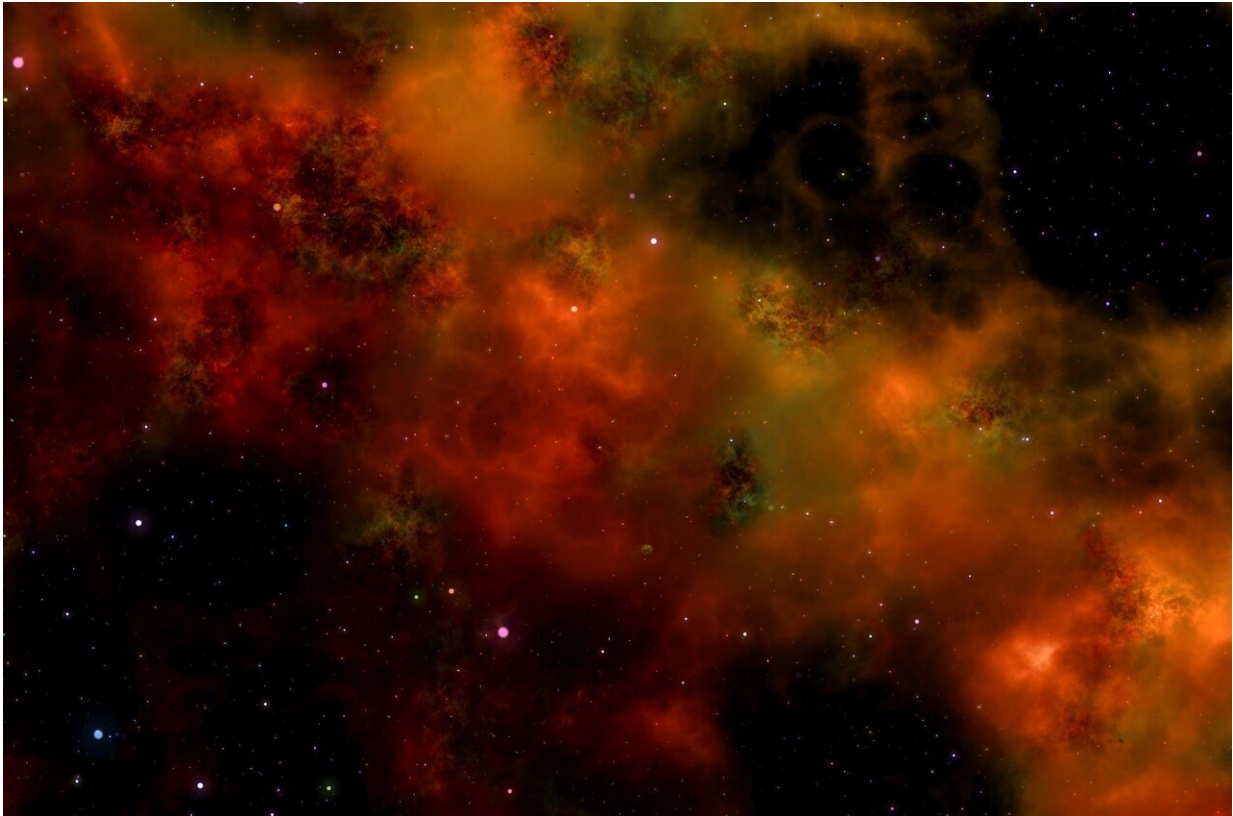


Do 'bouncing universes' have a beginning?

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In trying to understand the nature of the cosmos, some theorists propose that the universe expands and contracts in endless cycles.

Because this behavior is hypothesized to be perpetual, the [universe](#) should have no beginning and no end—only eternal cycles of growing

and shrinking that extend forever into the future, and forever into the past.

It's an appealing concept in part because it removes the need for a state called a singularity that corresponds to "beginning of time" in other models.

But a new study by University at Buffalo physicists Will Kinney and Nina Stein highlights one way that cyclic or "bouncing" cosmologies fall flat.

The research shows that the latest version of this theory—a cyclic model that resolves long-standing concerns about [entropy](#)—introduces a new problem (or rather, returns to an old one). Cyclic universes described under this model must have a beginning, Kinney and Stein conclude.

"People proposed bouncing universes to make the universe infinite into the past, but what we show is that one of the newest types of these models doesn't work," says Kinney, Ph.D., professor of physics in the UB College of Arts and Sciences. "In this new type of model, which addresses problems with entropy, even if the universe has cycles, it still has to have a beginning."

"There are a lot of reasons to be curious about the [early universe](#), but I think my favorite is the natural human tendency to want to know what came before," says Stein, a UB Ph.D. student in physics, regarding the importance of research. "Across cultures and histories, humans have told stories about creation, about 'in the beginning.' We always want to know where we came from."

The study, funded by the National Science Foundation, was published in June in the *Journal of Cosmology and Astroparticle Physics*. The paper is titled "Cyclic cosmology and geodesic completeness."

If the universe had a beginning, how did it begin?

Kinney is author of a 2022 book titled, "An Infinity of Worlds," which tells the epic story of cosmic inflation, a competing theory about the origins of the universe. Under this model, the early universe was characterized by a period of rapid expansion from a singularity, followed by the superhot Big Bang, which forged the primordial elements that went on to make galaxies and stars and planets, and the atoms in our bodies and all other living things.

Cosmic inflation is a leading theory. But it focuses on what happens during and after the age of rapid expansion. It doesn't explain what came before that, and it doesn't describe the conditions of the initial singularity.

A truly cyclic universe would circumvent these problems: If the universe is engaged in endless cycles of expansion and contraction, it need not have a beginning at all. But as Kinney notes, these bouncing models raise their own array of untenable questions.

"Unfortunately, it's been known for almost 100 years that these cyclic models don't work because disorder, or entropy, builds up in the universe over time, so each [cycle](#) is different from the last one. It's not truly cyclic," Kinney says. "A recent cyclic model gets around this entropy build-up problem by proposing that the universe expands a whole bunch with each cycle, diluting the entropy. You stretch everything out to get rid of cosmic structures such as [black holes](#), which returns the universe to its original homogenous state before another bounce begins."

"But," he adds, "long story short, we showed that in solving the entropy problem, you create a situation where the universe had to have a beginning. Our proof shows in general that any cyclic model which removes entropy by expansion must have a beginning."

"The idea that there was a point in time before which there was nothing, no time, bothers us, and we want to know what there was before that—scientists included," Stein says. "But as far as we can tell, there must have been a 'beginning.' There is a point for which there is no answer to the question, "What came before that?" "

And, of course, there are further research questions, Kinney says: "Our proof does not apply to a cyclic [model](#) proposed by Roger Penrose, in which the universe expands infinitely in each cycle. We're working on that one."

More information: William H. Kinney et al, Cyclic cosmology and geodesic completeness, *Journal of Cosmology and Astroparticle Physics* (2022). [DOI: 10.1088/1475-7516/2022/06/011](https://doi.org/10.1088/1475-7516/2022/06/011)

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