Bouncy cosmos makes inflation a sure thing

IS OUR universe a recycled version of an earlier cosmos? The idea, which replaces the big bang with a "big bounce", has received a boost: this vision of the birth of the universe can explain why a subsequent process, called inflation, occurred.

"The result puts the idea of inflation on firmer ground, and at the same time makes the bounce scenario much more credible," says Carlo Rovelli,who was not involved in the work but studies quantum gravity at the University of Marseille in France.

Inflation is an episode of exponential expansion thought to have occurred fractions of a second after the big bang. It is needed to explain, among other things, why the universe today has the geometry it does, but explaining what triggered inflation is tricky.

According to general relativity, inflation could have occurred if early space-time was suffused by a field called the inflaton. But it would also have required a set of initial conditions – such as particular properties of the vacuum of space-time – that have a probability of occurring by chance of about 6×10^{-92} (*Physical Review D*, DOI: 10.1103/physrevd.77.063516). "In general relativity, there is no way really of explaining why those initial conditions were what they were," says Gary Gibbons of the University of Cambridge, who did the calculation with Neil Turok of the Perimeter Institute in Waterloo, Ontario, Canada. "You have to go to some deeper theory."

Enter loop quantum gravity, devised by Abhay Ashtekar of Pennsylvannia State University (PSU) in University Park and colleagues to reconcile general relativity with quantum mechanics. When Ashtekar's team created cosmological models inspired by LQG in 2006, these suggested the universe emerged from the remnants of an earlier universe that was crunched down to a tiny volume by gravity, not from the big bang (see diagram).

Now, together with David Sloan, also at PSU, Ashtekar has calculated the probability of inflation occurring after this big bounce. "We find that the probability of inflation is incredibly close to 1," he says.

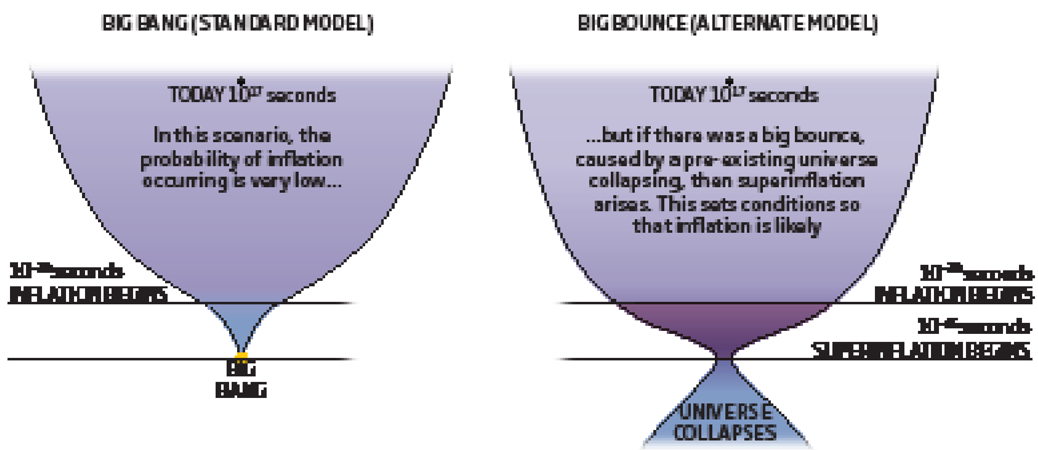
Earlier simulations showed that the big bounce creates a repulsive force and so is always followed by a period of rapid expansion that is even faster than inflation. Dubbed superinflation, this episode doesn't last long enough to replace inflation. But the pair's latest calculations show that it has a profound effect on space-time, such that no matter what the initial properties are in the early universe, superinflation "funnels" all the possible ways in which space-time can evolve towards one in which inflation is a near certainty (*Physics Letters B*, DOI: 10.1016/j.physletb.2010.09.058).

"Superinflation never occurs in general relativity, whereas it is compulsory in loop quantum cosmology," says Ashtekar.

That offers an explanation for why inflation might have occurred, and strengthens the idea that our origins lie in a big bounce, Ashtekar and Sloan conclude. **Anil Ananthaswamy** ■

Big bang vs big bounce

A period of inflation is needed to explain the geometry of our universe. Now there's an explanation for why it occurred



Water cycle goes bust in a warmer world

EARTH'S water cycle has been pushed to its limit. The amount of water transported from the land into the atmosphere hit a maximum 12 years ago and is now in decline, new calculations show.

Martin Jung of the Max Planck Institute for Biogeochemistry in Jena, Germany, and colleagues calculated trends in evapotranspiration - the amount of water vapour that entered the atmosphere - between 1982 and 2008. This moisture is either evaporated by the sun's heat or released by plants.

Evapotranspiration rose steadily until 1998, as would be expected in a warming global climate. But from then on, the amount of moisture being cycled into the atmosphere began to drop (*Nature*, DOI: 10.1038/nature09396).

Team member Steven Running of the University of Montana in Missoula says that in regions such as parts of Australia, the increased evaporation as temperatures rise has left the ground parched. Though the moisture returns to the ground as rain, most of it falls elsewhere, leaving the arid areas unable to contribute to the cycle.

The calculations are supported by satellite measurements that show falling levels of soil moisture in many parts of the world. The trend is strongest in the southern hemisphere. "Globally, we're seeing larger and longer droughts," says Running.

"In some regions, the increased evaporation as temperatures rise has left the ground parched"

Martin Wild of the Swiss Federal Institute of Technology in Zurich says rising temperatures are a plausible explanation, but adds that trends in air pollution, which blocks solar energy, could also be to blame. Pollution fell throughout the 1990s, thanks to measures to improve air quality in the developed world. This increased the amount of sunlight reaching the ground and boosted evaporation. But these changes levelled off at the end of the decade, around the same time evaporation stopped rising. Michael Marshall ■