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The Meaning of Mass

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Abstract: Der Waerden obtained the spinorial transcription of the Dirac equation from the relativistic energy-momentum relationship. The recent validation of the principle of the physical determination of equations in the special relativity theory enables us to deduce the meaning of mass from his results.
Keywords: energy-momentum relationship, weak coupling, mass.

Consider the relativistic energy-momentum relationship under the form

$$[E/c-(\boldsymbol{\sigma}.\mathbf{p})][E/c+(\boldsymbol{\sigma}.\mathbf{p})]=m_o^2c^2, \qquad (1)$$

where E, p and m_o are, respectively, the energy, linear momentum, and rest mass of a free particle, c is the speed of light, and $\boldsymbol{\sigma}(\sigma_x,\sigma_y,\sigma_z)$ are the Pauli 2x2 spin matrices. Passing from the physical quantities E and **p** to the suitable quantum operators $E=i\hbar\partial_o$, $\mathbf{p}=-i\hbar\boldsymbol{\delta}$ in Eq. (1), where $\partial_o=\partial/\partial(ct)$, $\boldsymbol{\delta}(\partial/\partial x,\partial/\partial y,\partial/\partial z)$, and ħ is the reduced Planck constant, applying the resulting equation to the spinor u, and putting

$$(i\hbar/m_oc)[\partial_o-(\sigma.\delta)]u=v,$$

where u and v are two-component spinors that correspond to the same spin polarity, der Waerden obtained from Eq. (1) the set of equations [1]

$$i\hbar[\partial_o-(\sigma.\delta)]u=m_ocv,\ \ i\hbar[\partial_o+(\sigma.\delta)]v=m_ocu, \qquad (2)$$

constituting the spinorial transcription of the Dirac equation as a step towards the covariant Dirac equation.

According to the recently proved validity of the classical principle of the physical determination of the equations in Einstein's relativity theory [2-4], der Waerden's derivation of Eqs. (2) from the relativistic energy-momentum relationship is, against the mathematical formal equivalence of all the representations, the only carrying physical information. We propose to disclose some of that information by considering the equation

$$i\hbar\partial_o\psi_1=(E/c)\psi_1+(K/c)\psi_2, \qquad (3)$$

where E is the eigenvalue of the hamiltonian equation and K is the coupling constant. Eq. (3) describes a weak coupling in the quantum mechanical formalism. Compare each of

Eqs. (2) with Eq. (3) and you will find that the results are 1^o. Applied to u and v, the hamiltonians ±(**σ.p**) describe opposite spin-momentum couplings within a free particle, and 2^o. m_oc^2 is coupling two simultaneous opposite spinning motions described by the action of the operator **σ** preceded by opposite signs upon the spinors u and v in Eqs. (2). A leakage of subquantum constituents between two physical entities is assumed by Eqs. (2). Therefore, there are two systems of subquantum particles that spin oppositely within a Dirac particle. The straightforward essential conclusion is that the mass is associated to, and defined by the coupling of these systems. That is, mass has a sub-quantum nature. The rest mass is associated to its state of equilibrium. Any mass change therefore arises by altering that coupling. Sub-quantum energy can be released, gravitational waves emitted in laboratory conditions, and the increased lifetime of the relativistic particles understood in terms of the dependence of their mass on velocity [3].

References:

[1] B.L. Van der Waerden, Gruppentheoretische Metode in der Quanten Mechanik (Springer, Berlin, 1932), Ch. 13.
[2] A.C.V. Ceapa, “Aspects of Relativity”, paper in Proc. PIRT VIII (London, Sept. 2002, Ed. M.C. Duffy, Liverpool, 2003), pp. 99-115.
[3] A.C.V. Ceapa, Physical Grounds of Einstein’s Theory of Relativity, 3rd ed., part III (Bucharest, l998, LC call No QC173.55.C43 1998).
[4] A.C.V. Ceapa, “Lorentz transformation as a Complementary Time-Dependent Coordinate Transformation”, Galilean Electrodynamics 16 (2005) 3-11.

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