The electric charge influence on space-time curvature

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Abstract

This article presents a novel approach to understanding the influence of electric Energy on space-time curvature. EFE actual calculations refer solely to gravitational charges. In this article, I expand them to include the electric charge with calculations carried specifically for electric charges, with exciting results. The article leverages the universal consistency of physical laws, applying the known effects of gravitational charges on space-time curvature to electric charges. The research focuses on calculating the specific impact of electric charges on space-time curvature, rooted in the principle that space-time curvature is omnipresent. The findings reveal that space-time curvature's alteration due to an electric charge is influenced by various factors, including the charge's location, magnitude, mass, density, associated electric field, and its motion through space-time. Notably, the conversion factor for electric charges differs from the conversion factor of gravitational charges. These insights significantly enhance our understanding of electromagnetism and general relativity, paving the way for a more profound comprehension of electric charges.

Article

1. Preface

Problem: EFE appears to be general to all forms of Energy and momentum. However, when analyzing its creation, it is clear that the calculations only pertain to gravitational charges because they were made using the Newtonian limit, resulting in $k_G = \frac{8\pi G}{c^4}$. There is a clear need to do it for the other charges as well.

2. Main

Premise: Space-time curvature exists at every point of space-time. Whenever Energy encounters space-time curvature, it changes the curvature (demonstrated for gravitational charges Energy by Prof Albert Einstein and proved in many subsequent observations.)

The Premise regarding the Energy impact on space-time curvature results from using the "Uniformity of Physical Laws in the Universe Principle" ("**Each physical law is the same throughout the Cosmos**"): I use the impact of gravitational charge Energy on space-time curvature to Energy from any charge type and in this article particularly to the electric charge. (1)

This conclusion perfectly aligns with our knowledge that charges behave similarly: all charges affect their local neighborhood, and moving charges radiate (observed in the case of gravitational and electric charges.) (2) (3)
However, different charges have different influences as they impact their neighborhood differently. At an equidistance from the charge, the electric charge has a stronger impact than the gravitational charge.

Changes in space-time curvature occur only when space-time curvature encounters Energy and, in particular, charges Energy. Space-time curvature also changes when space-time curvature encounters pure kinetic Energy in the form of photons. In this case, the photons also change the space-time curvature. Therefore, if an area in space-time never experienced Energy, then its space-time curvature is zero (known as "**flat space-time curvature**"). Thus, in a state of a point that never encountered Energy, I can write: $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 0$

According to the "Completeness Principle:" **Energy and nothing but Energy composes the Cosmos.**" Thus, Energy must exist everywhere in space-time.

The "Uniformity of Physical Laws in the Universe Principle." means that I need to use tensors when describing equations that portray space-time curvature and its changes.

The resulting equations describe space-time curvature after the charges' Energy changed it. (4)

Under these restrictions, the Energy-momentum tensor $(T_{\mu\nu-i})$ in space-time is a (0,2) tensor. Every part of our Universe follows the "Energy Conservation Principle" (**Energy is conserved in a closed system,**) and therefore, the Energy-momentum tensor must also follow the "Energy Conservation Principle." Therefore, the Curvature tensors on the opposite side of the equation must also keep the "Energy Conservation Principle" and be (0,2) tensors.

Thus, from one side of the equation $\nabla^{\mu} T_{\mu\nu-i} = 0$, and correspondingly on the other side of the equation $\nabla^{\mu}\left((Ri)_{\mu\nu} - \frac{1}{2}(Ri)g_{\mu\nu}\right) = 0$, where "*i*" associates with charge . (*i*=E for electric, G for gravitational.)

I will examine the electromagnetic stress-Energy tensor influence on the space-time curvature in this article. I will treat the electric charge as a particle with an electric charge for convenience.

Equation 1 Electric charge influence on space-time curvature (schematic version)

$$(RE)_{\mu\nu} - \frac{1}{2}(RE)g_{\mu\nu} = k_E T_{\mu\nu-E}, \forall r |\, r_{Source\ of\ electric\ charge\ boundary} < r < r_E$$

$(RE)_{\mu\nu}$ is the Ricci curvature tensor of the electric charge q_E.
$g_{\mu\nu}$ is the space-time metric.
(RE) is Ricci scalar of the charge q_E.
k_E is a conversion constant corresponding to the Energy expenditure of the charge q_E while changing space-time curvature at a specific distance from the source. [Einstein calculated $k_G = \frac{8\pi G}{c^4}$ for gravitational charges] (5)
$T_{\mu\nu-E}$ is the Energy-momentum (stress-Energy) tensor of the charge q_E.
r_E is the charge q_E diminishing point (the point where the electric charge influence on space-time curvature is no longer effective.) (4)

Now, I can explore the equations above:

I followed Einstein's reasoning for the gravitational charge. However, I used space-time curvature existence at all points of space-time as the common denominator for all charges (and not gravitation, which is limited to gravitation.)

I used the classical limit (similar to the "Newtonian" limit in the gravitational case); in this limit, I chose to examine the curvature of space-time change in a point far from a static electric charge. In this case, the electric charge does not move (it is static), and far from the charge, the electric field is weak and does not change in time.

The Poisson equation for a static electric charge: $\nabla^2\Phi_E = -\frac{\rho_E}{\varepsilon_0}$ where Φ_E is the Electric potential. Also $E = -\nabla\Phi_E$.

In the classical limit, the acceleration related to the electric charge:

Electric charge influence

$a = \frac{F}{m} = \frac{qE}{m} = -\frac{q}{m}\nabla\Phi_E = \frac{1}{2}\partial_i h_{00}$. So $h_{00} = -\frac{2q}{m}E$, and $g_{00} = -(1 + \frac{2q}{m}\mathrm{E})$

We express the Electric charge Energy-momentum tensor (it must be symmetric) with the Electric field tensor $F_{\mu\nu}$ (c=1): $T_{\mu\nu-E} = \frac{1}{\mu_0}\left(F_{\mu\alpha}F_{\nu}{}^{\alpha} - \frac{1}{4}g_{\mu\nu}F_{\alpha\beta}F^{\alpha\beta}\right)$. (3)

In the classical limit, the electric field is weak (far from the source,) time-independent, and does not move, therefore:

$T = 0$, $R_{00} = k_E\left(T_{00} - \frac{1}{2}Tg_{00}\right) = k_E\left(\frac{1}{2}\epsilon_0 E^2 + 0\right) = \frac{1}{2}k_E\epsilon_0 E^2$ (Reminder: k_E is the conversion constant.)

$R_{00} = R^i{}_{0i0} = \partial_j\left[\frac{1}{2}g^{i\lambda}(\partial_o g_{\lambda 0} + \partial_o g_{\lambda 0} - \partial_\lambda g_{00})\right] = -\frac{1}{2}\delta^{ij}\partial_i\partial_j h_{00} = -\frac{1}{2}\nabla^2 h_{00}$

so $\nabla^2 h_{00} = -k_E\epsilon_0 E^2$

$\nabla^2 h_{00} = \nabla^2\left(-\frac{2q}{m}\Phi_E\right) = -\frac{2q}{m}\nabla^2\Phi_E$, substituting the Poisson equation $\nabla^2\Phi_E = -\frac{\rho_E}{\varepsilon_0}$ yields $\nabla^2 h_{00} = -\frac{2q}{m}\left(-\frac{\rho}{\varepsilon_0}\right)$ and equating it to $\nabla^2 h_{00} = -k_E\epsilon_0 E^2$ yields $-\frac{2q}{m}\left(-\frac{\rho_E}{\varepsilon_0}\right) = -k_E\epsilon_0 E^2$, With "c" it yields $k_E = -\frac{2q\rho_E}{mc^2{\epsilon_0}^2E^2}$

So, the first equation takes the form:

Equation 2 Electric charge influence on space-time curvature with conversion constant

$$(RE)_{\mu\nu} - \frac{1}{2}(RE)g_{\mu\nu} = -\frac{2q\rho_E}{mc^2{\epsilon_0}^2E^2}T_{\mu\nu-E}, \forall r|\ r_{Source\ of\ electric\ charge\ boundary} < r < r_E$$

Units check: $\left[\frac{q\rho}{mc^2\epsilon_0}\right] = \left[\frac{AsAsm^{-3}}{Kgm^2s^{-2}Kg^{-1}m^{-3}A^2s^4}\right] = [m^{-2}]$ ✓

Conclusion: Electric charges have a different magnitude impact on space-time curvature than gravitational charges. When calculating the path of a particle with both gravitational and electric charges, we need to do two calculations and superimpose them: one for the electric charge-related space-time curvature and the other for the gravitational charge-related space-time curvature.
We will also have to consider the time it takes the influence of the different charges to reach different points in the space-time curvature.

Note: we may encounter non-linear components in the tensors in case of very strong gravitational and electric fields. In this case, a simple superposition of the influence of the individual charges is not enough. We will have to simultaneously calculate both sets of equations to add the new non-linear factors into the result (as in some cases, non-linear terms will influence existing non-linear terms.)

Remark: I did not use the cosmological constant in this article as it is not solely connected to the electric charge.

When we have data of an electrically charged particle circling a very small relativistically fast electrically charged rotating black hole (very small because a “big” black hole will usually have a zero net electric charge,) we can use the Kerr-Newman metric and geodesics equations for the gravitational charge and the electric charge simultaneously (taking into account the maximal speed of influence propagation - if required) to calculate the exact path of this charged particle circling the described black hole.

3. References

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