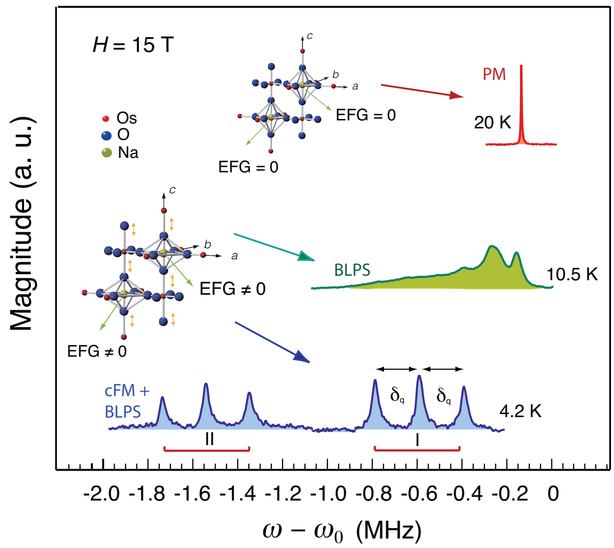
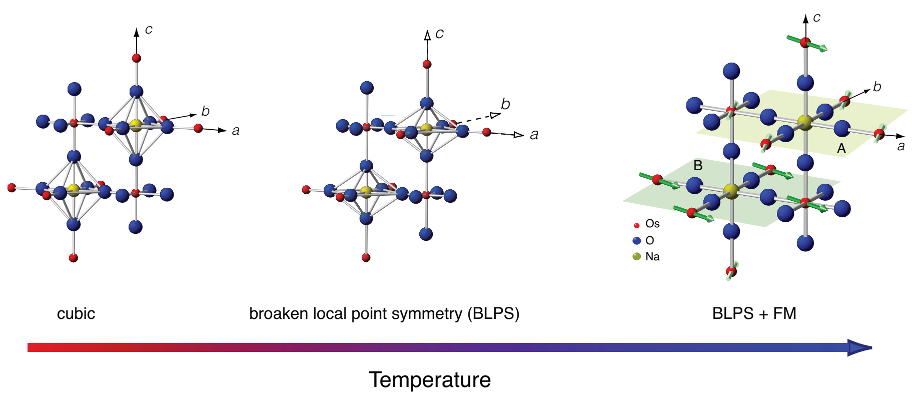
Novel magnetism and local symmetry breaking in a Mott insulator with strong spin orbit interactions

Vesna F. Mitrović

[1]Brown University, Providence, RI, USA

Study of the combined effects of strong electronic correlations with spin-orbit coupling (SOC) represents a central issue in quantum materials research. Predicting emergent properties represents a huge theoretical problem since the presence of SOC implies that the spin is not a good quantum number. Existing theories propose the emergence of a multitude of exotic quantum phases, distinguishable by either local point symmetry breaking or local spin expectation values, even in materials with simple cubic crystal structure such as Ba_2NaOsO_6. Experimental tests of these theories by local probes are highly sought for. Our local measurements designed to concurrently probe spin and orbital/lattice degrees of freedom of Ba_2NaOsO_6 provide such tests [1]. We show that a canted ferromagnetic phase which is preceded by local point symmetry breaking is stabilized at low temperatures, as predicted by quantum theories involving multipolar spin interactions [3]. Specifically, we find that the ferromagnetic state is in fact a type of canted ferromagnet with two sub-lattice magnetization, and that cubic symmetry breaking occurs at a temperature above the Néel temperature and it involves deformation of oxygen octahedra presumably reflecting a complicated pattern of staggered orbital order. Our findings are in startlingly good agreement with theoretical predictions based on quantum models [3]. Thus, our results, to be presented, establish that such quantum models represent an appropriate theoretical framework for predicting emergent properties in materials with both strong correlations and SOC, in general.





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E-mail for corresponding author: vemi@brown.edu