Physicists Shine light into Primordial Universe

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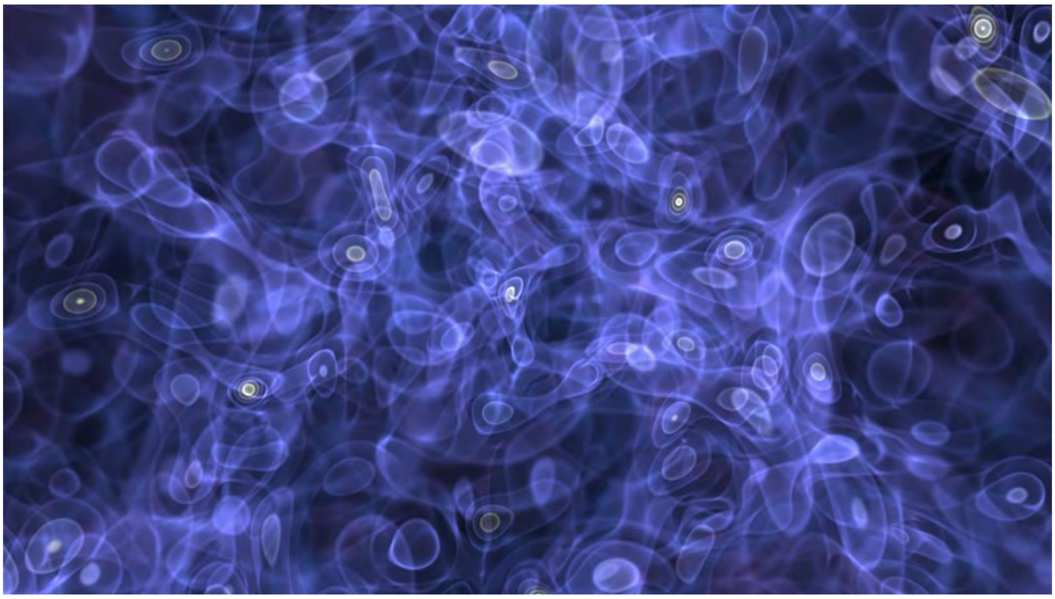

Primordial dark age research. Image credit: University of Auckland.

Following the Big Bang, the Universe passes through a series of epochs, each one longer than the last. For physicists to be sure that they understand the Universe, the predicted events in each of these eras must combine to match what astronomers see when they look into the sky.

University of Auckland researchers have now taken a major step forward in understanding one of these epochs in the evolution of the Universe, the mysterious "primordial dark age", when the Universe is entirely devoid of both light and all presently known subatomic particles.

Scientists think the primordial dark age lasted a trillionth of a second or even less, but that the Universe grew up 100 trillion times larger during this time. As the primordial dark age begins, the Universe is filled with a mirror-smooth, cold, ultra-dense quantum condensate, an exotic state of matter. This condensate can survive for much of this time, but must eventually fragment into particles and radiation due to the force of gravity.

In a paper published in *Physical Review Letters* [1], University of Auckland researchers PhD student

Nathan Musoke, Research Fellow Shaun Hotchkiss and Professor Richard Easther have shown that interactions between this condensate and its own gravitational field are captured by the so-called Schrodinger-Poisson equation. This equation describes the gravitational interactions of quantum matter.

Using this insight, the researchers performed the first numerical simulations of the gravitational collapse of the condensate, showing that the peak density would quickly grow to be hundreds of times larger than the average density once gravitationally-driven collapse begins.

This marks a key step forward in our understanding of the very early Universe. The work will allow cosmologists to better predict the properties of the "ripples" in the early Universe that eventually grow into galaxies and improve our ability to test theories of the Big Bang. In particular, it offers insight into the hypothetical inflationary phase which would precede the primordial dark age and generate the quantum condensate, a key part of most theories of the evolving Universe for close to 40 years.

Professor Richard Easther. Image credit: University of Auckland.

The research could also offer insight into the production of dark matter and the origin of the mismatch between matter and anti-matter in the early universe which ensures that our present-day cosmos is built from regular matter alone.

"This is an exciting result, and provides a pathway to understanding the predictions according to our theories about the first moments after the Big Bang, and to testing new ideas in ultra-high energy particle physics," Professor Easther says.

References

[1] "Lighting the Dark: Evolution of the Postinflationary Universe", Nathan Musoke, Shaun Hotchkiss, and Richard Easther, Phys. Rev. Lett., 14, 061301, https://doi.org/10.1103/PhysRevLett.124.061301