String Theory's Next Top Model

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Different "Calabi-Yau" spaces like the image above offer promising candidates for inflationary models of string theory. Shamit Kachru and his colleagues are hoping to find a simpler, "toy" model to help string theorists address deep conceptual issues. Credit: SLAC

Ernest Rutherford used to tell his physics students that if they couldn't explain a concept to a barmaid, they didn't really understand the concept. With regard to the cosmological implications of string theory, the barmaids and physicists are both struggling—a predicament that SLAC string theorist Shamit Kachru hopes to soon resolve.

String theory is currently the most popular candidate for a unified theory of the fundamental forces, but it is not completely understood—and experimental evidence is notoriously elusive. Physicists can, however, gain crucial insight into the theory by evaluating how accurately its models can predict the observed universe.

Using this indirect approach, Kachru, in collaboration with theorists at Rutgers University and the Massachusetts Institute of Technology, sought models that could reproduce inflation—the prevailing cosmological paradigm in which the nascent universe experienced a fleeting period of exponential expansion.

Although there is already a substantial body of literature presenting such models—spawned in part by publications of Kachru and his Stanford and SLAC colleagues Renata Kallosh, Andrei Linde and Eva Silverstein in 2003—the complexity of the models leaves room for doubt.

"They incorporate inflation, and they're the most realistic models of string theory," Kachru said, "but they're complicated. They're fancy. They have a lot of 'moving parts,' and we need to fine-tune all of them, so we can't verify anything to a high degree of accuracy. It forces us to ask—are we confident that we really understand what's going on?"

To achieve a comprehensive understanding of how inflation can be embedded in string theory, Kachru and his collaborators employed a pedagogical tactic. "What we wanted was an explicit 'toy' model," Kachru explained. "The goal wasn't to have something realistic, but to allow us to understand everything to every detail."

"There are deep conceptual questions about how inflation is supposed to work," Kachru continued. "In order to understand these issues, it's best to have a simple model. There's so much clutter in the complicated examples, you can't disentangle the conceptual issues from the clutter."

The group investigated three versions of the simplest formulation of string theory, and found that they were incompatible with inflation. "This means we're going to have to consider slightly more complicated scenarios," said Kachru. "There are a lot of levels between this and the fancier working models, so we'll find one eventually."

Kachru and his colleagues published their work in *Physical Review Letters D*, providing a framework for others in search of simple inflationary models of string theory. "There are so many successful models out there that incorporate string theory and inflation, so we'll undoubtedly find a simpler version. When we find that 'toy model,' where all the moving parts are obvious, we can address deep conceptual questions without getting lost in the details."

Source: by Elizabeth Buchen, SLAC