Light-control of materials via nonlinear phononics

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Intense excitations of phonons by mid-infrared lasers is emerging as a novel method to modify the structure and properties of materials. In addition to insulator-metal transitions and melting of charge and magnetic orders, mid-infrared light has been used to switch ferroelectricity and induce ferroelectric and ferrimagnetic polarizations. These light-induced phenomena rely on nonlinear couplings between phonons, which allow the pumped phonon to impart a coherent force along other phonon coordinates of the material. I will discuss the microscopic mechanism of this phenomena and illustrate how realistic calculations have helped identify a way for using light to break crystal symmetries in materials.

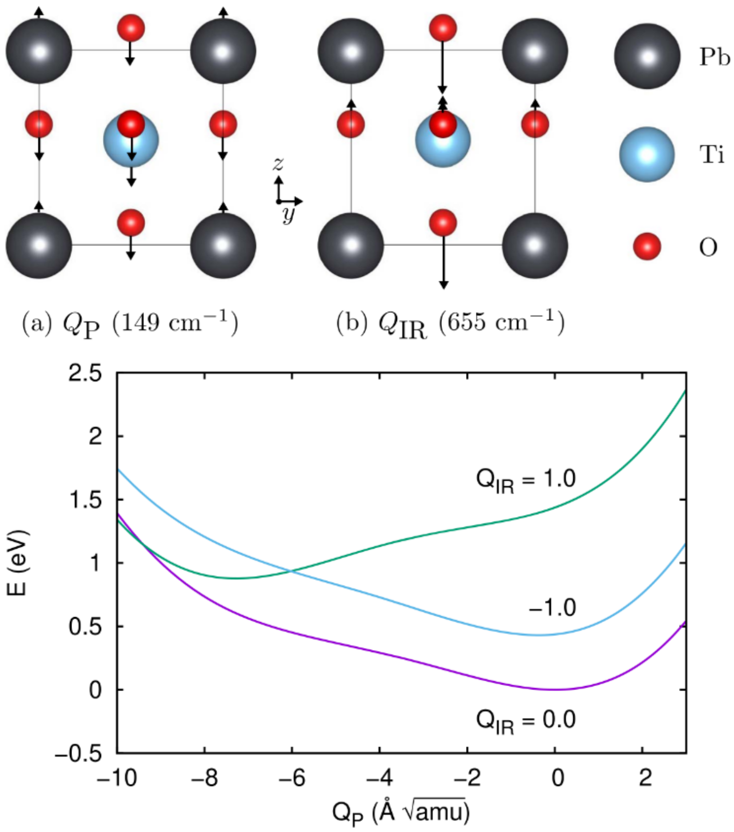

Figure: (Top) Displacement pattern of (a) lowest-frequency Q_P and (b) highest frequency Q_{IR} modes of the ferroelectric phase of $PbTiO_3$. (Bottom) Total energy as a function of the Q_P coordinate for several values of the Q_{IR} coordinate, illustrating that a finite value of the Q_{IR} coordinate can change the ferroelectric moment due to displacement along the Q_P coordinate.