Quantum Nonlinear Optics: New Materials and Interactions

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In this talk, I describe new results on three research topics within my research group. We first describe some of the unusual optical properties of materials, known as epsilon-near-zero (ENZ) materials, for which the dielectric permittivity is very small. We describe some of the unusual geometrical optical properties of such materials and present theoretical predictions of how fundamental radiative properties are modified under such conditions. We also describe how these materials can display extremely large nonlinear optical effects under ENZ conditions [1,2]. The second topic of study is the filamentation of intense laser beams as they propagate through nonlinear optical materials. Our recent work has demonstrated that the threshold for filamentation can be raised by properly controlling the polarization properties of the transverse structure of the beam [3]. The third topic is quantum radiometry. Historically, black body radiation has been taken to constitute a calibration standard for optical instruments. However, the zero-point fluctuations of the electromagnetic field constitute another fundamental calibration standard. We have devised a means for calibrating the response of a spectrophotometer by utilizing these vacuum fluctuations to seed the process of spontaneous parametric down conversion [4].

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