International Journal of Theoretical Physics, Vol. 44, No. 5, May 2005 (© 2005)
DOI: 10.1007/s10773-005-3986-5

A Short-Range Force

B. G. Sidharth[1]

Received September 10, 2004; accepted September 23, 2004

We consider a successful Kerr–Newman formulation of elementary particles and deduce a mass independent but spin-dependent short-range force and point out that exactly such an inexplicable force has been experimentally detected.

KEY WORDS:

In some ways the general relativistic gravitational field resembles the electromagnetic field, particularly in certain approximations, as for example when the field is stationary or nearly so and the velocities are small. In this case the equations of General Relativity can be put into a form resembling those of Maxwell's Theory, and then the fields have been called gravitoelectric and gravitomagnetic (Mashhoon *et al.*, 1989). Experiments have also been suggested for measuring the gravitomagnetic force components for the earth (Ruggiero and Tartaglia, 2005).

We can ask whether such a consideration can be applied to elementary particles, if in fact they can be considered in the context of General Relativity. It may be mentioned that apart from the approach of Quantum Gravity, there have been three other approaches for studying elementary particles via General Relativity (see Sachs, 1997; Sidharth, 2001a; Prugovecki, 1995 and references therein). We will now show that it is possible to extend the gravitomagnetic and gravitoelectric formulations to elementary particles within the framework of the theory developed in (Sidharth, 2001).

In (Sidharth, 2001), the linearized general relativistic equations are OC seen to describe the properties of elementary particles, such as spin, mass, charge and even the very quantum mechanical anomalous gyromagnetic ratio $g = 2$, apart from several other characteristics (Sidharth, 1993, 1997, 2001b, 2002).

We merely report that the linearized equations of General Relativity, viz.,

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}, h_{\mu\nu} = \int \frac{4T_{\mu\nu}(t - |\vec{x} - \vec{x}'|, \vec{x}')}{|\vec{x} - \vec{x}'|} d^3x' \tag{1}$$

[1] Centre for Applicable Mathematics & Computer Sciences, Adarsh Nagar, Hyderabad 500 063, India; e-mail: hyd1_birlasc@sancharnet.in.

where as usual,

$$T^{\mu\nu} = \rho u^u u^v \tag{2}$$

lead (on using (2) in (1)), to the mass, spin, gravitational potential and charge of an electron, if we work at the Compton scale (cf. ref. Sidharth, 2001a for details). Let us now apply the macro gravitoelectic and gravitomagnetic equations to the above case. In fact these equations are (cf. ref. Mashhoon *et al.*, 1989).

$$\nabla \cdot \vec{E}_g \approx -4\pi\rho, \nabla \times \vec{E}_g \approx -\partial\vec{H}_g/\partial t, \tag{3}$$

$$\vec{E}_g = -\nabla\phi - \partial\vec{A}/\partial t, \quad \vec{H}_g = \nabla \times \vec{A} \tag{4}$$

$$\phi \approx -\frac{1}{2}(g_{00} + 1), \vec{A}_\iota \approx g_{0\iota}, \tag{5}$$

The subscripts g in the Equations (3)–(5) are to indicate that the fields E and H in the macro case do not really represent the electromagnetic field, but rather resemble them. Let us apply Equation (4) to Equation (1), keeping in mind Equation (5). We then get, considering only the order of magnitude, which is what interests us here, after some manipulation

$$|\vec{H}| \approx \int \frac{\rho V}{r^2}\bar{r} \approx \frac{mV}{r^2} \tag{6}$$

and

$$|\vec{E}| = \frac{mV^2}{r^2} \tag{7}$$

V being the speed.

In (6) and (7) the distance r is much greater than a typical Compton wavelength to make the approximations considered in deriving the gravitomagnetic and gravitoelectric equations meaningful.

Remembering that we have, by the Uncertainity Principle,

$$mVr \approx h,$$

the electric and magnetic fields in (6) and (7) now become

$$|\vec{H}| \sim \frac{h}{r^3}, |\vec{E}| \sim \frac{hV}{r^3} \tag{8}$$

We now observe that (8) does not really contain the mass of the elementary particle. Could we get a further insight into this new force?

Indeed in the above linearized general relativistic characterisation of the electron, it turns out that the electron can be represented by the Kerr–Newman metric (cf. Sidharth, 2001 for details). This incidentally also gives the anomalous gyromagnetic ratio $g = 2$. This result has recently been reconfirmed by Nottale (2001) from a totally different point of view, using scaled relativity. It is well known that the Kerr–Newman field has extra electric and magnetic terms (cf. Newman, 1973), both of the order $\frac{1}{r^3}$, exactly as indicated in (8).

It may be asked if there is any candidate as yet for the above mass independent, spin dependent (through h) short range force. There is already one such experimental candidate—the inexplicable $B_{(3)}$ (Evans, 1997) short range force, first detected in 1992 at Cornell and since confirmed by subsequent experiments. It differs from the usual $B_{(1)}$ and $B_{(2)}$ long range fields of special relativity.

Interestingly, if we think of the above force as being mediated by a "massive" particle, that is, work with a massive vector field we can recover (7) and (8) (Itzkson and Zuber, 1980). In this case there is an upper limit on the mass of the photon $\sim 10^{-48}$g, that is, less than a trillionth the mass of a neutrino.

A final comment: It is quite remarkable that Equations (3)–(5) which resemble the equations of electromagnetism, have in the usual macro considerations no connection whatsoever with electromagnetism except in appearance. This would seem to be a rather miraculous coincidence. In fact the above considerations of Section 2 and linearized general relativistic theory of the electron as also the Kerr-Newman metric formulation, demonstrate that the resemblence to electromagnetism is not an accident, because in this latter formulation, both electromagnetism and gravitation arise from the metric (cf. also refs. Sidharth, 1998, 2001a, 2001b, 2002).

REFERENCES

Evans, M. W. (1997). In *The Present Status of the Quantum Theory of Light*, S. Jeffers *et al*., eds., Kluwer Academic Publishers, Netherlands, pp. 117–125 and several other references therein.

Itzkson, C. and Zuber, J. (1980). Quantum Field Theor, McGraw Hill, New York, pp. 134–138.

Mashhoon, B., Paik, H. J., and Will, C. M. (1989). *Physical Review D* **39**(10), 2825–2838.

Newman, E. T. (1973). *Journal of Mathematical Physics* **14**(1), 102.

Nottale, L. (2001). *Chaos, Solitons and Fractals* **12**(9), 1577ff.

Prugovecki, E. (1995). *Principles of Quantum General Relativity*, World Scientific, Singapore.

Ruggiero, M. L. and Tartaglia, A. (2005). *Grivitomagnetic Effects*, gr-qc/0207065.

Sachs, M. (1997). In *The Present Status of the Quantum Theory of Light*, S. Jeffers *et al*., ed. , Kluwer Academic Publishers, Netherlands, pp. 67–77.

Sidharth, B. G. (1993). *International Journal of Modern Physics A* **13**(15), 2599ff.

Sidharth, B. G. (1997). *Modern Physics Letters A* **12**(32), 2469–2471.

Sidharth, B. G. (1998). *Gravitation and Cosmology* **4**(2)(14), 158ff.

Sidharth, B. G. (2001a). *The Chaotic Universe: From Planck to the Hubble Scale*, Nova Science Publishers, Inc., New York.

Sidharth, B. G. (2001b). *Nuovo Cimento* **116B**(6), 4ff.

Sidharth, B. G. (2002). *Anales de la Foundation Louis de Broglie* **27**(2), 333ff.