MAR05-2004-006458

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Harnessing nonlinear optical phenomena for image-resolution enhancement[1]

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Nonlinear optics offers the researcher a remarkable range of opportunities for generating light with interesting, novel, and useful properties. In particular, twin beams generated via spontaneous optical parametric down-conversion exhibit unique quantum-correlation features that are of interest in the context of imaging. Photons are emitted in pairs in an entangled quantum state. Twin beams have found use in optical coherence tomography (OCT) as well as in quantum-optical coherence tomography (QOCT), a new method for carrying out tomographic measurements of objects with dispersion-cancelled resolution. Achieving high axial resolution in these coherence-based imaging systems requires the use of light with a broad spectral profile. The twin-beam spectral profile is mediated by the nature of the nonlinear optical material, by the geometry of the optical arrangement, and by the spatial profile of the pump laser radiation. A broad spectral profile can be generated by making use of a chirped quasi-phase-matching nonlinear crystal structure, non-collinear down-conversion, and a tightly focused laser pump. We present the results of simple OCT and QOCT experiments that demonstrate submicron axial resolution. The results confirm that the quantum technique exhibits immunity to dispersion, and additionally offers a factor of two enhancement in resolution, in accordance with theoretical expectations.

[1]From the Quantum Imaging Laboratory, Boston University