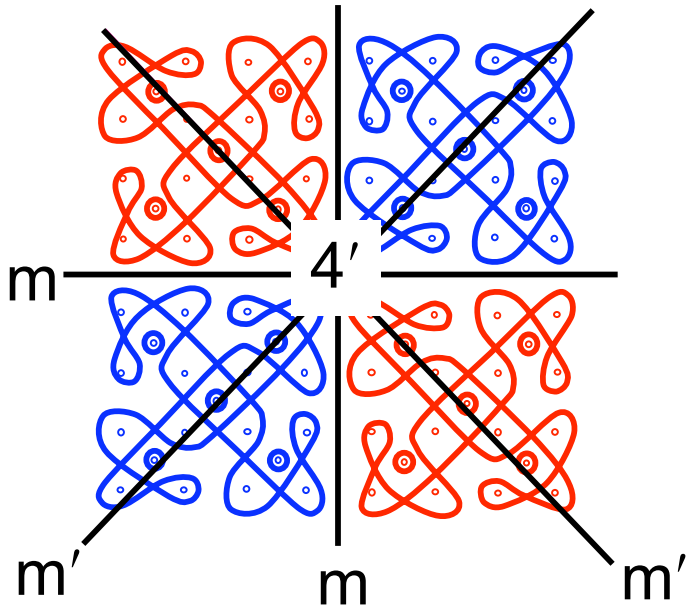
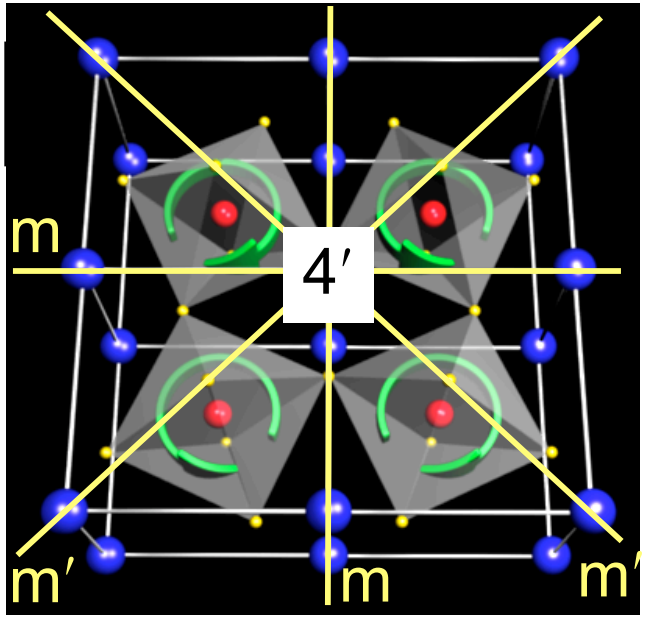
Magnetic Symmetry and Roto Properties in "Non"-Magnetic Materials

Gopalan (Penn State), *Schlom* (Cornell), *et. al.* DMR-0213623 (primary), 0820404, 0349632, 0512165, 0507146, 0602770, 0602986, ECCS- 0708759



Kolam, a south indian artform



Strontium Titanate, showing octahedral rotations

Symmetry is a powerful tool to understand nature. A recent insight of this group is that one can define a *rotation reversal symmetry*, 1′ which reverses the sense of rotation of any object, in complete analogy with the time reversal symmetry, 1′ that flips a magnetic spin . For example, the art-form on the left, and diamagnetic strained $SrTiO_3$ on the right, both possess rotational motifs that can be described by magnetic point groups (e.g site symmetries of *4 m′m′* and *4′mm′*) and magnetic space group ($P_I4\ m'm'$). New symmetries immediately implies the presence or absence of a new set of physical properties in material, called roto-properties. These rotational symmetries have recently been detected in $SrTiO_3$ using nonlinear optics. A range of new "roto" properties such as *rotoelectric, rotostrictive, rotooptic, piezorotation, rotomagnetic, roto-magnetoelectric* effects are predicted which the IRG is presently probing. (*Phys. Rev. Lett.* 100, 257601 (2008)).