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Terahertz electric-field driven dynamical multiferroicity in SrTiO3

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The emergence of collective order in matter is among the most fundamental and intriguing phenomena in physics. In recent years, the ultrafast dynamical control and creation of novel ordered states of matter, not accessible in thermodynamic equilibrium, is receiving much attention. Among those, the theoretical concept of dynamical multiferroicity has been introduced to describe the emergence of magnetization by means of a time-dependent electric polarization in non-ferromagnetic materials [1,2]. In simple terms, a large amplitude coherent rotating motion of the ions in a crystal induces a magnetic moment along the axis of rotation, as schematically shown in Figure 1. However, the experimental verification of this effect is still lacking. With our work [3], we provide the first evidence of room temperature magnetization in the archetypal paraelectric perovskite $SrTiO_3$ due to dynamical multiferroicity. To achieve it, we resonantly drive the infrared-active soft phonon mode with intense circularly polarized terahertz electric field, and detect a large magneto-optical Kerr effect. A simple model, which includes two coupled nonlinear oscillators whose forces and couplings are derived from ab-initio calculations using self-consistent phonon theory at finite temperature [4], qualitatively reproduces our experimental observations in the time and frequency domains. A quantitatively correct magnitude of the effect is obtained when one also considers the phonon analogue of the reciprocal of the Einstein - de Haas effect, also called the Barnett effect, where the total angular momentum is transferred from the coherent phonon motion to the electrons. Our findings show a new path for designing ultrafast magnetic switches by means of coherent control of lattice vibrations with light.

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