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From classical to quantum nonlinear optics in photonic structures

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Nonlinear polarizations described by the χ(2) and χ(3) susceptibilities are central to many of the phenomena of classical nonlinear optics, including processes as diverse as second harmonic generation and four-wave mixing. These same susceptibilities govern quantum optical processes in which correlated photons are generated, such as spontaneous parametric down-conversion and spontaneous four-wave mixing. We argue that it is useful to address classical and quantum calculations within the same framework, particularly in the integrated optics structures that will be important for quantum information processing "on a chip."When this is done a more unified picture of nonlinear optics, involving both classical and quantum regimes, results; we show how analytical or numerical classical calculations, or even just the results of classical experiments, can immediately be used to predict the behavior of a device in the quantum regime, and how it will scale as parameters are changed. We also show how it is possible to do a "virtual tomography"of the entangled states that would be generated in a quantum experiment by recording the results of a series of easily-performed classical experiments.

Author: Prof. SIPE, John (Department of Physics, University of Toronto)

Presenter: Prof. SIPE, John (Department of Physics, University of Toronto)

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