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Wednesday, 29 December 2010

The Unseen Universe Gets Much Weirder (Very OT!)

By **Ctein**

Last week I talked about dark matter. People may want to reread that column (and, importantly, my additional remarks in the comments) to refresh their memories, but here's the short summary:

There are numerous experimental observations and theoretical calculations that tell us that the universe should have a lot more mass than what we see. The best and most complete models to date tell us that not only do we not see it, we *can't* see it. Or touch it. In those respects, it is like neutrinos, but it is not neutrinos. Because of gravitational light-bending, though, we can make "photographs" of that unseen matter.

Amazing though this may be, it's not unprecedented in astronomy. The whole point of looking "out there" is to see things that we'd never see on earth. The second most abundant element in the universe, helium, is 10 times more abundant as all the other elements (save hydrogen) combined. It wasn't discovered on Earth because there's a lot less of it here and it's chemically inert. Dark matter is electromagnetically inert; it's no surprise we didn't notice if, even if is a bit of a shock to find out there's more of it in the universe than anything else we know, by a factor of five.

So, yeah, we learned something new and cool about the universe, but it didn't turn our basic preconceptions topsy-turvy.We just don't know many details about it.

But there's stuff that we don't understand at all, and it is really messing with our collective scientific heads. Once again, a little background:

Once cosmologists agreed that the universe was expanding and that the Big Bang theory was basically correct, they started to ask the Big Question: what ultimately happens to the universe? Does it keep expanding forever, slow to a stop, or even eventually reverse direction and fall back in on itself?

The question is analogous to launching a model rocket straight up and wondering if it will escape Earth's gravity. It's simple high school physics to solve that problem; you can measure the velocity of the rocket at various altitudes, do a little algebra, and figure out if your projectile will run out of steam or if it keeps on going forever. We can ask the same question about the entire universe; is the expansion rate so great that there isn't enough mass in the universe to pull everything back in, in which case it keeps expanding forever? Or not?

Cosmologists make their experimental measurements much the same way we did our high school experiment—they measure the velocities of objects at different distances from the earth, plot them out, and see what those curves give as a terminal velocity. A nice side result is that you can back-calculate from those curves when everything started. It's a twofer: you not only find out what the ultimate fate of the universe is but you find out how old it is. All you need is a bunch of velocities and a bunch of distances.

The first is easy. We take spectra and measure the Doppler shift (a.k.a. red shift) of emission and absorption lines in the spectra. Piece o' cake.

The second is very hard. We have no direct way of measuring the distance of objects that are really far away. We can only estimate indirectly. Happily, there are a few kinds of astronomical objects we can use as references. Astronomers call them "standard candles;" objects that we understand well enough to know how bright they really are. We can use them to determine distance, because we can measure how much light we receive from them, compared to how much light we know they emit, and apply the inverse square law.

These are difficult measurements. Our knowledge of the intrinsic brightnesses is not perfect. Things like interstellar dust absorb some of the light. It takes hard work and a lot of time to get good measurements. That was one of the jobs of the Hubble Space Telescope, to collect such measurements, and it came through like a trooper. We now know the age of the universe to within about 1%; before Hubble, astronomers were arguing over ± 50%. Hubble also confirmed something that had been suspected, which is that there seems to be just about enough matter (both light and dark combined) in the universe to balance the expansion rate, what cosmologists call a "flat universe."

That in itself is kind of curious, and there's a whole bunch of interesting physics work that is been done to explain that as more than coincidence. But that is not the topic of this column.

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As part of the business of understanding just exactly how "flat" the universe was, some astronomers started making ever-more-difficult measurements of ever-more-distant objects. About a dozen years ago, two different groups came up with the same unexpected answer (since confirmed by many other scientists and experiments). When the universe was about half as old as it is now, the expansion started *speeding up*.

That's wrong; that's really, really wrong.

It would be like doing our model rocket experiment, and when the rocket got about a mile up it started to move faster and faster even though it was out of fuel. Shades of Cavorite! That just can't happen with any physics we understand. How could gravity turn off and antigravity turn on for the universe?

Short answer? We really don't know. But we need a handle to hang on it just so we can talk about it. That handle is "dark energy." It's only a placeholder. While "dark matter" is an physically-accurate term—it's lumps of stuff we can't see that exert gravity—"dark energy" means nothing. We could just as readily call it "oobleck." The term is referential to "dark matter" (i.e., matter pulls stuff together while energy pushes it apart), but it doesn't tell us anything about the physics. We have no idea what is really behind this.

We have many theories. We physicists are good at creating theories. As I explained to a friend once, give me incontrovertible reason to believe the sun will rise in the west tomorrow morning and before dawn I will have come up with at least three physically plausible explanations for that that don't involve destroying the Earth or killing everybody on it. But just because we can come up with theories doesn't mean those theories are correct. They need to be supported with data, and we are much lacking in that.

One possibilities is that gravity leaks a little bit into the higher dimensions predicted by brane theory. In which case the strength of gravity would fall off a little bit faster than $1/r^2$ at long distances, and so it might become weak enough that stuff winds up moving faster.

Or maybe it's associated with a hypothesized fifth force called "quintessence." It's never been found experimentally but exists in some New Physics theories to explain some peculiar observations.

Or it may be an inherent property of the vacuum, *à la* Einstein's "cosmological constant." But that was just a term stuck in an equation; we have no idea what it means physically.

Or perhaps it's some aspect of vacuum energy. That's an irreducible amount of energy that exists in "empty" space time as a consequence of the uncertainty principle. We know vacuum energy exists; we've been able to measure its effects in the laboratory. (If you care to learn more, look up "Casimir effect.") Vacuum energy is the ordinary kind, not this weird expansive stuff, but we know we don't understand vacuum energy.

That's because we can calculate what the vacuum energy should be from quantum mechanics and compare it to the value we measured: about $10^{(-15)}$ joules per cubic centimeter of space (a joule is the amount of energy conveyed by one watt in one second; e.g., a kilowatt hour equals 3,600,000 joules).

When we calculate vacuum energy from quantum mechanical first principles, we get a slightly different answer: $10^{(107)}$ joules/cc. No, that's not a typo—our calculations differ from the experimental values by a modest factor of 10 to the 122nd power. This currently holds the record for the largest and most embarrassing error in physics. We have no idea what we're doing wrong, but clearly we are lacking a huge clue. So vacuum energy could be tied to dark energy; we don't know enough to say it isn't.

In other words, there's a huge amount of arm waving going on right now and we don't know what the answers are.

One thing we can do is measure the amount of this strange dark energy effect, just as we can measure how much our rocket is mysteriously and inexplicably accelerating. It's about three times stronger than all the mass in the universe combined. In other words, we (namely, baryons) are only 1/5 of all the matter in the universe, and all the matter in the universe is only about one quarter of the entire universe. Give or take a bit.

In summary, we—the ordinary and familiar stuff—comprise about 5% of the universe, another 20-odd percent of the universe consists of stuff we haven't met yet (although we know about its close cousins, neutrinos), and the remaining 70+% is currently an absolute and utter mystery.

Solving that mystery is the biggest question in physics for the 21st century. Dark matter is small potatoes; we probably do not need especially new physics to understand it, although we still need to find the stuff. Dark energy might just turn out to be a refinement of what we already know, but it's equally possible that it will utterly change the way we look at physical reality.

So much for this season's holiday columns. Next week I shall return to more mundane* matters.

Ctein

*[*Ctein's usage of this word is precise—it derives from the late Latin* mundanus, *and means "Of this Earthly world." —Ed.*]

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Ctein is a Caltech-trained physicist who has been writing for photography magazines for many years. He was one of the core writers of Darkroom Photography *and a Contributing Editor of* Photo Techniques *magazine, among others. His writings on photography encompass scientific and technical articles as well as popular ones. He is also the author of articles about display and printer technologies, electro-optics, web publishing, computer languages and hardware platforms. He has written two books about photography,* Post Exposure: Advanced Techniques for the Photographic Printer *and* Digital Restoration from Start to Finish*. His other interests include science fiction, astronomy, and parrots. His weekly column for TOP appears on Wednesdays.*

Posted on Wednesday, 29 December 2010 at 02:31 PM in Ctein | Permalink

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Comments

"This currently holds the record for the largest and most embarrassing error in physics."

I presume the medal is given at the annual banquet held by The Journal of Irreproducible Results.

Patrick

Posted by: Patrick Perez | Wednesday, 29 December 2010 at 02:52 PM

Ctein-

Feel free to continue in this vein if you wish. A physicist who can explain *anything* clearly is always an enjoyable read.

Posted by: Rob R | Wednesday, 29 December 2010 at 03:02 PM

Could some of this explain the Pioneer Anamoly?

Posted by: KeithB | Wednesday, 29 December 2010 at 03:26 PM

It's OK Ctein, probably turn out to be 'just turtles all the way down'

Posted by: john Robison | Wednesday, 29 December 2010 at 03:30 PM

Not off topic, off orbit, I like photography, sorry....GB

Posted by: glennbrown | Wednesday, 29 December 2010 at 03:37 PM

Bah, ten to the 122nd power is nothing. The "ultraviolet catastrophe" of the late 19th century predicted that stars should emit INFINITE amounts of energy, and we managed to wiggle our way out of that. All it took was quantum mechanics.

As you point out, the answer may already exist in current physics but we haven't tweezed it out yet. One of my favorite terms is "renormalization", which, as far as I can tell, means "do whatever you need to do to the model to make the problem go away". Works like a charm :-)

Posted by: Kevin Bourque | Wednesday, 29 December 2010 at 03:38 PM

Hell yes.

Posted by: Christian | Wednesday, 29 December 2010 at 03:59 PM

Personally, I believe, and this is hard to understand for most (and it hurts my head when I try) that the universe is a constant. It has always existed, will forever exist, did not start, will not end, it has no size, it is in all dimensions infinite. We can look in the micro and find ever smaller particules composed of ever smaller other particules. We can look in the macro and find that our galaxy is but a particule of a cluster of galaxies, that are probably clusters of mega clusters.
The concept of time is just something we force upon it. The expansion we detect? It's a localised to our little back garden. And the big bang? Maybee it happened, or it is just a working theory untill we find better. And what if the big bang was like one of those particules that pop up out of vaccum, out of nothing, but on a scale so massive that we are incapable to see beyond the bubble that it created.

Oooh, I need an aspirin now...

Posted by: gildasd | Wednesday, 29 December 2010 at 04:09 PM

Extremely interesting stuff, Ctein, even for someone like me: I'm a biologist (who, truth be told, are only specialized physicists, but that's another story).

Reading your article, I immediately recalled the recent selection of Top 10 scientific stories of 2010, published by the very influential Science magazine. I guess you are well aware, but just in case, this is their top 1:
http://news.sciencemag.org/sciencenow/2010/04/does-our-universe-live-inside-a-.html

And this is the article providing the full information for that hypothesis:
http://dx.doi.org/10.1016/j.physletb.2010.03.029

I would love to read your explanations, Ctein, from the content described the above article.

Posted by: Cateto/Jose | Wednesday, 29 December 2010 at 04:24 PM

Dear Patrick,

Heh. For all I know, it's already gotten one. This error's been on the books for decades, now. Many, many attempts to make the maths come out vaguely congruent with reality; no fixes that have been generally accepted.

It's a bit, ummm, awkward. We've got QM methodology that's been checked against reality to better than 10 decimal places. And this one's off by 122 zeroes.

~~~~~~~~

Dear Keith,

Great question!

The "Pioneer Anomaly" is that the Pioneer spacecraft, which is currently about half a light-day from earth as I recall, is very slightly off its predicted course.

Lots of things can slightly alter the course of a spacecraft-- light pressure from the sun on solar panels and radio antennae, the solar wind, even the impact of interplanetary dust. But when everything we can think of is taken into account, Pioneer is still drifting a bit.

So all that seems to be left is a gravitational pull we haven't taken into account. That could be some unseen body... but it remains unseen and undetected.

A dark matter chunk? 'Cept we don't really expect dark matter to condense very well, for the reasons I discussed last time.

Or it could be that gravity doesn't work exactly as expected on that scale? Difficulty is that it's not a scale where we have any alternate theories. MOND operates on a scale on tens of thousands of light years, with very different accelerations. If it were messing with Pioneer, it would mess with a whole bunch of other locally-observable stuff. Which it doesn't. The dark-energy-ish kinds of effects only show up on a scale of millions of light years, not fractions of a light day.

Or it could be some ordinary perturbing effect we haven't accounted for yet.

Which is why we call it an Anomaly [g].

pax / Ctein

Posted by: ctein | Wednesday, 29 December 2010 at 04:33 PM

Here's my take on cosmology: that our knowledge of the universe is absolutely, utterly remarkable, analogous to the ants in an anthill in my backyard knowing what the local bus schedule is (even though they have some of the routes and some of the times wrong, and they don't know where the busses go at night or how they manage to keep running). And the ants like to argue amongst themselves about whether there are busses in the next town over, or just here.

This is not a scientific opinion. [g]

I'm just sayin',

Mike

Posted by: Mike Johnston | Wednesday, 29 December 2010 at 04:38 PM

This video shows a useful application of the concepts :-)

http://www.youtube.com/watch?v=lSioSWz-u68

Posted by: Leigh Perry | Wednesday, 29 December 2010 at 05:32 PM

I just read "The Grand Design" by Hawking and Mlodinow, link below.

http://www.amazon.com/Grand-Design-Stephen-Hawking/dp/0553805371/ref=sr_1_1?ie=UTF8&qid=1293671430&sr=8-1

I took two years of physics in the mid 1970's and it seems that a lot has changed in 35 years. It was a great book, but if you don't grasp quantum theory, (or even if you do somewhat) this book will make your brain hurt.

As for me I'll second "just turtles all the way down"...

Posted by: Al Patterson | Wednesday, 29 December 2010 at 07:14 PM

Dear Glenn,

I fear you must be prepared for disappointment. Mike and I had a disagreement sometime back over this issue. He was convinced the readership would like to see me write occasionally off-topic. I was pretty sure they wouldn't. So he ran a reader poll, and about 2500 votes later we had a result:

Two in seven readers wanted me to write off topic. Four in seven wanted me to write on or off topic, as I chose. One in seven wanted me to stick to photography.

The populi has voxed; you are in a very small minority.

So, this is going to keep happening every month or so, as the muse strikes.

Believe me, I do appreciate your pain. Going an entire week without a new photographic column from me to read. The horror, the horror.

~~~~~~

Dear Kevin,

Indeed, that is part of the vexation. Renormalization has been incredibly successful (as I said, to 10 decimal places or more) for 50 years. It remains a mathematical manipulation that we have no proper physical understanding of. It seems like an arbitrary trick of arithmetic that can pull rabbits out of hats, and every time there is a rabbit in the hat, and, you know, by now we would really like to know WHY.

That's a big part of the reason why solving the zero point energy problem with a mathematical trick isn't very appealing. We already rely on one trick that we don't understand. Adding another one does not seem at all satisfactory.

~~~~~~

Dear Gil,

That is, in fact, not too far from the standard line of thinking by physicist today. There's just a bit of a vocabulary problem. We've decided to limit the term “universe” to refer to that bubble of space-time we inhabit, not the Other Thing it popped out of. We do believe that other universes, possibly even an infinite number of them, pop out of whatever our bubble is immersed in; figuring out how all of this works and experiments that we can build to look for it is a very hot topic in physics today.

The common way of speaking of it is that there are lots and lots and lots of "universes" appearing out of Something Else. I know that “lots of universes” is a bit of a linguistic oxymoron. Rather like “jumbo shrimp.”

Still, they are tasty and their existence is undeniable when they're lying on your plate.

pax \ Ctein
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Posted by: ctein | Wednesday, 29 December 2010 at 08:19 PM

"...a biologist (who, truth be told, are only specialized physicists, but that's another story)."

My high school physics teacher liked to say that you should study physics because that's really all there is. Everything else is just higher level effects of physics.

I kind of like that, myself.

Posted by: David Bostedo | Wednesday, 29 December 2010 at 10:17 PM

Ctein's writings are understandable, the words flow as if he is lecturing to students who neither understand nor comprehend anything beyond the end of their nose.

Perhaps then:
"This currently holds the record for the largest and most embarrassing error in physics."

Said error can always be utilized as an example of what happens when things are allowed to remain wrong.

The only constant we humans have is life itself which may end in an instant.

For proof just ask the nearest cockroach.

Posted by: Bryce Lee | Wednesday, 29 December 2010 at 10:28 PM

Dear Ctein
"our calculations differ from the experimental values by a modest factor of 10 to the 122nd power."
>Well, nothing's perfect.
"In summary, we—the ordinary and familiar stuff—comprise about 5% of the universe, another 20-odd percent of the universe consists of stuff we haven't met yet (although we know about its close cousins, neutrinos), and the remaining 70+% is currently an absolute and utter mystery."
>At the turn of the 19th to the 20th century we knew little of the 5%, none of the 20% and attributed the rest to God. Our progress in knowing what we don't know over the course of a century is inspiration enough to keep theory spinners at their wheels.
bd

Posted by: Bob Dales | Wednesday, 29 December 2010 at 10:54 PM

"All models are wrong, some models are useful." One of the few quotes from university that I actually recall, as it seems relevant many (most?) days.

The other thing to consider is that perhaps, as a species, we are just not smart enough to fully understand the universe. Would that be so bad? I'm not sure. We seem to have enough trouble getting along on this little planet of ours.

For what it's worth, I've enjoyed this little excursion of the blog. But then, I own a copy of "A brief history of time", so perhaps that is some sort of indicator. Though, some of that book seems rather behind the times now.

I do seem to recall Hawkins mentioning that humans trying to understand the universe is a bit like the universe thinking about itself... maybe it needs a shrink.
~~~~~~

Happy New Year. :)

Posted by: Bjorn | Thursday, 30 December 2010 at 01:16 AM

I guess Douglas Adams was just about right:

"There is a theory which states that if ever anyone discovers exactly what the Universe is for and why it is here, it will instantly disappear and be replaced by something even more bizarre and inexplicable.

There is another theory which states that this has already happened."

Except that it happens as we discover stuff. A version of this idea you can find in the novel *Definitely Maybe* by Arkadi and Boris Strugatki. Of course, it's not science but it does inspire some new controvesial theories like this one:

http://www.technologyreview.com/blog/arxiv/24975/

Posted by: ggl | Thursday, 30 December 2010 at 01:34 AM

Dear CTein

The bubble bath theory strikes me as way too simple and "human". I do not think that there are multiple universes, that's for science fiction. but a single simple "Universe" that our experience and instruments limit us to our little expanding bit.

The unseen mass/energy could be, in part, explained by this infinite beyond our perception, but that still affects us throu gravity and other phenomenons.

I think our "local universe" is a single randomn raisin in an infinite raisin cake "the Universe". And the most interesting thing is not the raisins, but what the hell is between them.

It's not yeast, flour, water, eggs and sugar. But it would be great if it was. And tasty.

Posted by: gildasd | Thursday, 30 December 2010 at 03:22 AM

in fact you could it this way;

Universe = X(∞ Raisins) + Y(∞ Water x ∞ Yeast x ∞ Flour x ∞ Eggs)

The mass of X and Y being roughtly equal.
In this equation, we have a very vague idea of one of ∞ Raisins...
And for all I know it could be a fruit cake. So how do we apply our physics knowledge of a raisin to a cherry or an apple. Because the Universe is not sentient, so probably a lousy cook, and put the apple whole in the mix.

And coconuts too.

Posted by: gildasd | Thursday, 30 December 2010 at 03:40 AM

One of the arguments put forward by the bean counters to kill the space program was that we already know enough of the universe and physics to be spending much in learning more.
Much easier to offshore everything to China and India. Including our brains.
Ctein: feel free to talk about this interesting stuff anytime you feel like it.
Most welcome and no, not all the engineers have died yet.

Posted by: Noons | Thursday, 30 December 2010 at 04:36 AM

Thanks for taking this subject up, Ctein. While I heartily believe that there are many kinds of intelligence and that all have value, astrophysics always seemed to be the most intelligent kind of intelligence. Mostly because I can't get my head around it.

Posted by: Plannerben | Thursday, 30 December 2010 at 07:57 AM

Dear Ctein,
I enjoy very much your OT posts. These last two have been especially interesting. As a young child I often wondered, if I was in a spaceship that reached the edge of space, what was on the other side of the edge.

Your writing style is very readable, I learn a lot, and it adds to the value of T.O.P. and is part of what keeps me coming back every day. I too am mostly interested in photography, I love Mike's writings, and hope that TOP stays mostly photo oriented. But your occasional OT contributions are a plus. Thanks for the good work.
- cj

Posted by: Clayton Jones | Thursday, 30 December 2010 at 08:23 AM

My layman unscientific take on the universe is that the void of space has always existed, will always exist, is eternal and timeless, and when we refer to God we are really referring to that, the infinite void. Our known universe exists within the void and it is finite and expanding but it will always be finite because it can't expand beyond the void, or God, which is infinite.

Our universe is the only known universe but it is just one universe among untold billions of universes within the void. Universes are like bubbles that expand for billions of years before eventually contracting to a solitary point and disappearing, but there are still billions of universes in existence left behind, and new universes are continually being created.

Posted by: Player | Thursday, 30 December 2010 at 10:11 AM

All I know is that all this experimental observation is putting more strain on the master builder, having to fill in more and more of the back lot with meaningful stuff that previously was just held together by force of will.

It may come as a surprise to you to know that atoms did not exist prior to the 1890s, when they had to be invented to fit the observations of Dalton, Thompson, Planck et al.

Posted by: David Bennett | Thursday, 30 December 2010 at 12:36 PM

Dear Player,

The data we have so far says that our particular universe will never collapse back into a point, but that is obviously subject to change given that we only know a small amount about dark energy so far. Check back with me in 10 or 25 years.

There is a general belief that lots, probably even most, of the bubble universes do what you say. Either they don't start out big enough to inflate, and so they never achieve “escape velocity,” or they are so massive that they collapse back in on themselves before dark energy can dominate over gravity.

Understand that that is merely a belief. We still know relatively little about the physics of universe creation or inflation. The default assumption in such circumstances is that there are no constraints on what can happen, but as we learn more we might very well discover that certain types of universes are favored over others.

God does not enter into it. Theology and physics coexist. They do not particularly intersect... except in the minds of folks who do not understand one or the other very well.

A good place to recommend one of my favorite books: GOD'S MECHANICS: HOW SCIENTISTS AND ENGINEERS MAKE SENSE OF RELIGION by Brother
Guy Consolmagno (bias alert: Guy is a friend and I am one of the subjects of the book). Guy is a former MIT physicist who got the calling in adulthood, became a Jesuit, and is now an astronomer attached to the Vatican, specializing in meteorites. He's published a fair number of fascinating essays and articles online; you can Google them.

pax \ Ctein
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Posted by: ctein | Thursday, 30 December 2010 at 01:41 PM

Dear Bryce,

Just to be sure we're clear: no one has intentionally “allowed [this] to remain wrong.” The vacuum point energy problem is not only intellectually irritating, but anyone who manages to resolve it pretty well has their career made. The whole business of renormalization is VERY frustrating: we stumbled on a magic trick that gives us the right answers, yet even after half a century of intense study we have no idea why that trick works or if it even has any connection to physical reality. That is not a happy state of affairs for physicists.

This is not an error that has been allowed to remain; it's an unsolved problem. There is quite a difference.

~~~~~

Dear Mike J.,

Not too far off, really. What's especially interesting is that the physicist ants are starting to deduce the hypothetical properties of buses and even beginning to develop ideas for experiments to study the buses over in the next town to see how they compare with ours. Furthermore, there appear to be rare and peculiar entities known as “greater metropolitan area” buses that would tell us even more about the nature of buses in general and whether our local ones are peculiar or not.

Some ants speculate on the possibility there might even be interstate buses. But they're just crazy.

Let's not mention the airplanes.

pax \ Ctein
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Posted by: ctein | Thursday, 30 December 2010 at 02:00 PM

Thanks for this posting Ctein, very interesting. Could you answer a question that it raised for me - is the "dark energy" you refer to the same as the "dark flow" alluded to here:
http://news.nationalgeographic.com/news/2008/11/081105-dark-flow.html
Thanks for considering.

Posted by: Patrick Dodds | Thursday, 30 December 2010 at 06:02 PM

How many of you believe that we are alone in the universe(s)?

I think it's next to impossible that we're alone.

Talk of astrophysics always makes me ponder this question.

Keep 'em coming, Ctein, as long as Mike tolerates you! :)

Posted by: Michael Sebastian | Thursday, 30 December 2010 at 06:29 PM

Dear Patrick,

Nope it's not the same thing-- "dark" is becoming synonymous with "mysterious" in cosmological nomenclature. This is more like the Pioneer Anomaly discussed previously, except a zillion times bigger.

But... it might turn out that dark flow is being caused by some aspect of dark matter or dark energy. We don't know enough yet to say one way or the other.

pax / Ctein

Posted by: ctein | Friday, 31 December 2010 at 12:20 AM

Ctein, perhaps the "eternal void" could at least be a metaphor for enlightenment if not the very essence of God :).
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And yes, I am one who does not understand theology and/ or physics very well.

Thankyou kindly for the book referral.

Posted by: Player | Friday, 31 December 2010 at 01:35 AM

"Or it may be an inherent property of the vacuum, à la Einstein's "cosmological constant." But that was just a term stuck in an equation; we have no idea what it means physically."

I'm really struck by the words, "what it means physically". Gravity for example: We can see the effects of it, but to actually "see" it in the physical sense, is something I'm not aware we can do. But then I'm just a mediocre Registered Nurse and an even more struggling photographer, not a physicist. I guess my point is that I don't have any trouble believing in things that we can't actually reach out and touch or see with our eyes, and that doesn't make this stuff any less "real", just a different form of matter in the universe.

Very much enjoy your posts, even though I frequently don't "grok" them completely.

Rod G.

Posted by: Rod Graham | Friday, 31 December 2010 at 02:38 AM

Ctein, your use here of the word "theory" is interesting, as it conflicts with the scientific use of the word: a model that has withstood all attempts to falsify it, and which, necessarily, has an abundance of data to support it. You may reply that this is not a scientific audience. My point here is not to try to correct you; indeed, I think that the scientific use of the word "theory" so conflicts with its colloquial meaning to non-scientists (i.e., almost every person on this planet) that it invites misunderstanding of the outcomes of science. Hence, we have people who have their own reasons for not wanting to accept the Theory of Evolution or the Big Bang Theory saying "Of course, it's only a theory", when to most non-scientists, the body of evidence required to elevate a particular hypothesis to the status of "theory" would be regarded as proof.

So, I've come to think that it would be in everybody's interests for science to use the word "theory" in its colloquial meaning (that is, an untested idea) and, for those models which have withstood all attempts to falsify, instead use another word such as "Law" or even develop some new word.

My question(s): Have you similarly grappled with the faulty communication engendered by the present scientific meanings of "theory" and "hypothesis"? Any thoughts on the above?

Posted by: Rod S | Friday, 31 December 2010 at 06:02 AM

Dear Rod G,

That's an excellent question. Physical theories don't just spring from the imagination of the physicist, there is some intuition, some logic, some set of observations of the world that underlie them. The physicist has some idea of how all those unseen clockwork gears are working and puts together a description, usually mathematical, of how they perform.

Newton, for example, whether or not he was actually inspired by a falling apple (probably not), wouldn't have come up with the inverse square law for attraction by looking at a falling apple; that required some mental model of how different bodies would sensibly interact with each other over different distances.

By the same token, Einstein's equations for Special Relativity and General Relativity were the logical mathematical consequences of his understanding of how the universe operated. What he did is really no different, in kind, for me deriving depth of field equations from geometry, trigonometry, and some clever diagrams with similar triangles on paper.

The problem is that Einstein's carefully thought out equations had an unexpected consequence: relativistic space-time is unstable, like balancing a pin on its point. Possible in the abstract, but in reality it's going to fall one way or the other. Einstein, like other physicists and astronomers of the time, believed the Universe was constant, eternal, and unchanging on the macro scale. That was incompatible with what his equation said. So he stuck a small constant, c, (not the same "c" as the speed of light) in one of the equations, and that made everything balance so that he could have a static universe. But it was entirely a fudge factor. None of the logic and reasoning led to c, he just got the “wrong” answer if he didn't stick it in.

It would be as if I finished my depth of field equations, and then I did measurements of lenses in the lab and my equations were always off by a factor of two. I can't puzzle out the source of the error, so I go stick a factor of two in my equation because it makes the answers come out right, but I have no understanding of WHY.

That's what Einstein's cosmological constant was. A fudge factor that basically says “Okay, there's something a bit wrong with my logic, but I haven't figured out what it is yet.”

What made it a big mistake was that Einstein's notion of the universe was wrong. It was only several years after his theory was published that it was discovered that the universe was expanding. At which point, the need for that fudge factor, c, went away. That was Einstein's embarrassment and big mistake, not accepting that his equations were telling him something new about the universe (which, after all, is the point of the game), but that they should be hacked to meet his preconceptions.

That's why, though, it wouldn't tell us anything if it turned out dark energy was mathematically equivalent to Einstein's cosmological constant. The constant doesn't have any physical meaning, it was just a hack. Worse, a hack for the wrong reason. So even if this were true, you couldn't give Einstein credit for having intuited this a century ago. It's just a massive coincidence that his very wrong idea of how the universe worked led to fudging an equation in a way that might end up describing how the universe actually works.

Some people have all the luck.

pax \ Ctein
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Posted by: ctein | Friday, 31 December 2010 at 12:26 PM

I much prefer the word "model" to "theory". It's visually descriptive (picture a model car) and gets around the "only a theory" nonsense.

To expand on the example, a model car can be as detailed as you need it to be. If all you care about is mass and motion, a box with wheels is fine. You can refine that all the way to a detailed, completely functional replica. It can even be full sized (not recommended when dealing with the Universe).

Of course some models are functional mathematical descriptions....Newtonian gravity, for instance. Even Newton said he had no idea what gravity was, but he could describe what it does. A model.

Posted by: Kevin Bourque | Friday, 31 December 2010 at 12:56 PM

"It can even be full sized"

Kevin,
Isn't a full-sized model called a "replica"? I would think a full-sized, fully functioning model of a car would be not a model but...a car.

Mike

Posted by: Mike Johnston | Friday, 31 December 2010 at 02:24 PM

Dear Rod S.,

I don't quite agree with your definition of “theory;” mine runs a little less phenomenological and a little more, um, theoretical. But that's a philosophical discussion for another time. Even using your definition, I did not misuse the word. I only used it twice in a specific way in these articles, and I used it precisely in the context the physics community uses it.

In the more general sense, I did refer to various and sundry “theories” in both articles, but I really did mean theories, not hypotheses.

Happily, in the world I run in, I do not often run into the “it's only a theory” problem. But on the very few occasions I have, my explanation is pretty simple. I tell laypeople that the word “theory” in science is not really like the common English usage of the word, it's a lot more like the word "theorem" in mathematics. (Which is overstating the rigor rather than understating it, but if laypeople are going to make an error it's better they make one in that direction.)

I then tell them that what we mean when we use "theory" in ordinary English is really more like having a notion-- just some idea that pops into our head that might be true. And science does have a word for that, it's “hypothesis." For a hypothesis to become a theory, it needs meat on its bones; it needs to be fleshed out with rigorous thinking and logic and supporting data. Until then, it's just the notion.

So far this has sufficed for everyone I've discussed it with.

Understand that if you're dealing with a crackpot/True believer, none of this is going to matter--when they say that Global Warming/Big Bang/Evolution/whatever are just theories, they're just playing rhetorical debating games. They don't really care about theory versus hypothesis, notions versus knowledge. They just know they're right and you're wrong.

Those kind of folks I simply dismiss from my presence pretty quickly. I feel no obligation to give them any respect.

It's not that I don't tolerate fools lightly.

It's that I won't tolerate them at all.

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Posted by: ctein | Friday, 31 December 2010 at 02:37 PM

Dear Kevin,

In physics, a theory doesn't have to tell you what the clockwork is made of, it only has to describe how it works.

It's properly called Newton's Theory of Gravitation. Just as it's properly called Einstein's Theory of General Relativity.

Models are essentially phenomenological, as you observe. Almost every theory has a model in the background. But they're not interchangeable terms.

Other branches of science may and do use slightly different parsings of the vocabulary. But in my judgement these distinctions are subtle and not truly of import, not like theory vs hypothesis.

pax / Ctein

Posted by: ctein | Friday, 31 December 2010 at 02:47 PM

Dear Kevin,

The Ultraviolet Catastrophe didn't predict infinite amounts of energy. It was this: shove a certain amount of heat energy into a box, bouncing around is radiation. What's the spectrum of that radiation when it reaches equilibrium? You're not changing the amount of energy, you're just asking what color a certain amount should look like. What, today, we call the black-body spectrum, or "color temperature."

The Catastrophe was that when you did those calculations using classical physics (which are not at all hard calculations to do-- at the college level), the equilibrium spectrum was one where most of the energy migrated to the shortest wavelengths. So, shove 1000 Joules worth of energy into an oven, let bake for a few seconds, and open the door; instead of being bathed in a toasty warm infrared glow, you're hit with about 900 J of ultraviolet light (actually, gamma radiation, but they hadn't discovered x-rays and gammas yet). Hence the name.

Incidentally, this unsolvable problem in classical physics was what directly led to quantum mechanics. When you replaced the idea of a continuous classical sea of radiation with the idea that the stuff was quantized, the standard blackbody curve that we know and love today popped out immediately. It was certainly a radical change in our view of the world, but it was a very compelling argument.

While the Ultraviolet Catastrophe would be extremely discomforting, probably even deadly for the hapless baker, it's not at all on the scale of the vacuum energy error. That one doesn't just kill the cook, it destroys the entire universe. Awkward, that.

Vacuum energy is ordinary energy, which has a mass equivalent, which means it exerts a certain amount of gravitational force. If the vacuum actually contained the energy density calculated by quantum mechanics, the gravitational force at every point in the universe would be so huge that everything would instantly collapse at the speed of light, squeezed out of existence. It wouldn't stop at condensed matter, it wouldn't even stop at neutronium. It would all go to singularities. Not turtles, but black holes all the way down.

Many of us feel this does not correspond very well with the observable universe (which is clearly turtles). Possibly we are being too picky.

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Posted by: ctein | Friday, 31 December 2010 at 03:06 PM

I stumbled on this while idly net-reading about photography. Very readable and riveting stuff! (I studied Physics and have had a career in fibre optics). I'm struggling to see what it has to do with photography (online or otherwise) but no matter (dark or otherwise): I will certainly be keeping a closer eye on this website!

Posted by: Jim Baker | Sunday, 02 January 2011 at 08:39 AM

Dear Jim,

Thanks!

The abbreviation "OT" (short for off-topic) in an article title means that that article won't have anything to do with photography. Mike goes off-topic about once a week, me once every month or so. The overwhelming majority of readers like it, but there's about 15% who don't, hence the warning in the title for thems what wants to skip those columns.

pax / Ctein

Posted by: ctein | Sunday, 02 January 2011 at 03:05 PM

Dear Ctein - thanks for an entertaining half-hour of thought.

My gut feeling tells me that the supposition that dark energy is similar to Einstein's c is probably near the mark. I reckon that at some future eureka moment we will gain a further inkling as to the nature of things, making one (or more) of our current beliefs that underpin the accelerating expansion of the universe an historical footnote, very much like the constant universe.

Posted by: ault | Wednesday, 12 January 2011 at 03:18 PM

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