Circular Phonons in Artificial Superlattices

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Artificial crystals synthesized by atomic-scale precision epitaxy is a suitable platform for exploring, controlling, and understanding the quantum mechanical regime of solid state. The excellent tunability of the crystal itself enables observation of exotic phenomena, that are not attainable in natural crystals.

In this presentation, we demonstrate the existence of chiral phonons and their unprecedented role of inducing novel exchange interaction. Phonons with broken chiral symmetry strongly couples to the spin degree of freedom, which mediates an interlayer exchange interaction. Using pulsed laser epitaxy, we fabricated atomically-designed $SrRuO_3/SrTiO_3$ superlattices. $SrRuO_3$ is a ferromagnetic metal, whereas $SrTiO_3$ is a nonmagnetic insulator. Between the ferromagnetic $SrRuO_3$ layers, a synthetic spiral (conical) spin state was observed. This originated from the rotation of the magnetic moments as a function of nonmagnetic insulating spacer $SrTiO_3$ layer thickness, via the chiral phonon propagation. The observation of phonon Zeeman effects further manifested the chiral phonon-spin coupling. The manifestation of the chiral phonons and their strong interaction with spins unveil the critical roles of chiral phonons in magnetic materials.

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