The Big Bang versus the 'Big Bounce'

July 6 2012

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Two fundamental concepts in physics, both of which explain the nature of the Universe in many ways, have been difficult to reconcile with each other. European researchers developed a mathematical approach to do so that has the potential to explain what came before the Big Bang.

According to Einstein's (classical) theory of general relativity, space is a continuum. Regions of space can be subdivided into smaller and smaller volumes without end.

The fundamental idea of quantum mechanics is that physical quantities exist in discrete packets (quanta) rather than in a continuum. Further, these quanta and the physical phenomena related to them exist on an extremely small scale (Planck scale).

So far, the theories of quantum mechanics have failed to 'quantise' gravity. Loop quantum gravity (LQG) is an attempt to do so. It represents space as a net of quantised intersecting loops of excited gravitational fields called spin networks. This network viewed over time is called spin foam.

Not only does LQG provide a precise mathematical picture of space and time, it enables mathematical solutions to long-standing problems related to black holes and the Big Bang. Amazingly, LQG predicts that the Big Bang was actually a 'Big Bounce', not a singularity but a continuum, where the collapse of a previous universe spawned the creation of ours.

European researchers initiated the 'Effective field theory for loop quantum gravity' (EFTFORLQG) project to further develop this exciting candidate theory reconciling classical and quantum descriptions of the Universe.

Scientists focused on the background-independent structure of LQG which requires that the mathematics defining the system of spacetime be independent of any coordinate system or reference frame (background).

They applied both semi-classical approximations (Wentzel-Kramers-Brillouin approximations, WKBs) and effective field theory (sort of approximate gravitational field theory) techniques to analyze a classical geometry of space, study the dynamics of semi-classical states of spin foam and apply the mathematical formulations to astrophysical phenomena such as black holes.

Results produced by the EFTFORLQG project team exceeded expectations. Scientists truly contributed to establishing LQG as a major contender for describing the quantum picture of space and time compatible with general relativity with exciting implications for unravelling some of the major mysteries of the Universe.

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