A Wider Span

by Alberto Orioli
e-mail address: me@albertoorioli.info
mailing address: via De Gasperi, 36 - 60027 OSIMO AN – Italy
submission date: 15-03-2023

Essay written for the Gravity Research Foundation 2023 Awards for Essays on Gravitation.

Abstract: Those who imagine a future era in which advances in computer science will allow the study of physical phenomena involving very large amounts of particles also by means of simulation techniques, including their gravitational effects, might find interesting a theory oriented toward that, which aids to define objects and methods underlying elementary particles.

The electric potential properties that I highlight in this short essay could be helpful for such a theory.

For simply figure out the context, think of a point near an atom of hydrogen (protium), in a space with no other physical objects... If it were possible to measure, instant by instant, the difference in electric potential between this point and another at "infinite distance from everything" we would obtain a signal that varies over time.
In fact, the "orbital movements" of the electron cyclically vary the distance between the position of its electric charge and the point of measurement, so that the value of the signal also varies cyclically. Here we name that signal Voltage.

If it were possible to observe the frequency spectrum of Voltage then a sort of noise would appear from which emerge, among others, the spectral components relating to the "orbital motion" of the electron (which occurs in the order of magnitude of 1E15 cycles per second).

Also, a zero spectral component would be observed at frequency 0. In fact, the positive charge of the proton, which constitutes the nucleus of the only atom present in the infinite space considered here, is exactly complementary to that of the electron; this atom is electrostatically neutral.

A frequency spectrum very similar to the one considered would be observed even if the signal were relative to points in space very close to the measurement point. It follows that the spectral components of greater magnitude are those which, on average, give the greatest contribution to the energy density u at the measurement point.

In fact, by differentiating Voltage with respect to space and to time, we obtain the intensities, respectively, of the electric field k and (by a constant factor) of the magnetic field B; and known equations state

$$\mu_0 = \frac{1}{c^2 \cdot \varepsilon_0}$$

$$u = \frac{k^2 \cdot \varepsilon_0}{2} + \frac{B^2}{\mu_0 \cdot 2} = \frac{(k^2 + B^2 \cdot c^2) \cdot \varepsilon_0}{2}$$

(c stands for speed-of-light-in-vacuum and ε_0 for vacuum-electric-permittivity.)

Moreover the spectral components of Voltage have, by definition, sinusoidal time courses; so k and B derived from each component have sinusoidal time courses, too.

Ultimately, it can be stated that the "root mean square" of Voltage, V_{RMS}, is representative of the "average energy effects" in a predefined time interval (whether V_{RMS} is calculated starting from the time course of Voltage or from the magnitudes of its spectral components). V_{RMS} is in fact considered equivalent, for "energetic effects", to the modulus of the electric potential difference between two points of an electrostatic field originated by a point charge of amount q, one at distance d from the charge and the other at infinite distance from it...

$$V_k = \left| \frac{q}{d \cdot \varepsilon_0 \cdot \pi \cdot 4} \right|$$

Since this electric field is static, we have

$$k = \frac{q}{d^2 \cdot \varepsilon_0 \cdot \pi \cdot 4} ; B = 0$$

$$u = \frac{k^2 \cdot \varepsilon_0}{2} = \frac{V_k^2 \cdot \varepsilon_0}{d^2 \cdot 2}$$

In the case study, as already noted, "there is" a zero spectral component at frequency 0, but other components contribute to the value of V_{RMS} (which has energetic effects equivalent to those of V_k). The average energy density, in the given time interval, is therefore

$$u = \frac{V_{RMS}^2 \cdot \varepsilon_0}{d^2 \cdot 2}$$

Now think about what would happen if the electron were not present in the context... a new context with just a proton in a space with no other physical objects.

In the frequency spectrum of Voltage there would be no trace of components relating to the motion of the electron; on the other hand, a non-zero spectral component would be observed at frequency 0. Indeed, the positive charge of the proton originates an electrostatic field such that, at the point of measurement, the modulus of Voltage is

$$V_k = \left| \frac{q}{d \cdot \varepsilon_0 \cdot \pi \cdot 4} \right|$$

Now q is equal to elementary-charge. It's a very simple case but we get

$$u > \frac{V_k^{\ 2} \cdot \varepsilon_0}{d^2 \cdot 2}$$

because, in addition to the electrostatic field, a gravitational field acts at the measurement point, whose contribution to the energy density u is

$$\frac{M^2 \cdot G}{d^4 \cdot \pi \cdot 8}$$

M stands for proton-mass and G for Newtonian-constant-of-gravitation.

By defining V_g as the modulus of the conventional gravitational potential

$$V_g = \left| -\frac{M \cdot G}{d} \right|$$

the relations become

$$u = \frac{V_k^{\,2} \cdot \varepsilon_0}{d^2 \cdot 2} + \frac{V_g^{\,2}}{d^2 \cdot G \cdot \pi \cdot 8}$$

$$V_{RMS}^{\,2} = \frac{u \cdot d^2 \cdot 2}{\varepsilon_0} = V_k^{\,2} + \frac{V_g^{\,2}}{G \cdot \varepsilon_0 \cdot \pi \cdot 4}$$

This relation between V_g and V_{RMS} has no physical meaning, unless one wants to look at particles as structured electrodynamic objects, whose gravitational effects are due to spectral components (of Voltage) at "very very high" frequencies (very very great frequency values).
Indeed, if in the first context (the one with a proton and an orbiting electron) spectral components relating to the electrodynamic structure of the atom are observed then it is conceivable that spectral components at much higher frequencies may exist in both contexts... the components relating to the much smaller structure of the proton with respect to the one of the atom.
Furthermore, we know that the proton is a compound of "simpler" particles; so the frequencies of the spectral components of Voltage that can be associated with gravitational effects are expected to be the ones characteristic of such simpler particles (if we also thinks of simpler particles as structured electrodynamic objects).

Thinking that way the non-interaction at distance, between an object with just electric charge and an object with just mass, is not due to a different nature of the fields originated by them (which would be of electromagnetic nature in both cases), but to the circumstance that the significant spectral components of the corresponding electric potentials have "uncorrelated" frequencies.

The predominant spectral component in the electric potential signal relating to an electron is that at frequency 0, which is "strongly correlated" to the spectral component at frequency 0 of a proton signal; while the significant spectral components in the electric potential signal relating to a neutron are (supposed to be) those characteristic of its constituent particles, so they are found in a very very high frequency portion of the spectrum.

Another example is a chemical bond; that can be established between two neutral hydrogen atoms because, as observed in the first context, they present relevant spectral components relating to the "orbital motion" of the electron. On the other hand, this chemical bond cannot be established between a hydrogen atom and a proton because the "voltage signal" of the latter has no relevant spectral components in those frequency bands.

If we imagine a third context, with just a neutron in a space with no other physical objects, we get

$$V_{RMS}^{2} = \frac{V_g^{2}}{G \cdot \varepsilon_0 \cdot \pi \cdot 4}$$

That is, only the very very high frequency spectral components (those detectable as gravitational effects) contribute to the V_{RMS} value; components that are also present (although not predominant) in the other contexts, in consideration that proton and neutron are made up of the same types of elementary particles. Therefore, although a chemical bond cannot be established between a hydrogen atom and a proton, there is interaction at distance between them which can be traced back to those spectral components, and that we normally observe (on very large amounts of both objects) like a gravitational interaction.

If, just for a while, we think of the term "gravitating" in the generic meaning of "moving toward something" we must recognize that the so-called "law of universal gravitation" is not so much "universal"... If the Moon, the "apple falling from the tree" and the Earth had (all three) also marked electrostatic or magnetic properties, that law would not be appropriate to describe their gravitating! Nor, probably, if those three objects weren't composed predominantly of "homogeneous particles" (protons and neutrons again, made up of the same types of elementary particles, implying electrodynamic structures with great correlation in spectral components of the electric potentials they contribute to).

If the present interpretation is shared then it becomes relevant to note that the ratio between the modulus of the conventional gravitational potential and the "root mean square" of the corresponding electric potential signal is apparently a fixed one...

$$\frac{V_g}{V_{RMS}} = \sqrt{G \cdot \varepsilon_0 \cdot \pi \cdot 2} = \frac{q_P \cdot c^2}{E_P}$$

q_P stands for Planck-charge and E_P for Planck-energy.

(The explanation of why the spectral components at frequencies greater than 0 produce energetic effects at distance with net prevalence of actractive phenomena between the interacting objects is beyond the scope of this short issue.)

All the reasoning here is around electric potential because, at any instant, the electric potential value at a given point in space is simply the sum of all the contributions of electric potential associated with each present electric charge; and, when the frequency spectrum is taken into consideration, that is also "simply" the sum of all contributions associated with each spectral component according to its own phase.

But we usually don't think of the existence of components at frequencies much higher than the ones we can measure some way, nor of the effects that can emerge when these lower ones are negligible with respect to the much higher ones; ending up attributing a different nature to the effects of the latter.

Of course, not only does the electric potential considered in this imagination vary over time, its frequency spectrum can vary over time, too... it all depends on what is happening around the point of measurement. Being this spectrum closely correlated to the electromagnetic spectrum various interesting things would be observed... like frequency shifting of "characteristic components"... or periodic "magnitude modulation" of the set of them contributing to the amount

$$\frac{V_g}{\sqrt{G \cdot \varepsilon_0 \cdot \pi} \cdot 2}$$

when, for example, the point of measurement is at a fixed distance from the Earth while the Moon, orbiting, causes V_g to vary... a sort of very slow periodic modulation.

Or even a "quick transient modulation"... when a so-called "gravitational wave" reaches the point of measurement.