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Dark Energy: Still a Puzzle

by Sean

The arrow of time wasn't the only big science problem garnering media attention last week: there was also a claim that dark energy doesn't exist. See Space.com (really just a press release), *USA Today*, and a bizarre op-ed in the Telegraph saying that maybe this means global warming isn't real either, so there.

The reports are referring to a paper by mathematicians Blake Temple and Joel Smoller, which is behind a paywall at *PNAS* but publicly available on the arxiv. (And folks wonder why journals are dying.) Now, some of my best friends are mathematicians, and in this paper they do the kind of thing that mathematicians are trained to do: they solve some equations. In particular, they solve Einstein's equation of general relativity, for the particular case of a giant spherical "wave" in the universe. So instead of a universe that looks basically the same (on large scales) throughout space, they consider a universe with a special point, so that the density changes as you move away from that point.

Then — here's the important part — they put the Earth right at that point, or close enough. And then they say, "Hey! In a universe like that, if we look at how fast distant galaxies and supernovae are receding from us, we can fit the data without any dark energy!" That is, they can cook up a result for distance vs. redshift in this model that looks like it would in a smooth model with dark energy, even though there's nothing but ordinary (and dark) matter in their cosmology.

There are three things to note about this result. First, it's already known; see e.g. Kolb, Marra, and Matarrese, or Clifton, Ferreira, and Land. In fact, I would argue that it's kind of obvious. When we observe distant galaxies, we don't see the full three dimensions of space at every moment in time; we can only look back along our own light cone. If the universe isn't homogeneous, but is only spherically symmetric around our location, I can arrange the velocities of galaxies along that past light cone to do whatever I want. We could have them spell out "Cosmic Variance" in Morse code if we so desired. So it's not very surprising we could reconstruct the observed distance vs. redshift curve of an accelerating universe; you don't have to solve Einstein's equation to do that.

Second, do you really want to put us right at the center of the universe? That's hard to rule out on the basis of data — although people are working on it. So it's definitely a possibility to keep in mind. But it seems a bit of a backwards step from Copernicus and all that. Most of us would like to save this as a move of last resort, at least while there are alternatives available.

Third, there are perfectly decent alternatives available! Namely, dark energy, and in particular the cosmological constant. This idea not only fits the data from supernovae concerning the distance vs. redshift relation, but a bunch of other data as well (cosmic microwave background, cluster abundances, baryon acoustic oscillations, etc.), which this new paper doesn't bother with. People should not be afraid of dark energy. Remember that the problem with the cosmological constant isn't that it's mysterious and illmotivated — it's that it's too small! The naive theoretical prediction is larger than what's required by observation by a factor of 10^{120}. That's a puzzle, no doubt, but setting it equal to zero doesn't make the puzzle go away — then it's smaller than the theoretical prediction by a factor of infinity.

The cosmological constant should exist, and it fits the data. It might not be the right answer, and we should certainly keep looking for alternatives. But my money is on Λ.

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55 Responses to "Dark Energy: Still a Puzzle"

1. 1. *LBBP* Says:
   August 28th, 2009 at 9:07 am

   "Second, do you really want to put us right at the center of the universe?"

   Well, this sure would make a lot of Catholics happy.

2. 2. *martin g* Says:
   August 28th, 2009 at 9:27 am

   That's right ' dark energy ' doesn't exist. Neither does ' dark matter '.

   My reasoning revolves around a simple question : viz. ' Where is it ? '

For it's certainly not around our bit of the universe. If it was, then all our calculations about how local astronomical objects (and very local ones here on earth) would be out by a factor of about 90% or so.

But every (local) observation matches more or less exactly with our traditional Newtonian and Einstein-ian calculations.

So there's no ' dark anything ' around here. If there was then, say, launching a satellite would be a very problematic exercise.

But it would be very weird indeed if our part of the universe was specifically excluded from all this ' dark stuff ' that is alleged to pervade the entire universe.

There's something peculiar going on of course (with the observations of distant galaxies etc) but ' dark-ness ' isn't the answer. More likely an as yet unknown phenomenon acting only at very large distances – or variable light speed / gravity etc etc .

Forcing the math to fit – with the invention of 90% or so invisible material and force – seems to me to be a gargantuan ' dark fudge '.

3. 3. *Fermi-Walker Public Transport* Says:
   August 28th, 2009 at 9:28 am

   The real reason for "putting us at the center of the universe" is to bring back epicycles.

4. 4. *Joseph Smidt* Says:
   August 28th, 2009 at 9:37 am

"This idea not only fits the data from supernovae concerning the distance vs. redshift relation, but a bunch of other data as well (cosmic microwave background, cluster abundances, baryon acoustic oscillations, etc.), which this new paper doesn't bother with."

For me this is the sticking point. I keep hearing "this explains this and that explains that", but there seems to be only one theory that explains them all in a very straight forward way: Dark Energy.

5. 5. *miller* Says:
   August 28th, 2009 at 9:55 am

   I am curious, what is the naive theoretical prediction of the cosmological constant? How is it made?

   Also, I would like to see upper bound error bars on our distance to the center of the universe.

6. 6. *tacitus* Says:
   August 28th, 2009 at 9:58 am

   > *My reasoning revolves around a simple question : viz. ' Where is it ? '*
   >
   > *For it's certainly not around our bit of the universe. If it was, then all our calculations about how local astronomical objects (and very local ones here on earth) would be out by a factor of about 90% or so.*

   I am no expert, but if this was as glaring a problem as you seem to think it is, then dark matter/energy would have been dismissed as a solution years ago. Astronomers may be puzzled, but they aren't dumb.

7. 7. *noname* Says:
[August 28th, 2009 at 10:14 am]

At tacitus (6) and martin g (2)-

The universe is about 5% ordinary matter, 20% or so dark matter, and 75% or so dark energy. This is the percentages you get when you add over all mass and energy in the universe.

Ordinary matter, however, tends to form very tight clumps, like stars, while dark energy clumps only on much larger scales. Dark energy is even more extended, being uniformly or almost uniformly spread accross the entire universe.

So- if you look at something like our solar system, almost all the mass and energy in it is comprised of ordinary matter. The density of the dark matter and dark energy is so small, than in the tiny volume compised by our solar system you don't find very much of it all- all the mass is contained in the tight clump formed of ordinary matter that we call the Sun.

If you now ask about the matter distribution in a much larger piece of the universe, like our galaxy, you will find that both ordinary matter and dark matter are important, and consitute comparable fractions of the total energy budget (which one is bigger depends on where exactly you decide to draw the "edge" of our galaxy). Even on galactic scales, however, the density of dark energy is low enough that the amount of dark energy contained in a galaxy is very small.

It is only once you add over the entire volume of the universe that dark energy becomes the dominant form of energy. This happens because ordinary matter and dark matter forms tight clumps (i.e. galaxies) that are separated by VERY large amounts of space that have dark energy, so even though the dark energy density is small, once you add over all that space in between galaxies, the net amount of dark energy over a given volume ends up being larger than that or dark matter or dark energy.

So, to summarize: the amount of dark matter and dark energy in our solar system is negligible compared to the amount of ordinary matter, and therefore all we need to keep track to understand the behaviour of planets and satellites in our solar system is the ordinary matter.

8. 8. *Joshua Zelinsky* Says:
   August 28th, 2009 at 10:56 am

   LBBP, most modern geocentrism is from Protestants not Catholics.

9. 9. *MickelsonMorley* Says:
   August 28th, 2009 at 11:03 am

   The dark energy/matter debate keeps reminding me of the debate about the ether (medium for light). Scientists couldn't fathom a world in which there was no medium for light to travel through … then these two guys proved there was no ether (medium) … I can't remember their names …. Anyway, that discovery seems to have kinda, I mean, you know, completely changed humanities understanding of physics … no? Maybe that's what will happen with Dark matter/energy?

10. 10. *Martin g* Says:
August 28th, 2009 at 11:13 am

The ‘ dark matter ‘ which inhabits the vast intergalactic voids must be even more unusual than I thought. Considering how massive it is and how much of it there is, it seems odd that it’s immune to, say, the gravity of our Sun – or indeed our entire Galaxy. Why hasn’t some of it been attracted here ? It’s had a few billion years to condense. But the most noticeable thing about it is its absence.

The ‘ Emperor’s New Matter ‘ I reckon.

11. 11. *Kernal* Says:
August 28th, 2009 at 11:30 am

@Martin g
Since dark matter interacts so rarely, a particle with some angular momentum will never lose that angular momentum, preventing it from being able to condense into the Sun. Regular matter doesn’t have this problem, so it does fall into gravitational wells and form stars, planets, etc.

Regarding your earlier point about lacking evidence, DAMA has claimed a direct detection of the stuff.

Cheers,
Kernal

12. 12. *Mark* Says:
August 28th, 2009 at 12:06 pm

I’d advise against feeding the trolls.

13. 13. *jpd* Says:
    August 28th, 2009 at 12:15 pm

    saying everyone is at the center of the universe no matter where they are is as
    crazy as saying everyone measures the same speed of light no matter how they
    are moving.

14. 14. *Matt* Says:
    August 28th, 2009 at 12:24 pm

    I'm just curious what happens if every point is the center of the universe, mathematically speaking?

15. 15. *jpd* Says:
    August 28th, 2009 at 12:50 pm

    its a big boost for my ego.

16. 16. *Albert Bakker* Says:
    August 28th, 2009 at 1:42 pm

    #7 noname and others, I don't share the DM scepticism of Martin G (#2) but his logical reasoning on the surface seems sound that if DM interacts gravitationally identically to baryonic matter, then given sufficient naivety, it seems inescapable to conclude that if baryonic matter clumps together in denser regions of space that DM would also. And therefore if that would be the case, ignorant of it's existence, we would just have assumed gravity to be a stronger force. Or in other words we would have measured a bigger value for G.

    Just stating however that it isn't so because dark matter clumps on larger scales, even if it is true, isn't really a statisfying answer.

I have the same naive concern with why DM remains so smoothly distributed, but I have no trouble postponing the demand for an answer until I can claim my ignorance to be no longer complete.

But the question has been asked before and some ideas were offered in response, like for example the kinetic energy collapsing cold DM particles would gain falling in would then be unable to dissipate by emitting radiation because the particle can't emit photons and so perhaps pressure would rise much too quick, resisting further collapse.

http://blogs.discovermagazine.com/cosmicvariance/2009/07/02/arxiv-find-the-local-density-of-dark-matter/

(The question is asked in comment 16 followed by attempts at answering this question.)

17. 17. *Aaron Sheldon* Says:
    August 28th, 2009 at 2:13 pm

    huh did I miss something? They make the claim that the truncated perturbation of the FWR metric solved the Einstein equation for the standard p=rho c^2 / /3 condition, but I did not see an explicit calculation of the stress-energy tensor anywhere in the paper. I think that would have been the least minimal 'oh yeah, prove it' sort of thing a reviewer would ask for.

18. 18. *noname* Says:
    August 28th, 2009 at 2:50 pm

Hi Albert.

You are right that there is indeed a deeper truth concerning my original response, and you are also right as to why dark matter does not collapse into tight clumps like stars.

Dark matter does not collapse into tight clumps because it is dissipationless. That means that as dark matter particles fall into the galaxy, they start moving faster and faster. For them to fall into a tight clump like a star, they would need to find a way of loosing this extra energy. For normal matter, this is not a problem: it looses energy by emitting light. Dark matter, on the other hand, can't emit light, and therefore does not have a way to slow down.

So what happens to the dark matter then? Well, it falls towards dense regions (like galaxies), but since it can't get rid of their extra energy, it ends up forming a "gas" of dark matter particles around the galaxy, in which there is a nice balance between the pull of the galaxy (including the gravity from the dark matter particles), and the velocity of the dark matter particles. We call this "gas" of dark matter particles the halo of the galaxy, and the balance between the velocity of the particles and how far they extend (which is related to how strongly the particles are pulled) is called "virial equilibrium".

The dark matter halo of a galaxy typically extends out to much larger radii than the stars, so much so that in the region of space where we can actually find stars (what we usually call the galaxy), there is typically more regular matter than dark matter. It is only when you go out to much larger radii and include all the dark matter in the dark matter halo that you discover that the matter around a galaxy is comprised mostly of dark matter. If you pick a small volume such as a Solar System sized chucnk around a star such as our Sun, the total matter in the Sun completely overwhelms the relatively small amount of dark matter in that piece of sky.

So, in short, the dark matter doesn't form tight clumps like stars because, as it falls, it gains velocity, and has no way of getting rid of this extra energy. Instead, the dark matter ends up forms extended halos around galaxies that reach out to much larger distances than the stars in the galaxy.

One things that is worth noting is that in the evolution of the universe, it is actually the dark matter halos that form first. That is, because most of the matter in the universe is dark matter, the dark matter start coallescing and forming these extended clumps that we call the halos. Then, the regular matter that is in these halos starts loosing energy (e.g. by emitting light), condensing into the middle of the halos. There, it starts forming stars, and that is what we end up seeing as galaxies, with the dark matter halo in which the galaxy forms being much larger than the galaxy itself.

Hopefully this is a more satisfying answer. :)

19. 19. *Albert Bakker* Says:
    August 28th, 2009 at 3:16 pm

    Thank you noname (#19) for spelling it out and making it so clear. That was a satisfying answer indeed. Thanks!

20. 20. *DG* Says:
    August 28th, 2009 at 3:47 pm

@Crackpot#1

No wonder my Cavendish experiment setup in Senior Lab produced such poor results: I did it with the lights on!

21. 21. *Just Learning* Says:
    August 28th, 2009 at 3:57 pm

    http://www.youtube.com/watch?v=5t99bpilCKw

22. 22. *BlackGriffen* Says:
    August 28th, 2009 at 4:08 pm

    Speaking of spelling "Cosmic Variance" in the stars, there's a potentially fun and challenging simulation project you could do with that. Make software that searches for a position in the present configuration of stars that makes a constellation of the desired shape. Even better, but more challenging, is to allow it to search time as well (ie simulate the motion of the stars).

    Once you've done that, have the tool search for an image of Jesus or Mary or whatever and then, hey bingo, manned space flight will have all the budget it needs from the religious lot because they'll want to get out there and see "space Jesus."

23. 23. *Arrow* Says:
    August 28th, 2009 at 4:15 pm

    The fact that we have no idea what 90+% of the Universe is made of is a clear indicator that something is *very* wrong with our fundamental physics.

24. 24. *Brian137* Says:

August 28th, 2009 at 5:09 pm

"Second, do you really want to put us right at the center of the universe?"

Forget the "us." Y'all seem to be forever approaching and receding, approaching and receding, mostly obliquely.

25. 25. *Pope Maledict XVI* Says:
August 28th, 2009 at 6:16 pm

Who publishes in PNAS anyway? Apart from publicity hounds.

26. 26. *cybertraveller777* Says:
August 28th, 2009 at 6:46 pm

What if an enormous energy field existing outside the void, with a density so great that
all matter is pulled toward it, and is the source of gravity throughout the void! A fraction
of that energy set into the center of the void billions of years ago, and all matter has been
since that time, impelled by it, and being drawn out to it.

27. 27. *eagle1879* Says:
August 28th, 2009 at 7:01 pm

There are many other theories about gravity, maybe sapce and time. They can also fit the data. Then, do they all have the Λ, namely the prediction of dark energy?

28. 28. *Ellipsis* Says:
August 28th, 2009 at 8:46 pm

As far as I know, nobody has very seriously tried to fit the data for an an _anisotropy_ of dark energy yet, so it we weren't really at the precise center of such a "wave", that would be consistent with the data as well. (I bug the ESSENCE and SNLS folks about this every time they give a talk — can't they at least fit for a dipole moment, for goodness sakes…?!)

29. 29. *The skepTick* Says:
    August 28th, 2009 at 9:19 pm

    Point 1 – My understanding on the significance of this paper is that it is the first time expanding wave solutions to the FRW metric have been derived from first principles (i.e. without having to provide an arbitrary acceleration parameter).

    Point 2 – Putting us at the center of the universe is an enormous drawback to their model, though it may satisfy the creationists. However, to be fair, the authors do note that their may be multiple expanding waves in the universe, and we could be at the center of one of those and not one 'centered' on the big bang.

    Point 3 – Despite dark energy being a perfectly valid alternative, it remains unsatisfying for some (as does dark matter), simply because of the 10^120 factor that must be overcome with the cosmological constant. Philosophically, you're correct and that shouldn't necessarily be a barrier to its legitimacy, given that the discovery is so recent. Nevertheless, I don't think this is a good criticism of their motivation to pursue an alternative explanation.

30. 30. *forrest noble* Says:
    August 28th, 2009 at 9:50 pm

Dark energy/ the Big Wave, dark matter, Inflation theory are all ad hoc. All of these hypothesis are necessary to account for observations that do not otherwise make sense. This does not bode well for the standard model. When the correct cosmological model comes along some day there should be much fewer observation surprises and addendum hypothesis such as this one.

31. 31. *John R Ramsden* Says:
[August 29th, 2009 at 2:13 am]

Is it possible that dark matter is simply back-scatter of dark energy from within black holes, or at least some complementary manifestation of the dark energy within them?

The snag is that to allow dark energy to leave the hole the first idea would require this energy to move at superluminal speeds, which seems a big no-no even if it could convey no information.

Also, one would have to assume its speed could vary, in order that dark energy exiting at just the right speed, of a possible distribution of speeds, would "slow to a standstill" (or approach its minimum speed) in the vicinity of the black hole and tend to pile up there as dark matter.

All the same, dark energy travelling at superluminal speed(s) would also be one possible explanation of its apparent uniformity outside black holes.

32. 32. *Igor Khavkine* Says:
[August 29th, 2009 at 4:40 am]

@miller#5

In quantum mechanics, the energy of a harmonic oscillator (or any simple system possessing a single stable equilibrium) cannot be lower than a certain positive number called the zero-point energy.

A field theory (electromagnetism, for instance, is a field theory) is similar. The field equal to zero everywhere is an equilibrium, which classically has zero energy. When quantum effects are taken into account, the minimum energy can no longer be zero. There will now be a positive zero-point energy density. If this energy density is constant everywhere, it is indistinguishable from a cosmological constant.

A first naive assessment of this energy density gives infinity. A slightly less naive assessment notices that the infinity can be eliminated if we discard the effects of field oscillations on Planck time and length scales (postulating some as yet unknown physics as the mechanism). The resulting number is on the order of a Planck mass per Planck volume, which happens to be about 10^{120} times the observed value. Even more sophisticated assessments note that the previously described prescription for eliminating an infinite zero-point energy density is not unique and that generalizations thereof (each postulating slightly different as yet unknown physics as mechanisms) can predict any value for this energy density, including the observed one.

With this outlook, the cosmological constant problem can be formulated as the lack of constraints on the theoretical prediction of the zero-point energy density in the universe, other than the observed value of the cosmological constant.

33. 33. *Anna* Says:
    [August 29th, 2009 at 7:57 am]

    Noname and Albert,

    The arguments are correct, but this is one of the rare papers that I found by searching the literature that make the arguments solid:

    Neutralino dark matter stars can not exist.
    De-Chang Dai, Dejan Stojkovic
    Published in JHEP 0908:052,2009.
    e-Print: arXiv:0902.3662 [hep-ph]

    Best,
    Anna

34. 34. *daisyrose* Says:
    [August 29th, 2009 at 6:54 pm]

    Oh Great ! This changes everything.

35. 35. *Serge* Says:
    [August 29th, 2009 at 11:29 pm]

    Blake Temple should change his name to Black

    "Black Temple sinisterly deny Dark Energy existence" sounds really good.

36. 36. *Jonathan Vos Post* Says:
    [August 30th, 2009 at 10:29 am]

    Copernicus gave us a first approximation. I can live with that. Galileo and Newton gave us a first approximation, and Special Relativity looked to the 2nd order terms.

Kepler gave us a first approximation, and I know the man at JPL who tweaks the solar system ephemeris with GR corrections. Maxwell's equations (as redone by Heaviside) are a first approximation. The Schrodinger equation is a first approximation, with Dirac giving the more general case.Dark Energy data is not conclusive either for nor against. Fine. Let the scientific method operate, without crackpottery nor trollish digressions on religious institutions. Thank you, Sean, for yet another clear, level-headed survey of a controversial subject.

37. 37. *Sam Gralla* Says:
    August 30th, 2009 at 8:50 pm

    What I don't get is why a "naive prediction" gets any stock. QFT makes lots of predictions, and the size of the cosmological constant isn't one of them. That's the end of the story.

    Why is this "naive prediction" any better than any body else's wild speculation about what might be true, based on vague physical reasoning?

    Is there any anolog, historically, of a "naive prediction" like this? Was it at all useful? I doubt it.

38. 38. *Sean* Says:
    August 30th, 2009 at 11:13 pm

    QFT certainly predicts the value of the cosmological constant. It's just a constant term in the action, which is renormalized up to a cutoff where new physics kicks in. So if you think we understand physics up to 1 TeV, the vacuum energy density should be at least 60 orders of magnitude larger than we observe; if we understand it up to the Planck scale, it should be at least 120 orders of magnitude bigger. It would be nice to know why the prediction is wrong, because it clearly is, but it's certainly a prediction.

39. 39. *Ian* Says:
[August 31st, 2009 at 3:26 am]

@1, As a Catholic such a solution does make me happy. What would make me happier however is to allow theories regardless of how daft they may seem to be explored, don;t just discount them.

Remember Georges Lemaitre was going against the trend of a static universe when he proposed the primeval atom theory – and he was a Catholic priest.

40. 40. *Igor Khavkine* Says:
[August 31st, 2009 at 7:43 am]

@Ian#39:
Is nothing too daft? Even the moon made of cheese theory? In the long run, physicists tend to be rather good at figuring out how well a theory works, regardless of its origin. So, if certain theories do get discounted, it's usually for good reason. Or did you have a specific example in mind?

Also, I'll throw in my own non-sequitur. Newton was an alchemist and a theologian much of the time, while Laplace was neither, nor a believer.

41. 41. *Alex* Says:
[August 31st, 2009 at 8:52 am]

This result reminds me a bit of Poincare's disc world thought experiment. …not sure how that might illuminate things, though. …other than reminding us of the ever-present undetermination of theory by evidence.

42. 42. *Count Iblis* Says:
[August 31st, 2009 at 9:48 am]

About Global Warming, [see also here:]

> Bottle says:
> 9:32 AM
> Hey, can we stay on topic? Which is, "Global warming is caused by the cosmological constant."

43. 43. *Brian* Says:
[August 31st, 2009 at 4:57 pm]

I don't know about anyone else, but I have problems with the whole Dark Matter/Dark Energy idea.

Correct me if I'm wrong, but the reason the term Dark is used, is because this stuff has been (thus far) undetectable. Not just dark, but undetectable. We're inferring the presence of DM/DE based upon observations that are fundamentally linked to gravity. The things we can directly detect, aren't behaving in the way we expect. Thus a clever soul develops DM and then later DE to explain away the discrepancies.

Now, it's not a fatal flaw at present. However someone had better start coming up with DIRECT observations of this DM/DE sometime soon. Because as long as DM/DE remains truly dark, it remains in the realm of the speculative. It's not enough to continuously say "oh well, we ruled out 19 things that were prospective explanations for the Dark things, leaving another 21 things it could be."

I'm not telling anyone here anything they don't already know, but it's worth restating. A theory worthy of the name has to be falsifiable. Eventually there has to be some direct observational evidence of DM/DE, or it doesn't exist. Then we'll have to face the fact that some other mechanism is at work, for instance (and speculatively) our understanding of gravity. Which is not such a crazy idea when you really consider that currently, we are expected to believe in undetectable Dark Matter and undetectable Dark Energy.

Well, if that's the case, then I have some undetectable leprechauns that I want to introduce you to!

44. 44. *Sam Gralla* Says:
August 31st, 2009 at 6:47 pm

Hi Sean,

I'm no expert in QFT, but it's a revelation to me that something cutoff-dependent could be called an observable. This means that when you formulate a QFT, you must give not only a lagrangian but also a cutoff energy scale. I can't stop you from calling this a "QFT" but it seems silly to me. You've introduced a new constant of nature with a completely bizarre interpretation, and the only prediction it features in is wrong.

I prefer the vesion of QFT I was taught, which adds only h-bar to the classical list of constants and makes no false predictions.

-Sam

45. 45. *Aaron Bergman* Says:
    August 31st, 2009 at 7:30 pm

    QFT certainly predicts the value of the cosmological constant.

    That's just not true. The cc is a superrenormalizable quantity, and you can set it to any value to you want. The problem is that in order to make it small, you have to (just like the Higgs mass) tune the bare value to cancel the large quantum corrections. But there's nothing in QFT to stop you from doing that; it's only our philosophical biases against fine tuning that make us not want to.

46. 46. *chris* Says:
    September 1st, 2009 at 12:41 am

    actually – what are the chances that we live sufficiently close to the center of a nonhomogenious universe compared to the chance that we live in one of the 10^500 string vacua? i suppose the distance-redshift relation only really kicks in beyond our local group. so we need to be in ~1Mlj radus, ~10^-4 of the radius of the universe. so the chances are O(10^-12). not that bad at all. and i am sure some antropic argument can easily be cooked up.

47. 47. *Anon* Says:
    September 1st, 2009 at 6:18 am

    Off topic but just found out that Neil DeGrasse Tyson has a radio show! Awesome.

    Website's at : http://startalkradio.net/

48. 48. *Albert Bakker* Says:
    [September 1st, 2009 at 11:59 am]

    Thanks very much Anna (#33) While not being able to follow the paper in as much detail as I would like at this point, it certainly was instructive. This is going to be a steep learning curve for me, but a very enjoying climb.

49. 49. *boreds* Says:
    [September 1st, 2009 at 1:33 pm]

    Off topic, but on journals, it is still important in a lot of fields to publish in Nature, Science or PNAS. Of those three, PNAS actually has the most non-terrible Open Access policy. I believe all articles are freely available after six months, and authors can choose to pay for their articles to be immediately OA. Usually this would be paid out of a grant (now a standard expense for funding agencies if PIs choose to put it in proposals), and so it's not as crazy as it might sound.

    Physics has been ahead of the OA game for a while, but I think that the kind of model used by PNAS might be more useful in the longer-term. The process of producing a high quality journal has costs—whereas the arXiv is free, but has some disadvantages. I believe that the most obvious difference, peer review, affects the process in a number of ways. First, there is the idea of quality control—or for a journal of PNAS's perceived stature, a stamp of quality. If a paper is published in Nature/Science/PNAS, it will be taken very seriously (in most fields) and a lot of people will read it, even if the author is relatively unknown. In physics, my memory is that people look on the arXiv each morning for papers by (a) famous people (b) people they know or (c) papers with something relevant in the title. There are other papers out there which are potentially important and worth reading, but don't fit these criteria, and the peer review process (ideally) helps you find those papers.

Second, I think the importance of the review process in fields which don't make use of the arXiv means that papers are better written. I don't know the numbers, but I would bet that more time is spent preparing a paper for submission to PNAS (I mean, after the science is already done), than is spent preparing your upload to the arXiv. You might argue that this slows down science (it probably does keep you from getting on with the next project) but I think better-written papers contribute in an important way to the communication of scientific ideas.

As a final point, again I know it's off-topic (cosmic variance post on Open Access?), is the physics arXiv model sustainable in the long-term? At the moment physics has (what I see as) an uneasy balance, with peer review coexisting with automatic OA on the arXiv. That means you kind of get the benefits above for free. Papers are immediately available, but in the medium term go through review process. But won't libraries will stop buying those journals eventually? Leaving physics with only the arXiv. Maybe that's what a lot of physicists would be happy with, but I think there is a cost to pay. Certainly in other fields which don't already have an arXiv, I think the PNAS model of author's paying for OA will be the way forward.

50. 50. *joseph2237* Says:
September 1st, 2009 at 3:44 pm

Is there a possibllity that dark matter doesn't exist? You bet! Dark matter isn't necessary if the universe only appears to be expanding and is actually in full contraction. Relativity supports the notion that two viewers on seperate rockets can not with any acturacy determine who is traveling and who is not. My suggestion is simply that after inflation the universe went into contrraction. This may also explain why enthropy is growing. The cl;oser we get to the big crunch the higher enthropy will grow.

51. 51. *Brian137* Says:
    September 1st, 2009 at 10:36 pm

    I am enjoying the ride. Whether centered near us or not centered anywhere in particular, expansion seems to be accelerating. It will take us several decades, at least, to get decent estimates of the rate of expansion as a function of time and, possibly, direction. In the meanwhile, I view all theories about the matter as tentative and vulnerable. None of the current theories seem at all convincing. For any reasonable discrimination, we need a lot better data. The accumulated observations seem to indicate something along the lines of Λ, but all those missing orders of magnitude are thoroughly perplexing.

52. 52. *BDO Adams* Says:
    September 5th, 2009 at 11:33 pm

    Although it didn't get published (except at Virxa) I came up with a novel explanation for dark energy, that still seams viable. Briefly, if you have a relatively massless weak force (say 1/20 or 1/60 of electric force strength) acting between neutrinos, a soap of neutrino interacting under this force will self attract with more negative pressure than mass, this will then produce a cosmical acceleration under general relativity. See my blog for details, and the paper.

53. 53. *eben ezer is* Says:
September 6th, 2009 at 12:14 pm

it is normal for scientists to ascribe information they are familiar with to new data in order to reach understanding of the new data. one supposes that all the general forces are constant which is in error. one also supposes that space time is a constant which is also in error. it would be easier to discover the qualities of dark matter and dark energy if one applies variables to these. dark matter and dark energy are misnamed. they are not really dark at all but seem so to our perspective. for more info and understanding e-mail eben_ezer_is@yahoo.com

54. 54. *Phillip Helbig* Says:
September 7th, 2009 at 11:16 pm

Sean, now that you're a blogging celebrity, please use your fame to re-introduce the term "smooth tension" as a much better replacement for "dark energy".

55. 55. *D. A. Watters* Says:
September 8th, 2009 at 7:47 am

Isn't DM based on the gravitational constant? What if that's wrong? And it seems very odd to have the little tiny electromagnetic forces (atomic–I forget the names, maybe strong, weak and something else). They seem like tiny gravitational forces.

For Einstein's and Quantum Theory to meld, I think all that is needed is for gravity to become an equation of density from galactic sizes and distances down to subatomic sizes and distances. That's where the 2 don't match. We need a 1 size fits all theory.

Einstein is big and distant, Quantum is tiny and close. An equation for gravity that uses both size and distance will bring them together.

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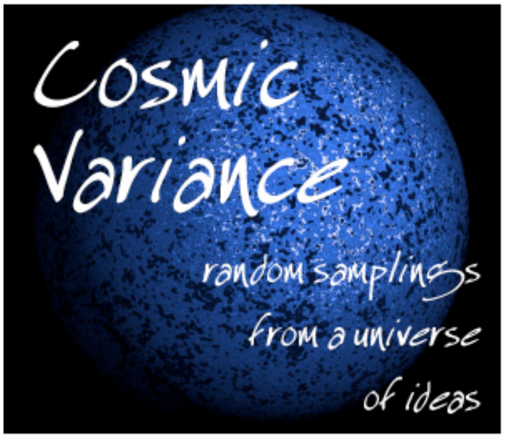
- 

Cosmic Variance is a group blog by people who, coincidentally or not, all happen to be physicists and astrophysicists:
  - Daniel Holz
  - JoAnne Hewett
  - John Conway
  - Julianne Dalcanton
  - Mark Trodden
  - Risa Wechsler
  - Sean Carroll

  Our day (and night) jobs notwithstanding, the blog is about whatever we find interesting — science, to be sure, but also arts, politics, culture, technology, academia, and miscellaneous trivia. We have similar outlooks on many things, widely disparate opinions about others, and will do our best to keep the discourse reasonably elevated.
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