Materials Research Science and Engineering Centers

DMR MRSEC Program

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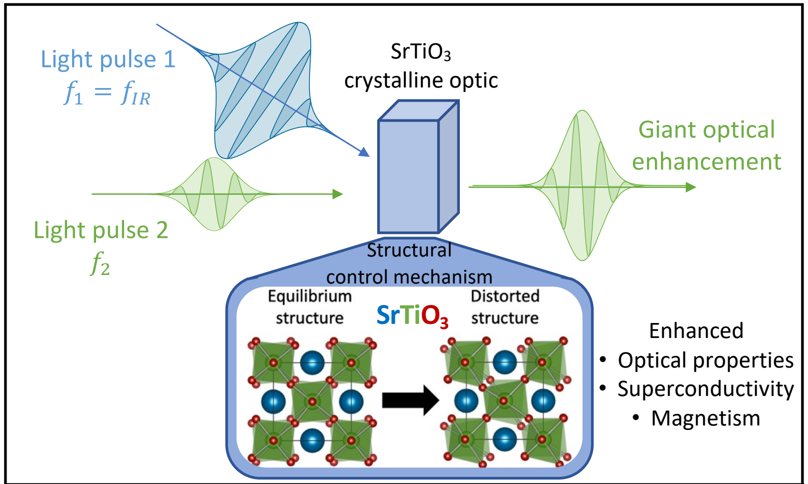
IR-Resonant Raman Scattering: Giant Optical Nonlinearities and Ultrafast Control of Optical Symmetry

Cornell Center for Materials Research: an NSF MRSEC

The Raman scattering effect, the scattering of light by lattice vibrations, has widespread scientific importance because it produces an optical response that is closely tied to a material's crystal structure. We have discovered theoretically that Raman scattering can be greatly enhanced when light in the mid-infrared range excites lattice vibrations to large amplitudes. This effect can be used for selective and dynamical control of the optical properties of materials, allowing a laser pulse to modify how the material affects a second laser pulse – a form of giant optical nonlinearity – on ultrafast timescales. In addition, this mechanism allows two laser pulses to selectively control the material's structure, which could allow ultrafast modifications of quantum material properties such as superconductivity and magnetism.



A first laser light pulse with frequency tuned to an infrared lattice vibrational frequency, $f_1 = f_{IR}$, can dramatically alter optical symmetry and properties for a second pulse at a frequency f_2. Giant nonlinear optical effects accompany structural distortions that can be selectively controlled. This new way of controlling materials may impact applications in optics, magnetism, and superconductivity.

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G. Khalsa, N. A. Benedek, and J. Moses, *Physical Review X* **11**, 021067 (2021).