Forum

Horizon: Before the Big Bang

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ABSTRACT

I think that explaining the universe requires us to look at ontological causality rather than temporal causality and the big bang is just one feature of the universe, not the reason for its existence. Although the experiments mentioned and others may throw some light on the nature of the big bang, we first need a better understanding of quantum gravity. There is still scope for theoretical developments that may help even before the experiments bear fruit. Even if you favour the string theory/M-theory route to quantum gravity (as I do), a better understanding of their foundations is required before we can hope to answer these questions about cosmology.

Key Words: before, Big Bang, ontological, universe, quantum theory, string theory, cosmology, BBC, Horizon.

This week the BBC showed a program in their long running "Horizon" series about the question "What came before the Big Bang?" Here is the gist of the message: A few years back cosmologists accepted that time did not exist before the big bang, so the question did not make sense. The universe along with time itself just started to exist and has been evolving nicely ever since. But now cosmologists are forming all kinds of theories that do put something before the big bang to explain how and why it happened.

So here is a list of the scientists that featured and the theory they adhere to:

- *Andrei Linde:* Multiverse inspired eternal inflation
- *Param Singh:* Big Bounce due to repulsive gravity at small distances
- *Lee Smolin:* Black Holes spawning baby universes
- *Michio Kaku:* Vacuum fluctuation from empty space
- *Neil Turok:* Colliding Branes
- *Roger Penrose:* The future is empty expanding space = a new big bang
- *Laura Mersini Houghton:* String cosmology

Each of these ideas has been around for some time and has been worked on by several people. The individuals mentioned here are not necessarily the ones who invented them. The Penrose theory is an exception in that it is a new idea that features in his next book.

In the program each of these scientists was interviewed while they tried to solve one of those wooden puzzles.

The obvious conclusion to draw is that there are a lot of viable theories out there which cannot all be right. Each of the scientists seemed to have quite a strong belief in the theory they supported, but they

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would all acknowledge that more experimental input is needed to resolve the question. All of them are driven by a philosophical argument that temporal causality must hold absolute so some prior cause of the big bang is needed.

Along with all the theorising and philosophising, a couple of experiments were mentioned which they think might help test these different hypothesis. The first was LOFAR, a low-frequency radio telescope array that may detect background remnants from the big bang. The standard prediction is that it will be white noise, but anything else could be a clue that separates different theories, prepare your predictions in advance please. The second experiment was the more familiar LIGO and its space bound successors LISA. These may be able to detect a gravitational wave remnant from the big bang that could also have a distinctive signature. It is hoped that either of these experiments may see past the wall of last scattering from which the cosmic microwave background emerged to provide information from an earlier time.

Personally, I don't accept the philosophical need for something before the big bang and I don't particularly like any of the theories mentioned. I think it is more likely that there was no space or time prior to big bang singularity which itself is a high temperature and density phase with no fixed topology or geometry for spacetime. I am not alone in preferring theories that do not require time to extend before the big bang, but the program has selected those that do. Where was Hawking's view for example?

I think that explaining the universe requires us to look at ontological causality rather than temporal causality and the big bang is just one feature of the universe, not the reason for its existence. Although the experiments mentioned and others may throw some light on the nature of the big bang, we first need a better understanding of quantum gravity. There is still scope for theoretical developments that may help even before the experiments bear fruit. Even if you favour the string theory/M-theory route to quantum gravity (as I do), a better understanding of their foundations is required before we can hope to answer these questions about cosmology.

Despite that, I don't think it is wrong to explore a wide range of cosmological ideas of this kind provided they have some good mathematics behind them. It is time for science to start trying to answer such questions. They will have to be looked at from all angles, philosophical, mathematical and experimental if we want to get the right understanding.

For the record I thought this was a good Horizon program, some of their physics/cosmology episodes lately have been a bit empty and ill-conceived. The position was too one-sided, but well researched. I'm glad they did not make the mistake of mentioning the LHC as if it was likely to resolve these questions, but did mention some other experiments that stand a better chance.

If you missed the program or it is has not yet aired in your country, I dare say you will find it on the web using Google video search. I won't provide any links because I don't know which if any are legal copies, or how long they will remain available, or whether the same links will work everywhere.

Response to Comments:

Feynman had a well known disrespect for authority so I always find it a little ironic when he is quoted as an authority on various topics like string theory or philosophy. He had an opinion on these things, not a divine insight. Let's not forget that he died in 1988 when string theory was at a very early stage.

OK, so physics is both fun and serious at the same time. Does anyone here really disagree with that?

I thought the theories described on Horizon were all very speculative and they were selected to try to make a particular point about there being something before the big bang. Personally I think physicists need to speculate beyond what we currently know. It's just a series of thought experiments. I should worry that some people watching this program would misunderstand the process that is going on and conclude that all cosmologists are crazy, but perhaps I won't.

Aside from that I enjoyed the program. For me it underlined the fact that there is a lot of disagreement still on the subjects discussed. The missing Hawking-Hartle idea is closer to what I would find philosophically right and the math possibly a little better, but it is still just another speculative idea based semi-classical reasoning that we know must break down at some point.

The real need is to have a working theory of quantum gravity that can be applied to these ideas to see if they are consistent. Ultimately we need experimental tests to determine which quantum gravity theory is right, but so far we don't have any theory of quantum gravity that can be tested.

Loop Quantum Gravity is interesting in that it highlights some particular mathematical ideas such as spin networks that might be relevant in some form. As far as I know it does not recover a classical limit. I have heard some talk of its problems being fixed but until I see some phenomenology of quantum gravity effects I take that with a pinch of salt.

I prefer string theory but it still lacks a formulation that can be used to understand what happens to spacetime at the Planck scale. Such a formulation must exist someone just has to find it. The way we see string theory now is very different from how it was seen ten years ago, and then it was very different from how it was seen over twenty years ago when Feynman was around. Who knows what another ten years will bring?

String theory has a good stab at approaching the Planck scale. Its perturbation series is thought to be finite at all orders and it has target space duality that makes very small distance scales dual to very large scales.

The problem is that the perturbation series most likely diverges just like they usually do in QFT. As temperatures and densities approach the Planck scale it fails. There are some arguments that suggest a phase transition is approached, but what is beyond that transition, nobody knows exactly. Matrix theory is non-perturbative, but it too fails to answer these questions for other reasons. There are known dualities that tell us a bit more, but still not a complete solution. It is frustrating that there is so much that works but not quite enough to seal it.

I don't think string theory is an effective theory for something else. There is no indication of that like there is for some QFTs. It's more a question of finding the right non-perturbative formulation for string theory then we can start to look at whether it really solves the quantum gravity problem, and whether the mutiverse of vaccua is real etc.