Re: THIS STATEMENT HAS NO PROOF IN ANY SYSTEM = true or false?

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From: John Baez (*baez_at_math−cl−n03.math.ucr.edu*)
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Date: Thu, 3 Feb 2005 20:52:47 +0000 (UTC)
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In article <1107418335.324750.294210@o13g2000cwo.googlegroups.com>,
Keith Ramsay <kramsay@aol.com> wrote:

>examachine@gmail.com wrote:

>| I think the evidence for a discrete world far outweighs the evidence
>| for a continuous world, which is basically non−existent.

>On the contrary, there's essentially no evidence that the
>world is discrete. Really, there's not much that could
>reasonably be called evidence in either direction.

Hi, Keith.

Indeed, there's not a shred of experimental evidence that "the world is discrete". If you take quantum theory seriously, it's natural to guess it applies even to the geometry of spacetime, and this would mean that you can't simultaneously measure everything about the geometry of spacetime with arbitrary precision. But, that's not yet "discreteness". Quantum theory allows for lots of options.

For example, in ordinary quantum mechanics you can't measure the position and velocity of a particle both at the same time with arbitrarily good precision, but there's nothing "discrete" going on here. You can measure either the position or velocity with as much precision as you like, and they don't come in discrete steps.

There are other quantum systems, like the energy levels of an atom, that show a kind of discreteness − though not the naive discreteness of evenly spaced steps.

And while a bunch of people including myself have worked on theories where area and volume are "discrete" in about the same way as the energy levels of an atom:

Loop Quantum Gravity

http://math.ucr.edu/home/baez/acm/

these are still theories, not "evidence" of discreteness. And, they
are highly controversial theories!

>If the world were discrete, one could hope to observe the
>fact by examining it at a small enough scale. In principle,
>then, one should be able to model it at that level. But none
>of our best actually working models of the world is entirely
>discrete.

Right.

>The approach to quantum gravity known as "spin networks"
>comes close, but still the state of a system is
>a superposition of states, where the weights can vary
>continuously. John Baez has pointed out that it's also
>consistent to have both a model such as the spin network
>model and a model in which the states are treated as having
>continuous space. The model is discrete in some respects
>and continuous in others.

Right. And, the spin network theory of quantum gravity has not
received any experimental confirmation thus far.

>| There is also something called Heisenberg's uncertainty principle. Why
>| would I believe that something exists beneath the Planck scale, while
>| our physics tells us that you cannot physically subdivide the Planck
>| scale.

>Where does it say that? The Planck length is simply a length
>small enough that to model physics on that scale, quantum
>gravity effects have to be taken into consideration.

Right. And in fact, even this is just a guess. To be very clear,
we should admit that the Planck length is the simplest quantity
with units of length that we can cook up from the speed of light (c),
Newton's gravitational constant (G), and Planck's constant (hbar).
It's about 1.6 x 10^{−35} meters.

By dimensional analysis, we can *guess* that if quantum gravity
effects become important at some length scale, it's around the
Planck length.

But, this guess assumes that no other physical quantities are
important in determining this length scale! E.g., not the mass
of the electron, or anything else like that.

So, this guess could easily be wrong. And, it's important to
remember that we don't have any direct evidence for what happens
at the Planck scale, or even length scales much bigger than this.

The diameter of a proton is about 10^{−15} meters. We've done experiments that probe much shorter distance scales, but they're still vastly larger than the Planck length.

I always forget how short are the distance scales we've probed so far... let me work it out. Cheating, I'll start by looking in T. D. Lee's book on particle physics, in the chapter "Order−of−Magnitude Estimates"... let's see... good! He says the electron mass is .51 MeV, and that this corresponds to (4 x 10^{−11} cm)^{−1}, where he's using c and hbar to convert energies to inverse lengths. So, doing particle collision experiments at an energy of .51 MeV we can probe distance scales of about 4 x 10^{−13} meters. Or, roughly, 1 Mev corresponds to 10^{−13} meters. That's what I should remember! Anyway, the best accelerator in the world is still LEP (until LHC comes online), and that reached energies of about 113 GeV. So, roughly 100 GeV, or 10^5 MeV − so distance scales of about 10^{−18} meters.

So, unless I made a stupid mistake, we can currently probe distances about 1/1000th the size of a proton, and we haven't seen any trace of spacetime discreteness...

... but these length scales are still about 10^{17} times as big as the Planck scale!

So, when we are speculating about what happens at the Planck length, we are extrapolating our ideas on physics to distance scales that are 100,000,000,000,000,000 smaller than anything we have experimental access to, and hoping that nothing really unexpected happens at these shorter distances!

This is a wild extrapolation. Physicists indulge in it mainly because it's more fun to think about what physics would be like at these distance scales based on what we know, than to throw up our hands in despair give up.

So, I would not say "our physics tells us that you cannot physically subdivide the Planck scale".

>In some sense I would say all of this is fairly irrelevant
>to the meaningfulness of the continuum hypothesis.

Wow! Is that what you guys were talking about? I would never have guessed. Yeah − fairly irrelevant!!!

By the way, I hope someone pointed out that the capitalized statement in the subject of this thread is false, and provably false in, say, Peano arithmetic.