The true meaning of Newton's gravitational constant G.

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abstract:

This work analyses the real meaning of Newton's gravitational constant **G.**
This constant is necessary to quantify the gravitational force between two body but, presumably, it must ride on the global Universe's mass allocated in the full Universe's volume at a definite time.

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1. Introduction

The universal gravitational constant G at present is regarded as a numerical factor that must be taken into account in the calculation of the gravitational force between two body. This paper suggests that this numerical factor is not a constant but varies over time in the same way of Hubble's constant Ho (the ratio of velocity to distance in the expansion of the Universe at the time of observation). It changes with time but it is the same everywhere in the Universe at a given time.
Moreover, investigating its dimensions we notice:

$$[G] = [m^3 / (sec^2 * Kg)].$$

That is, it depends on a volume, a time squared and a mass. (It is directly proportional to a volume and inversely proportional to the square of a time and a mass).
Now, if **G** is an universal constant, it seems logical to refer these dependencies to the macroscopic quantities of the Universe. That is the Universe's **volume**, the global Universe's **mass** and the present **time** elapsed from Big Bang.
To test this idea now let's try, for example, to calculate the value of the universe's density by using the value of **G** and let's see if we get a result that is congruent with the value estimated by astronomers.

2. . Calculation of the universe's density by means of Newton's gravitational constant G and Universe age

The gravitational constant is a physical constant that is difficult to measure with high accuracy. [1]

The 2014 CODATA-recommended value of the gravitational constant is [2]:

$$G = 6{,}67408 * 10^{-11}\ m^3 / (sec^2 * Kg)$$

Denoting by:
V_u Universe's volume.
t_u Universe's age.
M_u Universe's mass.
ρ_u Universe's density.

We make this hypothesis :

$$G = V_u / (t_u^2\ M_u)$$

So we have:

$$M_u / V_u = 1 / (G\ t_u^2) = \rho_u$$

In physical cosmology, the age of the universe is the time elapsed since the Big Bang.
The best measurement of the age of the universe, within the **Lambda-CDM concordance model**, is [3]:

13.798±0.037 billion years (13.798±0.037×10^9 years or 4.354±0.012×10^17 seconds)

The age of the Universe can be estimated by means of other methods too.
There are at least 3 ways:

The age of the chemical elements that gives a value of [4]:

14.5+2.8/-2.2 Gyr.

The age of the oldest star clusters that gives a value of [5]:

14.1 +/- 2.5 Gyr

The age of the oldest white dwarf stars that give a value of [6]:

12.8 +/- 1.1 Gyr.

Then, replacing known values in the mathematical density formula:

$$\rho_u = 1 / (G * t^2) = 1 / ((6.67408 * 10^{-11}) * (4.354 * 10^{17})^2)$$

$$\rho_u = 1 / ((6.67408 * 10^{-11}) * (18.957316 * 10^{34}))$$

$$\rho_u = 1 / (126.52264356928 * 10^{23}) = 0.0079 * 10^{-23}$$

$$\rho_u = 7.9 * 10^{-26}\ Kg/m^3$$

$$\rho_u = 7.9 * 10^{-29}\ g/cm^3$$

It is important to note that the achieved **ρ** is the total mass/energy density of the Universe. In other words, it is the sum of a number of different components including **both normal (baryonic)** and **dark matter** as well as the **dark energy**.

3. Discussion and future work

Amazingly, the achieved result gives a density value of about one order of magnitude greater than the estimated values obtained by other methods. So may be justified since we do not know accurately all the matter and the energy existent in the whole universe.

It's notable that we do not have obtained a less value that would have invalidated the assumptions we have made.

Furthermore, thanks to a deep-sky census assembled from surveys taken by NASA's Hubble Space Telescope and other observatories, astronomers came to the surprising conclusion that there are at least 10 times more galaxies in the observable universe than previously thought..[7]

This discovery might very well justify the difference between the obtained result and that estimated by astronomers.

It is customary to express the density as a fraction of the density required for the critical condition with the density parameter Ω_0.

The density parameter Ω_0 is given by:

$$\Omega_0 = \rho / \rho_c$$

where (ρ) is the actual density of the Universe and (ρ_c) is the critical density (the average density of matter required for the Universe to just halt its expansion, but only after an infinite time).

This relation determines the overall geometry of the universe.

When the ratio is exactly equal to 1, the geometry of the universe is flat (Euclidean) and contains enough matter to halt the expansion but not enough to recollapse it.

If Ω_0 is less than 1, the Universe is open and will continue to expand forever. If Ω_0 is greater than 1, the Universe is closed and will halt its expansion and recollapse.

The current critical density is given by:

$$\rho_c = 3H_0^2/8\pi G$$

where H_0 is the Hubble constant (it is approximately [8] : (**(50-100) km * s^{-1} * Mpc^{-1}**) and **G** is Newton's gravitational constant.

The current critical density is approximately [9]:

$$(5\text{-}20) * 10^{-30}\ g/cm^3 = (0.5 - 2.0) * 10^{-29}\ g/cm^3$$

Using the value of density: $\rho_u = 7.9 * 10^{-29}$ and the average value of ρ_c to calculate the density parameter Ω_0, we have:

$$\Omega_0 = \rho_u / \rho_c = 7.9 * 10^{-29} / 1.25 * 10^{-29} = 6.32$$

With the value of Ω_0 = **6.32** the Universe is closed.

References:

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[5] Shinya Wanajo *Astrophys.J.* **577** (2002) 853-865.

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[9]
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