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THE SPLITTING OF A SMALL DISCONTINUITY IN MAGNETOHYDRODYNAMICS

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In 1926 Kochin[1,2] investigated the break-up of an arbitrary hydrodynamic plane discontinuity. In doing this he made essential use of the fact that either a single shock wave or a single self-similar rarefaction wave can be propagated in each direction from the initial discontinuity.

In magnetohydrodynamics a discontinuity breaks up, generally speaking, in a considerably more complicated manner: up to three waves (shock waves or self-similar waves) can be propagated in each direction from the initial discontinuity. This is connected with the fact that in magnetohydrodynamics there exist three different types of stable shock waves[3] (fast and slow magnetoacoustic waves and magnetohydrodynamic waves) and two types of self-similar waves[4] (fast and slow magnetoacoustic waves). Because the different speeds of propagation, up to three waves of the types enumerated above may be propagated in each direction from the initial discontinuity.

We note that the initial discontinuity is characterized by seven parameters — the discontinuities in the density $\Delta\rho$, in the entropy Δs, in the velocity ΔV and in the tangential component of the magnetic field ΔH_t. Since each wave is characterized by one parameter, the initial discontinuity breaks up into seven waves, of which three are propagated to the left, three are propagated to the right and one — a contact discontinuity — remains stationary. As has been shown by Akhiezer et al.,[3] two waves of the same type move in such a way that the wave in the rear overtakes the wave in front. Therefore waves of three different types must be propagated in each direction: in front there will be the fast magnetoacoustic (shock or self-similar) wave, followed by the Alfven shock wave, and finally, the slow magnetoacoustic (shock or self-similar) wave.

One should have in mind the fact that the self-similar wave is a rarefaction wave,[4] while the shock wave is a compression wave.[5]

The problem now consists of choosing the amplitudes of these seven waves in such a way as to make a transition from the state to the left of the initial discontinuity to the state to the right of the initial discontinuity. For the sake of simplicity, we shall restrict ourselves to the case when the initial discontinuity is very small. Then all the secondary discontinuities will also be small. The relation between the discontinuities in the magnetohydrodynamic quantities in the self-similar and the shock waves (in the case of low intensity) is the same as between the amplitudes of the corresponding linearized wave. We now state these relations:

(1) Magnetoacoustic waves (shock and self-similar waves)

$$\Delta_{\pm}^{(\varepsilon)} v_x = \varepsilon (u_{\pm}/\rho)\, \Delta_{\pm}^{(\varepsilon)}\rho,$$

$$\Delta_{\pm}^{(\varepsilon)} \mathbf{v}_t = -\varepsilon H_x \mathbf{H}_t u_{\pm} \Delta_{\pm}^{(\varepsilon)}\rho / 4\pi\rho^2 (u_{\pm}^2 - V_x^2),$$

$$\Delta_{\pm}^{(\varepsilon)} \mathbf{H}_t = u_{\pm}^2 \mathbf{H}_t \Delta_{\pm}^{(\varepsilon)}\rho / \rho (u_{\pm}^2 - V_x^2),$$

$$\Delta_{\pm}^{(\varepsilon)} s = 0, \qquad \Delta_{\pm}^{(\varepsilon)} p = c^2 \Delta_{\pm}^{(\varepsilon)}\rho,$$

where c is the speed of sound, $\mathbf{V}_t$ is the tangential component of the velocity of the liquid $\mathbf{V}$, and

$$\mathbf{V} = \mathbf{H}/\sqrt{4\pi\rho}, \quad u_{\pm}^2 = \tfrac{1}{2}\left[V^2 + c^2 \pm \sqrt{(V^2+c^2)^2 - 4c^2V_x^2}\right].$$

The plus sign corresponds to the fast magnetoacoustic wave, the minus sign corresponds to the slow one. For waves moving to the right $\epsilon = +1$; for waves moving to the left $\epsilon = -1$. The difference between the shock and the self-similar magnetoacoustic waves is that in the former the density increases, while in the latter it decreases.

(2) Alfven shock waves

$$\Delta_{A}^{(\varepsilon)} \mathbf{v}_t = -\varepsilon \Delta_{A}^{(\varepsilon)} \mathbf{H}_t / \sqrt{4\pi\rho},$$

$$\Delta_{A}^{(\varepsilon)} v_x = \Delta_{A}^{(\varepsilon)} p = \Delta_{A}^{(\varepsilon)} \rho = 0, \qquad \Delta_{A}^{(\varepsilon)} H_t^2 = 0.$$

(3) Contact discontinuity

$$\Delta_C v_x = \Delta_C v_y = \Delta_C v_z = \Delta_C p = \Delta_C H_y = \Delta_C H_z = 0,$$

$$\Delta_C \rho = (\partial\rho/\partial s)_p \Delta_C s, \quad H_x \neq 0.$$

The sum of the discontinuities of each magnetohydrodynamic quantity at the seven new waves is equal to the initial discontinuity. We thus obtain seven equations in seven unknowns, on solving which we obtain all the discontinuities. We give the expression for the discontinuities in the density:

$$\Delta_{\pm}^{(\epsilon)}\rho = \frac{1}{2R}\left\{\frac{c^2V_t^2[\Delta\rho - (\partial\rho/\partial s)_p\Delta s]}{u_{\mp}^2 - V^2} - \frac{\Delta H_t^2}{8\pi} + \frac{\epsilon\rho V_x^2}{u_{\pm}}\left[\frac{\mathbf{H}_t\Delta\mathbf{v}_t}{H_x} + \frac{V_t^2\Delta v_x}{u_{\mp}^2 - V_x^2}\right]\right\},$$

where

$$R = \sqrt{(V^2+c^2)^2 - 4c^2V_x^2}.$$

The formulas obtained above enable us to determine the signs of $\Delta_{\pm}^{(\epsilon)}\rho$ and in this way to determine the type of wave into which the initial discontinuity breaks up.

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ON A METHOD FOR DETERMINING THE PARITY OF STRANGE PARTICLES

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SINCE parity is not conserved in weak interactions that are responsible for the decay of elementary particles, the intrinsic parity of particles may be determined only from strong interaction processes. On the other hand, due to strangeness conservation, only the relative parity of strange particles can be determined in strong interactions. This letter discusses an experiment by which the relative parity of K mesons and hyperons may be determined.

Consider the process of absorption of a K^- meson from an s state by a polarized proton with the production of a Y hyperon (Y stands for Λ or Σ) and π-meson:

$$K^- + p \rightarrow Y + \pi. \quad (1)$$

In the following it is assumed that the spin of the K-meson is zero and that of the hyperon is $\frac{1}{2}$. Let ξ_K be the intrinsic parity of the K meson, ξ the relative hyperon-proton parity, L the orbital angular momentum of the relative hyperon — π meson motion in their center of mass system, and P_p the degree of polarization of the proton. Conservation of parity and angular momentum in process (1) leads to the relations: $\xi_K\xi = (-)^{L+1}$ and $L = 0$ or 1. There are two possibilities: (a) $\xi_K\xi = +1$, hence $L = 1$, and (b) $\xi_K\xi = -1$, hence $L = 0$.

It is easy to show that: (1) in both cases the hyperons are emitted isotropically; (2) the degree of polarization $P_Y(\theta)$ of the hyperon emitted at an angle θ relative to the direction of polarization of the proton is $P_Y(\theta) = \cos(2\theta)P_p$ in case (a) and $P_Y(\theta) = P_p$ in case (b); (3) the degree of polarization $\overline{P}_Y$ of the hyperon averaged over the emission angle θ is $\overline{P}_Y = -\frac{1}{3}P_p$ in case (a) and $P_Y = P_p$ in case (b). Since parity is not conserved in the decay $Y \rightarrow N + \pi$ (N stands for nucleon), the possibilities (a) and (b) can be distinguished and the sign of $\xi_K\xi$ determined by measuring the asymmetry in the angular distribution of the decay π mesons.

The experiment described can also be performed with polarized nuclei. Let the nuclear spin j be determined entirely by one nucleon N outside a closed subshell (or by a "hole" in a subshell) and suppose that as a result of capture of a K^- meson, from an s state, a hyperon and π meson are emitted by this nucleon and the daughter nucleus suffers no recoil. Conservation of parity and angular momentum leads then to the relations $\xi_K\xi = (-)^{L+l+1}$ (l is the orbital angular momentum of the nucleon in the nucleus) and $L = j - \frac{1}{2}$ or $j + \frac{1}{2}$. A simple calculation shows that for $L = j - \frac{1}{2}$, $\overline{P}_Y = P_n$ and for $L = j + \frac{1}{2}$, $\overline{P}_Y = -P_n/(j+1)$ where P_n denotes the degree of polarization of the nucleus. Clearly, due to parity conservation, for a given j and l the two values $\xi_K\xi = +1$ and -1 will correspond to different values of L. It should be noted that the indicated values of $\overline{P}_Y$ will be decreased due to the background of unpolar-