

Card 2/2

AKHIYEZER, A.N.

57-6-22/36.

AUTHOR: AKHIYEZER,A.N.

TITLE: The Effect of the Screen Finite Thickness in Some Diffraction Problems. (Ob uchete tolshchiny ekrana v nekotorykh zadachakh diffraktsii, Russian)

PERIODICAL: Zhurnal Tekhn.Fiz. 1957, Vol 27, Nr 6, pp 1294-1300 (U.S.S.R.)

ABSTRACT: Here the quasistatic theory developed by BETHE (Phys.Rev. 66, 163, 1944) on the diffraction on small holes in a flat ideally conducting screen is generalised for the case in which the screen is of finite thickness. For this purpose it was necessary first to solve a certain boundary problem of the potential theory.

This problem may be raised both for electrostatic and for magnetostatic cases.

Here the magnetostatic one, which corresponds to the "magnetic connection", i.e. for the case in which the component of the electric field near the hole of the connection, which is vertical to the screen, is investigated.

This boundary problem is reduced here to two independent integral equations which permit an approximated solution.

Card 1/2

57-6-22/36

The Effect of the Screen Finite Thickness in Some Diffraction Problems.

The first approximation is found and used for the computation of the connection of two wave conductors. The correction with respect to thickness, which is based upon this approximation, corresponds to the experimental data obtained. (With 1 Table, 4 Illustrations, and 3 Slavic References).

ASSOCIATION: Institute for Measures and Measuring Devices, Charkow. (Institut mer i izmeritel'nykh priborov, Khar'kov)

PRESENTED BY:
SUBMITTED: 29.12.1956
AVAILABLE: Library of Congress

Card 2/2

AKHIYEZER, A. N.

А. Н. Брянский, А. Н. Ахиезер, В. Н. Магда, А. П. Сенько

Образцовая калориметрическая установка для поверки измерителей малой мощности в диапазоне 0,75—1,8 см.

А. Л. Самовоевский,
В. А. Югов,
В. Н. Красноплохов,
А. Н. Дурасова

Пленочные болометры для измерения мощности СВЧ.

А. Н. Малышев

Оптимальные параметры радиометра.

Н. В. Михайлова

О корреляционном измерителе малых сигналов в диапазоне 3—30 Мгц.

В. С. Бушмин

Метод калибровки и поверки измерителей напряженности поля в диапазоне от 10 кгц до 30 Мгц

10 июня
(с 16 до 22 часов)

Г. Д. Бурдун,
Е. Б. Зельманов,
В. Е. Петренко

Метод точного измерения параметров диэлектриков в миллиметровом диапазоне волн

И. Р. Гинзбург, В. Н. Юрьев

Устройство для исследования спектра излучения в миллиметровом и субмиллиметровом диапазоне.

Ю. Я. Юров,
В. Н. Виноградов

Измерение диэлектрической проницаемости стержневых образцов в диапазоне СВЧ

Л. Н. Брянский

Точное измерение КСВН с помощью фазовращателя в зондовой головке.

11 июня
(с 10 до 16 часов)

Л. Н. Брянский

Методы поверки волноводных измерительных линий в диапазоне 0,75—10,0 см.

report submitted for the Centennial Meeting of the Scientific Technological Society of Radio Engineering and Electrical Communications im. A. S. Popov (VNORIE), Moscow, 8-12 June, 1959

24(3) SOV/20-125-2-15/64

AUTHOR: Akhiyezer, A. N.

TITLE: On the Reflection of Electromagnetic Waves by a Turnstile-junction (Ob otrazhenii elektromagnitnykh voln turniketnym soyedineniyem)

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 125, Nr 2, pp 300-303 (USSR)

ABSTRACT: The author investigates an adjusted turnstile-junction, to arms 1 and 3 of which(there are altogether 4 arms) reflecting pistons are connected. In the waveguides 1 to 4 waves of the type TE_{10}, and in the cylindrical waveguide, waves of the type TE_{11} are propagated. Also the two basis-polarizations are shown in the drawing. The scattering matrix for such a system may easily be determined from the scattering matrix of a turnstile-junction by introducing additional relations between the amplitudes a_i of the inciding waves and the amplitudes b_i of the reflected waves in arms 1 and 3:

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On the Reflection of Electromagnetic Waves by a Turnstile-junction

$a_i = b_i \Gamma_i$, $i = 1,3$. Here $\Gamma_i = e^{j\varphi_i}$ denotes the reflection coefficient of the piston in the corresponding arm; s_1 and s_2 - the eigenvalues of the scattering matrix, and it holds that $|s_1| = |s_2| = 1$. After several steps 4 equations are obtained which may be written down also in matrix form. The two special cases $\Gamma = 1$ and $\Gamma = j$ correspond to the application of turnstile-junctions described in publications (Ref 2) for the emission and for the reception of waves with linear and circular polarization. Next, the case is investigated in which reflecting pistons with the reflection coefficients

$$\Gamma_2 = e^{j\varphi_2} \quad \text{and} \quad \Gamma_4 = e^{j\varphi_4}$$

are connected also to arms 2 and 4 of the turnstile-junction. As before, the position of the pistons 1 and 3 is to satisfy the condition $\Gamma_1 + \Gamma_3 = 0$. Also for this case a matrix

Card 2/4 equation is written down. This connection has no losses,

SOV/20-125-2-15/64

On the Reflection of Electromagnetic Waves by a Turnstile-junction

and therefore the scattering matrix is unitary. The polarizations p and q of the inciding and of the reflected waves respectively are connected by means of a broken-linear connection. Because of the unitarity of the scattering matrix, this transformation may be represented by the rotation of a Riemann sphere round an axis passing through its center. The points of the equator of this sphere correspond to purely linear polarizations, whereas the north- and the south-poles correspond to the right-circular and left-circular polarization respectively. By the difference in phase of the waves reflected on the pistons 2 and 4 it is possible to influence $|q|$. In conclusion, it is shown that in the case of an arbitrary polarization p_1 of the inciding wave it is possible to obtain an arbitrary given polarization q_1 of the reflected wave. There are 4 figures and 3 references, 1 of which is Soviet.

Card 3/4

SOV/20-125-2-15/64

On the Reflection of Electromagnetic Waves by a Turnstile-junction

ASSOCIATION: Khar'kovskiy gosudarstvennyy institut mer i izmeritel'nykh priborov (Khar'kov State Institute of Measures and Measuring Devices)

PRESENTED: December 3, 1958, by M. A. Leontovich, Academician

SUBMITTED: December 3, 1958

Card 4/4

AKHIYEZER, A.N.

PHASE I BOOK EXPLOITATION SOV/5135

Nauchno-tekhnicheskoye obshchestvo radiotekhniki i elektrosvyazi im. A.S. Popova

100 let so dnya rozhdeniya A.S. Popova; yubileynaya sessiya (One Hundredth Anniversary of the Birth of A.S. Popov; Anniversary Session) [Moscow] Izd-vo AN SSSR, 1960. 312 p. Errata slip inserted. 2,800 copies printed.

Sponsoring Agency: Akademiya SSSR.

Chief Ed.: A.L. Mints, Academician; Editorial Board: G.D. Burdun, A.R. Vol'pert, I. Ye. Goron, L. I. Gutenmakher, I.I. Grodnev, N.D. Devyatkov, L.A. Zhekulin, S.I. Kataev, M.S. Neyman, V.I. Siforov and N.I. Chistyakov; Ed. of Publishing House: L.V. Gessen; Tech. Ed.: S.G. Markovich.

PURPOSE: This collection of reports is intended for scientists and technicians working in radio engineering and telecommunications.

COVERAGE: The reports included in this collection were submitted at the scientific meeting held in 1959 by the Nauchno-tekhnicheskoye obshchestvo radiotekhniki i elektrosvyazi im.A.S. Popova (Scientific and Technical Society of Radio

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Engineering and Telecommunication imeni A.S. Popov) in commemoration of the
100th anniversary of A.S. Popov's birth. Only 89 of the more than 300 reports
submitted at the meeting are included. The remainder are published in the peri-
odicals of the AS USSR, State Committees, the Ministry of Communications, and
the Society imeni A.S. Popov. The book contains the reports read at plenary
sessions by A.N. Shchukin, Academician, A.A. Pistol'kors, Corresponding Member,
AS USSR, and E.I. Adirovich and L.I. Gutenmakher, Professors, as well as those
selected as the most interesting given in the following sections by their re-
spective chairmen: Theory of Information, Antenna Systems, Receiving Devices,
Wire Communications, Television, Electronics, Radio Measurements, General Radio
Engineering, Transmitting Devices, Radio Wave Propagation, Electron Microscopy,
Radio Broadcasting, Electroacoustics and Sound Recording, Electronic Computer
Engineering, and SHF Ferrite Devices. These chairmen were on the Editorial
Board which prepared the papers for publication. References accompany most of
the reports.

One Hundredth Anniversary (Cont.) SOV/5135

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29773
S/194/61/000/006/064/077
D201/D302

9,6000 (1089,1159)

AUTHORS: Brodskiy, A.I., Akhiyezer, A.N., Magda, V.I. and Sen'ko, A.P.

TITLE: Standard calorimetric equipment for checking small power meters

PERIODICAL: Referativnyy zhurnal. Avtomatika i radioelektronika, no. 6, 1961, 18-19, abstract 6 I107 (V sb. '100 let so dnya rozhd. A.S. Popova', M., AN SSSR, 1960, 188-193)

TEXT: The arrangement is based on the division of the power measured by the calorimeter by means of a standard directional coupler. It consists of power source, wavemeter, SHF power level-stabilizer, attenuator, standard directional coupler and a standard calorimeter. The SHF power sources are typical, oil immersed klystrons. The use of an oil bath and a good supply stabilization makes the 15 min. frequency drift better than 1-2 x 10^{-5}. The power level stabilizer

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Standard calorimetric equipment...

consists of a directional coupler, a reference detector, d.c. amplifier and magnetically controlled attenuator with an irreversible rotation of the plane of TE_{11} wave in a circular waveguide with a ferrite in a longitudinal magnetic field. The power level stabilizer keeps the output power level within ~ ±0.5% with changes of ±20% of the input power. The standard directional coupler has the straight-through attenuation of about 10 db and directivity $\geqslant$ 25 db SWR $\leqslant$ 1.07. The standard microcalorimeters permit measurement of power levels of 2-100 milliwatts with an error $\leqslant$ ±1.5%. The SWR of the calorimeters is better than 1.16. The process of measurement is semi-automatic and takes 2-3 minutes. The calorimeter works on the principle of a cooled thermocouple which makes it possible to replace the SHF power by that of d.c. at a constant temperature of the calorimetric system. The sources of errors have been analyzed. [Abstracter's note: Complete translation]

Card 2/2

80299
S/115/60/000/04/025/041
D002/D006

~~9(6)~~ 9.1300

AUTHOR: Akhiyezer, A.N.

TITLE: A Waveguide Power-Divider With Elliptical Polarization

PERIODICAL: Izmeritel'naya tekhnika, 1960, Nr 4, pp 50-52 (USSR)

ABSTRACT: Information is given on the design and operation of a waveguide power-divider based on a new principle: viz., the conversion of the initial wave into an elliptically polarized N_{11} wave in a round waveguide, and the subsequent reverse conversion into an N_{01} wave in the rectangular waveguide. The power division is determined by means of the relation between the polarization coefficients. The single-amplitude wave is divided by the method described previously by Meyer and Goldberg /Ref. 2, English7. For analyzis of the

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S/194/61/000/009/046/053
D271/D302

9,1300

AUTHOR: Akhiyezer, A.N.

TITLE: Measurement of small attenuations in waveguides

PERIODICAL: Referativnyy zhurnal. Avtomatika i radioelektronika, no. 9, 1961, 55-56, abstract 9 I314 (Tr. in-tov Kom-ta standartov, mer i izmerit. priborov pri Sov. Min. SSSR, 1960, no. 48 (108), 65-85)

TEXT: Most widely used methods are considered for measuring small attenuations in waveguides, with modifications and supplements introduced as a result of experimental work in KhGIMIP. An analytical expression for attenuating an element of waveguide line is considered. Methods described are: Substitution of a calibrated attenuator by the use of balance method, thermistor bridge, circle diagram, double three-port junction. Resonance methods are considered which are based on measurement of resonance resistance, Q-factor and propagation coefficient of the investigated waveguide used

VB

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as a resonator: 1) Method of equivalent transformer, 2) method of Q-measurement of waveguide resonator, 3) measurement of the transfer coefficient of waveguide resonator. Results are shown of attenuation measurements in waveguides by applying the first four of the above methods. The errors of the method of circle diagram and of the method of equivalent transformer are considered in the appendix; also, the influence is considered of lumped losses inside the measured waveguide when methods involving standing waves are used; fundamental data are given of the apparatus used for measuring attenuation. 25 references. /Abstracter's note: Complete translation/

B

AKHIYEZER, A.N.

Connection of rectangular wave guides by means of an opening in a wide wall. Zhur. tekh. fiz. 30 no.7:851-854 Jl '60. (MIRA 13:8)

1. Khar'kovskiy gosudarstvennyy institut mer i izmeritel'nykh priborov. (Wave guides)

AKHIYEZER, A.N.

Widening the range of the balancing connection in resonators having H01-shape oscillations. Izm.tekh. no.1:50-51 Ja '62. (MIRA 14:12)

(Resonators)

45660

S/115/63/000/001/017/017
E192/E382

9,1300

AUTHOR: Akhiyezer, A.N.

TITLE: Method of measuring the directivity of waveguide directional couplers

PERIODICAL: Izmeritel'naya tekhnika, no. 1, 1963, 48 - 50

TEXT: The method proposed is based on the use of a "sliding" load and a detector probe and differs from known methods in that it does not require a calibrated attenuator. The measurement system is shown in Fig. 1a. When shifting the load in the waveguide the maximum I_2 and the minimum I_1 readings of the indicator И_1 are noted. If a square-detector is employed, the directivity of the coupler is expressed by:

X

$$D = -20 \log \left| \frac{a}{b} \Gamma_H \right| = -20 \log \frac{1-s}{1+s} \pm 20 \log \frac{1-n}{1+n} \qquad (3)$$

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Method of measuring ....

where Γ_H is the reflection coefficient of the sliding load, s is the standing-wave ratio, $n = \sqrt{I_1/I_2}$ and $\Gamma_H = (1-s)/(1+s)$. In order to determine the directivity, it is necessary to measure n, s and to choose the sign in Eq. (3). Measurement of s is carried out by means of the detector head when shifting the sliding load. The sign in Eq. (3) can be determined either by employing an auxiliary sliding load with a different standing-wave ratio or using a transformer which is inserted between the coupler and the sliding load and is adjusted in such a way as to obtain zero deflection on the indicator for any position of the load. The error of measurement in this method is due to the errors in the measurement of s and n, which are caused by: deviation of the detector characteristic from a true square law; error of the indicating instrument; multiple reflections between the detector and the sliding load; perturbation of the field due to the probe; imperfections in the sliding load, drift of the detector and changes in the power level during measurement. The method was verified experimentally and it was found that for n = 0.277 and

Method of measuring ....

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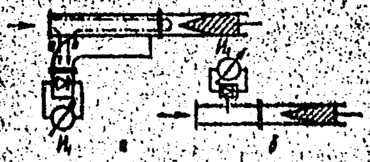
s = 0.905 the directivity was D = 31 ± 1 d.b. The directivity of the same coupler measured by the attenuator method was D = 29.7 ± 0.3 d.b. There are 2 figures.

Fig. 1:



Card 3/3

AKHIYEZER, A.N.

Measuring the directivity of wave guide coupler. Izm.tekh.
no.1:48-50 Ja '63. (MIRA 16:2)
(Wave guides—Measurement)