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**Quantum Spin States, Multiferroicity, Orbital Ordering, and Metal-Insulator Transition in New Layered-Perovskites**

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The high chemical tunability of the layered-perovskites  $\text{Ba}_3\text{BC}_2\text{O}_9$  ( $\text{B} = \text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Mn}^{2+}$ , and  $\text{C} = \text{Nb}^{5+}$ ,  $\text{Ru}^{5+}$ ,  $\text{Ir}^{5+}$ ) makes them ideal systems to study various physical behaviors, such as quantum spin states, multiferroicity, orbital ordering, and metal-insulator transition, based on the geometrically frustrated lattices. In this talk we present several examples to discuss these intriguing properties: (i)  $\text{Ba}_3\text{CoNb}_2\text{O}_9$ ,  $\text{Ba}_3\text{NiNb}_2\text{O}_9$ , and  $\text{Ba}_3\text{MnNb}_2\text{O}_9$ . For these samples, the only magnetic ions  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ , or  $\text{Mn}^{2+}$  on the B sites form a triangular lattice in the ab plane, which makes them new triangular lattice antiferromagnets (TLAFs). The detailed magnetic and electric properties show that the samples not only exhibit successive spin state transitions under magnetic fields but also multiferroic behaviors [1]; (ii)  $\text{Ba}_3\text{CoRu}_2\text{O}_9$ . With  $\text{Ru}^{5+}$  ions occupying the face-shared octahedral C-sites, the system exhibits an orbital ordering for the  $\text{Ru}^{5+}$  orbitals which leads to complex magnetic and structural phase transitions [2]; (iii)  $\text{Ba}_3\text{CoIr}_2\text{O}_9$ . This system exhibits metal-insulator transition under high pressure, which is accompanied with complex magnetic behaviors.

[1] J. Hwang et al., Phys. Rev. Lett. 109, 257205 (2012).

[2] H. D. Zhou et al., Phys. Rev. B 85, 041201(R) (2012).