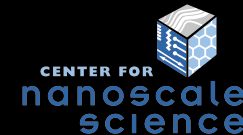
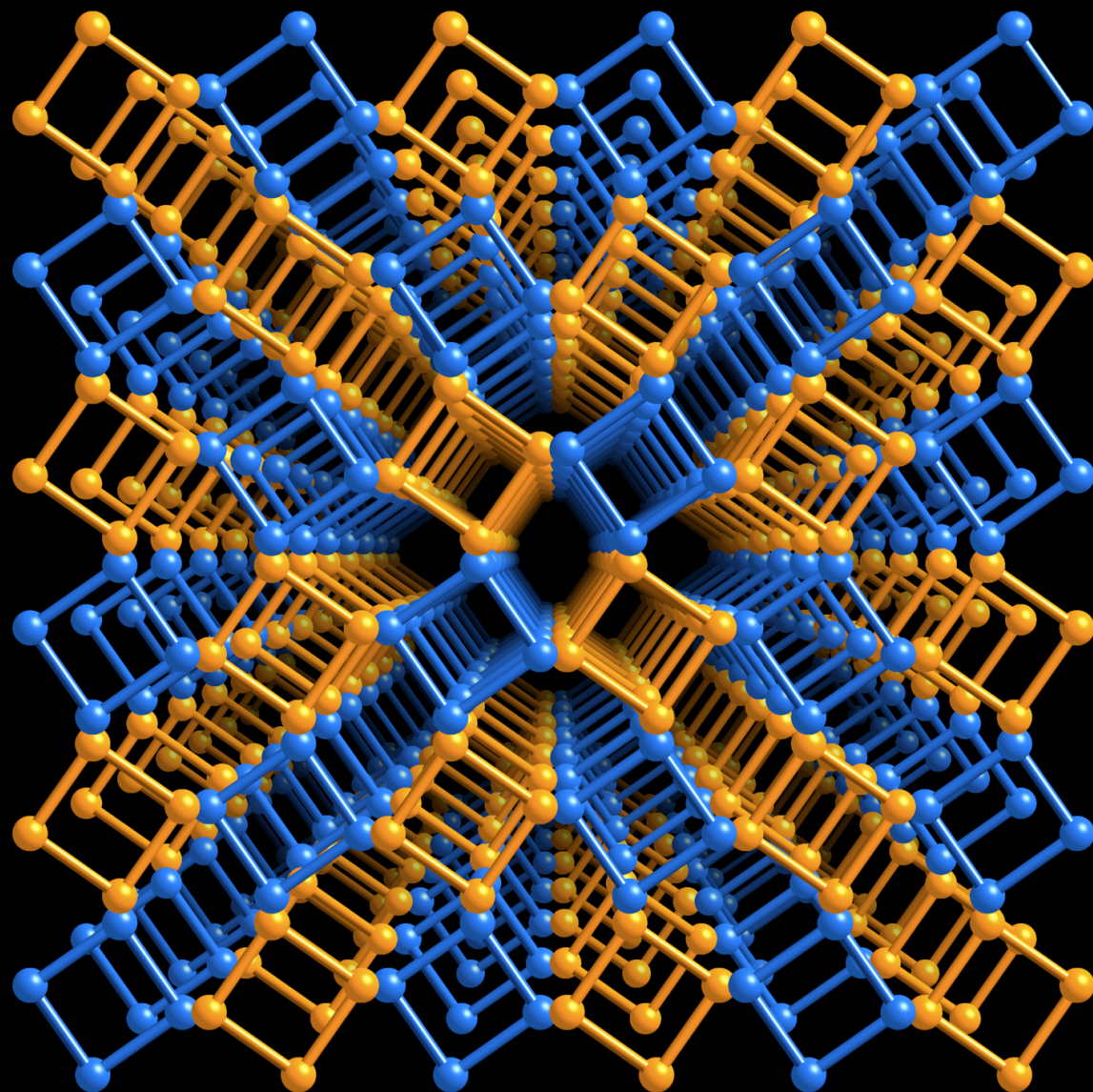


Hidden Roto Symmetries in Nature Discovered



Penn State MRSEC DMR-0820404: Venkatraman Gopalan and D. B. Litvin *Rotation-reversal Symmetries in Crystals and Handed Structures* Nature Materials, **10**, 376 (2011)

MRSEC researchers have discovered a missing spatial operation in nature called *rotation-reversal* symmetry that reverses the sense of all static rotations in a crystal. Certain minerals, organic crystals or metamaterials are composed of subunits that can exist in two states: clockwise or counter-clockwise rotated. The symmetry of a crystal lattice helps determine the material's properties, and certain properties can only exist in lattices with special symmetries. In perovskite complex oxides, for example, oxygen cages counter-rotate (see image); these crystals have twice as many new “roto” symmetries as previously recognized. These new symmetries imply new materials properties: lattice rotation coupled to magnetism, ferroelectricity, multiferroicity, charge ordering, elasticity, and optical. These properties could be useful in electrical control of magnetism, high-speed transistors based on correlated phenomena and high-temperature actuators.



Rotation-reversal symmetry operation switches between the orange and aqua molecules that are counter-tilted in the lattice above.