A Note on the Action at a Distance

March 30, 2011.

José Francisco García Juliá
C/ Dr. Marco Merenciano, 65, 5.
46025 Valencia (Spain)
E-mail: jose.garcia@dival.es

Abstract

We consider that the action at a distance is carried out by virtual carriers of the force, which are created and annihilated in the vacuum by the field in a time less than that of the Heisenberg's uncertainty.

Key words: action at a distance, virtual carrier.

In this short and very simple note, we consider that the action at a distance is carried out by virtual carriers of the force [1], which are created and annihilated in the vacuum by the field in a time less than that of the Heisenberg's uncertainty

$$\Delta t_1 \leq \frac{\hbar}{2\Delta E_1} \tag{1}$$

where t is the time, $\hbar = h/2\pi$ and h is the Planck's constant, and E the energy. There is no violation of the law of the energy conservation, because it continues fulfilling the uncertainty principle:

$$\Delta E \Delta t \geq \Delta E_1 \Delta t_1 = \frac{\hbar}{2} \tag{2}$$

The source field creates and annihilates the virtual carriers in the vacuum (ket $|0\rangle$) with the operators of creation (a^+) and annihilation (a, its adjoint) of the Dirac's second quantization [2]:

$$aa^+|0\rangle = |0\rangle \tag{3}$$

where

$$a^+|0\rangle = |\psi\rangle = |1\rangle_\psi, \; a|1\rangle_\psi = |0\rangle \tag{4}$$

and ψ is the wave function. The virtual quantum fluctuation, (3), is reproduced by all the space, although it is attenuated with the distance to the source: $d = ct = c\sum \Delta t_n$, where c is the light speed in vacuum and n a positive integer, and $0 < \Delta t_1 \le \Delta t_2 \le \cdots \le \Delta t_n \le \Delta t$ and $\Delta E \ge \Delta E_1 \ge \Delta E_2 \ge \cdots \ge \Delta E_n > 0$. The source field produces a first vibration in the vacuum Δs_1 (where s is the space-time interval) that creates the first group of (one or more) virtual particles, which before to be annihilated (be absorbed by the vacuum) produces a second vibration in the contiguous vacuum Δs_2 that creates the second group of virtual particles and so on. The virtual particles, while they exist, follow the hypothetical force lines created by the source field.

For the electromagnetic field, the virtual carrier is a virtual photon that would follow the force lines, which are outward for a positive electric charge or a magnetic north pole and inward for a negative electric charge or a magnetic south pole. Therefore, virtual photons in opposite directions would produce repulsion and in the same direction would produce attraction; that is, electric charges of the same sign (or same magnetic poles) repel each other, and conversely, electric charges of opposite sign (or opposite magnetic poles) attract each other. The square of the incremental space-time interval is:

$$\Delta {s_n}^2 = c^2 \Delta {t_n}^2 - \Delta {x_n}^2 - \Delta {y_n}^2 - \Delta {z_n}^2 \tag{5}$$

where x, y and z are the rectangular coordinates.

For the gravitational field, the virtual carrier would be the virtual graviton. However, the virtual graviton would not drag the bodies in the same form as the virtual photon, because so whether we consider the gravitational force lines outgoing or incoming, the force would always be repulsive instead of attractive. We assume that the virtual graviton produces the gravitational attraction bending the space and that this curvature decreases with the distance to the source field. The square of the incremental space-time interval would be [3]:

$$\Delta {s_n}^2 = \left(1 - \frac{r_g}{r_n}\right) c^2 \Delta {t_n}^2 - {r_n}^2 \left(\sin^2 \theta_n \Delta {\phi_n}^2 + \Delta {\theta_n}^2\right) - \frac{\Delta {r_n}^2}{1 - \frac{r_g}{r_n}} \tag{6}$$

where $r_g = 2GM/c^2$ is the Schwarzschild's gravitational radius of the body of mass M that produces the gravitational source field, G the Newton's gravitational constant and r, θ and ϕ the spherical coordinates.

We deduce that the vacuum vibrates because of the presence of the fields, acting as a quantum oscillator. Hence, in absence of fields, the vacuum does not contain any energy, including the vacuum zero point energy, $\hbar\omega/2$, where $\omega = 2\pi\nu$ is the angular frequency and ν the frequency. With the electromagnetic field, as the positive and negative electric charges exist, the vacuum vibrates like an electric dipole quantum oscillator, which implies that the photon has a spin of $2\hbar/2 = 1\hbar$. With the gravitational field, as the negative mass does not exist, the vacuum vibrates like a mass quadrupole quantum oscillator, which implies that the graviton would have a spin of $4\hbar/2 = 2\hbar$.

For last, as (5) and (6) refer to the vacuum space-time, they have to be quantized. From (5), with $\Delta s_n = 0$ and

$$\Delta r_n^{\ 2} = \Delta x_n^{\ 2} + \Delta y_n^{\ 2} + \Delta z_n^{\ 2} \tag{7}$$

$$\Delta r_n = j\lambda_n \tag{8}$$

$$\Delta t_n = j/\nu_n \tag{9}$$

where r is the rectangular distance (equal to the spherical coordinate r, the radial distance), j a positive integer and λ the wavelength; we obtain that: $c = \Delta r_n / \Delta t_n = \lambda_n \nu_n$. From (6), with $\Delta s_n = 0$ and

$$\Delta \ell_n^{\ 2} = r_n^{\ 2}\left(\sin^2\theta_n \Delta\phi_n^{\ 2} + \Delta\theta_n^{\ 2}\right) + \frac{\Delta r_n^{\ 2}}{1 - \dfrac{r_g}{r_n}} \tag{10}$$

$$\Delta \tau_n^{\ 2} = \left(1 - \frac{r_g}{r_n}\right)\Delta t_n^{\ 2} \tag{11}$$

$$\Delta \ell_n = k\lambda_n \tag{12}$$

$$\Delta \tau_n = k/\nu_n \tag{13}$$

where ℓ and τ are the distance and the time in a curved space-time, respectively, and k a positive integer; we obtain again that: $c = \Delta \ell_n / \Delta \tau_n = \lambda_n \nu_n$. And (8) and (9), and (12) and (13), would be the quantization rules for the vacuum space-time, for the electromagnetic and gravitational fields, respectively.

We have showed, in a simple manner, that the action at a distance is carried out by virtual carriers of the force, travelling to the speed of the light in the vacuum (it is not instantaneous), and that these virtual carriers are produced by the fields through the quantum vibrations of the vacuum space-time.

[1] Donald H. Perkins, Introduction to High Energy Physics, pp. 154, 188 and 288, Addison-Wesley, Reading, Massachusetts, 1972.

[2] P. A. M. Dirac, Principios de Mecánica Cuántica, pp. 149, 244 and 265, in Spanish, Ariel, Barcelona, 1967. Original edition, The Principles of Quantum Mechanics, Oxford University Press, 1958.

[3] L. D. Landau and E. M. Lifshitz, Teoría Clásica de los Campos, p. 398, in Spanish, Reverté, Barcelona, 1973. Original edition by Nauka, Moscow, 1967.