Nonlinear optical and acoustic processes using EIT

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Electromagnetically induced transparency (EIT) is a striking manifestation of quantum interference. When used with dense cold atoms, special effects become possible. Media with optical depths exceeding 100 may be made transparent and a pulse of light may propagate with a group velocity 10^7 times slower than in free space. The light pulse is also spatially compressed in the ratio of c/Vg; for example, a 1 μs pulse which is 300 m long in free space will compress to 30 μm in the EIT medium. Slow group velocity inherently leads to optical nonlinearities which are sufficiently large so as to allow frequency conversion and giant Kerr nonlinearities at energy densities which correspond to several photons per square wavelength. Media which absorb two photons, but do not absorb a single photon, may be possible.

The spatial compression which is associated with the slow group velocity allows a strong longitudinal dipole force which may transfer many quanta of momenta in a time less than the spontaneous emission time. Both ballistic and acoustic effects should be observable. When the optical group velocity is equal to the phase velocity of sound, extremely efficient light-to-sound and sound-to-light conversion is expected.

The talk will also describe recent experiments demonstrating collinear Raman generation in molecular deuterium driven by two lasers so as to excite either the phased or antiphased EIT-like molecular state. The Raman spectrum consists of 17 sidebands extending from the near infrared to the vacuum ultraviolet with a spectral width of about 50,000 cm^{-1}. By adjusting the phases of these sidebands we expect to examine multiphoton processes on a subfemtosecond time scale.