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Dirac Equation and the Correspondence Principle

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Abstract
Dirac equation and the correspondence principle is the author's assertion that it is possible to justify the well-known Dirac equation for the electron using Dirac's correspondence principle.

Keywords: Dirac Equation, Correspondence Principle , Quantum Mechanics, Relativistic Quantum Theory, Special Relativity, Electron, Bispinor Field, Dirac Hamiltonian, Velocity Operator.

Introduction

The Dirac equation is a relativistic Ally invariant equation of motion for the bispinor classical electron field. Proposed by Paul Dirac [1]. Einstein said he lost his understanding of physics after this equation. Dirac claimed to have discovered his famous equation by playing with formulas. It is shown below that this equation can be justified using the correspondence principle, something Dirac himself was unaware of [2, 3].

Formulation

The Dirac equation can be justified using the correspondence principle as formulated by Dirac: "The correspondence between quantum and classical theories consists not so much in the limiting greement at k 0, but in the fact that the mathematical operations of the two theories obey the same laws in many cases." In special relativity, the energy and momentum of a particle are expressed through the relation

$$E^2 = p^2c^2 + p^2c^2 + p^2c^2 + m^2c^4 \quad (1.1)$$

This can be transformed, by dividing both sides by E, to the following form [4].

$$E = \frac{v1}{c} p_1 c + \frac{v2}{c} p_2 c + \frac{v3}{c} p_3 c + \frac{v0}{c} m c^2 \quad (1.2)$$

where the value is $v_0 = \sqrt{c^2 - v^2}$, and $v^2 = v^2 + v^2 + v^2$;
Indeed,

$$\frac{p_1 c}{E} = \frac{m v_1 c (c/v_0)}{mc^2 (c/v_0)} = \frac{v_1}{c}$$

etc., and also

$$\frac{mc^2}{E} = \frac{mc^2}{mc^2 (c/v_0)} = \frac{v_0}{c}$$

Here, relation (1.1) should not be considered a notational constraint (meaning that the notations E^2 and $p^2c^2 + p^2c^2 + p^2c^2 + m^2c^4$ have the same meaning). Relation (1.1) is considered a true (meaningful) equality, indicating the relationship between E(v), p(v), and the independent variable v. To return to the original equation (1.1) (as if "squared"), equation (1.2) must be multiplied by E on both sides.

The Dirac equation (in the absence of an electromagnetic field) has the form

$$ik\frac{\partial \psi}{\partial t} = (\alpha_1 p_1 c + \alpha_2 p_2 c + \alpha_3 p_3 c + \alpha_0 m c^2)\psi \quad (1.3)$$

where αj are matrices, (j = 0, 1, 2, 3,).
From the correspondence principle between equations (1.2) and (1.3), it follows that $v_j/c = \alpha_j$ or $v_j = c\alpha_j$. In quantum mechanics it is shown (the phenomenon of Zitterbewegung) that the relativistic velocity operator $v_\nu = dx_\nu/dt$; (ν = 1, 2, 3) ; has the form $v_\nu = c\alpha_\nu$, that is, it is a matrix operator [6] Indeed, the velocity operator is found according to the general rules for differentiating operators with respect to time.

$$\frac{dx_{vj}}{dt} = \frac{\partial x_v}{\partial t} + [H, x_v] \quad (1.4)$$

where H is the Hamiltonian operator.

$$H = \alpha_\nu p_\nu c + \alpha_0 m c^2$$

Since x_ν, the coordinate operator, does not explicitly depend on time, then $dx_\nu/dt = [H, x_\nu]$. Substituting the Hamiltonian operator here, we obtain

$$\frac{dx_\nu}{dt} = [(\alpha_\mu p_\mu c + \alpha_0 m c^2), x_\nu]$$

The matrix αμ commutes with x_ν, so the matrix operator can be factored out.

$$dx_\nu/dt = c\alpha_\mu [p_\mu, x_\nu] = c\alpha_\mu \delta_{\mu\nu} = c\alpha_\nu$$

The eigenvalues of the matrix velocity operator are equal to c, but since the velocity operator does not commute with the Ham-

iltonian operator, the average value of the relativistic velocity operator is always measured experimentally, and it is less than c. Thus, the correspondence between equations (1.2) and (1.3) is confirmed.

Our new conclusion is that the matrix α0 corresponds in special relativity to the quantity $v/c = \sqrt{c^2 - v^2}/c = 1 - v^2$. This expression can be either positive or negative. This leads to the existence in nature of not only electrons but also positrons [5-7].

References

1. Pais, A. (1989). The scientific activity and life of Albert Einstein. Nauka.
2. Dirac, P. A. M. (2003). Collected scientific works (Vol. 2: Quantum theory: Scientific articles, 1924–1947). FIZMATLIT. (Original work published 1983)
3. Dirac, P. A. M. (1990). Towards the creation of quantum field theory: Main articles, 1925–1958. Nauka.
4. Klimets, A. P. (2007). Understanding the universe: Physical and philosophical essays. Piter PEN Publishing House.
5. Dirac, P. A. M. (2003). Quantum theory of the electron. In Collected scientific works (Vol. 2, pp. 327–340). FIZMATLIT.
6. Dirac, P. A. M. (2003). Some problems of quantum mechanics. In Collected scientific works (Vol. 2, pp. 264–326). FIZMATLIT.
7. Borisoglebsky, L. A. (1988). Quantum mechanics. University Publishing House.

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