Short Summary of Research Directions

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Abstract

This proposal details the experimental and theoretical aspects of the research which is to be done under the premise of the irreducible representation of the Einstein translation group. The inherently non-abelian electrodynamic field theory resulting from this will provide experimentally testable results that would provide significant new technologies. New theoretical directions will also be examined as a logical extension to the experimental aspects.

1 Introduction

In 1916, Einstein published the general theory of relativity. The paradigm shift of this achievement was provided by the use of manifolds which deviated from the conventionally used flat Euclidean geometry. Physics was now to be made covariant, in that all laws of nature should adhere to the strict notion of taking the same form in all inertial frames. The mechanism by which one could compare laws in different frames is known as the Einstein group of transformations. The representation of this group corresponds to 10 free parameters to influence the curvature of the spacetime.

The research in this proposal will be the study of the experimental and theoretical physics arising from an enhancement of the underlying Einstein group to that which has odd spacetime parity under reflection, as first proposed by M. Sachs. This takes place on the stage of the irreducible representation of the original Einstein group. Such an enhancement leaves the well verified physics of the reducible Einstein group in tact, yet defines the *antisymmetrized* general theory in terms quaternionic formalism, which provides a spinor index alongside that of a spacetime coordinate index.

The quaternionic formulation has $10 + 6$ degrees of freedom in addition to the 10 of the traditional Einstein group. The extra descriptiveness of 6 equations is encoded in an electromagnetic tensor. Such a tensor field comprises of components whose genus is from a non-abelian gauge group. Since one is dealing with an irreducible representation of the general relativistic translation group, it is then appreciated that the encoding of electromagnetic dynamics is naturally enlarged. The group has an O(3) structure, which separately has been shown to have many advantages over it's contemporary subgroup, U(1). The field equations of O(3) electrodynamics (which is a Yang Mills theory), have been examined as an aspect of the quaternion GR (Sachs theory) [8].

Important and unsolved concepts in fundamental physics such as the concept of charge quantization can be found to have a grounding within the antisymmetrized GR theory. The theory a priori contains a description of the neutrino to be massive, which recent data collected supports.

The Sagnac effect which has been observed is an occurrence which is not within the resolution of the O(3) subgroup U(1). The O(3) extension embedded in the quaternion formulation successfully explains this with a proper phase shift.

The original encoding of electromagnetism in the unphysical vector potential A_μ of $U(1)$, is now described in terms of cyclical relations of an enlarged set [7] that originate from the non-abelian field tensor as

$$\frac{1}{c}G^{(k)\mu\nu} = \partial^\nu A^{(k)\mu} - \partial^\mu A^{(k)\nu} - ig[A^{(l)\mu}, A^{(m)\nu}] \tag{1.1}$$

comprising three equations, $k = 1, 2, 3$. Whose analogy is the familiar

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

of conventional electrodynamics.

Alongside those of the familiar Maxwell equations, the extended electromagnetic description provides an additional field alongside the already familiar components of the photon. This extra degree of freedom of photon propagation, denoted as $B^{(3)}$, constitutes a longitudinal oscillation of the photon. Additional support for the idea of longitudinal EM radiation can be found in [3].

As will be described, the field has been shown to vanish in flat spacetime in accordance with the vanishing of the measure of scalar curvature of the manifold (the Ricci scalar, R). Part of the purpose of this proposal will be to provide some qualitative insight to the effects and consequences that a non-zero Ricci field and higher symmetry group has on spacetime. And indeed, the possibilities for experimental verification through the effect of the field surrounding a massive charged object.

However, more substantial would be the successful testing of the inverse Faraday effect and radiatively induced fermion resonance as will be considered in the following section. These will provide great insight into further experimentation and direction for the development of technologies that would benefit.

2 Experimental Proposals

The inverse Faraday effect (IFE) is static magnetization by a circularly polarized electromagnetic beam The IFE has been demonstrated at 3.0 GHz by Deschamps et al. (Phys. Rev. Lett., 25, 1330 (1970)) and this experiment provides clues as to how to go about detecting the IFE in an electron beam and also radiatively induced fermion resonance (RFR), which is electron, proton or neutron resonance induced by a circularly polarized electromagnetic pump beam. The theory of RFR is developed extensively in the www.aias.us books and papers, but to date the phenomenon has not been observed experimentally. The simplest demonstration of RFR is auto-resonance, where the circularly polarized pump frequency ω is adjusted to be the same as the expected RFR resonance frequency ω_{res}:

$$\omega_{res} = \omega \tag{2.1}$$

Under this condition, the pump beam itself is absorbed at resonance because the pump frequency matches the resonance frequency exactly. The RFR auto-resonance condition in one electron is then:

$$\omega_{res}^3 = 1.007 \times 10^{28} I \tag{2.2}$$

where I is the beam power density in watts per meters squared.

Therefore we can tune $omega_{res}$ for a given I or vice versa, using interacting fermion and electromagnetic beams. Since auto-resonance must appear in the GHz range if the pump frequency is in this microwave range, the set up described by Deschamps et al. can be used as the starting point of the RFR design. In the first instance it would be optimum to repeat the experiment by Deschamps et alia, but using an electron beam instead of a plasma sample. We would then have gained experience to attempt the first RFR experiment with optimized design. In the experiment by Deschamps et alia, a pulsed microwave signal at 3.0 GHz was detected from a klystron delivering megawatts of power over 12 microseconds with a repetition rate of 10 Hz. The TE_{11} mode was circularly polarized inside a circular waveguide of 7.5 cm diameter. A plasma was created by the very intense microwave pulse. In order to detect the inverse Faraday effect in an electron beam, the pulsed microwave beam would have to be carefully interfaced with the electron beam using a design for maximum interaction efficiency. The inverse Faraday effect should then be looked for in the electron beam, and its characteristics noted, i.e. 1) the inverse Faraday effect is proportional to pump beam intensity, I 2) it is the same in right and left circular polarization and vanishes in linear polarization.

Having observed the inverse Faraday effect in the electron beam, the search should then begin for radiatively induced fermion resonance in an electron beam. To detect RFR, the intensity of the microwave beam would be much lower, and governed by the above auto-resonance equation, or the more generally applicable equations available in the www.aias.us literature. As in the design used by Deschamps et alia, the section of the waveguide surrounding the tube would perhaps be made of nylon coated with a micrometer range layer of copper. The incoming electron beam would have to be guided carefully into the circular waveguide used to circularly polarize the microwave radiation. The engineering design for RFR has to be at least as accurate as in the Deschamps experiment and the characteristics of RFR must be determined carefully for one electron. The resonance peak is, as in the IFE, proportional to beam intensity, inversely proportional to angular frequency squared, and is the same in left and right circular polarization, vanishing in linear polarization.

The auto-resonance equation above predicts that auto-resonance occurs in an electron beam at 3.0 GHz if I is tuned to 0.0665 watts per square centimeter. For a circular waveguide of 7.0 cm diameter this requires only 2.94 watts of power, compared with megawatts for the inverse Faraday effect.

The preceding estimate is based on one electron theory, (www.aias.us), so the observed resonance frequency in an electron beam may be different as a result of electron electron interaction in an electron beam consisting of many electrons. Therefore it is strongly advisable that I be tunable over a wide range in search for the actual resonance pattern.

The experiment can be repeated in a proton, neutron and atomic beam to begin to understand RFR in elementary matter, atoms and molecules.

The theory of RFR is extensively developed in the literature, e.g. in the monograph by Crowell and Evans, [1], and RFR theory is reviewed in Advances in Chemical Physics, vol. 119(2) (Wiley, 2001). If developed, RFR is fermion resonance without magnets, and in theory leads to nuclear magnetic resonance (NMR) and electron spin resonance (ESR) without magnets. It provides unique spectral patterns, and at a much higher resolution than conventional NMR and ESR. It may be possible eventually to develop magnetic resonance imaging (MRI) without permanent magnets. These developments would have extensive applications in physics, chemistry, biochemistry and medicine.

The proposed experiment using facilities at the Oak Ridge National Laboratory is therefore an important first step towards this development of a potentially powerful analytical technique.

Fermion resonance of this type also allows for an accurate test of the B(3) theory and Einstein Sachs theory, a theory which produces the inverse Faraday effect from the first principles of antisymmetrized general relativity. The inverse Faraday effect and RFR are simple and accurate experimental tests of this theory.

3 Theory Directions

While independently well developed, sachs' quaternion general relativity and O(3) field theory are set on sound footing. However, much work is needed to extend the ties between them. The established form of the B(3)[1] field from established work in [1], [2] and other previous references, is

$$B^{(3)} = \frac{1}{8} QR(q^1 q^{2*} - q^2 q^{1*}). \tag{3.1}$$

Which can be written in terms of the conventional potentials as

$$B^{(3)*} = -ig\mathbf{A} \times \mathbf{A}^* \tag{3.2}$$

(as can be seen from (1.1) with the component $\mathbf{A}^{(3)}$ having zero curl as discussed in [1]), which illustrates its longitudinal nature. While longitudinal radiation is absent from the conventional U(1) abelian theory, this extended radiative form has recently been given support in [3].

In the irreducible form of the Einstein group, the metric, as defined in the sachs' theory, has quaternion structure

$$g^{\mu\nu} = \frac{1}{2}(q^\mu q^{\nu\dagger} + q^\nu q^{\mu\dagger}). \tag{3.3}$$

The origin of this and general results of physics from the irreducible form of the Einstein group is put forth in [2], part I, p. 677.

The paper I'm constructing deals with the form of the B(3) field from a curved manifold in the sachs' theory. The example done so far is a calculation showing a non-zero B(3) for an expanding diagonal metric near to the origin of the reference frame using first order perturbation on the quaternion fields

$$q_i(\epsilon)^\mu_a = \sigma^\mu_a + \epsilon^a_i \nabla_{\mathbf{X}_\delta} q_i(0)^\mu_a + \mathcal{O}(\epsilon^2) \tag{3.4}$$

for a chosen direction $\mathbf{X}_\delta$, for tangent vector $\mathbf{X}$ to an integral curve δ. Here, σ is the SU(2) clifford algebra. The metric of this more simple example has the form, after imposing O(3) commutation conditions on the quaternion fields,

$$g^{\mu\nu} = \begin{pmatrix} c_{00}^2\big(1 + f_{00}(\epsilon)\big)^2 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix} \tag{3.5}$$

[1] as a component in the EM force tensor of the sachs' theory

which yields a non zero $B(3)$ field

$$B^{(3)} = -\frac{1}{4} QR(f_{00}(\epsilon))\sigma^3. \tag{3.6}$$

From within the same constructive context, work is currently being done on the solution for a manifold with an electron. The results from this would be used in conjunction with data to be collected from radiatively induced fermion resonance and inverse Faraday effect experiments, as detailed in section 2 (the theoretical backing can be found in [1] and [4]). A fully non-perturbative approach for the B(3) from quaternion GR has yet to be established, and the properties of the resulting embedded O(3) field theory need to examined.

While the first order approximation is a first useful step at a scale that is expected to provide qualitative support for the RFR and IFE phenomena, a non-perturbative form, once it is described formally, would allow a test comparison at larger scales. Such a generalization, due to its expected complexity, would eventually call for the use of computer resources to compile data of physical effects for comparison with corresponding experimental data. It is intended that the computer facilities at Oak Ridge will be utilized for this.

With non trivial holonomy, the O(3) framework offers a formalism to describe a structured vacuum. One such property of a structured vacuum is the Sagnac effect, as put forward in [5]. There have been many cases of anomalous vacuum behavior through past studies and literature. The extension to a non-perturbatively derived non abelian gauge field theory are expected to be an under pinning to a qualitative explanation of such phenomena.

It is therefore necessary to see if the non-perturbative formulation can encompass already experimentally acknowledged anomalies, and also provide a theoretical base form which to make predictions that might be tested.

References

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