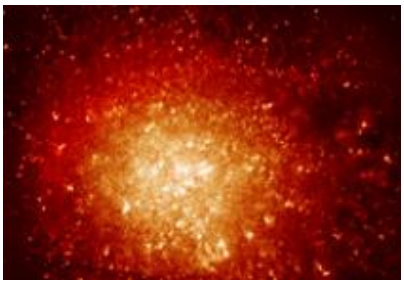
Probing Question: What happened before the Big Bang?



Red explosion. Credit iStock

The question of what happened before the Big Bang long has frustrated cosmologists, both amateur and professional.

Though Einstein's theory of general relativity does an excellent job of describing the universe almost back to its beginning, near the Big Bang matter becomes so dense that relativity breaks down, says Penn State physicist Abhay Ashtekar. "Beyond that point, we need to apply quantum tools that were not available to Einstein."

Now Ashtekar and two of his post-doctoral researchers, Tomasz Pawlowski and Parmpreet Singh, have done just that. Using a theory called loop quantum gravity, they have developed a mathematical model that skates right up to the Big Bang -- and steps through it. On the other side, Ashtekar says, exists another universe with space-time geometry similar to our own, except that instead of expanding, it is shrinking. "In place of a classical Big Bang, there is in fact a quantum Bounce," he says.

Loop quantum gravity, one of the leading approaches to the unification of general relativity with quantum physics, was pioneered at the Institute of Gravitational Physics and Geometry at Penn State, which Ashtekar directs. The theory posits that space-time geometry itself has a discrete "atomic" structure, Ashtekar explains. Instead of the familiar space-time continuum, the fabric of space is made up of one-dimensional quantum threads. Near the Big Bang, this fabric is violently torn, and these quantum properties cause gravity to become repulsive, rather than attractive.

While the idea of another universe existing prior to the Big Bang has been proposed before, he adds, this is the first mathematical description that systematically establishes its existence and deduces its space-time geometry.

"Our initial work assumes a homogenous model of our universe," Ashtekar acknowledges. "However, it has given us confidence in the underlying ideas of loop quantum gravity. We will continue to refine the model to better portray the universe as we know it and to better understand the features of quantum gravity."

Source: By Barbara Kennedy, Research/Penn State