Time variation of a fundamental dimensionless constant

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We examine the time variation of a previously-uninvestigated fundamental dimensionless constant. Constraints are placed on this time variation using historical measurements. A model is presented for the time variation, and it is shown to lead to an accelerated expansion for the universe. Directions for future research are discussed.

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I. INTRODUCTION

Physicists have long speculated that the fundamental constants might not, in fact, be constant, but instead might vary with time. Dirac was the first to suggest this possibility [1], and time variation of the fundamental constants has been investigated numerous times since then. Among the various possibilities, the fine structure constant and the gravitational constant have received the greatest attention, but work has also been done, for example, on constants related to the weak and strong interactions, the electron-proton mass ratio, and several others.

It is well-known that only time variation of dimensionless fundamental constants has any physical meaning. Here we consider the time variation of a dimensionless constant not previously discussed in the literature: π. It is impossible to overstate the significance of this constant. Indeed, nearly every paper in astrophysics makes use of it. (For a randomly-selected collection of such papers, see Refs. [2, 3, 4, 5, 6, 7, 8, 9, 10]).

In the next section, we discuss the observational evidence for the time variation of π. In Sec. III, we present a theoretical model, based on string theory, which produces such a time variation, and we show that this model leads naturally to an accelerated expansion for the universe. The Oklo reactor is discussed in Sec. IV, and directions for future research are presented in Sec. V.

II. EVIDENCE FOR TIME VARIATION OF π

The value of π has been measured in various locations over the past 4000 years. In Table 1, we compile a list of representative historical measurements [11]. We see evidence for both spatial and time variation of π. We will leave the former for a later investigation, and concentrate on the latter. In Fig. 1, we provide a graph illustrating the time variation more clearly. The values of π(t) show a systematic trend, varying monotonically with time and converging to the present-day measured value. The evidence for time variation of π is overwhelming.

![Graph showing time variation of π](http://example.com/graph.png)

FIG. 1: The value of π relative to its present-day value, π₀, as a function of t - t₀, where t₀ is the present time. Time is measured in years, and the quantity plotted on the vertical axis has been chosen to make the time variation appear larger than it really is.

TABLE I: The value of π measured at the indicated location at the indicated time.

| Location  | Time   | π(t)   |
|-----------|--------|--------|
| Babylon   | 1900 BC| 3.125  |
| India     | 900 BC | 3.139  |
| China     | 263 AD | 3.14   |
| China     | 500 AD | 3.1415926 |
| India     | 1400 AD| 3.14159265359 |

III. A THEORETICAL MODEL

Inspired by string theory [12], we propose the following model for the time variation of π. Consider the possibility that our observable universe is actually a 4-dimensional
brane embedded in a 5-dimensional bulk. In this case, “slices” of $\pi$ can leak into the higher dimension, resulting in a value of $\pi$ that decreases with time. This leakage into a higher dimension results in a characteristic geometric distortion, illustrated in Fig. 2. Such “leakage” has been observed previously in both automobile and bicycle tires. However, it is clear that more controlled experiments are necessary to verify this effect.

It might appear that the observational data quoted in the previous section suggest a value of $\pi$ that increases with time, rather than decreasing as our model indicates. Since our theoretical model is clearly correct, this must be attributed to 4000 years of systematic errors.

Now consider the cosmological consequences of this time variation in $\pi$. The Friedmann equation gives

$$\frac{\dot{a}}{a} = \sqrt{\frac{8\pi G \rho}{3}},$$  \(1\)

where $a$ is the scale factor and $\rho$ is the total density. At late times $\rho$ is dominated by matter, so that $\rho \propto a^{-3}$. Hence, if $\pi$ increases faster than $a$, the result will be an accelerated expansion. Of course, our model gives the opposite sign for the time-variation of $\pi$, but this is a minor glitch which is probably easy to fix.

This model for the time variation of $\pi$ has several other consequences. It provides a model for the dark matter [14], and it can be used to derive a solution to the cosmological constant coincidence problem [15]. Further, it can be developed into a quantum theory of gravity [16].

IV. THE OKLO REACTOR

No discussion of the time-variation of fundamental constants would be complete without a mention of the Oklo natural fission reactor.

V. DIRECTIONS FOR FUTURE INVESTIGATION

This investigation clearly opens up an entirely new direction in the study of the time variation of fundamental constants. The next obvious possibility is the investigation of the time variation of $e$. Following this, there is a plethora of other constants that could be examined: the Euler-Mascheroni constant $\gamma$, the golden ratio $\phi$, Soldner’s constant, and Catelan’s constant. More speculatively, one might consider the possibility that the values of the integers could vary with time, a result suggested by several early Fortran simulations. This possibility would have obvious implications for finance and accounting.

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[16] R.J. Scherrer, I haven’t actually done this yet, but I do have a title for the paper picked out.