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Selfassembled Metamaterials: Minkowski Spacetime Analogue[1]

BRADLEY YOST, DAVID LAHNEMAN, EVAN BATES, VERA SMOLYANINOVA, Towson University, IGOR SMOLYANINOV, University of Maryland, College Park — Hyperbolic metamaterials are artificially created materials with optical properties that are drastically different along different axes. Due to the hyperbolic dispersion relation, light rays propagating inside a hyperbolic metamaterial look similar to particle world lines in a 2+1 dimensional Minkowski spacetime. In our study we used a ferrofluid, which is much easier to fabricate than typical metamaterials. A ferrofluid contains a known concentration of ferromagnetic nanoparticles in a carrier fluid. In the absence of an external magnetic field, the particles are in random order. When an external magnetic field is applied, the particles form nanocolumns, which align in the direction of the applied magnetic field, resulting in geometry similar to a metal nanowire array seen in hyperbolic metamaterials. These nanocolumns align along the magnetic field, so that a hyperbolic metamaterial may be formed at sufficient concentrations, n_H. We have studied polarization-dependent optical transmission of the cobalt based ferrofluid just below n_H. Due to thermal fluctuations of the concentration of cobalt nanoparticles in the ferrofluid, hyperbolic regions spontaneously appear. Light rays inside these regions look similar to particle world lines in a 2+1 dimensional Minkowski spacetime. These regions in the ferrofluid are analogous to transient "Minkowski spacetimes" or individual Minkowski universes, which appear and disappear.

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