AUTHORS: Akhiyezer, I. A., Polovin, R. V., Tsintsadze, N. L.

SOV/56-37-3-25/62

TITLE: Simple Waves in the Chew, Goldberger, and Low Approximation

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 37, Nr 3(9), pp 756-759 (USSR)

ABSTRACT: Chew, Goldberger, and Low showed that a dilute plasma in a magnetic field in which collisions play an important role, may be defined by a system of magnetohydrodynamic equations with anisotropic pressure. It is of interest to use these equations for investigating the nonlinear motions of a plasma (above all, of simple waves). The present paper deals with this problem. The system of magnetohydrodynamic equations has the following form in the Chew, Goldberger, and Low approximation:

$$\varrho \frac{d\vec{v}}{dt} = \vec{F} + \frac{1}{4\pi}\left[\mathrm{curl}\,\vec{H}, \vec{H}\right], \quad F_i = -\frac{\partial p_{ik}}{\partial x_k}, \quad \frac{\partial \vec{H}}{\partial t} = \mathrm{curl}\left[\vec{v}\,\vec{H}\right],$$

$$\mathrm{div} = \vec{H} = 0 \quad \frac{\partial \varrho}{\partial t} + \mathrm{div}(\varrho\vec{v}) = 0, \quad p_{ik} = p_{\perp}\delta_{ik} + (p_{\parallel} - p_{\perp})h_i h_k,$$

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$$\vec{h} = \vec{H}/H \quad \frac{d}{dt}\left(\frac{p_{\perp}}{\rho H}\right) = 0 \, , \quad \frac{d}{dt}\left(\frac{\rho_{\parallel} H^2}{\rho^3}\right) = 0$$

The author investigates one-dimensional plane waves in which all magnetohydrodynamic quantities are functions of one of these quantities (e.g. of ρ). ρ on its part depends on the coordinate x and on the time t: $x - V_{\Phi}(\rho)t = f(\rho)$. $V_{\Phi}(\rho)$ denotes the translation velocity of the point where density ρ has a given value; $f(\rho)$ - a function which is reciprocal to the density distribution $\rho(x)$ in the initial instant of time $t = 0$. $f(\rho) = 0$ holds for the self-simulating waves in the ranges of compression $f'(\rho) < 0$ and in the ranges of expansion $f'(\rho) > 0$. The simple waves are closely connected with the waves of small amplitudes. Like in magnetohydrodynamics with scalar pressure, there exist 3 types of waves. The partly very extensive differential equations of the Alfvén waves and magnetic sound waves are written down explicitly. The Alfvén waves propagate without changing their shape. Investigation of the equations of the magnetic sound waves in general form frequently meets with considerable difficulties. The authors deal only with the most

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interesting case in which hydrostatic pressure is considerably lower than magnetic pressure. In the ranges with expansion the density gradient decreases, and in the ranges of compression it increases. In the ranges with expansion ($f' > 0$) and in the self-simulating waves ($f = 0$) density decreases. In the ranges of the compression ($f' < 0$) density increases until a certain expression written down by the authors becomes negative. As soon as this expression equals zero, a compression shock wave is formed. In a fast magnetic sound wave, the quantities $p_{\parallel}$, $p_{\perp}$, H, $p_{\perp}/p_{\parallel}$ change in the same way as in the magnetic sound wave. The authors then investigate a slow magnetic sound wave. There are two possibilities: (1) In the normal case, density changes in the same way as in a fast magnetic sound wave. Shock waves are formed especially in the ranges of compression, and the self-simulating waves are expansion waves.

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(2) In the abnormal case the density gradient decreases in the ranges of compression and increases in the ranges of thinning In the ranges of expansion a shock wave is formed. In contrast to magnetohydrodynamics with scalar pressure, expansion shock waves may form in this case. The authors thank A. I. Akhiyezer and G. Ya. Lyubarskiy for useful discussions. There are 8 references, 5 of which are Soviet.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR (Physical-technical Institute of the Academy of Sciences, Ukrainskaya SSR) Institut fiziki Akademii nauk Gruz. SSR (Physics Institute of the Academy of Sciences of the Gruzinskaya SSR)

SUBMITTED: April 3, 1959

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21(7)

AUTHORS: Lyubarskiy, G. Ya., Polovin, R. V.

SOV/20-128-4-13/65

TITLE: On the Piston Problem in Magnetic Hydrodynamics

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 128, Nr 4, pp 684-687 (USSR)

ABSTRACT: The theorem of Chapman-Zhuge which remained a hypothesis for a long time, was first investigated by Ya. B. Zel'dovich (Ref 1) by detonation in a cylinder. The present investigation aims at a qualitative examination of the simplest piston problem in magneto-hydrodynamics while the piston is moving with a constant velocity. The motion of the substance ahead of the piston must be more complicated in magneto-hydrodynamics than in hydrodynamics as the state of the compressible conducting fluid is characterized by 7 instead of 3 quantities. The authors investigated the semi-space $x > 0$; it is filled with an ideal conductive fluid which is in a magnetic field and is at rest at the time $t = 0$. The fluid's state is characterized by the density ρ_o, the pressure p_o, and the components H_x, H_{oy}, $H_{oz} = 0$ of the magnetic field. The thermodynamical state equation of the fluid is optional and the

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validity of the inequalities $\left(\frac{\partial^2}{\partial p^2}\frac{1}{\varrho}\right)_s > 0$, $\left(\frac{\partial p}{\partial T}\right)_\varrho > 0$ is assumed. The fluid is bounded on the left by the piston which is in the plane x = 0. At the time t the piston begins moving with a constant velocity parallel to the Ox-axis. The motion of the fluid will be described by application of similarity and therefore all quantities depend solely on the ratio x/t. The developing discontinuity should be stable as related to a splitting up. According to A. I. Akhiyezer, G. Ya. Lyubarskiy, R. V. Polovin (Ref 4), V. M. Kontorovich (Ref 5), and S. I. Syrovatskiy (Ref 6) there are 3 types of steady shock waves, i.e. fast and slow magneto sound waves and Alfvén waves. Only the magneto sound wave can run ahead (shock wave or a wave by application of similarity), followed by the Alfvén wave and finally by the slow magneto sound wave (shock wave or wave by application of similarity). Some of these waves may be missing; there is a total of 17 variants. But actually there only are 2 variants, a slow and a fast magneto sonic wave in case the piston is moving against the fluid and a fast and a slow "self-modelling" wave when the piston moves in opposite direction. The Alfvén wave is missing

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in both cases. In this way the peculiar phenomenon of the "electrodynamic viscosity" is obtained. A tangential magnetic field in magnetic sound waves does not change the direction (L. D. Landau, Ye. M. Lifshits Ref 7; A. I. Akhiyezer, G. Ya. Lyubarskiy, R. V. Polovin Refs 8,9). The tangential magnetic field increases in fast shock waves and decreases in slow ones. When the tangential component equals zero on one side of the shock wave or of the magneto sonic wave obtained by application of similarity then it is parallel to the tangential component of the magnetic field on the other side. The density increases in shock-like magneto sound waves and remains constant in Alfvén waves. The tangential magnetic field turns in an Alfvén wave about an arbitrary angle without changing its magnitude. The corresponding mathematical relations are written down and briefly discussed. The authors express their gratitude for the suggestion of the theme to L. I. Sedov, to A. I. Akhiyezer and A. S. Kompaneyets for discussing the results of this investigation. There are 13 references, 12 of which are Soviet.

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On the Piston Problem in Magnetic Hydrodynamics SOV/20-128-4-13/65

ASSOCIATION: Khar'kovskiy gosudarstvennyy universitet im. A. M. Gor'kogo (Khar'kov State University imeni A. M. Gor'kiy). Fiziko-tekhnicheskiy institut Akademii nauk USSR (Physical-technical Institute of the Academy of Sciences, UkrSSR)

PRESENTED: May 27, 1959, by L. I. Sedov, Academician

SUBMITTED: May 16, 1959

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AKHIYEZER, A.I.; LYUBARSKIY, G.Ya.; POLOVIN, R.V.

[Evolutional discontinuities in magnetohydrodynamics] Evoliutsionnye razryvy v magnitnoi gidrodinamike. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 8-24 p. MIRA 17:3)

POLOVIN, R.V.; DEMUTSKIY, V.P.

[Shock adiabats in magnetohydrodynamics] Udarnaia adiabata v magnitnoi gidrodinamike. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 25-34 p. (MIRA 17:2)

LYUBARSKIY, G.Ya.; POLOVIN, R.V.

[Theory of simple waves] K teorii prostykh voln. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 40-43 p. (MIRA 17:1)
(Shock waves) (Magnetohydrodynamics)

LYUBARSKIY, G.Ya.; POLOVIN, R.V.

[The piston problem in magnetohydrodynamics] Zadacha o porshne v magnitnoi gidrodinamike. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 40-43 p. (MIRA 17:2)

AKHIYEZER, I.A.; POLOVIN, R.V.

[Motion of a conducting plane in a magnetohydrodynamic medium] O dvizhenii provodiashchei ploskosti v magnito-gidrodinamicheskoi srede. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 44-53 p. (MIRA 17:2)

AKHIYEZER, I.A.; POLOVIN, R.V.; TSINTSADZE, N.L.

[Simple waves in Chew's, Goldberger's and Low's approximations] Prostye volny v priblizhenii Ch'iu, Gol'dbergera i Lou. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. Page 57. (MIRA 17:3)

AKHIYEZER, I.A.; POLOVIN, R.V.

[Theory of relativistic magnetohydrodynamic waves] K teorii reliativistskikh magnitogidrodinamicheskikh voln. Khar'kov, Fiziko-tekhn. in-t AN USSR, 1960. 54-55 p. (MIRA 17:1)

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S/185/60/005/001/001/018
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AUTHORS: Polovin, R.V.; Demutskiy, V.P.

TITLE: The Shock Adiabatic in Magnetic Hydrodynamics.

PERIODICAL: Ukrayins'kyy Fizychnyy Zhurnal, 1960, Vol. 5, No. 1, pp. 3 - 11

TEXT: The aim of this paper is the investigation of the evolutionary parts of a shock adiabatic within the limiting conditions of low-intensity shock waves, as well as of the "almost parallel" and "almost perpendicular" shock waves of an arbitrary intensity. The authors state that in the case of low-intensity shock waves, the inequalities (4) and (5) follow from the limiting conditions and Tsemplen's [ABSTRACTOR'S NOTE: The name Tsemplen is given as it appears in the Ukrainian transliteration] theory (see Refs. 10, 8, 11, 12). The inequalities (4) and (5) mean that the low-intensity shock waves are always evolutionary, i.e., resistant to splitting. As to that shock wave, which in the limiting case $\Delta\rho \to 0$ turns into an "al'fvenovs'ka" [ABSTRACTOR'S NOTE: the word "al'fvenovs'ka" is given in the Ukrainian transliteration, since no English equivalent could be found] shock wave it may be said that it is always non-evolutionary. Such a shock should not be confused with an "al'fvenovs'kyy" discontinuity, in which $\Delta\rho = 0$ and the magnetic

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field turns around the normal at a certain angle not changing its value. The "alfvenovs'kyy" discontinuity is always evolutionary (Ref. 5). The following two types of shock waves are possible in the case when in front of the shock wave the magnetic field is directed along the normal toward the surface of the discontinuity (Ref. 6): 1) the "sonic" shock wave, in which $H_{2y} = 0$, 2) a particular shock wave, in which $H_{2y} \neq 0$ (Ref. 10). On the sonic shock wave, the correlations between the jumps of the magneto-hydrodynamic values are such as they appear in the absence of the magnetic field. The presence of a normal magnetic field, however, narrows the evolution zone (Ref. 5). In the plane (v_{1x}, v_{2x}) the sonic shock wave is represented by the line abcg in Figure 1, and by the line fg in Figure 3. (The Figures 1,2 correspond to the case $V_{1x} > c_1$, the Figures 3,4 - to the case $V_{1x} < c_1$). The continuous line corresponds to the evolutionary part of the adiabatic, the interrupted or dotted line to the non-evolutionary one. (In Figs. 1, 3, 5 the evolution zones are shaded. They are limited by the lines given by A.I. Akhiyezer, H.Ya. Lyubarskyy and R.V. Polovyn, (Ref. 5): $v_{1x} = u_1^{\pm}$; $v_{1x} = V_{1x}$; $v_{2x} = u_2^{\pm}$; $v_{2x} = V_{2x}$. In the plane $(\frac{1}{\rho_2}, p_2)$, the sonic shock adiabatic is depicted in Figure 2 by the line abfg, in Figure 4 by the line fg. In Figure 1, the particular shock wave adiabatic lies between the infinitely close lines cd and ef, in Figure 3 between the lines bcd and de. The particular shock adiabatic is represented by the line ef in Figure 2, and by the line cd in Figure 4. It should be noted that
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The Shock Adiabatic in Magnetic Hydrodynamics.

the particular shock wave lies on the border of the evolution zone and is non--evolutionary. If the inequalities (10) are accomplished, the sonic shock adiabatic changes in the sections abc and fg (Fig. 1) infinitely little as compared to the case $H_{1y} = 0$. The particular shock adiabatic splits into two branches: the non-evolutionary branch cd and the evolutionary one ef (Fig. 1). Thus, in Figure 1, the "slow" adiabatic which corresponds to a slow magneto-sonic shock wave (Ref. 5) is represented by a continuous line ab, the "quick" adiabatic by the continuous line efg. In the plane $(\frac{1}{\rho_2}, p_2)$ (Fig. 2) the slow adiabatic is represented by the line ab, the quick one by the line efg. In the case when the inequalities (15) are accomplished, the shock adiabatic in the plane (v_{1x}, v_{2x}) is shown in Figure 3. The quick adiabatic is depicted by the line fg, the slow one by the line cd. Figure 4 shows the same shock adiabatic in the plane $(\frac{1}{\rho_2}, p_2)$. It should be pointed out that at $|H_{1y}| \ll |H_x|$, the quick adiabatic in the plane $(\frac{1}{\rho_2}, p_2)$ lies higher than the slow one. This means that in the quick shock wave a more intense heating takes place than in the slow one. In other words, in this case the quick shock wave proves to be more convenient from the thermodynamic point of view since the energy increase in it is higher. In the case when the inequalities (17) are accomplished, the shock adiabatic is represented in Figure 5 [plane (v_{1x}, v_{2x})] and in Figure 6 [plane $(\frac{1}{\rho_2}, p_2)$]. The quick adiabatic is represented by the line cd, the slow one by the line ab. It should be pointed out

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that in this case the quick shock adiabatic is located lower than the slow one. The difference in the mutual location of the quick and slow shock adiabatics in the instances (10), (15) and (17) may be explained in the following way. A transition of the kinetic energy $\frac{\rho_1 v_{1x}^2}{2}$ into the magnetic energy $\frac{H_2^2}{8\pi}$ and thermal energy $\frac{3}{2}p_2$ takes place. The high quantity of the energy transmitted corresponds to the quick shock wave. In cases (10) and (15) the magnetic energy practically does not change. In the case (17), the magnetic energy is subject to a considerable change. In quick shock waves of a high intensity ($\frac{p_2}{p_1} \gg 1$) the presence of the magnetic field is unimportant (Refs 2 and 13). In particular, the largest compression which may be reached in a shock wave, equals four (for ideal gas with $\gamma = \frac{5}{3}$). The intensity of the slow shock wave cannot be as high as desired. Therefore, at $\frac{p_2}{p_1} > 1$, there exists only one shock adiabatic (Refs. 2 and 8) which is a quick one. It is pointed out that in all four cases investigated the graph of the shock adiabatic in the plane ($\frac{1}{\rho_2}$, p_2) was convex. In closing, the authors express their sincere appreciation to O.I. Akhiyezer and G.Ya. Lyubars'kyy for useful advices. There are 6 figures and 14 references: 10 Soviet, 2 English and 2 German.

ASSOCIATION: Fizyko-Tekhnichnyy instytut AN URSR (Physico-Technical Institute, AS UkrSSR).

AKHIYEZER, I.A.; POLOVIN, R.V.

Motion of a conducting piston in a magnetohydrodynamic medium. Zhur. eksp.i teor.fiz. 38 no.2:529-533 F '60. (MIRA 14:5)

1. Fiziko-tekhnicheskiy institut Akademii nauk Ukrainskoy SSR.
(Magnetohydrodynamics)

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AUTHOR: Polovin, R. V.

TITLE: Motion of a Piston in a Conducting Medium

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 38, No. 5, pp. 1544 - 1555

TEXT: Different special cases of the motion of a magnetohydrodynamic medium under the action of an ideally conducting piston moving in the medium with constant velocity were theoretically investigated by Bazer, G. Ya. Lyubarskiy, R. V. Polovin, I. A. Akhiyezer, and G. S. Golitsyn. The author of the present paper considers a piston moving with an arbitrary constant velocity in an arbitrarily directed magnetic field. The different forms of the resulting waves are described. The author limits his theoretical investigation to the most interesting case where the magnetic field, the velocity of the piston, and the normal to the surface of the piston are coplanar. The resulting waves are shown in a Fig. The individual wave forms are separately analyzed theoretically. First, the propagating waves and the special cases of the slow

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and fast waves are treated, and then the shock waves are dealt with (1) the 180° Alfvèn discontinuity; 2) the fast; and 3) the slow shock wave). Then, the cases of one rarefaction wave (1) slow wave; 2) slow wave with cavities; 3) fast rarefaction wave; and 4) fast rarefaction wave with Alfvèn discontinuity) and of one shock wave (slow, fast, and fast shock waves with Alfvèn discontinuity) are treated. The cases of two rarefaction waves and two shock waves are treated in an analogous manner. Finally, special cases of the combination of shock wave + rarefaction wave are studied, and an expression for the resistance to the motion of the piston is derived. The results of the extensive investigations are summarized as follows: If the transverse component of the velocity of the piston exceeds the velocity of sound in the undisturbed medium, a magnetic field is generated. In this case, the magnetic pressure becomes comparable to the hydrostatic pressure. At supersonic velocities, a vacuum is created between the piston and the medium (cavitation). In comparison with ordinary hydrodynamics, there occur here additional cavitations when the piston moves perpendicular to its surface normal with supersonic velocity, and also when the piston advances and the angle between its velocity vector and the normal to its surface

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AUTHOR: Polovin, R. V.

TITLE: Theory of Simple Magneto-hydrodynamical Waves

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 2(8), pp. 463 - 470

TEXT: In the present paper, the Riemann invariants for simple magneto-hydrodynamical waves are calculated. By simple waves those solutions of the magneto-hydrodynamical equations are understood which have the form of a travelling wave $u_i = f_i(x \pm Vt)$, $i = 1,2...n$. The u_i denote the totality of all magneto-hydrodynamical quantities. The author limits himself to plane one-dimensional waves propagating in the x-direction. For an ideal conducting non-viscous medium, $n = 7$. For a simple magneto-hydrodynamical wave, all u_i are functions of a magneto-hydrodynamical quantity, e.g., ϱ, which in turn depends on the coordinates and the time. On account of $V = V(\varrho)$, the wave profile is distorted during the propagation and can form a shock wave. (Condensations and rarefactions occur). If a piston

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Theory of Simple Magneto-hydrodynamical Waves S/056/60/039/002/034/044
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moves in a magneto-hydrodynamical medium with a constant velocity, u_i are functions of x/t; such waves are here given the name "automodel" waves. They are a special case of the simple waves and are always waves of rarefaction. There are three kinds of simple waves in magnetohydrodynamics: fast and slow magneto-acoustic waves, Alfven waves, and entropy waves; of which the most interesting are the magneto-acoustic waves. Fig. 1 shows waves produced by the motion of a piston in the usual and the magneto-hydrodynamic cases. The author studies only the changes in the velocities of fast and slow magneto-acoustic waves when the magnetic pressure in front of the wave is much smaller than the hydrostatic pressure. After considering the qualitative relations for the propagation of these waves (See Fig. 2), the author turns to the determination of the Riemann invariants. It is first shown that if the definition of Riemann invariants is taken over from the usual hydrodynamics (those functions $J(u_1 \ldots u_n)$ which remain constant along fixed characteristics) there exist no such invariants in magneto-hydrodynamics. Here such functions $J(u_1 \ldots u_n)$ have to be designated as Riemann invariants which remain constant for a simple

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wave. The four Riemann invariants occurring in the case treated here are written down. Calculations are made for two special cases: propagation of fast waves for $U_1 \ll c_1$ and of slow waves for $U_1 \ll c_1$, ($\vec{U} = \vec{H}/\sqrt{4\pi\varrho}$, the Alfven velocity). From the formulas derived by the author, the solutions of problems of magneto-hydrodynamical piston and the out-flow of a magneto-hydrodynamical medium in vacuum can be solved. The author thanks A. I. Akhiyezer and G. Ya. Lyubarskiy for discussions. A. G. Kulikovskiy is mentioned. There are 2 figures and 9 references: 6 Soviet, 2 US, and 1 Belgian.

ASSOCIATION: Fiziko-tekhnicheskiy institut Akademii nauk SSSR (Institute of Physics and Technology of the Academy of Sciences, USSR)

SUBMITTED: March 23, 1960

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AUTHOR: Polovin, R. V.

TITLE: The Outflow of Plasma in Vacuum in the Presence of a Magnetic Field

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 3 (9), pp. 657-661

TEXT: The author studied the following problem: a plasma at rest possessing infinite conductivity fills the half-space $x > 0$ at the instant $t = 0$. The state of the plasma is described by the pressure p_1, the density ρ_1, and the components H_x, H_{1y} of the magnetic field ($H_x > 0$, $H_{1y} > 0$, $H_{1z} = 0$). The vacuum has a constant magnetic field with the components H_x, H_{0y}, and a constant electric field $E_{0z} \ll H_{0y}$. Since the boundary conditions are not fulfilled at the discontinuity, it splits into several waves. A fast wave will propagate in the plasma (shock wave or propagating wave) along with an Alfvén discontinuity and

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a slow wave, while an electromagnetic wave will propagate in the vacuum. The author wanted to determine the characteristic of these waves, their amplitudes, and the velocity of the plasma at the boundary with the vacuum. For $H_x = 0$ this problem has already been solved by S. G. Golitsyn (Ref. 4). The boundary conditions (plasma - vacuum) are written down: $p = 0$, $\{H_y\} = 0$, $\{E_z\} = 0$ (1). If the plasma velocity is assumed to be nonrelativistic, the jump of the magnetic field in the electromagnetic wave remains smaller than its strength. Hence, only the first two conditions of (1) need be fulfilled when solving the problem. The following relations are written down for the amplitude of the fast and the slow wave: $p_1 + \Delta_+ p + \Delta_- p = 0$ (2), $H_{1y} + \Delta_+ H_y + \Delta_A H_y + \Delta_- H_y = H_{0y}$ (3). Δ_+, Δ_-, Δ_A denote the jumps of the magnetic-hydrodynamic quantities of the fast and slow wave and of the Alfvén discontinuity. The differential equation is integrated in order to determine the relationship between $\Delta_+ H_y$ and $\Delta_+ p$, as well as $\Delta_- H_y$ and $\Delta_- p$:

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$dq_{\pm}/dr = q_{\pm}^2(q_{\pm} - 1)/\theta(rq_{\pm}^2 - 1)$ (4). $r = c^2/U_x^2 \equiv 4\pi\gamma p/H_x^2$; $c(r) = \text{const.}r^{(\gamma - 1)/2\gamma}$; $\vec{U} = \vec{H}/\sqrt{4\pi\varrho}$; $\theta = \gamma/(2 - \gamma)$; $q_{\pm} = U_{\pm}^2/c^2$; $U_{\pm} = \left\{U^2 + c^2 \pm \left[(U^2 + c^2)^2 - 4c^2U_x^2\right]^{1/2}\right\}^{1/2}/\sqrt{2}$. γ is the exponent of Poisson's adiabatic curve, c is the sound velocity, r the dimensionless pressure. The upper signs refer to the fast wave, the lower ones to the slow wave. Equations (5) - (8) are obtained for the jumps Δ_+v_x, Δ_+v_y, Δ_-v_x, Δ_-v_y of the velocity, equation (14) for v_x and v_y if there is no Alfvén discontinuity, and equation (15) if there is one. The electric field at the boundary plasma - vacuum is determined by $E_z = v_yH_x - v_xH_y$ (16). The amplitude ΔE_z of the electromagnetic wave irradiated into the vacuum can be calculated from (16). For the case of

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the Alfvén velocity $\vec{U}_1 = \vec{H}_1/\sqrt{4\pi\varrho_1}$ being considerably lower than the sound velocity c_1, the relations thus simplified are derived and graphically illustrated in a Fig. A paper by A. G. Kulikovskiy and G. A. Lyubimov (Ref. 3) is mentioned. The author thanks L. I. Sedov for having posed the problem, and A. I. Akhiyezer and G. Ya. Lyubarskiy for their discussions. There are 1 figure and 12 references: 9 Soviet and 3 US.

ASSOCIATION: Fiziko-matematicheskiy institut Akademii nauk Ukrainskoy SSR (Institute of Physics and Mathematics of the Academy of Sciences, Ukrainskaya SSR)

SUBMITTED: March 23, 1960

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AUTHOR: Polovin, R. V.

TITLE: Motion of Shock Waves Along a Magnetic Field

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 4(10), pp. 1005-1007

TEXT: Since unilateral propagation of two shock waves, a fast one and a slow one, is possible in magnetohydrodynamics, it is of interest to study the jumps of the magnetohydrodynamic quantities of two successive shock waves. The present paper is intended to make a contribution to this problem. Such waves are produced, for example, by a conducting piston moving within a magnetohydrodynamic medium along the magnetic lines of force. This case is considered in the present paper. The following assumptions are made: The semispace $x > 0$ is filled with an ideally conducting medium, and is placed in the field H_x ($H_y=H_z=0$). At the instant $t = 0$, the medium is at rest, is characterized by ρ_0 and p_0, and described by the equation of state of an ideal gas with $\gamma = 5/3$. An

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Motion of Shock Waves Along a Magnetic Field S/056/60/039/004/019/048
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ideally conducting piston lies in the plane $x = 0$; at $t = 0$, this piston starts moving along the x-axis with a constant velocity u. The three possible cases of this problem are then studied: 1) $(0 < u < u_-)$: the fast shock wave has an infinitely small amplitude, and the slow shock wave behaves as if there were no magnetic field. Formulas are given for the velocity of the slow shock wave and for the jumps of density, pressure, and velocity. 2) $(u_- < u < u_+)$; the propagating shock wave is similar to that observed in the absence of the magnetic field. However, this wave is split, so that two shock waves with infinitely similar velocities are produced: $D_+ = D_- = 2u/3 + \sqrt{4u^2/9 + c_0^2}$. Between the two waves there exists a transverse field lying in the y-direction, which may be described by $H_{1y}^2/4\pi\rho_1 = 2(D_+^2 - U_{ox}^2)(4U_{ox}^2 - D_+^2 - 3c_0^2)/3D_+^2$. The subscript 1 refers to the spacing between the two shock waves. The jumps of the other quantities are given by

$\rho_1/\rho_0 = D_+^2/U_{ox}^2$, $p_1 = p_0 + \rho_0(D_+^2 - U_{ox}^2)(3c_0^2 + D_+^2 - U_{ox}^2)/3U_{ox}^2$,

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Motion of Shock Waves Along a Magnetic Field S/056/60/039/004/019/048
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$\rho_2/\rho_1 = U_{ox}^2/D_+(D_+-u)$, $p_2 = p_o(1+5uD_+/3c_o^2)$, $\Delta_+v_x = (D_+^2-U_{ox}^2)/D_+$,

$\Delta_-v_x = u - \Delta_+v_x$.

The behavior of these quantities is shown in Figs. 1 and 2. 3) $u_+ < u$. The fast wave behaves as if there were no magnetic field, and the following relations hold: $D_+ = 2u/3 \sqrt{4u^2/9 + c_o^2}$, $\rho_1/\rho_o = D_+(D_+-u)$, $p_1 = p_o(1 + 5uD_+/3c_o^2)$, $\Delta_+v_x = u$. The slow wave has an infinitely small amplitude. The author believes that the filamentary nebulae observable in the Galaxy are similar to an instantaneous photograph of all splitting magnetohydrodynamic shock waves. A. I. Akhiyezer, G. Ya. Lyubarskiy, and K. D. Sinel'nikov are thanked for discussions. There are 2 figures and 5 Soviet references.

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

Card 3/4

S/053/60/072/001/002/005
B013/B060

AUTHOR: Polovin, R. V.

TITLE: Shock Waves in Magnetohydrodynamics

PERIODICAL: Uspekhi fizicheskikh nauk, 1960, Vol. 72, No. 1, pp. 33 - 52

TEXT: The present survey covers a number of theoretical studies dealing with magnetohydrodynamic shock waves. By way of introduction, plane elementary waves are discussed in greater detail (Refs. 19-29). The special part played by these waves in magnetohydrodynamics is related to the fact that, in the absence of discontinuities, only they can border the region of steady flow. Discontinuities arise in an elementary wave in the region of compression following a distortion of their flow chart (Refs. 18,30,31). All possible kinds of magnetohydrodynamic discontinuities have been classified by S. I. Syrovatskiy (Refs. 32,33). It is a well-known fact (Refs. 34,35) that Tsemplen's law holds in ordinary hydrodynamics when condition (3,1) is observed. In Ref. 18, this law has been proved only for vertical shock waves with small amplitudes. It also holds, however, for any wave intensity and any direction of the magnetic field (Refs. 36-38). The conditions for the ability of building up discontinuities are treated in Refs. 19,33a-35,39-44. The author describes a method of demonstrating that contact-, tangential-, and Alfven discontinuities are evolutional. Important conclusions are derived from the conditions of the building-up ability (Refs. 14,38,43,46-53). It is found that magnetohydrodynamic waves represent one of the mechanisms of formation of interstellar magnetic fields. The following problems are further treated: the adiabatic shock curve - Figs.3-4 (Refs. 14,20,31, 36,38,46,47,53-57); the piston problem - Figs.5-7 (Refs. 29,38,58-61); disintegration of discontinuity - Fig.8 (Refs. 19,30,32,34,45,47,62-66). Mention is made of A. G. Kulikovskiy, S. I. Syrovatskiy, L. D. Landau, Ye. M. Lifshits, S. A. Kaplan, K. P. Stanyukovich, I. M. Gel'fand, K. I. Babenko, G. S. Golitsyn, N. Ye. Kochin, and T. F. Volkov. There are 8 figures and 67 references: 42 Soviet.

NEKRICH, M.I.; POLOVIN, R.V.

Rate of solid phase reactions. Dop.AN URSR no.4:511-513 '61.
(MIRA 14:6)

1. Khar'kovskiy politekhnicheskiy institut im. V. I. Lenina.
Predstavleno akademikom AN USSR P. P. Budnikovym.
(Chemical reaction, Rate of)

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S/207/61/000/006/001/025
A001/A101

26.1410

AUTHOR: Polovin, R.V. (Khar'kov)

TITLE: On conditions which magnetohydrodynamical streams must satisfy to be "evolutional"

PERIODICAL: Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki, no. 6, 1961, 3 - 7

TEXT: The author has two purposes: 1) to investigate restrictions imposed on the possible types of continuous magnetohydrodynamical streams by the condition of their evolvability, and 2) to determine the evolvability conditions for skew magnetohydrodynamical waves adjoint at the vertex of a streamlined angle. Investigating these streams the author makes use of the conservation laws: for mass, momentum, energy, and continuity laws for the transverse component of electric field and longitudinal component of magnetic field. Two possible extreme cases are considered: 1) Reynolds magnetic number is large and Joule dissipation can be neglected; in this case the following types of streams without passing through the characteristic phase velocity are possible: "slow" stream, "sub-Alfvén" stream, "trans-Alfvén" stream, and "fast" stream. 2) Reynolds magnetic num-

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originate if the conductivity of the streamlined wall were finite. When the magnetic field is parallel to the wall surface, two cases are possible in two-dimensional streamlining: 1) magnetic field is parallel to an edge of the streamlined angle, and 2) magnetic field is parallel to the velocity vector. In the first case only shock waves of "weak" family are possible; in the second case one of the three additional conditions should be satisfied, which are described. The following Soviet-bloc personalities are mentioned: Pavlov, Chekmarev, Kolosnitsyn. The author thanks A.I. Akhiyezer and L.I. Sedov for valuable discussions. There are 18 references, 11 of which are Soviet-bloc.

SUBMITTED: June 30, 1961

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AUTHOR: Polovin, R.V.

TITLE: On magnetohydrodynamic characteristics

PERIODICAL: Ukrayins'kyy fizychnyy zhurnal, v. 6, no. 6, 1961, 614 - 617

TEXT: It is shown that the lines which bound the various regions of hyperbolicity of the magnetohydrodynamic equations are the graphs of the phase, and group velocity of the magnetoacoustic waves. The system of magnetohydrodynamic equations is hyperbolic if the fluid velocity v varies in the interval

$$\frac{cU_A}{\sqrt{c^2 + U_A^2}} < v < \min(c,\ U_A) \qquad (1)$$

or

$$\max(c,\ U_A) < v, \qquad (2)$$

where c is the velocity of sound and $U_A \equiv H/\sqrt{4\pi\rho}$ is the Alfvén ve-

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locity. Various authors have investigated the regions of hyperbolicity for different directions of magnetic field. The regions of existence of the characteristics which originate at the points of the flow contour, are shown in Fig. 2. The fluid velocity is represented by the point with polar coordinates v, θ. The letter H denotes the presence of a characteristic directed downstream, and B - upstream. The positive sign denotes a fast magnetoacoustic wave, and the negative - a slow one. The line 1-3-2 represents the group velocity of a slow magnetoacoustic wave in polar coordinates; the line [illegible]-4-2 represents their phase velocity. The line 5-6-7 represents the phase velocity of fast magnetoacoustic waves, and the line 7-8-5-9-10 represents their group velocity. It is noted that the fast characteristics are possible only with sufficiently fast fluid velocities, whereas the slow ones - for any slow waves. The foregoing argument is proved as follows. A magnetohydrodynamic disturbance is considered which originates from a point source. The phase velocity of the magnetoacoustic wave is expressed by

$$V_{\pm}(\theta) = \sqrt{\frac{U_A^2 + c^2 \pm \sqrt{(U_A^2 + c^2)^2 - 4c^2U_A^2 \cos\theta}}{2}}.$$

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On magnetohydrodynamic ...

The graphs of the function $V_{\pm}(\theta)$ in polar coordinates is called phase polar. From the phase polar, a curve called the group polar is obtained. By means of the group polar it is possible to determine the wave front. As an example, the disturbances are considered which leave a plane shock-wave at any angle with the normal. The characteristic is a wave front which travels from a point source which has the velocity v of the fluid. The characteristic can be found geometrically, by constructing the envelope of the group polars whose centers are at the points v.t (where t varies from zero to infinity). If the characteristic makes a sharp angle with the velocity vector, it is directed downstream; otherwise it is directed upstream. There are 2 figures and 11 references: 5 Soviet-bloc and 6 non-Soviet-bloc. The 4 most recent references to the English-language publications read as follows: Y. Kato, T. Taniuti, Prog. Theor. Phys., 21, 606, 1959; J.E. McCune, E.L. Resler, J. Aero/Space Sci., 27, 493, 1960; M.J. Lighthill, Phil. Trans Roy. Soc., 252 A, 397, 1960; J. Bazer, O. Fleishman, Phys. Fluids., 2, 366, 1959.

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On magnetohydrodynamic ...

ASSOCIATION: Fizyko-tekhnichnyy instytut AN URSR m. Kharkiv (Physicotechnical Institute AS UkrSSR, Kharkhiv)

SUBMITTED: February 20, 1961

Fig. 2.

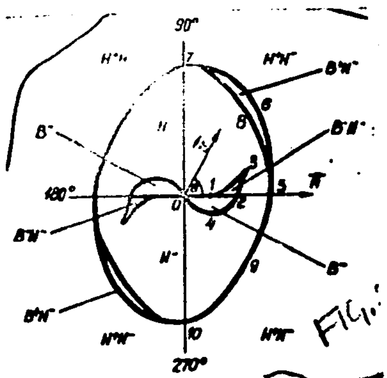

Рис. 2.

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21539

S/057/61/031/004/005/018
B125/B205

AUTHORS: Demutskiy, V. P. and Polovin, R. V.

TITLE: Impact ionization and detonation in magnetohydrodynamics

PERIODICAL: Zhurnal tekhnicheskoy fiziki, v. 31, no. 4, 1961, 419-427

TEXT: An astrophysical study has been made of the methods of impact ionization and detonation applied to the motion of a conducting body in a magnetohydrodynamic medium with any direction of the magnetic field. The energy of ionization has been taken into account. Reference is made to papers by E. Larish, I. Shekhtman, G. A. Lyubimov, and A. G. Kulikovskiy. The medium is considered to be a piston moving at a constant velocity $\vec{u}$. The velocity of the piston and the Alfvèn velocity $\vec{U} = \vec{H}/\sqrt{4\pi\varrho}$ are assumed to be much smaller than the sonic velocity c, and the reaction energy referred to zero temperature to be much lower than the square of sonic velocity. The magnetic field, the velocity of the piston, and the normal onto its surface lie in one plane, i.e., the xy plane. When the shock wave of ionization propagates through a non-conductive medium, an electromagnetic wave runs in front of the ionization wave. But such a wave does

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Impact ionization and...

not exist if the medium has been ionized from the very outset, and if the degree of ionization in the shock wave is enhanced. This case is the subject of the present paper. The tangential electric and the normal magnetic field remain constant.

$$\left\{p + \frac{(v_x - \zeta)^2}{V} + \frac{H_y^2}{8\pi}\right\} = 0, \quad (2)$$

$$\left\{\frac{\gamma p V}{\gamma - 1} + \frac{(v_x - \zeta)^2}{2} + \frac{v_y^2}{2} + \frac{VH_y^2}{4\pi} - \frac{VH_xH_yv_y}{4\pi(v_x - \zeta)}\right\} = q, \quad (3)$$

$$\left\{\frac{(v_x - \zeta)\, v_y}{V} - \frac{H_xH_y}{4\pi}\right\} = 0, \quad (4)$$

$$\{H_xv_y - (v_x - \zeta)H_y\} = 0, \quad (5)$$

$$\{H_x\} = 0, \quad (6)$$

hold, where $V = 1/\varrho$ is the specific volume, and $\vec{v}$ the velocity of the medium. The x-axis is perpendicular to the discontinuity surface, and the coordinate system is such that $H_z = 0$, $v_z = 0$. p denotes the pressure, and γ the coefficient of the Poisson adiabatic line which, for the sake

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of simplicity, is assumed to be equal on either side of the discontinuity surface. q is the amount of energy released on this surface. The detonation corresponds to $q > 0$, and the ionization to $q < 0$. A detonation or ionization exists only if the ionization or the detonation wave has a steady structure. In this way, Ya. B. Zel'dovich proved the existence of a wave without previous compression. The conditions for the development of a magnetohydrodynamic detonation or ionization wave of low intensity read: $\int > U_{1\pm}$ (7) and $|v_{2x} - \int| \leqslant U_{2\pm}$ (8), where $\int$ is the propagation velocity of the discontinuity, U_x the normal component of the velocity of the medium, U_+ and U_- the velocities of the fast and the slow magnetohydrodynamic wave, respectively: $U_{\pm} = \frac{\{U^2+c^2 \pm [(U^2+c^2)^2-4c^2U_x^2]^{1/2}\}^{1/2}}{\sqrt{2}}$. The indices 1 and 2 refer to the region behind and in front of the discontinuity, respectively. The signs + and - are to be used for fast and slow waves, respectively. The fast and the slow detonation wave correspond to the two propagation velocities of slight disturbances. If the velocity of the detonation wave relative to the reaction products is equal to or smaller than the propagation velocity of small disturbances, one has a detonation in the "Chapman-Jouguet" point (equality sign in (8)) and a "supercompressed" detonation, respectively (inequality in (8)). The conditions for the development of such waves limit the number of waves moving simultaneously in one direction. If a detonation in the Chapman-Jouguet point occurs on a fast wave, the detonation wave will be followed by a fast similarity-type wave, and the latter, in turn, will be followed by an Alfvèn discontinuity; finally, there is a slow shock wave or a slow similarity-type wave. When a "supercompressed" detonation takes place on the fast shock wave, it may be followed by an Alfvèn discontinuity and, subsequently, a slow shock wave or a similarity-type wave. If a "supercompressed" detonation occurs on a slow wave, a fast shock wave or a fast similarity-type wave will appear first, then an Alfvèn discontinuity and, finally, a slow wave of the "supercompressed" detonation. Analogous results are obtained for the shock wave of the ionization $q < 0$. Chapman-Jouguet waves, however, are impossible in this case. For a fast detonation wave in the Chapman-Jouguet point, it follows from the boundary conditions and (8) for the discontinuity of the specific volume that

$$\frac{\Delta_+^* V}{V_1} = -\frac{1}{c_1}\sqrt{2\frac{\gamma-1}{\gamma+1}|q|}\left(1-\frac{1}{c_1}\sqrt{\frac{(\gamma^2-1)|q|}{2}}\right), \qquad (15)$$

The jumps of velocity $\Delta_+^{*}\vec{v}$ in the detonation wave were determined from (9) and (10).

$$\frac{\Delta_+^{*} V}{V_1} < -\frac{1}{c_1}\sqrt{2\frac{\gamma-1}{\gamma+1}|q|}\left(1-\frac{1}{c_1}\sqrt{\frac{(\gamma^2-1)|q|}{2}}\right) \qquad (17)$$

and

$$\frac{\Delta_-^{*} V}{V_1} < -\frac{|U_{1y}|}{c_1^2}\sqrt{\frac{2}{3}(\gamma-1)|q|} \qquad (18)$$

hold for "supercompressed" detonations on fast and slow waves, respectively. Inequality (7) is automatically satisfied for detonation waves. The "supercompressed" detonation changes automatically into a Chapman-Jouguet detonation. (8) is automatically valid for impact ionization. Then, one obtains

$$\frac{\Delta_+^{*} V}{V_1} < -\frac{1}{c_1}\sqrt{2\frac{\gamma-1}{\gamma+1}|q|} \qquad (19)$$

and

$$\frac{\Delta_-^{*} V}{V_1} < -\frac{|U_{1y}|}{c_1^2}\sqrt{\frac{2}{3}(\gamma-1)|q|} \qquad (20)$$

for fast and slow ionization waves, respectively. Figs. 1,3,4 show the various possible types of magnetohydrodynamic waves corresponding to detonation or ionization shock waves. In these figures, the longitudinal

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component u_x of the piston velocity is plotted on the abscissa, and the transverse component u_y on the ordinate. The letters Д, $Д_0$, И, У, P, and A in this order indicate a "supercompressed" detonation, a detonation in the Chapman-Jouguet point, the shock wave of ionization, the shock wave, the expansion wave, and the Alfvèn discontinuity. The plus and the minus sign refer to a fast and a slow wave, respectively. Formulas for the boundary lines between the individual regions are finally presented:

линии $Д_0^+P^-$, $Д_0^+У^-$, $Д_0^+AУ^-$, $Д_0^+AP^-$

$$u_y + \frac{U_x(u_y - 2U_y)u_y}{2c^2} - \sqrt{\frac{2(\gamma-1)|q|}{\gamma+1}} = 0; \qquad (21)$$

линии $Д_0^+P^+$, $Д^+$, $И^+$

$$u_y + \frac{U_x U_y u_x}{c^2} - \frac{(\gamma-1)U_x U_y(u_x^2+2q)}{2c^3} = 0; \qquad (22)$$

линии $Д_0^+P^+A$, $Д^+A$, $И^+A$

$$u_y - 2U_y - \frac{U_y u_x\left(1-\frac{U_x}{c}\right)}{c} + \frac{U_y[2(\gamma-1)q-(2-\gamma)u_x^2]}{4c^2} = 0; \qquad (23)$$

линии $Д_0^-P^-$, $AД_0^-P^-$

$$u_x + \frac{U_x (u_y - 2U_y) u_y}{2c^2} = 0; \qquad (24)$$

линии $Д^-$, $И^-$

$$u_x - \frac{U_x U_y u_y}{c^2} = 0; \qquad (25)$$

линии $AД^-$, $AИ^-$

$$u_x + \frac{U_x U_y (u_y - 2U_y)}{c^2} = 0; \qquad (26)$$

линии $P^+ Д_0^-$, $У^+ Д_0^-$

$$u_y + \frac{U_x U_y u_x}{c^2} - \sqrt{\frac{2|q|(\gamma - 1)}{3}} - \frac{U_x U_y (\gamma - 1) u_x^2}{2c^3} = 0; \qquad (27)$$

линии $P^+ AД_0^-$, $У^+ AД_0^-$

$$u_y - \frac{U_y u_x}{c} - 2U_y + \sqrt{\frac{2|q|(\gamma - 1)}{3}} + \frac{U_x U_y u_x}{c^2} - \frac{(2 - \gamma) U_y u_x^2}{4c^2} = 0. \qquad (28)$$

There are 4 figures and 16 references: 15 Soviet-bloc and 1 non-Soviet-bloc. The reference to the English-language publication reads as follows: L.I.Sedov, Rev.Mod.Phys., 30, 1077, 1959.

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Impact ionization and...

ASSOCIATION: Fiziko-tekhnicheskiy institut AN USSR (Institute of Physics and Technology of the AS UkrSSR). Khar'kovskiy gosudarstvennyy universitet (Khar'kov State University)

SUBMITTED: June 29, 1960

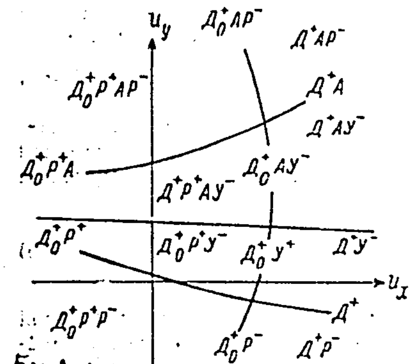

Fig. 1.

Legend to Fig. 1: Possible modes of detonation on a fast wave. Letters in Figs. 1, 3, 4 explained above.

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AUTHOR: Polovin, R. V.

TITLE: Criteria of instability and intensification

PERIODICAL: Zhurnal tekhnicheskoy fiziki, v. 31, no. 10, 1961, 1220-1230

TEXT: General criteria of absolute and convective instabilities, as well as criteria of intensification and imperviousness have been studied. The difference between absolute and convective instabilities has been defined by L. D. Landau and Ye. M. Lifshits (Mekhanika sploshnykh sred (Mechanics of continuous media), Gostekhizdat, M.), and that between intensification and imperviousness has been defined by P. A. Sturrock (Ref. 2: Phys. Rev., 112, 1488, 1959; Ref. 5: Phys. Rev., 117, 1426, 1960). Sturrock has shown that a study of stability and intensification leads to the theory of conformal representations. A general qualitative study of instability and intensification has been made by the author. The criteria obtained are more exact than Sturrock's. The stability of plasma against small disturbances is examined on the assumption that they depend on coordinates and time in the form $e^{ikx-i\omega t}$. The relationship between ω and k is given

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Criteria of instability... S/057/61/0... B104/B125

by the dispersion equation $F(\omega,k;\lambda) = 0$. λ is a parameter characterizing the system. F is a polynomial in ω, k, and λ with real coefficients. Dispersion curves are graphically shown in Fig. 1. Criteria of absolute and convective instabilities, as well as of intensification and impervi-ousness are discussed. In the author's opinion, the proofs ... by Sturrock for these criteria are insufficient, as he did not ... into account the positions of the singular points of the dispersion equation, which are able to change the character of instability. New proofs are presented for these criteria. The character of the singular points of the dispersion equation is examined. It is shown that the case illustrated in Fig. 1a corresponds to an absolute instability, while that of Fig. 1b corresponds to a convective instability. The motion of an electron beam in crossed electric and magnetic fields in a slowing-down system is finally examined. For $v_0 > s$ (v_0 being the electron velocity, ... the velocity of electromagnetic waves in the slowing-down system) the electron beam has a convective instability, and oscillations are intensified. If $v_0 < s$, the beam will be stable, and oscillations will not be intensified. A region of absolute instability is missing. V. I. Kurilko and

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Criteria of instability...

V. D. Shapiro are mentioned. A. I. Akhiyezer, B. Ya. Levin, G. Ya. Lyubarskiy, N. N. Meyman, and Ya. B. Faynberg are thanked for advice and discussions. There are 5 figures and 8 references: 3 Soviet and 5 non-Soviet. The most important reference to the English-language publication reads as follows: E. Drummond et al., Bull. Am. Phys. Soc., 3, 411, 1958.

ASSOCIATION: Fiziko-tekhnicheskiy institut AN USSR Khar'kov (Physico-technical Institute, AS UkrSSR, Khar'kov)

SUBMITTED: January 27, 1961

24.2120 (1049, 1502, 1482)
26.2311

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S/056/61/040/003/027/031
B113/B202

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

TITLE: Stability conditions of the electron distribution function in the plasma

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 3, 1961, 963-969

TEXT: The authors deal with the problem of the stability of the electron distribution function toward plasma oscillations. The behavior of these functions at $t\to\infty$ (t-time) is determined by special points of their Laplace transforms φ_p and f_p with respect to time ($p = i\omega$, ω - complex oscillation frequency). In the free plasma φ_p and f_p are connected by $f_p(u) = (p+iku)^{-1}\{g(u)+ikem^{-1}\varphi_p f_o'(u)\}$ (1) where u is the projection of the electron velocity on the wave vector $\vec{k}$, $f_o(u)$ the initial function of the distribution of u, and g the initial value of f(u,t). The necessary and sufficient condition for the stability of the distribution function $F_o(v)$

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is given by the vanishing of the roots of

$$G(s) \equiv \int_{-\infty}^{\infty} \frac{f_0'(u)du}{u-s} = \frac{k^2}{\omega_0^2}, \quad s = \frac{ip}{k} \tag{3}$$

(ω_0 plasma frequency) in the upper semiplane s at an arbitrary value $k(k > 0)$. The criterion for the stability of the distribution function $f_0(u)$ has the form

$$\int_{-\infty}^{\infty} \frac{f_0''(u)\,du}{u-u_l} < 0, \quad f_0'(u_l) = 0, \quad f_0''(u_l) > 0. \tag{6}$$

from which it follows that a distribution function having only one maximum is stable. This stability condition was observed by P. L. Auer (Ref.7: Phys.Rev.Lett.,1,411,1958). If the distribution function has two maxima, the function will not be stable. A further condition is that any spherically symmetrical distribution function $F_0(|v|)$ which is nowhere vanishing is stable. Since

$$f_0(u) = \int F_0(v)\,dv_\perp = 2\pi \int_0^\infty F_0\left(\sqrt{u^2 + v_\perp^2}\right) v_\perp dv_\perp, \tag{A}$$

holds, where $v_\perp$ is the velocity component of the electron which is perpendicular to $\vec{k}$, $f_0'(u) = -2\pi u F_0(|u|)$ is obtained. Hence (3) takes on the form

$$2\pi \int_{-\infty}^{\infty} \frac{uF_0(|u|)}{s-u} du = \frac{k^2}{\omega_0^2}. \quad (7)$$

from which

$$2\pi \int_{-\infty}^{\infty} \frac{uF_0(|u|)}{s-u} du - 2\pi^2 i s F_0(|s|) = \frac{k^2}{\omega_0^2}. \quad (8)$$

follows. The stability condition leads to the fulfillment of the inequality: $-\int_{-\infty}^{\infty} F_0(|u|)du < 0$. If $g(\xi)$ is the Fourier component of the function $f_0'(u) = \int_{-\infty}^{\infty} g(\xi)e^{i\xi u}\cdot d\xi$ it can be represented in form

$$g(\xi) = -\int_0^{\xi} \psi(\xi-\xi')\psi(\xi')d\xi', \quad (10)$$

$$\psi(\xi) = \int_{-\infty}^{\infty} e^{-i\xi\lambda} d\sigma(\lambda)$$

22147

if the distribution function is stable. Here $\sigma(\lambda)$ is an arbitrary continuous non-decreasing limited function. A certain stable distribution function corresponds to each of these functions. Representation (10) was obtained by A. I. Achizer, G. Ya. Lyubarskiy (Ref.3: Tr.fiz.otd.fiz.-mat. f-ta KhGU,6,13). With a sufficient length of the plasma wave and a sufficiently strong magnetic field $\vec{H}$ the dispersion equation has the following form:

$$1-\frac{\omega_0^2\cos^2\theta}{\chi}\int_{-\infty}^{\infty}\frac{f_0'(u)du}{\chi u-\omega}+\frac{\omega_0^2\sin^2\theta}{2\omega_H}\int_{-\infty}^{\infty}\left(\frac{1}{\chi u-\omega+\omega_H}-\frac{1}{\chi u-\omega-\omega_H}\right)f_0(u)\,du=0, \quad (12)$$

where $\chi = |k\cos\theta|$ and θ are the angles between $\vec{k}$ and $\vec{H}$ and $\omega_H = eH/mc$ the electronic gyrofrequency. In the following,

$$G_H(s)\equiv\int_{-\infty}^{\infty}\left(\frac{\cos^2\theta}{u-s}+\frac{\sin^2\theta}{2s_H}\ln\frac{u-s+s_H}{u-s-s_H}\right)f_0'(u)\,du=\frac{\chi^2}{\omega_0^2}, \quad (13)$$

$$s_H=|\omega_H|/\chi.$$

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

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

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

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

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

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

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S/056/61/040/006/015/031
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11.7300

AUTHORS: Polovin, R. V., Demutskiy, V. P.

TITLE: Magnetohydrodynamic combustion

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1746 - 1754

TEXT: A study has been made of the effect of the magnetic field upon the combustion process. The general laws of conservation are valid along with the boundary conditions for the electromagnetic field:

$$\{(v_x - \zeta)/V\} = 0, \tag{7}$$

$$\{p + (v_x - \zeta)^2/V + H_y^2/8\pi\} = 0, \tag{8}$$

$$\{\gamma pV/(\gamma - 1) + (v_x - \zeta)^2/2 + v_y^2/2 + VH_y^2/4\pi - VH_xH_yv_y/4\pi\,(v_x - \zeta)\} = q, \tag{9}$$

$$\{(v_x - \zeta)\,v_y/V - H_xH_y/4\pi\} = 0, \tag{10}$$

$$\{H_xv_y - (v_x - \zeta)\,H_y\} = 0, \tag{11}$$

$$\{H_x\} = 0, \tag{12}$$

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Magnetohydrodynamic combustion

where $V = 1/\rho$, ρ is the propagation velocity of explosion waves in the laboratory system, q is the energy liberated on the combustion surface. These equations are not sufficient for the complete solution of the combustion process, since also the condition must be satisfied that the number of waves starting on both sides of the combustion surface be equal to the number of independent boundary conditions. On the basis of Fig. 1, the solution is discussed with respect to "slow", "subsonic", "supersonic", and "fast" combustions. In this connection, index 1 refers to the region in front of the explosion wave, while index 2 refers to the one behind it. Index x denotes the component of a given quantity in direction of the x-axis, the propagation direction of explosion waves. The signs + and - denote fast and slow waves, respectively. Furthermore,

$$U_{\pm} = \left\{U^2 + c^2 \pm \left[(U^2 + c^2)^2 - 4c^2U_x^2\right]^{1/2}\right\}^{1/2}/\sqrt{2} \quad (I),$$

where $\vec{U} = \vec{H}/\sqrt{4\pi\rho}$.

From Eqs. (10), (11)

$$H_{2y} = \frac{1/\rho_1 - H_x^2/4\pi j^2}{1/\rho_2 - H_x^2/4\pi j^2} H_{1y} \quad (19)$$

is derived, where $j = \rho_1 v_{1x} = \rho_2 v_{2x}$. The sign of H_y is found not to change in any of the four

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S/056/61/041/001/018/021
B102/B231

AUTHORS: Polovin, R. V., Cherkasova, K. P.

TITLE: Disintegration of non-evolutional shock waves

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 1(7), 1961, 263 - 266.

TEXT: Subject of the present work is a mathematical study of the disintegration of a magnetohydrodynamical shock wave with a small density discontinuity. For the existence of a magnetohydrodynamical shock wave it is not sufficient that the boundary conditions at the discontinuity surface are satisfied and that entropy increases; the so-called conditions of evolution (the number of divergent waves must be equal to the number of independent boundary conditions at the discontinuity surface) must be satisfied as well. Otherwise the problem of small perturbations of the shock wave has no solution, which means that the initial shock wave disintegrates. The theorem stating that the region of non-evolutionality coincides with those regions within which a primary shock wave might disintegrate, has hitherto been verified for one particular case only

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(shock-wave velocity is close to the Alfvén velocity; $\vec{H}$ encloses a small angle on both sides of the shock wave with the perpendicular to the discontinuity surface). The present work furnishes proof for another particular case: that of a shock wave with a small jump of density. The case of this wave being non-evolutional has already been investigated by J. Bazer and W. B. Ericson (Ref. 3: Astrophys. J., 129, 758, 1959; Phys. Fluids, 3, 631, 1960). Here, use is made of a result obtained by G. Ya. Lyubarskiy and R. V. Polovin (Ref. 4: ZhETF, 35, 1291, 1958) who found the amplitudes of such waves as originate in the process of disintegration of the small discontinuity to be given by

$$\Delta^{(s)}_{\pm}\rho = \pm\frac{1}{2R}\left\{e\frac{U_y^2 c^2 [\Delta\rho - (\partial\rho/\partial s)_p \Delta s]}{U_{\pm}^2 - U^2} - e\frac{\Delta H_y^2}{8\pi} + \frac{\rho U_x^2}{U_{\pm}}\left[\frac{H_y \Delta v_y}{H_x} + \frac{U_y^2 \Delta v_x}{U_{\pm}^2 - U_x^2}\right]\right\}. \quad (1)$$

Здесь

$\mathbf{U} \equiv \mathbf{H}/\sqrt{4\pi\rho}$, $U_{\pm} = [(U^2 + c^2 \pm R)/2]^{1/2}$, $R = [(U^2 + c^2)^2 - 4c^2 U_x^2]^{1/2}$;

$\Delta\varrho$, Δs, Δv, and ΔH_y denote the jumps of density, entropy, velocity and transverse magnetic field, respectively; c is the velocity of sound; ± indicates fast and slow magnetoacoustic waves. For waves propagating in the positive x-direction relative to the medium, ε is equal to +1, whereas for waves propagating in opposite direction $\varepsilon = -1$. x is perpendicular to the discontinuity. The shock wave corresponds to $\Delta_{\pm}^{(\varepsilon)}\varrho > 0$, and the progressing wave to $\Delta_{\pm}^{(\varepsilon)}\varrho < 0$. The jumps of the magnetohydrodynamic quantities are interrelated by

$$\Delta v_x/\Delta\rho = \varepsilon U_{\pm}/\rho, \quad \Delta v_y/\Delta\rho = -\varepsilon H_x H_y U_{\pm}/4\pi\rho^2 (U_{\pm}^2 - U_x^2),$$
$$\Delta H_y/\Delta\rho = U_{\pm}^2 H_y/\rho\,(U_{\pm}^2 - U_x^2), \quad \Delta p/\Delta\rho = c^2. \qquad (2).$$

Considering the concrete case $\varepsilon = -1$, the following is obtained: $\Delta_{\pm}^{(-)}\varrho = \Delta_{\pm}\varrho$, $\Delta_{\pm}^{(-)}\varrho = \Delta_{\pm}^{(+)}\varrho = \Delta_{\mp}^{(+)}\varrho = 0$. This means that it is impossible for a weak evolutional shock wave to disintegrate. In the following, the case of a non-evolutional shock wave exhibiting a small $\Delta\rho$ is examined. The jumps of the magnetohydrodynamic quantities are in this case interrelated by

$$\Delta v_x = -U_{1x}\rho_1^{-1}\Delta\rho, \qquad \Delta p = \left[c_1^2 + (\gamma - 1)U_{1y}^2\right]\Delta\rho,$$
$$\Delta H_y = -2H_{1y}\left[1 + \frac{U_{1x}^2 - c_1^2 - (\gamma - 1)U_{1y}^2}{2U_{1y}^2}\frac{\Delta\rho}{\rho_1}\right],$$
$$\Delta v_y = -2U_{1y}\left[1 + \frac{U_{1x}^2 - c_1^2 - \left(\gamma - \frac{1}{2}\right)U_{1y}^2}{2U_{1y}^2}\frac{\Delta\rho}{\rho_1}\right]. \qquad (3).$$

The index 1 indicates that the region in front of the shock wave is concerned. This primary shock wave may disintegrate into seven waves: three of them propagating to the right, three to the left (fast magnetoacoustic wave, Alfvèn discontinuity, slow magnetoacoustic wave), and the discontinuity establishing contact between them, resting relative to the medium. For the Alfvèn discontinuities one finds

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$\Delta_A^{(\varepsilon)} H_y = H_{1y}(\eta_\varepsilon - 1)$; $\Delta_A^{(\varepsilon)} v_y = \varepsilon \mathcal{U}_{1y}(1 - \eta_\varepsilon)$. The jumps of the other quantities are equal to zero. The amplitudes of the magnetoacoustic waves and of the contact discontinuity are given by

$$\Delta_k\rho = -(\gamma - 1)\, c_1^{-2} U_{1y}^2 \Delta\rho, \qquad \Delta_+^+\rho = \left[\frac{U_{1x}^2 + U_{1-}^2}{2(U_{1x}^2 - U_{1-}^2)} + \frac{U_1^2 - c_1^2 - \gamma U_{1y}^2}{U_{1y}^2} - \right.$$

$$\left. - b_+\left(\frac{U_{1x}U_{1+}}{U_{1x}^2 - U_{1-}^2} + \frac{U_{1+}^2 + U_{1x}^2 - U_{1+}U_{1x}}{U_{1-}^2 - U_{1x}^2}\right)\right]\frac{\Delta\rho}{a}.$$

$$\Delta_+^-\rho = \left[\frac{U_{1x}^2 + U_{1-}^2}{2(U_{1x}^2 - U_{1-}^2)} + \frac{U_1^2 - c_1^2 - \gamma U_{1y}^3}{U_{1y}^2} + \frac{U_{1+}Rb_+}{U_{1x}U_{1y}^2}\right]\frac{\Delta\rho}{a}, \qquad (5).$$

$$\Delta_-^{(\varepsilon)}\rho = \left[\frac{U_{1+}^2}{2(U_{1+} - U_{1x})} - \frac{U_{1x}^2}{2(U_{1+} + U_{1x})} - \frac{U_{1+}(U_1^2 - c_1^2 - \gamma U_{1y}^2)}{U_{1y}^2} + \right.$$

$$\left. + \frac{1}{2}\frac{U_{1+} - U_{1x}}{U_{1+} + U_{1x}} U_{1+}b_+\right]\frac{\Delta\rho}{U_{1-}a} - \frac{\varepsilon b_-}{2}\Delta\rho,$$

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$$R = \sqrt{(U_1^2 + c_1^2)^2 - 4c_1^2 U_{1x}^2},$$

$$\alpha = (U_{1+}^2 + U_{1x}^2)/(U_{1+}^2 - U_{1x}^2) + 2U_{1x}U_{1+}/(U_{1x}^2 - U_{1-}^2),$$

$$b_{\pm} = \pm \frac{U_{1y}^2}{R}\left[\frac{U_1^2 - c_1^2 - \gamma U_{1y}^2}{U_{1y}^2} - \frac{c_1^2 + (\gamma - 1) U_{1y}^2}{U_{1\mp}^2 - U_1^2}\right].$$

The authors thank A. I. Akhiyezer for discussions. There are 4 references: 3 Soviet-bloc and 1 non-Soviet-bloc.

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

SUBMITTED: February 17, 1961

27189

S/056/61/041/002/010/028
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26.2114

AUTHOR: Polovin, R. V.

TITLE: Evolutionality conditions of steady flows

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 2 (8), 1961, 394-399

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TEXT: The investigation and consideration of the evolutionality conditions is of specific importance not only for problems concerning the realization of magnetohydrodynamic shock waves but also for those concerning the realization of gas-dynamic flows without any fields. The latter case is discussed here. The author analyzes the evolutionality conditions of continuous flows and of the discontinuities moving along with them. It is shown that in a reversed Laval nozzle transforming a supersonic flow into a subsonic one, shock waves will occur in any case. The same phenomenon is observable with a transonic flow around a bounded body. First of all, the author deals with a continuous, one-dimensional flow of gas, and discusses the formulation of evolutionality conditions for this simple case. Then, he briefly discusses the case of transonic

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flow around a bounded body, in which a continuity is impossible since even infinitely small perturbations would change the flow conditions completely. Next, the conservation theorems holding for moving discontinuities and the course of the shock adiabates are briefly discussed. In the case of shock waves, the propagation velocity of which depends on their amplitude, the evolutionality conditions for discontinuities read $M_1>1$, $M_2<1$. These shock waves are, or are not, accompanied by a positive or negative change in energy. For shock waves with a velocity independent of their amplitude one finds: a) $M_1<1$, $M_2<1$; b) $M_1>1$, $M_2>1$, M_1 being the Mach number in front of the discontinuity, and M_2 that behind it. Such waves occur without a change in energy only in the trivial case $M_1=M_2$ (no discontinuity). For discontinuities in which a subsonic flow changes to a supersonic one, one finds $M_1<1$, $M_2>1$. Such flows may occur in a nozzle. In the following, the author deals with the shock wave associated with the vertex of an angle subjected to a flow in the presence of two-dimensional perturbations of velocity, pressure, and entropy. The final part of this article deals with the reflection of a shock wave from
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a solid wall and with some particular cases. In conclusion, it is pointed out that the application of evolutionality conditions to flows in nozzles and to transonic flows leads to the conclusion that a continuous transition from subsonic to supersonic velocities is possible, whilst a change from supersonic to subsonic velocities is accompanied by the formation of shock waves. The application of evolutionality conditions to an oblique shock wave connected with a wedge indicates that the flow behind the shock wave is subsonic. A. I. Akhiyezer, L. D. Landau, M. A. Leontovich, and L. I. Sedov are thanked for discussions. Ya. B. Zel'dovich is mentioned. There are 3 figures and 23 references: 8 Soviet and 15 non-Soviet. The two most recent references to English-language publications read as follows: C. S. Morawetz. Comm. Pure Appl. Math. 9, 45, 1956; R. A. Gross, A. K. Oppenheim. ARS. Journ. 29, 173, 1959.

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

SUBMITTED: January 25, 1961

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

AUTHORS: Akhiezer, A. I., Lyubarsk , 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 reresults 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

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

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).

S/781/62/000/000/017/036.

AUTHORS: Lyubarskiy G. Ya., Polovin R. V.

TITLE: Contribution to the theory of simple waves

SOURCE: Fizika plazmy i problemy upravlyayemogo termoyadernogo sinteza; doklady I konferentsii po fizike plazmy i probleme upravlyayemykh termoyadernykh reaktisy. Fiz.-tekh. inst. AN Ukr. SSR. Kiev, Izd-vo AN Ukr. SSR. 1962. 79-82

TEXT:
Simple waves are defined as solutions of the magnetohydrodynamic differential equations in a form such that all the quantities can be expressed as functions of one of them. Their importance to hydrodynamic or magnetohydrodynamic theory lies in the fact that they are the only ones that can border on the region of continuous flow if there are no shock waves. The differential equations themselves have been derived in various approximations by Chew, Goldberger, and Low (ref. 1: Proc. Royal Soc. A236, 112, 1956) and others. It is shown that a region of continuous flow can border in magnetohydrodynamics only on a strong discontinuity or a simple wave. Although there exist proofs of this statement for ordinar

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hydrodynamics (two variables), as for example in the book by Courant and Friedrichs (ref. 3: Supersonic Flow and Shock Waves, Interscience, 1948), there is no such proof for more than two variables. The proof is based on the fact that the approximate differential equations for the plasma are hyperbolic,and the correspondence existing between the characteristics of the equations and the simple waves. This leads to a system of ordinary differential equations,which can be integrated. The integrability is demonstrated by proving a uniqueness theorem that has much in common with the theorem given by Friedrichs (ref. 5: Am. J. Matl 70, 555, 1948). The three references in the text are the only non-Russian ones.

POLOVIN, R.V.; CHERKASOVA, K.P.

Magnetohydrodynamic description of a plasma. Zhur. tekh. fiz. 32 no.6:649-656 Je '62. (MIRA 15:7)
(Plasma (Ionized gases)) (Magnetohydrodynamics)

POLOVIN, R.V.

Two-beam instability; review. Ukr. fiz. zhur. 8 no.7:709-716 Jl '63. (MIRA 16:8)

1. Fiziko-tekhnicheskiy institut AN UkrSSR, Khar'kov.
(Electron beams)

POLOVIN, R.V.

Shock waves in a plasma in the absence of collisions. Ukr. fiz. zhur. 8 no.8:830-834 Ag '63. (MIRA 16:11)

1. Fiziko-tekhnicheskiy institut AN UkrSSR, Khar'kov.

S/057/63/033/002/023/023
B108/B186

AUTHOR: Polovin, R. V.

TITLE: On the applicability of Sturrock's criteria

PERIODICAL: Zhurnal tekhnicheskoy fiziki, v. 33, no. 2, 1963, 255 - 256

TEXT: In a paper by P. A. Sturrock (Phys. Rev., 112, 1488, 1959) criteria are given which make it possible to distinguish between absolute and convective instabilities, and between intensification and impermeability. It is shown here that it is sufficient for the applicability of these criteria that the dispersion relation is a polynomial of n-th order, which for $k \to \infty$, is split up into n real branches $\omega = \beta_i k$ so that all β_i are different from one another and from zero or infinity.

ASSOCIATION: Fiziko-tekhnicheskiy institut AN USSR, Khar'kov (Physico-technical Institute AS UkrSSR, Khar'kov)

SUBMITTED: September 26, 1962

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ACCESSION NR: AP4013410

S/0057/64/034/002/0259/0261

AUTHOR: Polovin, R.V.

TITLE: On kinetic instability in a magnetic field

SOURCE: Zhurnal tekhn.fiz.,v.34, no.2, 1964, 259-261

TOPIC TAGS: plasma, stability, velocity distribution, electron velocity distribution, electron velocity distribution stability

ABSTRACT: It is shown that a necessary and sufficient condition for the stability of an electron velocity distribution in a sufficiently dense plasma in a magnetic field, with respect to longitudinal oscillations of wavelength long compared with the Larmor radius, is that the distribution function be even and have a single maximum. The sufficiency of this condition was previously shown (A.I.Akhiezer, G.Ya. Lyubarskiy, R.V.Polovin,ZhETH,40,963,1961). The present proof of necessity is based on a more involved necessary and sufficient condition given in the reference cited above and makes use of two previously known stability conditions of which one was given by D.Bohm and E.P.Gross (Phys.Rev.75,1864,1949) and others, and the other was given by W.E.Nexsen, W.F.Cummins, F.H.Coensgen and A.E.Sherman (Phys.Rev.119,

ACCESSION NR: AP4013410

1457,1960). "The author expresses his gratitude to A. I. Akhiezer for a valuable discussion." Orig.art.has: 12 formulas and 1 figure..

ASSOCIATON: none

SUBMITTED: 13Dec62 DATE ACQ: 26Feb64 ENCL: 00

SUB CODE: PH NR REF SOV: 002 OTHER: 004

Card 2/2

AKHIYEZER, A.I.; AKHIYEZER, I.A.; POLOVIN, R.V.; SITENKO, A.G.; STEPANOV, K.N.; VENGRENYUK, L.I., red.

[Collective plasma oscillations] Kollektivnye kolebaniia v plazme. Moskva, Atomizdat, 1964. 162 p. (MIRA 18:2)

FOLOVIN, R.V.

Oblique shock waves in magnetohydrodynamics. Zhur. tekh. fiz. 34 no.10:1798-1802 O '64. (MIRA 17:12)

POLOVIN, R.V.

Oblique and conical shock waves and transonic flows. Ukr. fiz.zhur. 10 no.10:1045-1050 O '65.
(MIRA 19:1)

1. Fiziko-tekhnicheskiy institut AN UkrSSR, Khar'kov. Submitted November 19, 1964.

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

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

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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ACC NR: AT6020575

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

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L 20384-66 EWT(1)/EWP(m)/EWA(d)/EWA(h)/EWA(1) WW
ACC NR: AT6001617 SOURCE CODE: UR/3137/64/000/096/0001/0025

AUTHOR: Polovin, R. V.

ORG: Physicotechnical Institute AN UkrSSR (Fiziko-tekhnicheskiy institut AN UkrSSR)

76
B+1 72

TITLE: Conditions for evolutionality of oblique and conical shock waves in transonic flow

SOURCE: AN UkrSSR. Fiziko-tekhnicheskiy institut. Doklady, no. 96, 1964. Usloviya evolyutsionnosti kosykh i konicheskikh udarnykh voln i transzvukovykh techeniy, 1-25

TOPIC TAGS: shock wave formation, oblique shock wave, supersonic flow, transonic flow, attached shock wave, hydrodynamic theory, magnetohydrodynamics, shock wave reflection, elliptic differential equation

ABSTRACT: This is a review of papers dealing with transonic flow around bodies and with attached oblique and conical shock waves. It is shown first, starting from the evolutionality condition, that in ordinary hydrodynamics a continuous transition through the speed of sound in one dimensional flow is possible only when the Mach number is included. It is shown further that this theorem is valid also for two dimensional flow, if the sound line joins the wall at a point where the velocity vector has a definite direction. Other proofs of this theorem are also re-

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ACC NR: AT6001617

4

viewed, and the theorem is generalized to the case of magnetohydrodynamics. This is followed by a discussion of oblique shock waves attached to the corner about which the flow takes place. Possible bends in the discontinuity line are investigated, and the impossibility of strong oblique shock wave is proved. Other proofs of this statement are reviewed. It is then shown, again on the basis of the evolutionality condition, that the flow behind an oblique shock wave attached to a corner should be supersonic. The theory is compared with experiment and the regular and Mach reflections of shock waves are discussed. Work devoted to oblique magnetohydrodynamic shock waves is reviewed. It is shown that oblique detonation waves can exist in a channel of constant cross section only in the Chapman-Jouguet regime. The reason why the flow can be subsonic behind conical shock waves is explained, and also why a continuous transition to the speed of sound with deceleration is possible in a continuous conical flow. The Buseman paradox, namely supersonic flow described by elliptic differential equation, is examined. The author thanks A. I. Akhiyezer, M. N. Kogan, G. A. Lyubimov, and L. A. Sedov for valuable discussions. Orig. art. has: 5 figures and 22 formulas.

SUB CODE: 20/ SUBM DATE: none/ ORIG REF: 046/ PRJ REF: 105

Card 2/2 vmb

L 24113-66 EWT(1)/ETC(m)-6 IJP(c) WW/RB

ACC NR: AP6011509 SOURCE CODE: UR/0382/66/000/001/0003/0034

AUTHOR: Polovin, R. V.; Cherkasova, K. P.

ORG: none

TITLE: Magnetosonic waves

SOURCE: Magnitnaya gidrodinamika, no. 1, 1966, 3-34

TOPIC TAGS: sound wave, perturbation, perturbation zone, sound propagation, wave equation, magnetosonic wave

ABSTRACT: The propagation of magnetosonic waves in a uniform medium has been investigated. The wave-front of the system of hydromagnetic equations was analyzed. It was proved the Huygens' principle is valid only for one-dimensional waves. There are two lacoons (zero perturbation regions) inside the region of perturbation in the two-dimensional case. The lacoons are absent in the three-dimensional case. The distinction between fast and slow magnetosonic waves is valid only in a one-dimensional case. In two-dimensional and three-dimensional cases, all perturbations propagate at the fast magneto-sonic-wave velocity. The only case when Altven's speed equals the speed of sound was analyzed. Orig. art. has: 6 figures and 7 formulas. [Based on author's abstract] [NT]

Card 1/2 UDC: 538.4

L 24113-66

ACC NR: AP6011509

SUB CODE: 20/ SUBM DATE: 30Jun65/ ORIG REF: 007/ OTH REF: 011/

Card 2/2

L 21119-66 EWT(1)/EWP(m)/T-2 IJP(c)

ACC NR: AP6011985 SOURCE CODE: UR/0376/65/001/004/0499/0522

AUTHOR: Polovin, R. V.

ORG: Physicotechnical Institute, AN UkrSSR, Khar'kov (Fiziko-tekhnicheskiy institut AN UkrSSR)

TITLE: Nonlinear magnetohydrodynamic waves 72

SOURCE: Differentsial'nyye uravneniya, v. 1, no. 4, 1965, 499-522 B

TOPIC TAGS: magnetohydrodynamics, shock wave, weak shock wave

ABSTRACT: The article is a survey of work done on nonlinear, one-dimensional magnetohydrodynamic waves. A wide class of hyperbolic systems of partial quasi-linear equations is investigated. The author states that the article makes no claim to mathematical strictness but is intended for mathematicians interested in applications and for mechanical engineers and physicists interested in mathematical questions of magnetohydrodynamics. Section 1 of the article explains the significance of curves and their connection with waves of small amplitude. Section 2 states the simple wave theory, discusses the question of Riemann invariants, and shows that in the absence of discontinuities the constant flow region can be bounded only by a simple wave. Section 3 considers the character of the change of the profile of a simple wave during motion and shows that in a number of cases this change results in the formation of discontinuities. Section 4, dealing with discontinuities, shows that boundary conditions on discontinuous surfaces are obtained from conservation laws in integral form. Section 5 indicates that the conservation

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laws are satisfied not only by true discontinuities but also by extraneous solutions, and to exclude them, the conservation laws need to be supplemented by conditions of evolution. Section 6, dealing with waves of small intensity, indicates that for them the difference between a shock wave and a self-similar wave (correct to magnitudes of second order inclusive) consists only in the sign of the density jump; from this is follows particularly that a change in a Riemann invariant in a weak shock wave is of the third order of smallness. Section 7 shows that the use of these correlations allows a general solution to the problem of the decay of a discontinuity under initial conditions for waves of small intensity. Section 8 explains the reasons for the appearance of discontinuities when dissipation factors tend to zero and investigates the structure of a shock wave. The article concludes with an extensive bibliography. Orig. art. has: 1 figure and 8 formulas. [JPRS]

SUB CODE: 20 / SUBM DATE: 28Dec64 / ORIG REF: 060 / OTH REF: 026

Card 2/2 dda

L 34478-66 EWT(1)/EWP(m)/T-2 IJP(c)

ACC NR: AP6014161 SOURCE CODE: UR/0053/66/088/004/0593/0617

AUTHOR: Polovin, R. V.; Cherkasova, K. P.

ORG: Physicotechnical Institute, AN UkrSSR, Khar'kov (Fiziko-tekhnicheskiy institut AN UkrSSR)

TITLE: Magnetohydrodynamic waves

SOURCE: Uspekhi fizicheskikh nauk, v. 88, no. 4, 1966, 593-617

TOPIC TAGS: magnetohydrodynamics, mhd flow, mhd instability, mhd shock wave, plasma wave, detonation wave, oblique shock wave, shock induced combustion

ABSTRACT: This is a review article reporting on the latest results of research on magnetohydrodynamic waves in homogeneous media with special attention to stability of the magnetohydrodynamic currents and its relation to the evolutionality conditions. Only qualitative results and simple formulas are presented, reference being made to the original sources for more complicated formulas and derivations. Detailed descriptions are presented of the seven possible magnetohydrodynamic waves that can exist in a stationary homogeneous medium (two fast magnetosonic waves, two slow magnetosonic waves, two Alfven waves, entropy wave) together with their appropriate group and phase polars and their characteristic equations; the possible flows that can exist in such a medium (slow, pre-Alfven, super-Alfven, and fast); the changes of the longitudinal and transverse velocities, density, pressure, and magnetic field in the different waves; the effects of ionization, detonation, combustion, shock, and

UDC: 532.5

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

AM5007590 BOOK EXPLOITATION UR/ 533.9

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

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.

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TABLE OF CONTENTS (abridged):

SUB CODE: ME, NP

SUBMITTED: 26Sep64

NR REF SOV: 100

OTHER: 045

Card 2/2

L 00306-66 EWT(1)/EWP(m)/EPA(sp)-2/EPA(w)-2/T-2/EWA(m)-2 IJP(c)

ACCESSION NR: AP5016648 UR/0382/65/000/002/0019/0022

533.95 : 538.4

AUTHOR: Polovin, R. V.

TITLE: Chapman-Jouguet theorem in magnetohydrodynamics

SOURCE: Magnitnaya gidrodinamika, no. 2, 1965, 19-22

TOPIC TAGS: MHD shock wave, detonation wave, thermonuclear reaction

ABSTRACT: It is shown theoretically that the speed of reaction products in a magnetohydrodynamic detonation (occuring in a tube with an end closed by a conducting wall) equals the phase velocity of small disturbances when the reference frame is chosen to move with the detonation front. The direction and magnitude of the magnetic field and the energy of the reaction are arbitrary. Any equation of state can be employed, but the conductivity must be infinite. The results are obtained using the Chapman-Jouguet theorem. It is noted that the infinite conductivity requirement implies that only thermonuclear detonations are suitable cases for this approach. Also it is indicated that of great interest is a variant of this problem where the conductivity of the medium ahead of the detonation is zero, in which case an electromagnetic wave is generated. "The author thanks A. I. Akhuyezer for

L 00306-66

ACCESSION NR: AP5016648

valuable discussions." Orig. art. has: 14 formulas.

ASSOCIATION: none

SUBMITTED: 24Nov64 ENCL: 00 SUB CODE: ME, WA

NO REF SOV: 024 OTHER: 012

Card 2/2 dg

L 3954-66 EWT(1)/EWP(m)/EWA(d)/FCS(k)/EWA(1)

ACC NR: AP5026915 SOURCE CODE: UR/0185/65/010/010/1045/1050

AUTHOR: Polovin, R. V.

ORG: Physicotechnical Institute, AN UkrSSR (Fiziko-tekhnichnyy institut AN URSR)

48 B

TITLE: On oblique and conical shock waves and transonic flows

SOURCE: Ukrayins'kiy fizychnyy zhurnal, v. 10, no. 10, 1965, 1045-1050

TOPIC TAGS: supersonic flow, transonic flow, shock wave, oblique shock wave, attached shock wave, detached shock wave, sonic line, shock wave analysis, aerodynamics

ABSTRACT: The general evolutionary conditions take the form of "sweeping out" conditions in the case of oblique and conical shock waves. It is proved that the flow downstream from an oblique shock wave attached to the apex of the wedge is supersonic, though the flow downstream from a conical shock wave may be subsonic. The possibility of continuous transition with deceleration through the velocity of sound is proved for the case when the sonic line does not rest against the wall anywhere or at a singular point. On the contrary, a continuous transition with deceleration through the velocity of sound is nonevolutionary, and thus is

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POLOVIN, R.V.

Nonlinear magnetohydrodynamic waves. Dif. urav. 1 no.4:499-522
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1. Fiziko-tekhnicheskiy institut AN UkrSSR, Khar'kov.

L 8898-65 EWT(1)/EPA(b)/EPA(sp)-2/EWG(v)/EPR/EPA(w)-2/T-2/EWA(m)-2 Pd-4/Pe-5/Pab-24/Ps-4/Pi-4 IJP(c)/ESD(t)/AFETR/AEDC(a)/SSD/ASD(p)-3/ESD(gs)/AFWL/BSD/RAEM(c)/ASD(f) WW

ACCESSION NR: AP4046339 S/0057/64/034/010/1798/1802

AUTHOR: Polovin, R. V.

B

TITLE: Oblique shock waves in magnetohydrodynamics

SOURCE: Zhurnal tekhnicheskoy fiziki, v. 34, no. 10, 1964, 1798-1802

TOPIC TAGS: shock wave, oblique shock wave, fast shock wave, slow shock wave, evolution condition, magnetohydrodynamics

ABSTRACT: The limitations imposed on various types of oblique shock waves in magnetohydrodynamics by evolution conditions and by the so-called "sweeping-out" condition are considered in the case when the magnetic field is parallel to the velocity of the fluid. Conditions concerning the evolution and sweeping of fast and slow shock waves are outlined, and it is shown that there cannot be a slow shock wave behind a fast shock wave or vice versa. It is also proved that no more than one shock wave can be attached to the vertex of a streamlined angle. Orig. art. has: 5 figures and 13 formulas.

ASSOCIATION: None

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L 8898-65

ACCESSION NR: AP4046339

SUBMITTED: 19Dec63 ATD PRESS: 3109 ENCL: 00

SUB CODE: ME NO REF SOV: 010 OTHER: 007

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