The reason for the cosmological constant discrepancy: An observation vs. theory

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Abstract

An attempt is made to solve the cosmological constant discrepancy problem by “untying” the Planck mass from the Planck length. As a consequence, the Planck constant is the only fundamental constant, in contrast to the gravitational “constant” and the speed of light “constant” which vary.

Introduction

A fundamental understanding of vacuum energy in the Universe is an important challenge for theory and connects the cosmological scale with the subatomic scale in physics. If one uses the naïve naturalness arguments of quantum field theory, then one cannot explain why the observed cosmological constant is so small, therefore the cosmological constant problem \([1, 2]\) arises. Quantum mechanical calculations that sum the contributions from all vacuum modes below the Planck scale ultraviolet cutoff give a vacuum energy density which this exceeds the cosmologically observed value by approximately 120 orders of magnitude \([1, 2]\).

The cosmological constant is not diluted as the Universe expands, whereas the matter density drops in inverse proportion to the volume \([3]\); this implies that there is only a fleeting moment of cosmological time during which the matter density will be of comparable magnitude to the vacuum energy density \([3]\). Many scientists argue that to be living in that particular moment is far too un-likely to be coincidence \([3]\); this is termed the coincidence problem and has motivated theories beyond the cosmological constant with more general forms of dark energy that may change with time \([3]\).

The cosmological constant is identified as

\[
\Lambda \sim 2 \times 10^{110} \text{ erg/cm}^3
\]

for theory and

\[
\Lambda \sim 2 \times 10^{-10} \text{ erg/cm}^3
\]

for observation \([1]\), which clearly differ. Thus, the conjecture is: the possible cause for the \(\Lambda\) discrepancy is the irrelevance between the three distinct Planck units.

Planck units are known as natural units because their definition originates solely from properties of nature and not from any human construct. Planck units are only one system of natural units among other systems, but are considered to be unique because these units are not based on properties of any prototype object or particle (that would be arbitrarily chosen), but rather entirely on the properties of free space. By definition, Planck units as universal constants must normalize to 1. Therefore, all quantities that ordinarily have dimensions involving length, mass, and time become dimensionless in Planck units. The speed of light constant in a vacuum is

\[
c = 2.99792458 \times 10^8 \text{ m/s}^{-1},
\]
the gravitational constant is
\[ G = 6.67384(80) \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-1}, \]
and the reduced Planck constant is
\[ \hbar = 1.054571726(47) \times 10^{-34} \text{ J s}. \]
Therefore, the Planck mass is
\[ m_p = \sqrt{\frac{\hbar c}{G}} \approx 2.17651(13) \times 10^{-8} \text{ kg}, \]
the Planck length is
\[ l_p = \sqrt{\frac{\hbar G}{c^3}} \approx 1.1616199(97) \times 10^{-35} \text{ m}, \]
and the Planck time is
\[ t_p = \sqrt{\frac{\hbar G}{c^5}} \approx 5.39106(32) \times 10^{-44} \text{ s}. \]

The physical significance of \( l_P \) is an argumentative topic of research. Therefore, research on \( l_P \) has been primarily theoretical. For example, in string theory, \( l_P \) is the magnitude order of the oscillating strings that form the elementary particles, so shorter lengths do not make physical sense. But string theory is only one approach to establishing a unified field theory and is not yet supported by experiment. An alternative unification candidate is loop quantum gravity, which competes with string theory. In loop quantum gravity, the area is quantized so the Planck area is the smallest possible area value within a factor of order unity.

**Thought Experiment**

My proposal is to “untie” \( m_P \) from \( l_P \), which is based on the “common sense” defined below:

- If \( m_P \) remains the same and \( \hbar \) is constant, then \( G \) and \( c \) can vary simultaneously.
- We don’t have any guarantee that \( G \) and \( c \) are
  - eternal constants during the evolution of the Universe;
  - dependent or independent of each other;
  - both dependent on the vacuum energy density; and
  - two sides of the same coin.

Thus, we do not have proof that \( A \) is constant. Therefore, imagine that \( G \) and \( c \) can vary simultaneously because the vacuum energy varies according to the temporal evolution of the Universe (see Figure 1). So why is it that most physicists are naïve enough to believe that the

1. Schwarzschild black hole radius is \( R = \frac{G}{c^2} \) if \( G = f(c)^2 \);
2. \( l_P = \frac{c}{c^2} \) if \( G = f(c)^3 \);
3. \( t_P = \frac{G}{c^5} \) if \( G = f(c)^5 \); and
4. \( m_P = \frac{c}{G} \) if \( G = f(c)^3 \)?
What is the correspondence to nature? If there does exist such a correspondence, then it would be absurd in all conceivable versions. In my opinion, #4 is the only true statement, which is the “linear link” between the synchronously varying $G$ and $c$; #1, #2, and #3 are false statements that are teasing physicists!

Therefore, this thought experiment and analysis suggests that physics equations may be simplified if they only assume $c = \hbar = 1$ so the energy, momentum, and mass share the same dimension. Likewise, $l_p$ and $t_p$ also have the same dimension. This proceeding lets us measure all physical values in terms of mass or energy units. Hence, in the case that $G$ and $c$ do vary simultaneously and $\hbar$ is constant, this reception does not work. Also, the fundamental difference arises between $m_pl_p$ and $E_pl_p$, where

$$E_pl_p = m_pl_p \times \var(c)^2.$$ 

Figure 1: The simultaneous variation of $G$ and $C$ in accordance to the exponential law.

![Figure 1](image)

Depiction of the Universe expansion (left - picture 1); depiction of the $G$ and $c$ simultaneous variation (center - picture 2); depiction of the time variation (right – picture 3).

**Conclusion**

In this paper, we determined that the

1. Planck mass is the only acceptable natural unit, and
2. Planck constant is the only acceptable fundamental constant.

**Inquiry**

Is the solution to the many unsolved problems in physics hidden in the disclosure of Planck scale dogmas?

**References**

