Resonant Soft X-ray Scattering of Correlated-Electron Materials

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Elucidating the nature of phase transitions is one of the most important subjects in condensed-matter physics. Many phase transitions of electron-correlated materials are closely related to spin, charge, and orbital orderings. In this talk, we will present our recent studies on spin, charge, and orbital ordering of of correlated-electron materials, particularly manganites and magnetites. We will discuss the longstanding debate on the existence of charge ordering in Fe_3O_4 which exhibits a classic example of phase transition known as the Verwey transition. Such a transition was first interpreted as a charge order-disorder transition. Despite intensive investigations over half a century, the existence of charge ordering in magnetite remains controversial. Using resonant soft x-ray scattering measurements, we report direct experimental evidence for the existence of charge-orbital ordering in magnetite and the data corroborate the LDA+U prediction. In addition, we will address of the multiferroicity of $TbMn_2O_5$ based on scattering measurements and the Ginzburg-Landau approach.