DAMOP18-2018-000301
Abstract for an Invited Paper
for the DAMOP18 Meeting of
the American Physical Society

Emulating gravity with linear and nonlinear optical settings.

RIVKA BEKENSTEIN, Harvard University, ITAMP

A century passed since Einstein published the theory of General Relativity (GR), and some predictions of GR still elude observation. Hence, analogous systems, such as optical systems, have been suggested as emulation platforms. GR is inherently nonlinear: for example, masses dynamics is affected by the curved space they themselves induce. However, thus far all GR optical emulation demonstrated linear dynamics, where fix curved background determines the evolution of the electromagnetic (EM) waves. We demonstrate analogous gravitational effects with optical wavepackets under a long-range thermal nonlinearity. This optical system is mathematically equivalent to the Newton-Schrodinger model, which has been studied strictly theoretically, and describe a mass density evolving according to the Schrodinger equation in the presence of a gravitational potential created by the mass density itself. These wavepackets interact by the curved space they themselves induce, exhibiting complex nonlinear dynamics arising from the interplay between diffraction and the emulated gravity. We observe emulated gravitational lensing, tidal forces and gravitational redshift in this system, including modification of these phenomena that rise due to the nonlinear nature of gravity which exists in the Newton-Schrodinger model. Finally, we exploit the properties of EM fields in curved space, to present a new class of nanophotonic structures which facilitate control over the evolution of light, through the space curvature of the medium within which the light is propagating. This general method of fabricating curved-space structures for controlling electromagnetic waves can serve as the basis for curved nanophotonics: a generic concept for controlling EM waves that can be employed in integrated complex photonic circuits.