International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 12 Issue 3 March 2023 || PP 21-23

Balancing the gravitational and Coulombic forces

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ABSTRACT*: This research paper views the gravitational force of the sun that bends light as a Coulombic force between electrons and protons separated by 1 cm and gives a sense of the strength of the force. Also, it is shown that gravity being the weaker force than electromagnetism by 10^{40} times is difficult to unify with the other three forces of nature. A proton has to reach to an energy of 10^{28} eV for the gravitational force between two protons to become stronger than the repulsive Coulombic force between them.*
KEYWORDS: *Coulomb, Force, Gravity, Light, Particle Physics*

Date of Submission: 06-03-2023 Date of Acceptance: 19-03-2023

I. INTRODUCTION

Starting of the twentieth century saw two formulae for energy discovered, one by Max Planck and the other by Albert Einstein. Max Planck discovered the formula for energy, E= hν in 1900, and Einstein discovered the formula for energy as $E=mc^2$ in 1905. Combining the two above gives:
$mc^2=h\nu$
$c\ (mc)=hc/\lambda$.
Cancelling c on both sides and taking p for momentum in place of mc for a massless photon, $p=h/\lambda$.
This is the beginning of quantum mechanics. In the above formulae, E is the energy, h is the Planck's constant, ν is the frequency of radiation, m is the mass of the particle, λ is the wavelength of radiation, and c is the speed of light which is an electromagnetic radiation.

II. THEORY

There are four concepts relevant to the present research which are laid out below.
The force of gravity is given by the formula:

$F_g=GMm/r^2$.

Here, G is the gravitational constant as $6.7 \times 10^{-11}\ m^3Kg^{-1}s^{-2}$, M and m are the two masses in Kg, between which the attractive force of gravity is acting, and r is the distance in meters, between the centre of the two masses.

The attractive Coulombic force between a proton and an electron, or the repulsive Coulombic force between two protons is given by:

$F_c= (1/4\pi\varepsilon_0)q_1q_2/r^2$.

Here, $(1/4\pi\varepsilon_0)$ is a constant equal to $8.988 \times 10^9\ N\text{-}m^2\text{-}C^{-2}$, q_1 and q_2 are the magnitude of the charges in Coulomb, and r is the distance from the centre of the two charges.

Among the above two forces, gravity is a weak force being 10^{40} times smaller than the Coulombic force. If one considers a proton and an electronseparated by a distance r, then the ratio of theattractive Coulombic force to the gravitational force can be found to be about 10^{40}.

Consider a 1000Watt light source, and the energy of a photon is 7.8×10^{-20} joules from the formula E= hν for a 2540 nm wavelength, then the number of photons emitted from the source is given by:
Number of photons/ sec = 1000 / (7.8×10^{-20}) $=1.3 \times 10^{22}$ photons/sec. This light source is comparable to direct sunlight (or any other star). 2540 nm is about the middle of the simulation range of 500 nm to 5500 nm range of electromagnetic radiation wavelengths and is also one end of the infrared wavelength of 2.5 micrometres.

III. RESULTS AND DISCUSSIONS

The first result is the calculation of the gravitational force between the sun and the photons of light. The speed of light being 3×10^8 m/s and the diameter of the sun being 1.4×10^9 metres, it will take about 5 seconds for the light to travel across the diameter. Referring to the light source in the theory, in 5 seconds, there will be 6.5×10^{22} photons emitted from the starlight.

Referring to the introduction, if m is not massless, then the mass of red photon of wavelength 700 nm is given as:
$m=h/(c\lambda)$
$m=3 \times 10^{-36}$ Kg.
The mass of the photon of the wavelength of 2540 nm will be $3 \times 700/2540 = 0.82 \times 10^{-36}$ Kg.
These photons with a wavelength of 2540 nm will constitute a mass of about 5.33×10^{-14} Kg, given that the mass of one photon is 0.82×10^{-36} Kg.
Mass of the sun = 2×10^{30} Kg.
Attractive gravitational force F_g,
$G=6.7 \times 10^{-11}$ $m^3Kg^{-1}s$-2
$m=5.33 \times 10^{-14}$ Kg.
$M=2 \times 10^{30}$ Kg.
Let r (radius of the sun) = 0.7×10^9 metres.
Force $F_g= 6.7 \times 10^{-11} \times 5.33 \times 2 \times 10^{16} / (0.7 \times 10^9)^2$ Kg (m/s^2).
Force $F_g=1.46 \times 10^{-11}$ N.

The second result is the value of the charge q that balances the gravitational force to the Coulombic force. One considers two equal and opposite charges q, separated by 1 cm. Then, equating the two forces gives the value of the charge q as below:
1.46×10^{-11} N = 9×10^9(Newton -metre^2/Coul^2) q^2/r^2.
1.46×10^{-11}Coul^2= 9×10^9 $q^2/10^{-4}$.
$(1.46/9) \times 10^{-24}$ Coul^2 = q^2.
$q^2 = 0.16 \times 10^{-24}$ Coul^2.
$q = 0.4 \times 10^{-12}$ Coulombs.

The third result is the calculation of the number of electrons equal to the calculated charge q above. The number of electrons having the total above charge is calculated by diving the above charge by the charge of one electron. Thus, number of electrons approximately = $4 \times 10^{-13}/1.6 \times 10^{-19} = 25 \times 10^5$.

25×10^5 electrons and 25×10^5 protons separated by 1 cm will have the same attractive force that a beam of light 0.7×10^9 metres from the centre of the sun across the diameter of the sun in 5 seconds will have. Certainly, we can sense this force is strong to bend the light.It can be observed that to have a strong enough gravitational force for the photon as a particle, the mass of the sun had to be very large. If the mass of all the photons of 5.3×10^{-14} Kg times the mass of the sun at 2×10^{30} Kg equals the square of two equal masses of objects, then the mass of one object will be sqrt(product of masses). This will be equal to sqrt (10.6×10^{16}) Kg. This becomes 3.25×10^8 Kg. The energy required for this mass given by $E = mc^2$ will be 1.8×10^{44} eV.
Another way of looking at this is by considering two protons accelerated towards each other in a linear accelerator. Then, if the repulsive coulombic force between two protons at the time of collision is equated to the gravitational force between the accelerated protons of effective mass m_{eff} separated by the distance 2r at the time of collision, where r is the radius of the proton, then this equation gives the mass m_{eff} as 1.85×10^{-9} Kg. The energy of this mass from $E = mc^2$equation will be about 10^{27} eV. Taking ten times more energy makes the gravitational force ten times stronger than the repulsive Coulombic force. The energy becomes 10^{28} eV. This energy scale would be a requirement for observing gravitational force between two accelerated protons, gravity being a weak force compared to electromagnetism by 10^{40} times as mentioned in the theory section. This energy of 10^{28} eVis very large and a collider or accelerator to attain this energy is not viable.Also, this large energy will be required in order to unify the four forces of nature. They are the forces of gravity, electromagnetism, weak nuclear, and the strong nuclear. The present-day energy levels are of 10^{13} eV in colliders or accelerators. An alternative theory for unifying the forces has been the String Theory. It has been unsuccessful so far, but much has been learnt from it.

The 1965 Nobel Laureate for Physics, Richard P. Feynman, in one of his Feynman Lecture series talks about two theories giving the same result and how different ideas come out of them. Here, we have an example of the above where the same force value that relates to two theories of gravitational and Coulombic forces give different ideas and meaning.

IV. CONCLUSIONS

It is concluded from the study that the bending of light by the sun is equivalent to the Coulombic attractive force between 25 x10^5 electrons and 25 x 10^5 protons which are 1 cm apart. Also, gravity is a weak force as compared to the Coulombic force by 10^{40} times. It requires 10^{28} eV energy of accelerated protons to make the gravitational force between protons ten times stronger than the repulsive Coulombic force. This energy is very large. Thus, it is difficult to unify the force of gravity with the other three namely electromagnetism, weak and strong nuclear forces.

Dr. Ravi Kumar Chanana. "Balancing the gravitational and Coulombic forces." *International Journal of Engineering Science Invention (IJESI)*, Vol. 12(3), 2023, PP 21-23. Journal DOI- 10.35629/6734