Interpretation of Higher Order Field Terms

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February 26, 2023

1 Abstract

In this paper, the higher-order terms are evaluated for an electric potential field equation derived from a unified classical electrostatic-gravitational field theory. It is shown that the higher order terms represent higher order gravitational interactions arising due to gravity coupling to itself. It is shown that in the low-voltage limit, these approximately correspond to the expected magnitude and sign expected from classical gravitation. In the high-voltage limit, these terms are of a hyperbolic trigonometric form and appear to have a finite sum. This strongly suggests that this theory will not require re-normalization even in higher dimensions. After evaluation of the mathematics, a new mechanistic explanation for these self-gravitation terms is also provided from the new theory.

2 Introduction

In previous papers, we have derived the formula for an electrostatic potential based on a modified Lagrangian that is compatible with the idea of a maximum voltage at the Planck Scale [1, 2]. The formula for electrostatic potential as a function of position was shown to take a hyperbolic tangent form for our single-dimensional model. We identified the first several terms in the sequence. The 0th order term in position x was the electric potential energy, the 1st order term was classical electrostatics, and the 2nd order term was shown to represent classical gravitation. In this paper, we investigate the higher order terms in the Taylor series expansion. We show that the term that is 3rd order in x is actually part of the full formula for classical gravitation. We show that the 4th and 5th order terms represent the gravitation generated by the energy density of the gravitational field. We suggest that each pair of higher order terms (6th and 7th, 8th and 9th, etc.) represent the gravitation generated by the energy density of the previous pair. In other words, the 4th and higher order terms represent the infinite series of gravitational terms that result from gravity coupling to itself. These higher order terms come naturally from the Lagrangian we have proposed, but they can not be derived from Newtonian gravity or even from standard general relativity without modifying the Lagrangians for those theories. Instead, such higher order terms are typically derivable from quantum field theory. In quantum field theory, these terms result from the gravitational coupling of the force-carrying graviton, which we have obviously not pre-supposed in constructing our Lagrangian. Thus, the simple modification we performed to the Lagrangian resulted in an infinite sum of gravitational interactions, which this paper will show to have approximately the expected magnitude and sign.

3 Second and Third Order Terms

The second and third order terms in the expansion of $\phi(x)$ are as follows with the definitions of the variables as generally defined in our previous papers and subscripts on the left side of the equation are used for term numbers [1,2]:

$$\phi_{2,3} = -\frac{(E_x)^2 \tanh(\frac{\phi_0}{V_p}) sech^2(\frac{\phi_0}{V_p})}{V_p} x^2 - \frac{(E_x)^3 * (\cosh(\frac{2\phi_0}{V_p}) - 2) * sech^4(\frac{\phi_0}{V_p})}{3V_p^2} x^3 \tag{1}$$

When we take the small hyperbolic angle approximation that $\phi_0 << V_p$ this produces

$$\phi_{2,3} = \frac{-(E_x)^2}{V_p^2}\phi_0 * x^2 - \frac{(E_x)^3 * (-1)}{3V_p^2} x^3 \tag{2}$$

$$\phi_{2,3} = \frac{-(E_x)^2}{V_p^2}\phi_0 * x^2 + \frac{(E_x)^3}{3V_p^2} x^3 \tag{3}$$

The field resulting from this is as follows:

$$f_{2,3} = \frac{(E_x)^2}{V_p^2}\phi_0 * x - \frac{(E_x)^3}{V_p^2} x^2 \tag{4}$$

$$f_{2,3} = \frac{(E_x)^2}{V_p^2}\phi_0 * x - \frac{(E_x)^2}{V_p^2} * (E_x x) * x \tag{5}$$

$$f_{2,3} = \frac{(E_x)^2}{V_p^2}(\phi_0 - E_x x) * x \tag{6}$$

$$f_{2,3} = \frac{(E_x)^2}{V_p^2} * \phi(x) * x \tag{7}$$

The force associated with a test particle of charge q for these two terms is then as follows:

$$f_{2,3} = \frac{(E_x)^2}{V_p^2} q\phi_x * x \tag{8}$$

$$f_{2,3} = \frac{4\pi G\epsilon_0}{c^4} * (E_x)^2 * q\phi(x) * x \tag{9}$$

$$f_{2,3} = \frac{4\pi G}{c^4} * \epsilon_0 (E_x)^2 * q\phi(x) * x \tag{10}$$

Suppose we center our coordinate system at the source charge and also let $\phi_0 = 0$, so that the potential at the source charge is defined as being 0. If E_x points in the positive x-direction, then ϕ will be negative on the right side of the x-axis and positive on the left side of the x-axis. Therefore, the gravitational force will point inward for a positive test charge +q, as we would expect for a system with positive interaction energy.

4 Fourth and Fifth Order Terms

Here it will be shown that the fifth and sixth order terms represent the gravitational field produced by the gravitational energy itself. Since the gravitational energy is negative, this field being a negative of a negative will point outward from the source charge at the origin. The fourth and fifth order terms of the series are as follows:

$$\phi_4(x) = -\frac{(E_x)^4(\cosh(\frac{2\phi_0}{V_p}) - 5)\tanh(\frac{\phi_0}{V_p})sech^4(\frac{\phi_0}{V_p})}{6(V_p)^3}x^4 \tag{11}$$

$$\phi_5(x) = \frac{-(E_x)^5(-26\cosh(\frac{2\phi_0}{V_p}) + \cosh(\frac{4\phi_0}{V_p}) + 33)sech^6(\frac{\phi_0}{V_p}))}{60(V_p)^4}x^5 \tag{12}$$

For the 4th order term, the small hyperbolic angle approximation $\phi_0 << V_p$ then produces

$$\phi_4(x) = -\frac{(E_x)^4 * (-4) * \frac{\phi_0}{V_p}}{6(V_p)^3}x^4 \tag{13}$$

$$\phi_4(x) = \frac{2}{3} * \frac{(E_x)^4 * \phi_0}{(V_p)^4}x^4 \tag{14}$$

For the 5th order term, the small hyperbolic angle approximation $\phi_0 << V_p$ then produces

$$\phi_5(x) = \frac{-8}{60V_p^4}(E_x)^5 \tag{15}$$

$$\phi_5(x) = \frac{-2}{15V_p^4}{E_x}^5 \tag{16}$$

The sum of these two terms is as follows:

$$\phi_{4,5}(x) = \frac{2}{3} * \frac{(E_x)^4 * \phi_0}{(V_p)^4} x^4 - \frac{2}{15 V_p^4} {E_x}^5 x^5 \tag{17}$$

$$\phi_{4,5}(x) = \frac{10}{15} * \frac{(E_x)^4 * \phi_0}{(V_p)^4} x^4 - \frac{2}{15 V_p^4} {E_x}^5 x^5 \tag{18}$$

$$\phi_{4,5}(x) = \frac{10}{15} * \frac{(E_x)^4 * \phi_0}{(V_p)^4} x^4 - \frac{2}{15 V_p^4} {E_x}^5 x^5 \tag{19}$$

The field resulting in this potential is the following:

$$f_{4,5}(x) = -\frac{40}{15} * \frac{(E_x)^4 * \phi_0}{(V_p)^4} x^3 + \frac{10}{15} \frac{{E_x}^5}{(V_p)^4} x^4 \tag{20}$$

$$f_{4,5}(x) = -\frac{40}{15} * \frac{(E_x)^4 * \phi_0}{(V_p)^4} x^3 + \frac{10}{15} \frac{{E_x}^4 * (E_x * x)}{(V_p)^4} x^3 \tag{21}$$

$$f_{4,5}(x) = -\frac{30}{15} * \frac{(E_x)^4 * (\phi_0 - E_x * x)}{(V_p)^4} x^3 \tag{22}$$

$$f_{4,5}(x) = -2 * \frac{(E_x)^4 * \phi(x)}{(V_p)^4} x^3 \tag{23}$$

It will now be demonstrated that this term represents the repulsive gravitational force due to the negative energy of the gravitational field itself. The gravitational field strength in one dimension is as follows. Note this is half the value we derived previously, as here in the derivation we choose to integrate the electrostatic energy only from 0 to x [1, 2].

$$g_x(x) = \frac{-4\pi G E_{enc}}{c^4} = \frac{-4\pi G \epsilon_0 E_x^2}{c^4} * x = -\frac{Ex^2}{V_p^2} x \tag{24}$$

The gravitational field energy density is then as follows:

$$\rho_g = \frac{1}{4\pi G} g_x^2 = \frac{(E_x)^4}{4\pi G (V_p)^4} x^2 \tag{25}$$

With the total gravitational energy bound between 0 and x being

$$E_{g-enc} = \frac{(E_x)^4}{4\pi G (V_p)^4} x^3 \tag{26}$$

Then the field generated by this bound negative energy is as follows:

$$g_{x2} = -\frac{4\pi G E_{g-enc}}{c^4} = -\frac{4\pi G (E_x)^4}{4\pi G (V_p)^4} x^3 \tag{27}$$

$$g_{x2} = -\frac{(Ex)^4}{(V_p)^4} x^3 \tag{28}$$

Here g_{x2} denotes the (repulsive) gravitational field produced by the negative energy stored in the gravitational field. Note that the force on a test particle from this field would be as follows:

$$f = -E_{test} \frac{(E_x)^4}{(V_p)^4} x^3 \tag{29}$$

If we write assume that the test particle is otherwise massless and its only energy is through the electromagnetic interaction then we would write

$$f = -q\phi(x) \frac{(E_x)^4}{(V_p)^4} x^3 \tag{30}$$

This equation matches the force that would be generated by $f_{4,5}$ (the forces derived from the 4th order and 5th order terms) acting on a test charge q, except for a factor of two. Thus except for this factor of two which is to be investigated further, we have shown that these terms do represent the gravitational force produced by the gravitational field energy.

5 Discussion

In this paper we have evaluated the higher order terms in the modified electrostatic Lagrangian we previously proposed [1, 2] We showed that in the low-voltage limit, they correspond to an infinite series of gravitational terms resulting from the gravitational charge of the gravitational energy density. It is interesting to note that all of the terms in the electrostatic potential we derived are actually of a hyperbolic trigonometric type. Such terms only take on a power law form at voltages much lower than the Planck Voltage, as we have previously illustrated. We believe that this property may have striking implications for the renormalization of gravity and possibly for quantum gravity in general. In particular, such a property allows the gravitational energy terms to "deform" automatically at voltages near the Planck Voltage. As a result, for a source with finite charge the total electrostatic plus gravitational energy in this theory is finite despite having an infinite number of terms. In the single-dimensional case outlined here, the theory does not require renormalization at all. Our theory does not require renormalization despite the fact that we made no special effort to prevent infinities when constructing the theory. That is, we did not modify spacetime as in loop quantum gravity nor did we need to turn the point particles into strings. It is known that other classical theories of gravity, such as general relativity, can not be renormalized in a spacetime dimension greater than 2. Thus far, we have constructed our new theory only in a single dimension of space. Therefore, we cannot technically claim that this new theory solves the problem of gravitational re-normalizability at least until the theory has been extended to additional dimensions. However, it does seem clear that for a source particle with a finite charge, any version of the theory we propose no matter the number of dimensions of spacetime will have a finite total electrostatic plus gravitational energy for all terms. That is because we have limited the total potential to the Planck Voltage, and we have shown that this potential includes both electric and gravitational interactions. Therefore, we contend that this theory will not require re-normalization at all no matter the number of dimensions. This will be evaluated in future papers.

6 Future Directions

Future papers will address any minor sign or factor of two differences that appear in the formulas we have derived. In addition, we will continue to work on developing the mechanistic understanding behind these formulas. We believe that a mechanistic understanding is roughly as follows:

1) Generally, any electrically charged test particle will be at a slightly different potential (voltage) than the electrically-charged source. Due to the "voltage boost" formula previously derived [1, 2], there is a small difference in the way the test charge at its potential will measure the magnitude of the source charge, relative to an observer at the same voltage level at the source.

2) The magnitude of the source charge from the "voltage frame" of the test charge will therefore be altered. The source charge magnitude will be different than it would otherwise be in classical electromagnetism, and this difference will depend on the voltage of the test charge. Therefore, a voltage "voltage-dependent" potential arises, and this is the force we know as classical gravitation. It is in direct analogy to the way that magnetism depends on velocity, and we have shown the formulas to be of the same form [1, 2].

3) The perceived change in source charge (by the test particle) then actually affects the potential at the test charge again, because it is the source of the electric potential. This new potential alters the "voltage frame" of the test charge again by the voltage boost formulas, which then alters the way it measures the source charge magnitude again. This produces another term, which can likely be identified with the gravitation of the gravitational field energy itself.

4) The modified source charge magnitude then affects the potential again, and this goes on infinitely. This recursive behavior ends up producing an infinite number of terms that represent gravity coupling to itself. As discussed, the terms according to our Lagrangian end up with a finite sum and appear not to require re-normalizability even though there are an infinite number of them. They are of a hyperbolic tangent form and only reduce to power law form at low voltages. Therefore, we now have a mechanistic explanation behind why gravity couples to itself, as well as a theory that does not appear to require re-normalization.

In future papers, we will set up other thought experiments to try to derive this mechanistically. In addition to the mechanism described above, we may attempt similar thought experiments to the ones used by Einstein to unify electricity and magnetism. For example, these may involve neutral rods that have both positive and negative charges. We then "voltage boost" using our new transformation laws such that upon voltage boosting the rods are no longer neutral, but appear to have a net charge. That small net charge is then effectively gravitation in the "voltage-boosted" frame. This net charge will then affect the voltage experienced by the test particle, which slightly changes its "voltage reference frame again". This results in another more minor "voltage boost" that affects the source again, producing another minor change to the effective net source charge. The term resulting from this secondary interaction will effectively be the gravitational field produced by the gravitational field energy. This will go on infinitely producing an infinite number of terms and again provides a kind of explanation for why gravitational fields themselves must have a gravitational charge. We may also use any of the thought experiments described in this "Future Directions" section to derive new Lagrangians, which may or may not be equivalent to the ones already derived.

7 References

1) Bluver, Dennis. Unification Without Extra Dimensions. Preprint available at https://vixra.org/pdf/2302.0106v1.pdf (2023).

2) Bluver, Dennis. The Planck Voltage and Gravitation. Preprint available at https://vixra.org/pdf/1906.0108v1.pdf (2019).