Metamaterials used to mimic the Big Crunch

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Spacetime analogs is an emerging field of physics in which scientists investigate systems having mathematical links with general relativity, and test their theories about the early behavior of the universe. The latest in a series of such experiments is one that uses spacetime analogs to model the end of time theory, dubbed the "Big Crunch," at which the universe is predicted to contract and eventually collapse into a black hole.

An example of a spacetime analog is the behaviour of light in electromagnetic space, which is mathematically analogous to its behavior in spacetime. Recent developments have enabled scientists to use metamaterials to manipulate electromagnetic space and create electromagnetic analogs to the multiverse, quantum foam and the big bang.

Now University of Maryland visiting research scientist Igor Smolyaninov and colleagues have developed an experiment using metamaterials to model the end of time.

Metamaterials can be manipulated and forced to behave as various analogs, such as a system with two dimensions of space and one of time, or one with one dimension of space and two of time. The experiments designed by Smolyaninov and colleagues used a metamaterial comprising stripes of polymethyl methacrylate (PMMA), which were deposited on a gold film.

Laser light traveling through the metamaterial is described by

mathematical equations that are used to describe space and time. In the gold film the movement of photon-electron waves (plasmons) followed the equations representing a universe with two space dimensions and one time dimension, but in the metamerial they followed the equations of a universe with one space dimension and two time dimensions In the “end of time” experiment the photons became very hot, experiencing a sudden rise in energy and frequency, described as a “higher harmonic generation.”

Smolyaninov analyzed what happened when the metamerial was placed at various orientations to the gold and discovered that if they were placed end on, with a space dimension perpendicular to a time dimension, time stops, which is essentially a simulation of “end of time”.

When the metamaterial boundary is perpendicular to the “space-like direction” the scientists observed a Rindler horizon, which produces Hawking radiation. If it is perpendicular to the “time-like direction” time ends. The electromagnetic field diverges at the interface between the two materials.

The experiment is described in the July 20 edition of arXiv, the physics preprint journal. Future experiments planned include adding quantum dot semiconductors to a metamaterial to allow the researchers to simulate the center of a black hole and look for an analog for Hawking radiation, predicted to exist at the edge of black holes.

More information: Hyperbolic metamaterial interfaces: Hawking radiation from Rindler horizons and the "end of time" arxiv.org/abs/1107.4053