**Stephen Hawking's last study – published May 2, 2018**

Hawking in the 1960s with his first wife Jane.
He said: "My goal is simple. It is a complete understanding of the universe,
why it is as it is and why it exists at all."

Published in the peer-reviewed Journal of High Energy Physics – does it prove or disprove the existence of parallel worlds? No. It's a theory, one of the many ideas in modern cosmology, many of which lead to the multiverse concept, the idea that our universe of stars and galaxies is just one of many possible separate universes. **Some physicists told media sources that Hawking's final paper did set out the groundbreaking mathematics needed for a spacecraft to find traces of multiple Big Bangs**.

Professor **Stephen Hawking** worked on his final theory on the origin of the universe in collaboration with Professor **Thomas Hertog** from KU Leuven. Hertog, whose work has been supported by the European Research Council, first announced the new theory at a conference at the University of Cambridge in July of last year, organised on the occasion of Professor Hawking's 75th birthday. Hawking said in one of his last interviews: I have never been a fan of the multiverse. If the scale of different universes in the multiverse is large or infinite, the theory can't be tested. The theory, which was submitted for publication before Hawking's death earlier this year, is based on string theory and predicts the universe is finite and far simpler than many current theories about the Big Bang say.

Modern theories of the Big Bang predict that our local universe came into existence with a brief burst of inflation – in other words, a tiny fraction of a second after the Big Bang itself, the universe expanded at an exponential rate. It is widely believed, however, that once inflation starts, there are regions where it never stops. It is thought that quantum effects can keep inflation going forever in some regions of the universe, so that globally, inflation is eternal. The observable part of our universe would then be just a hospitable pocket universe, a region in which inflation has ended and stars and galaxies formed.

The problem with the usual account of eternal inflation is that it assumes an existing background universe that evolves according to **Einstein's** theory of general relativity and treats the quantum effects as small fluctuations around this. However, the dynamics of eternal inflation wipes out the separation between classical and quantum physics. As a consequence, Einstein's theory breaks down in eternal inflation. **We predict, said Hawking, that our universe, on the largest scales, is reasonably smooth and globally finite. So it is not a fractal structure. When we trace the evolution of our universe backwards in time, at some point we arrive at the threshold of eternal inflation, where our familiar notion of time ceases to have any meaning**.

Hawking's earlier 'no boundary theory' predicted that if you go back in time to the beginning of the universe, the universe shrinks and closes off like a sphere, but this new theory represents a step away from the earlier work. "Now we're saying that there is a boundary in our past," said Hertog.

**Hertog and Hawking used their new theory to derive more reliable predictions about the global structure of the universe. Now the universe that emerges from eternal inflation on the past boundary is finite and far simpler than the infinite fractal structure predicted by the old theory of eternal inflation**.

Their results, if confirmed by further work, would have far-reaching implications for the multiverse paradigm. "While we are not down to a single, unique universe, our findings imply a significant reduction of the multiverse, to a much smaller range of possible universes," said Hawking.

This makes the theory more predictive and testable.

**Hertog now plans to study the implications of the new theory on smaller scales that are within reach of our space telescopes. He believes that primordial gravitational waves – ripples in spacetime – generated at the exit from eternal inflation constitute the most promising "smoking gun" to test the model. The expansion of our universe since the beginning means such gravitational waves would have very long wavelengths, outside the range of the current LIGO detectors. But they might be heard by the planned European space-based gravitational wave observatory, LISA, or seen in future experiments measuring the cosmic microwave background**.

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