COSMIC STRINGS: THE CRACKS IN THE UNIVERSE

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ABSTRACT: This research editorial covers the topic of cosmic strings, theoretical one-dimensional faults in space-time formed in the immediate aftermath of the Big Bang. Of particular note are oscillating cosmic string loops, which produce gravitational waves detectable by instruments such as LIGO (Laser Interferometer Gravitational wave Observatory), and gravitational lensing, a visual distortion of distant objects potentially caused by the interference of cosmic strings in the foreground of images. While conclusive data on the phenomenon remains elusive, the potential insights into cosmology, particle physics, and other fields keep the search alive.

Introduction

The inception of the theory of cosmic strings can be traced back to Descartes' model of the cosmos, in which planets swept through space along a great vortex-line that lay perpendicular to the plane of the solar system (Vilenkin & Shellard, 1994). Although this particular theory was quickly shot down by Newton and other scientists of the time, more recent developments in cosmology have revealed that supposedly "empty" space is anything but, prompting inquiries into the nature of the void and the possibility of "topological defects" in its fundamental makeup.

Cosmic strings are one-dimensional faults in space-time, a theoretical result of the Big Bang and its immediate aftermath. In much the same way that water undergoes a "phase transition" from liquid to solid when sufficiently cooled, the universe was fundamentally altered by the immense decrease in temperature which occurred after the initial heat of the Big Bang (Naculich, 2003). The theory goes that this process of phase transition caused three of the four fundamental forces of nature (strong, weak, and electromagnetic) – which once were unified as one force – to split into their current separate states. This phenomenon is known as symmetry breaking, and it is believed to be the cause of the long, thin fissures in space that have come to be known as cosmic strings (Naculich). Another way to describe the concept of cosmic strings is to think of them as a region of trapped potential energy density, one which can be moved around but never truly spread out or eliminated.

If the recent theories are correct, we would expect cosmic strings to have started off chaotically tangled in the compressed early universe, only stretching out later as space itself expanded. As part of this outward movement, some of the strings would inevitably cross and intermingle with others, creating separate, broken-off loops, like rubber bands. These cosmic string loops and the "cusps" they form are the key to further study of this theory, as the oscillating loops are the aspects of cosmic strings possible to detect from here on Earth (Moskowitz, 2013). Much like the merging of two black holes, cosmic string loops oscillate and produce "ripples" in the fabric of space-time – gravitational waves. Mechanisms such as LIGO (Laser Interferometer Gravitational wave Observatory) can be used to search for these elusive indicators of cosmic string cusps (Aasi et al., 2014). The LIGO-Virgo collaboration has searched through data from 2005 to 2010, seeking evidence of these mysterious loops by collecting signals from the skies and mapping them to models of what the loops' emitted waves may look like. So far, scientists have been able to estimate a minimum and maximum tension in the cosmic strings sweeping through space, a major step towards pinpointing and studying them more directly (Aasi et al.).

Another potential method of detecting the presence of cosmic strings is to search for gravitational lensing, a visual distortion of distant objects caused by strings curving space-time between the viewer and the object. One example of this phenomenon was observed in the mid-1990s, when the image of a double quasar near Ursa Major behaved strangely; normally, the image is split in two by the gravity of an enormous galaxy located between the quasar and Earth, causing the two images to vary in brightness 417 days out of sync with each other. But during this unusual window of time, the brightness of the two images pulsed in sync with each other several times over the span of a year (Schilling, 2005). A US-Ukrainian team of scientists studying the phenomenon announced in 2004 that according to their calculations, “it is difficult to propose a less exotic model” for the anomaly than gravitational lensing caused by a cosmic string loop close to our galaxy (Schilling). In addition, a Russian-Italian team found an even more compelling object of study in the constellation Corvus – the image of a distant galaxy split into two oddly similar, undistorted copies, a behavior entirely different from normal gravitational lensing (Schilling). This strange duplication is part of a series of similar anomalies littering the surrounding region. It seems very much as though a cosmic string may be stretched out across the foreground of this area, causing the chain of distortions, though the data is still inconclusive (Schilling).

Given their theoretical origins in the early stages of the universe, observing the geometry of a cosmic string network stretched across space-time could lend enormous insight into the topography of the cosmos. Additionally, since they possess a strong gravitational force, cosmic strings could be responsible for everything from black holes to the structure of gigantic galaxy clusters. And, of course, the proper detection and study of cosmic strings could help establish a solid theory of elementary particles themselves. In short, these enigmatic cracks in space-time may be elusive, but their untold potential makes the search well worth the effort.

References

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