Emerging physics of spin-lattice-orbital coupling in oxide materials

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Magnetism is arguably one of the oldest disciplines known to mankind. It has a rich history with a long list of interesting examples, where magnetic materials have played a prominent role in either advancing our intellectuality or bring to existence some of marvelous everyday appliances. Despite the long history, however it is somehow surprising that it still remains on the center stage of modern material sciences with ever fascinating phenomena. Of particular importance in recent basic researches is new emerging physics out of a strong coupling among the four fundamental degrees of freedom of solid: *spin, orbital, lattice, and charge*. In this talk, I will highlight two such examples, to which my group has recently made some contributions.

The first example is the metal insulator transition observed in $Tl_2Ru_2O_7$. This material exhibits a distinct metal-insulator transition at 120 K. At the same time, it shows a drastic drop in the susceptibility below the transition temperature of 120 K. Using high resolution neutron powder diffraction technique and LDA+U band calculation, we could demonstrate that this unusual phenomenon is the direct consequence of a strong spin-orbital-lattice coupling [1].

The second example is a multiferroic $RMnO_3$. Hexagonal manganites, $RMnO_3$, have ferroelectric transition at somewhat high temperatures, mostly higher than 800 K, and antiferromagnetic transition below 100 K although their Curie-Weiss temperatures are quite high: e.g. ΘCW=-500 K for $YMnO_3$, and comparable to their ferroelectric transition temperatures. This coexistence of both magnetic and electric transitions has been the subject of recent intensive studies. Our latest works have shown how a spin-lattice coupling induces such a desirable connection between the magnetic moment and the electric polarization [2].

References

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