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Tuning quantum properties in bilayer ruthenates

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The mutual coupling among spin, charge, lattice and orbital degrees of freedom in transition-metal oxide materials often leads to the competition of various types of energetic states. This makes such materials dramatically susceptible to external parameters, giving rise to novel physical properties and rich phase diagrams. In this talk, I shall use a bilayer ruthenate, $Ca_3Ru_2O_7$, as an example to discuss the emergent phenomena achieved by systematically tuning materials magnetic and electronic properties via chemical doping, magnetic field, and pressure. I shall show that this system provides a rare opportunity to investigate the interplay between correlated metal and Mott insulator. This work was done in collaboration with M. Zhu, T. Tao, S. D. Mahanti, Z. Q. Mao, J. Peng, T. Hong, W. Tian, H. Cao, C. R. dela Cruz, D. Singh, and K. Prokes.