THEORY OF STRANGE PARTICLES

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IN the mathematical interpretation of the scheme of Gell-Mann[1-3] proposed by d'Espagnat and Prentki,[4,5] a new constant of motion appeared — the isofermion charge of a system of elementary particles u, conserved in all strong and electromagnetic interactions. For a single particle, the isofermion charge u characterizes the transformation properties of the particle relative to inversion in a three-dimensional isotopic space.

Under the very general postulates adopted by d'Espagnat and Prentki, only four types of particles are allowable: isoscalar $(u = 0)$, isopseudovector $(u = 0)$, isospinor of the first type $(u = +1)$ and isospinor of the second type $(u = -1)$. Therefore, for a single particle only three values $u = \pm 1, 0$ are permissible.*

The connection between the electric charge Q and third component of isotopic spin I_3 in the theory of d'Espagnat and Prentki is expressed by the same relation

$$Q = I_3 + u/2, \tag{1}$$

for all mesons and baryons. The value of u is preserved in strong and electromagnetic interactions and $\Delta u = \pm 1$ are allowable in weak interactions,[5] which is equivalent to the Gell-Mann $\Delta S = \pm 1$. It is of interest to consider all conclusions coming from such a theory.

In comparing (1) with the scheme of Gell-Mann, we note that the Gell-Mann strangeness S is the difference between the isofermion charge of the particle u and its nucleon (baryon) charge n:

$$S = u - n. \tag{2}$$

The nucleon charge n of a particle can take on only one of three values: +1 (baryon), −1 (antibaryon), 0 (meson).

Only three values of the electric charge $Q = \pm 1, 0$ are allowed and, in connection with Eq. (1), only three values of the total isotopic spin I: $\frac{1}{2}$, 0, 1 (Ref. 2).

The isofermion charge of a particle u also takes on, according to the above, only three values: +1 for isofermions having $I = \frac{1}{2}$; −1 for anti-isofermions; 0 for isobosons, having $I = 0$ or $I = 1$.

The limitations on n and u, together with Eq. (2), leave for S only the possibilities: $S = 1, 0, -1$ for mesons; $S = 0, -1, -2$ for baryons; $S = 2, 1, 0$ for antibaryons. Consequently, the hyperons, allowed by Gell-Mann[1-3] and Terletskii,[6] $Z^+(S = +1)$, $\Omega^-(S = -3)$ and mesons $\omega^+(S = +2)$ and $\omega^-(S = -2)$† are completely excluded.

The isofermion charge u can be considered, together with n and I, as a primary characteristic of the particle, and the strangeness S as only one of the possible combinations of them.

In the rational symbolism of elementary particles proposed by Terletskii, in which together with the electric charge Q, there are also the nuclear (n), neutrino (ν) and neutron (ϵ) charges of the particle, in place of the latter it is natural to use the isofermion charge u, connected with it, as is easily established, by the relation: $u = \epsilon + Q$ (Ref. 6).

Basic characteristics			Charge Q	Multiplets
n	u	I		
0	+1	1/2	+1, 0	K^+, K^0
	−1		0, −1	K^0, K^-
	0	1	+1, 0, −1	π^+, π^0, π^-
	0	0	0	ω^0
+1	+1	1/2	+1, 0	N^+, N^0
	−1		−1, 0	Ξ^-, Ξ^0
	0	1	+1, 0, −1	Σ^+, Σ^0, Σ^-
	0	0	0	Λ^0
−1	−1		−1, 0	Antinucleons
	1	1/2	+1, 0	Anti Ξ hyperons
	0	1	−1, 0, +1	Anti Σ hyperons
	0	0	0	Anti Λ hyperons

Exhausting the possible multiplets of particles with all possible allowable combinations of n, u, and I, it is easy to see that the number of them is limited to those given above in the table. The only new one, aside from those given above, could be the neutral meson noted in the review of Okun'[2] having total isotopic spin $I = 0$, which we denote as a ω^0 meson.‡ This truly neutral particle differs from the π^0 meson.

Within the framework of the theory of d'Espagnat and Prentki, it is impossible to use the hypothetical ω^- meson to explain the K^--decays of secondary particles,[7,8] as assumed by Karpman.[5] Only the ω^0 meson can be used for their explanation.

*For example, the values $u = \pm 2$ would correspond to isopseudoscalar and isovector particles, which are not acceptable within the framework of this theory.

†The conclusion of Karpman[5] about the admissibility of a ω meson of strangeness $S = -2$ within the framework of the theory of d'Espagnat and Prentki is in error.

‡For mesons (n = 0), which are bosons in ordinary space (but not for hyperons with n = 1), the number of possible multiplets can be doubled, corresponding to the two possibilities for ordinary spin of the boson, 1 or 0 (Ref. 9).

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ON THE THEORY OF THE STABILITY OF LIQUID JETS IN AN ELECTRIC FIELD

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We shall consider the behavior of a cylindrical jet (of radius R_0) of a liquid dielectric in an electric field. (All that follows is also applicable to a magnetic liquid in a magnetic field). The behavior of an incompressible viscous fluid, in the absence of body forces, is described by the hydrodynamic equations

$$\operatorname{div} \mathbf{v} = 0, \quad \frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} = -\frac{1}{\rho} \operatorname{grad} p + \nu \nabla^2 \mathbf{v}. \quad (1)$$

To these must be added the electrostatic equation

$$\operatorname{div} (\varepsilon \mathbf{E}) = 0. \quad (2)$$

Let the jet be subjected to a perturbation which is symmetrical about the axis. Then, introducing the flow function Ψ and making use of Eq. (1), we obtain

$$(\nu L - \partial / \partial t) L \Psi = (v_x \partial / \partial x + v_r \partial / \partial r - 2 v_r / r) L \Psi \quad (3)$$

and the following conditions for force equilibrium at the surface $r = R_0$:

$$p_{rx} = p_{xr} = 0, \qquad p_{rr} = -(N + T_{rr}), \quad (4)$$

where

$$L = \partial^2 / \partial r^2 - r^{-1} \partial / \partial r + \partial^2 / \partial x^2,$$

$$p_{rx} = \nu\rho (\partial v_r / \partial x + \partial v_x / \partial r), \qquad p_{rr} = -p + 2\nu\rho\, \partial v_r / \partial r,$$

T_{rr} is the normal component of the stress tensor in the electric field, and N represents the effect of the surface forces.

Consider a perturbation of the type

$$q = q_0 + q(r) \exp [i (kx + \omega t)], \quad (5)$$

where q_0 is the equilibrium value and $q(r)$ is to be determined. Solving Eqs. (1) to (3) for such a perturbation, assuming that the amplitudes are small (linearized theory) and using the boundary conditions (4), we obtain the following dispersion equation for the perturbation frequency in the presence of a longitudinal field E_0:

$$(\omega - 2ik^2\nu)^2 \frac{I_0(z)}{kI_1(z)} + 2i \frac{\nu}{R_0} (\omega - 2ik^2\nu) + \frac{4k^2\nu^2}{R_0 I_1(nR_0)} [nR_0 I_0(nR_0) - I_1(nR_0)] - \frac{\sigma}{\rho R_0^2}(z^2 - 1) - \frac{(\varepsilon - 1)^2 E_0^2 k}{4\pi\rho} \frac{I_0(z) K_0(z)}{\varepsilon I_1(z) K_0(z) + K_1(z) I_0(z)} = 0,$$

$$z = kR_0, \quad n^2 = k^2 + i\omega/\nu, \quad (6)$$

where I_0, I_1, K_0, and K_1 are the Bessel functions of the first and second kind for imaginary argument, and σ is the surface tension.

The solution of (6) leads to the following conclusions. (1) The viscosity has a stabilizing effect (as Rayleigh has already shown). (2) A jet is always dynamically stable for $kR_0 > 1$. (3) For $kR_0 < 1$ a jet of incompressible non-viscous liquid dielectric is stable under the conditions

$$E_0^2 > \frac{4\pi\sigma}{(\varepsilon - 1)^2 R_0^2 k} \frac{\varepsilon I_1(z) K_0(z) + K_1(z) I_0(z)}{I_0(z) K_0(z)}. \quad (7)$$

For a water jet with $\epsilon = 81$, $\sigma = 74$ dynes/cm, and $R_0 = 2$ cm, (7) gives $E_0 > 597$ v/cm for $kR_0 = 0.2$; and $E_0 > 729$ v/cm for $kR_0 = 0.1$.

Investigation shows that a transverse electric field has no effect on the dynamic stability of jets.