No Big Bang? Endless Universe Made Possible by New Model

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A new cosmological model demonstrates the universe can endlessly expand and contract, providing a rival to Big Bang theories and solving a thorny modern physics problem, according to University of North Carolina at Chapel Hill physicists.

The cyclic model proposed by Dr. Paul Frampton, Louis J. Rubin Jr. distinguished professor of physics in UNC's College of Arts & Sciences, and co-author Lauris Baum, a UNC graduate student in physics, has four key parts: expansion, turnaround, contraction and bounce.

During expansion, dark energy -- the unknown force causing the universe to expand at an accelerating rate -- pushes and pushes until all matter fragments into patches so far apart that nothing can bridge the gaps. Everything from black holes to atoms disintegrates. This point, just a fraction of a second before the end of time, is the turnaround.

At the turnaround, each fragmented patch collapses and contracts individually instead of pulling back together in a reversal of the Big Bang. The patches become an infinite number of independent universes that contract and then bounce outward again, reinflating in a manner similar to the Big Bang. One patch becomes our universe.

"This cycle happens an infinite number of times, thus eliminating any start or end of time," Frampton said. "There is no Big Bang."

An article describing the model is available on the arXiv.org e-print archive and will appear in an upcoming issue of *Physical Review Letters*.

Cosmologists first offered an oscillating universe model, with no beginning or end, as a Big Bang alternative in the 1930s. The idea was abandoned because the oscillations could not be reconciled with the rules of physics, including the second law of thermodynamics, Frampton said.

The second law says entropy (a measure of disorder) can't be destroyed. But if entropy increases from one oscillation to the next, the universe becomes larger with each cycle. "The universe would grow like a runaway snowball," Frampton said. Each oscillation will also become successively longer. "Extrapolating backwards in time, this implies that the oscillations before our present one were shorter and shorter. This leads inevitably to a Big Bang," he said.

Frampton and Baum circumvent the Big Bang by postulating that, at the turnaround, any remaining entropy is in patches too remote for interaction. Having each "causal patch" become a separate universe allows each universe to contract essentially empty of matter and entropy. "The presence of any matter creates insuperable difficulties with contraction," Frampton said. "The idea of coming back empty is the most important ingredient of this new cyclic model."

This concept jolted Frampton when it popped into his head last October.

"I suddenly saw there was a new way of solving this seemingly impossible problem," he said. "I was sitting with my feet on my desk, half-asleep and puzzled, and I almost fell out of my chair when I realized there was a much, much simpler possibility."

Also key to Frampton and Baum's model is an assumption about dark energy's equation of state -- the mathematical description of its pressure and density. Frampton and Baum assume dark energy's equation of state is always less than -1. This distinguishes their work from a similar cyclic model proposed in 2002 by physicists Paul Steinhardt and Neil Turok, who assumed the equation of state is never less than -1.

A negative equation of state gives Frampton and Baum a way to stop the universe from blowing itself apart irreversibly, an end physicists call the "Big Rip." The pair found that in their model, the density of dark energy becomes equal to the density of the universe and expansion stops just before the Big Rip.

New satellites currently under construction, such as the European Space Agency's Planck satellite, could gather enough information to determine dark energy's equation of state, Frampton said.

A copy of the paper may be downloaded at arxiv.org/abs/hep-th/0610213

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