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Short Communication

Some aspects of spin-spin interaction

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Abstract

Mathematical formulations of the tensors for angular velocity, momentum, moment of inertia of a particle due to spin-spin interaction in a four dimensional space-time have been discussed. Mention has been made to the case of photon. Also, for the same type of interaction electric current density in a nucleus has been considered in mathematical form which can explain the form of strong field. From these studies trial has been made to establish a basic principle of formation of fundamental electric charges (positive or negative).

Keywords: Superimposed spins, Complex momentum, Wave density, Angular momentum tensor, Strong field.

Introduction

According to relativistic theory a moving mass may be a source of kinetic energy depending on the velocity of it. This energy may be acquired due to two superimposed motions to the view of an observer[1]. According to Einstein a field is a form of energy-momentum tensor[2]. Again, it has been mentioned[3,4] that a photon contains electromagnetic field and electric charge also.

Now, relativistic aspects due to spin of any rigid body of radius r has been previously[5] discussed. Also, a photon has a spin about an axis[6]. It has a mass ($h\nu/c^2$) concentrated in a ring of radius r rotating with velocity of light. It has, also, a linear motion (L say) with velocity of light along the rotation axis. Hence, the motion of photon is a kind of S-L interaction[7]. Again, a particle may possess two or more S-S interactions[8] where this type of interaction would be the intrinsic property of a fundamental charged particle like electron and proton[7]. On the other hand, photon also carries a small amount of electric charge[3,4] due to S-L interaction[7]. But, it is not at rest in the view of an observer at rest. In this section we shall consider Spin-Spin interaction in brief and study its effect on velocity, linear momentum, angular momentum, moment of inertia etc.

Frames considered for Spin-Spin Interaction

We shall consider inertial frames S_1, S_2, S_3 and S_4 in three dimensional space. X-axes of frames S_1 and S_2 are aligned parallel and S_2 is spinning at an angular speed ω_1 about X_2 axis which is observed by S_1. S_2 is connected to another co-ordinate frame S_3 where X_3 axis makes an angle θ in X_2Y_2 plane in counter clockwise sense with respect to S_2. Frames S_3 and S_4 have their X-axes parallel and S_4 is rotating with an angular velocity ω_2 about X_4 axis as it appears to S_3. Origin of all the frames is same with respect to S_1.

Mathematical Formulations

We have the resultant velocity (w) of any event in S_4 would be

$$w = a \pm \frac{i}{c} b \quad (1)$$

while the momentum is

$$P = P_1 \pm \frac{i}{c} P_2 \quad (2)$$

as observed by S_1, where $u = \omega_1 \times r$ and $v = \omega_2 \times r$ are separately the relativistic velocities[7]. Also,

$$P_1 = \gamma\, m\, a,\quad P_2 = \gamma\, m\, b,\quad a = \frac{u+v}{\frac{u.v}{c^2}+1},\quad b = \frac{u \times v}{\frac{u.v}{c^2}+1} \text{ and}$$

$$\gamma = \frac{1}{\sqrt{(1-\frac{w^2}{c^2})}} \quad (3)$$

When θ = 90° then

$$w = u + v \pm \frac{i}{c}(u \times v) \quad (4)$$

and

$$P = m\,u + m\,v \pm \frac{i}{c} m\,u\,v\,s \quad (5)$$

Now, S_1 observes that a particle residing at the origin of S_4 would have two superimposed spins as observed by S_1. Under this condition the particle acquires a large amount of kinetic energy (E_k) which may be considered as the energy of an oscillating field. Taking θ = 90° and u = v = 0 we obtain from (1) and (2)

$$w = c\,\hat{p} + c\,\hat{q} + i\,c\,\hat{r} \quad (6)$$

where

$$\hat{p} = \hat{\omega}_1 \times \hat{r},\quad \hat{q} = \hat{\omega}_2 \times \hat{r} \text{ and } (\hat{\omega}_1 \times \hat{r}) \times (\hat{\omega}_2 \times \hat{r}) = \hat{r} \quad (7)$$

Here $\hat{r}$ is along the position vector r.

Let the energy attributed by a wave is E_k' then the corresponding momentum would be

$$P' = \frac{E_k'}{c}\,\hat{p} + \frac{E_k'}{c}\,\hat{q} \pm i\,\frac{E_k'}{c}\,\hat{r} \tag{8}$$

Due to spin-spin interaction of the particle as observed by S_1, equations (6) and (8) would be

$$w = \pm\, i\, c\, \hat{r} \quad \text{and} \quad P' = \pm\, i\,\frac{E_k'}{c}\,\hat{r} \tag{9}$$

Now, (1) could be written in tensor form in which the components of it would be written as

$$w_{\mu\nu} = a_{\mu\nu} + i\,\frac{b_{\mu\nu}}{c} \tag{10}$$

Where: μ, ν represent x, y, z and t. Similarly, the components of momentum tensor would be

$$P_{\mu\nu} = P_{1(\mu\nu)} + \frac{i}{c}\,P_{2(\mu\nu)} \tag{11}$$

Now, we are to find out the moment of inertia of the system. For this we proceed as follows:

We know that the angular momentum tensor may be written as

$$L_{\mu\nu} = P_{\mu\nu}\ r_{\mu\nu} \tag{12}$$

Also, due to S-S interaction of a particle, the spin-angular momentum tensor is

$$L_{\mu\nu} = I_{\mu\nu}\ \omega_{\mu\nu} \tag{13}$$

It is to be mentioned that the moment of inertia (I) and angular velocity (ω) are functions as mentioned below.

$I = I\,(m, r, \omega_1, \omega_2, \theta)$ and $\omega = \omega\,(\omega_1, \omega_2, \theta)$

Again, $w = \omega \times r$ gives $w_{\mu\nu} = \omega_{\mu\nu}\ r_{\mu\nu}$ which leads to

$$\omega_{\mu\nu} = w_{\mu\nu}\ r_{\mu\nu}^{-1} \tag{14}$$

Using (12) and (14) we obtain from (13)

$$I_{\mu\nu} = P_{\mu\nu}\ w_{\mu\nu}^{-1}\ (r_{\mu\nu})^2 \tag{15}$$

This is the expression for moment of inertia tensor in 4-D space-time when there is S-S or R-R interaction of a particle.

Electric Charge and Electric Field of a Fundamental Particle

It has been shown[9] that a part of the mass of a particle is dependent on electric field. Again, within a wave packet associated with an electron there is superposition of violent oscillations[10] each with angular frequency $2me^2/\hbar$. Also, spin of a particle is connected to zero-point energy associated with the charged fundamental particle. On the other hand, field is due to the energy-momentum tensor which depends upon the complex motion of virtual mass (E_k/c^2).

According to the above conceptions we may assume that the electromagnetic field of a particle has been attributed to it due to the spin-spin interaction as a result of which the particle becomes charged. So, charge is an entity which is nothing but a kind of compact form of kinetic energy or some function of kinetic energy.

Again, (8) shows that due to the two types of spins of a photon there would be two values of momentum due to the ± sign which, also, shows two opposite types of charges of photons.

Basic Principle of Formation of Fundamental Electric Charge

At different times different workers were of different opinion about the photon charge as mentioned: i. Photon charge (+ve or –ve) is possible[3,4] and the upper limit of this charge is $e_\gamma \leq 3 \times 10^{-33}$ of an elementary charge. ii. Photon possesses S-L interaction due to which energy-momentum tensor of photon gives rise to electromagnetic field[6,7] giving out kinetic energy which amounts to ħω. iii. It is clear that[11] photon may be right rotating and left rotating which means that it may have anti-clockwise (S_a) and clockwise (S_c) spins. Accordingly, S-L interactions may be of two types: S_a-L and S_c-L interactions.

For these two types of interactions there would be two types of charges in photon which supports (i). But, rest charge of the photon is nil with respect to a rest frame.

Considering the similarity with S-L interaction in photon, it is assumed that[7] S-S interaction is valid for an elementary particle with rest mass. Again, from the above we shall come across three types of S-S interactions viz. S_a-S_c, S_a-S_a, S_c-S_c interactions. In the case of photon it has been proposed that – i. S_a-S_c interaction is responsible for one kind of charge (may be called positive charge) and ii. S_a-S_a and S_c-S_c interactions are responsible for another kind of charge (may be the negative charge).

These are the basic principles of fundamental charge formation. It must be assumed that particles like electrons possess only one type of interaction i.e. (ii) while a photon will possess both types of interactions (i) and (iii).

Electric Current Density Tensor in Nucleus

It is known that[12] nucleus possesses S-S interaction. Due to this the moment of inertia tensor of the nucleus[15] and velocity of every proton would be given by (1). So, electric current (C, say) in nucleus due to velocity of a proton and electric charge (q) in nucleus would be respectively given by

$$C = \iint J \,.\, ds \quad \text{and} \quad q = \iint \sigma \,.\, ds \tag{16}$$

Hence, the current density in nucleus would be

$$J = n\,\sigma \tag{17}$$

where: n is the frequency due to S - S interaction in nucleus. Using (14) and (17) we get

$$J_{\mu\nu} = \frac{1}{k\pi} w_{\mu\nu} \cdot r_{\mu\nu}^{-1} \sigma_{\mu\nu} \quad (18)$$

where: k would be an arbitrary constant depending upon the system.

Again, since $\sigma_{\mu\nu} = \epsilon_0 E_{\mu\nu}$ hence, (18) may take the generalized form

$$J_{\mu\nu} = \frac{\epsilon_0}{k\pi} w_{\mu\nu} r_{\mu\nu}^{-1} E_{\mu\nu} \quad (19)$$

Now, from Maxwell's equations we have $\nabla \times H = J + \frac{\partial D}{\partial t}$. This shows the interactions between changes in magnetic and electric fields. Also, it may be said that $J_{\mu\nu}$ in (19) would perform the role of J in Maxwell's equations in producing a kind of magnetic field in nucleus which would be stronger than known magnetic fields in physics but would be of more complicated character.

Conclusion

Present work leads us a step forward over our existing idea that photon carries electric field but is not a charged particle at rest unlike some other fundamental charged particles. Here, it is revealed that if a relativistic particle like photon has two superimposed perpendicular spins then due to the spin-spin interaction the particle may become charged. So, it is possible that a rigid particle would be a fundamental charged particle if it possesses two perpendicular superimposed spins with high angular speeds. This is the intrinsic property of elementary particles.

It is, also, shown that in case of nucleus strong force would be formed due to the flow of current $J_{\mu\nu}$ produced by relativistic movement between a charge and an observer.

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