# Scientists discover possible cosmic defect, remnant from Big Bang

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Scientists from the Institute of Physics of Cantabria (IFCA) and the University of Cambridge may have discovered an example of a cosmic defect, a remnant from the Big Bang called a texture. If confirmed, their discovery, reported today in *Science*, will provide dramatic new insight into how the universe evolved following the Big Bang.

Textures are defects in the structure of the vacuum left over from the hot early universe. Professor Neil Turok of Cambridge's Department of Applied Mathematics and Theoretical Physics first showed how textures form in the 1990s, highlighting that some would survive from the Big Bang and should be visible in today's universe. Textures can be observed by the hot and cold spots they create in the cosmic microwave background radiation (CMB) which fills the universe and was released in the Big Bang 14 billion years ago.

The Big Bang theory proposes that the cosmos began in a very high density, high temperature state, cooling as it expands. In the early hot universe, physicists believe that the different types of elementary particle (particles such as a quark from which larger particles are created) behaved identically. As the universe cooled, the vacuum changed and the symmetry between the particles was broken, in a phase transition analogous to the freezing of water. During this kind of phase transition, quarks become distinct from electrons and neutrinos, for example.

Just as misalignments in the crystalline structure of ice lead to defects,

misalignments in the symmetry-breaking pattern form cosmic defects. Textures, such as the one which may have been discovered, are one type of defect.

Professor Turok provides the following analogy: “Imagine a large crowd of people with everyone standing. To any person in it, the crowd looks roughly the same in all directions. Now tell them all to lie down. People would tend to lie in the same direction as their neighbours, but over large distances the direction chosen would vary. In some places, people would be unable to decide which was the best direction to lie in: if everyone lies down pointing directly away from you, you are forced to stand. You are now a defect in the symmetry, a texture.”

It is believed that textures collapse and unwind on progressively larger scales, creating intense energy as well as gravitational potential. This unwinding also creates areas of extreme cold or hot, such as the very cold spot in the South Galactic Hemisphere discovered by the IFCA team in 2004.

Marcos Cruz and his colleagues, Dr. Patricio Vielva and Professor Enrique Martínez-González with the IFCA, pursued numerous possibilities for the existence of the cold spot. In particular, they thoroughly explored the possibility of being due to systematic effects, foreground contamination from our own galaxy or due to the scattering of cosmic microwave background radiation by large galaxy clusters.

Each time they came to the same conclusion: there were not any convincing arguments for any of these possibilities. They also hypothesised that it could be a texture and with the assistance of Dr Mike Hobson, a member of the Astrophysics Group at Cambridge's Cavendish Laboratory, and Professor Neil Turok, they were able to examine this possibility in detail.

Professor Turok performed large scale simulations using the COSMOS supercomputer at Cambridge to more accurately compare the theory with the event. Dr Hobson ranked the relative probabilities that the cold spot is due to a texture rather than just an extreme statistical fluctuation. The researchers concluded that the texture hypothesis is the most plausible explanation for the cold spot but acknowledge that additional tests are necessary.

“The possibility that this is a texture is very exciting,” said Professor Turok. “If it is, it will revolutionise our understanding of how the fundamental symmetries between the particles and forces were broken as the universe emerged from the big bang. The current data is suggestive but not yet compelling. There are a number of follow-up tests which can be made with future data. It's a very testable hypothesis and we will know the answer within the next decade.”

Dr Hobson said: “The prominent cold spot in the image of the cosmic microwave background taken by the WMAP satellite is a very puzzling feature that has attracted a lot of attention in the cosmological community, but has not as yet been convincingly explained.

“Our work investigates the exciting possibility that the cold spot is due to the presence of a cosmic texture; some current particle physics theories predict textures to be produced as the universe evolves, but they had never been observed. Somewhat to our surprise, we found that the cold spot, and in fact the cosmic microwave background radiation over the whole sky, is indeed consistent with such a texture model. Although the current data are not yet compelling, we suggest future observations that should be able to test our hypothesis definitively. If the cold spot is indeed proven to be a texture it will completely change our view of how the universe evolved following the Big Bang.”

The paper “A Cosmic Microwave Background feature consistent with a

cosmic texture" can be found in the 25 October 2007 edition of *Science*.

Source: University of Cambridge