

P6_8 The Effects of Macroscopic Quantisation

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Abstract

In the video game *Minecraft* all matter is quantised into cubes of length 1 meter ($1m$). We examine the effects on the physical constants c , G , and \hbar in this universe were the Planck Length $1m$ long. If any of these values were changed to allow the Planck length to be $1m$ the consequences on gravity and on energy quantisation would be catastrophic.

Introduction

The popular video game *Minecraft* [1] is based in a world constructed almost entirely from cubes of length $1m$. Although in this game there are other smaller items we shall consider the implications on the world should all matter be quantised into such $1m$ cubes. The Planck Length is a subatomic and fundamental length which represents the shortest possible measurable distance by any physical process. The origins of the Planck Length are too detailed to be discussed here, but the quantity is inferred from the Generalised Uncertainty Principle [2] and has the value

$$l_P = \sqrt{\frac{\hbar G}{c^3}} = 1.62 \times 10^{-35} m \quad (1)$$

where \hbar is the reduced Planck constant, G is the gravitational constant, and c is the speed of light *in vacuo* [3]. It is widely believed these three values are constant across the Universe, but we shall examine the effects of each of these three “constants” in the *Minecraft* universe taking a different value to accommodate for the Planck length being exactly $1m$. It is also worth noting that matter as we know it, consisting of protons and neutrons etc. (all much smaller than $1m$), could not exist anyway if the Planck length were this large.

Changing c

In the instance where G and \hbar remain the same and c changes to facilitate the change in l_P we have the following equation for the new value of c :

$$c \rightarrow \sqrt[3]{\frac{\hbar G}{1m}} = 1.92 \times 10^{-15} m s^{-1}. \quad (2)$$

This reduced value for the speed of light would imply that light from the Sun would take $> 10^{25}$ years to reach the Earth [4]. As this is many orders of magnitude greater than the age of the Universe (1.34×10^{10} years [5]) we can deduce that in the *Minecraft* universe there would be no light from the Sun.

Another implication of this change is in the mass-energy equivalence equation $E_m = m_0 c^2$ where E_m is the rest mass energy of a particle, and m_0 is its rest mass [6]. Assuming then that the energy of each unique particle in this universe is the same as in ours, the rest mass of each particle must change by a factor of $\left(\frac{l_P}{1m}\right)^{-4/3} = 2.47 \times 10^{46}$. This would also have incredible consequences on the force of gravity. As gravity depends on the product of two masses the force from gravity in the *Minecraft* universe would be modified by a factor of $\left(\frac{l_P}{1m}\right)^{-8/3} = 6.00 \times 10^{92}$. In this instance the gravitational force between two protons would be 4.75×10^{56} times greater than the coulomb repulsion between them [7] [4]. If ϵ_0 were to increase to facilitate this reduced c , the Coulomb force would diminish even further. If this were the case then atoms would cease to exist, and instead electrons would be pulled in to the nucleus where they would combine with the protons to form neutrons. As neutrons have no coulomb repulsion, all of this baryonic matter would attract and most likely collapse to initially form some sort of neutron star, until a time when enough mass accreted to form a black hole [8]. This would obviously be disastrous for all life, and as such we can assume this is not the case in this fictional universe.

Changing G

It may be that in this fictional universe c takes the same value as in our universe. In this instance G may be the constant that differs. To accommodate $l_P = 1m$, G must take a greatly increased value of

$$G \rightarrow 2.55 \times 10^{59} m^3 kg^{-1} s^{-2}, \quad (3)$$

instead of $6.67 \times 10^{-11} m^3 kg^{-1} s^{-2}$ [4]. This would have a similar effect to the one described above wherein all matter would form black holes. The gravitational force between two protons would be 2.97×10^{33} times greater than the coulomb repulsion between them [7] [4].

Changing \hbar

The final fundamental constant that may take a different value in the *Minecraft* universe is the reduced Planck constant, \hbar , and as such h , the Planck constant, equal to $2\pi\hbar$. h is the ratio between the energy of an electromagnetic wave and its frequency and takes the value $6.63 \times 10^{-34} Js$ [9]. In the *Minecraft* universe h may instead take the value

$$h \rightarrow 2.53 \times 10^{36} Js. \quad (4)$$

A photon of a given frequency in this universe would have an energy 3.8×10^{69} times greater than the same photon in our universe. Visible light in such a situation would have an energy of between $1.01 \times 10^{51} J$ and $1.90 \times 10^{51} J$, roughly 7×10^{33} times the energy of the most powerful nuclear detonations in history [10]. This one photon would have the same energy as the Earth would receive from the Sun in over 2×10^{26} years.

Many other physical constants depend on the value of h and as such would also have different values. The rest mass of the electron would increase by a factor of 10^{69} ; the Avagadro constant would decrease by a factor of 10^{69} ; and the elementary charge, Bohr magneton, and nuclear magneton would all increase by a factor of 10^{35} [11].

Conclusions

It is obvious to see that changing any of the three parameters in Eq. 1 would have catastrophic effects on the universe. As such we can conclude with a great deal of certainty that could a universe such as the one in *Minecraft*, allow for living organisms to exist, it would be life, but not as we know it.

References

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