Quantum Spin Configurations in Rare Earth Titanate Pyrochlores

Stephanie Curnoe
Memorial University of Newfoundland

$Tb_2Ti_2O_7$, and other rare earth titanates, are geometrically frustrated due to their pyrochlore structure. The pyrochlore structure is complicated: it has a non-symmorphic space group on a fcc lattice with octahedral point group symmetry. Group theory is used to simplify the spin configurations such that analytic expressions are obtained for the sixteen lowest-energy local collective angular momentum states of the rare earth spins on a single tetrahedron in a unit cell. Degeneracy lifting due to the exchange interaction is then treated analytically.

It is shown that a $\vec{k} = 0$, A_{2u} distortion of the terbium corner-sharing tetrahedral network in $Tb_2Ti_2O_7$ causes the apparent isolation of single tetrahedra as seen in neutron scattering studies. Such a distortion results in a space group reduction $Fd\bar{3}m \rightarrow F\bar{4}3m$ which is consistent with experimental observations. Single tetrahedron quantum collective spin states, rather than individual spins, account for the main features of the spin liquid state, namely, fluctuating local moments and the absence of long range order.