Forum

Krauss Misunderstands Energy in General Relativity to Argue against GOD

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ABSTRACT

Stephen Hawking has a new book "Grand Design" out that claims God did not create the universe & Cosmologist Lawrence Krauss writing in the Wall Street Journal says that Hawking does not go far enough, but his argument is based on a misunderstanding of energy in general relativity. I'll explain why.

Key Words: GOD, General Relativity, energy, Lawrence Krauss.

Stephen Hawking has a new book out that claims God did not create the universe (this is probably not news to you). Cosmologist Lawrence Krauss writing in the Wall Street Journal says that Hawking does not go far enough, but his argument is based on a misunderstanding of energy in general relativity. Since we have discussed this recently here I'll explain why.

[Before I do, and just for the record, I am an atheist too, but I think science can only say that a God is not necessary. If people still want to believe in one (or more) I don't claim to be able to argue against them, after all, my philosophy of existence may not be very scientific either. If people make claims which are at odds with science, such as denying evolution, that is a different matter... Feel free to discuss.]

Coming back to the article by Krauss, what he says is that the energy in the universe is zero only when the universe is flat (he means the 3d part of the metric for space is Euclidean, the full 4d metric has curvature). He then says that "Observations of the cosmic microwave background from the Big Bang have unambiguously confirmed that we live in a precisely flat universe." A more accurate statement would be that the observation confirms that the part of the universe we can observe is flat to within observational errors, but let's not be picky.

The thrust of his argument then is that the energy of the universe did not have to be zero, but observation confirms that it is. If it was not zero you would then need something to create it, e.g. a God. Since we observe it to be zero we therefore have an observational confirmation that God is not needed. He did not put it in those terms, but that is essentially the point he is trying to make. Feel free to dispute the argument already at this level.

I am going to overlook the weakness of this argument and instead dispute the claim that the energy of the universe is zero only when it is flat. It is a very strange statement from a cosmologist because it is more commonly said that the total energy of the universe is zero for a closed universe, i.e. for positive curvature, not flat space. I agree with this since in a closed universe you can integrate the energy current density over all space and it must be zero because it has zero divergence.

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In an open universe the case is not so clear since the volume of space to sum up the energy over is infinite. However, for a perfectly homogeneous and isotropic universe the energy current must itself be zero because the only vector field that respects the symmetry and which has zero divergence is the one that is zero everywhere. In the real universe we can only say that the energy current density is zero on average if the universe is homogeneous on average. In other words we can make a good case that no energy is needed to create the universe whether it is closed, flat or open with negative curvature. So actually Krauss's argument fails even before you worry about its overall lack of logic.

So how did Krauss get the idea that the energy of the universe is zero only if space is flat? To answer this I'll start with the equation I gave for energy in cosmology which was

$$E = Mc^2 + \frac{\Gamma}{a} + \frac{\Lambda c^2}{\kappa}a^3 - \frac{3}{\kappa}\dot{a}^2 a = 0$$

This only covered the case of flat space, but it is easily generalised to curved space like this

$$E = Mc^2 + \frac{\Gamma}{a} + \frac{\Lambda c^2}{\kappa}a^3 - \frac{3}{\kappa}\dot{a}^2 a - Ka = 0$$

Where K is a constant that is zero for flat open space, positive for spherical closed space and negative for hyperbolic open space. To simplify I'll ignore the radiation terms and dark energy but you can put them back in if you want.

$$Mc^2 - \frac{3}{\kappa}\dot{a}^2 a - Ka = 0$$

It is important to remember that the first term is the energy contribution from cold matter in a fixed expanding volume while the other two terms are the negative energy contribution from the gravitational terms. However, people who don't know the origins of these terms sometimes turn the equation round to look like this

$$-\frac{\kappa M c^2}{a} + 3\dot{a}^2 = -\kappa K$$

This now looks like the Newtonian equation for a particle of fixed mass trying to escape the gravitational pull of an object of mass M with $-\kappa K$ being the total energy. This is the interpretation that Krauss is using. He then says that the energy is zero only in the case K = 0 which is the flat universe. But notice how wrong this interpretation is. Starting from the true energy equation we had to reverse the sign and divide by a. Then the term from the energy of cold matter looked like the Newtonian term for gravitational energy while part of the term for gravitational energy looked like the term for the kinetic energy of a particle and the other part became a constant total energy. Everything was swapped over so the interpretation could not be more wrong!

Apparently Krauss is about to publish his own book based on this false interpretation of the energy equation. I have enjoyed a few of his previous books that I read so I hope this one has some saving grace. At least he is not saying that energy is not conserved in general relativity!