In the early universe, rapid expansion or something very weird

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(PhysOrg.com) -- The widely-accepted theory of cosmic inflation states that our universe expanded rapidly in the moments after its birth, resulting in the immense expanse we see today.

Cosmic inflation explains why the universe is billions of years old, as well as why the universe is nearly flat. The theory's conclusions about how the universe should look match observations by NASA's Wilkinson Microwave Anisotropy Probe (WMAP).

But is inflation the only model that can explain the beginnings of the universe?

That's the question that University at Buffalo physicists Ghazal Geshnizjani, Will Kinney and Azadeh Moradinezhad Dizgah set out to answer with their study, "General Conditions for Scale-Invariant Perturbations in an Expanding Universe."

The research, which appeared November in the online *Journal of Cosmology and* Astroparticle Physics, found that while inflation isn't the only viable model of the early universe, other possibilities would require strange physics -- such as a speed of sound faster than the speed of light.

The UB team found that only three kinds of early universe theories can explain the distribution of matter in today's universe, assuming that the standard theory of gravity is correct and that the universe was expanding in early times (both widely accepted suppositions).

According to the physicists' calculations, viable early universe theories must incorporate either an accelerated cosmic expansion (inflation); a speed of sound faster than the speed of light; or energies so high that scientists would need to invoke a theory of quantum gravity such as string theory, which predicts the existence of extra dimensions of space-time.

"The takeaway result here is that this idea of inflation turns out to be the only way to do it within the context of standard physics," said Kinney, an associate professor of physics who credits UB research scientist Geshnizjani, with formulating the idea for the study. "I think in many ways it puts the idea of inflation on a much stronger footing, because the available alternatives have problems, or weirdnesses, with them.

"It may well be that you can come up with a speed of sound faster than the speed of light, but I think people, as a general rule, would be more comfortable with something that doesn't involve super-luminal propagation," Kinney continued. "Inflation doesn't require any exotic physics. It's just standard particle physics."

Cosmic inflation accounts for the distribution of the matter in the universe by incorporating quantum field theory, which states that under "normal" circumstances, particles of matter and something called antimatter can pop into existence suddenly -- before meeting and annihilating each other almost instantly.

According to cosmic inflation, materializing pairs of matter and antimatter particles flew apart so quickly in the rapidly expanding early universe that they did not have time to recombine. The same principle applied to gravitons and antigravitons, which form gravity waves.

These particles became the basis of all structure in the universe today, with tiny fluctuations in the matter in the universe collapsing to form stars, planets and galaxies. The concept relies on widely studied ideas to explain how the universe began and evolved.

Still, however bizarre alternatives to inflation might seem, Kinney acknowledges that other models are possible. His own work has included exploring other theories, including ones that rely on superluminal sound speeds.

One colleague in UB's physics department, Assistant Professor Dejan Stojkovic, recently published a paper examining the possibility that the very early universe may have had just one spatial dimension before expanding to include two, and then three and possibly four (this model would fall under the category of theories invoking quantum gravity).

Provided by University at Buffalo

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