

Three-dimensionally aligned V trimers in various vanadates

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We found that V^{3+} ($3d^2$) trimers are formed and three-dimensionally aligned as a phase transition in three different series of vanadates [$AV_{10}O_{15}$, $A_2V_{13}O_{22}$, and $AV_{13}O_{18}$ (A=Ba,Sr)], in which V ions occupy a part of the fcc lattice in the high-temperature phase.¹ We also found that this V trimerization substantially affects the transport and magnetic properties of these compounds. From various measurements, e.g., resonance x-ray scattering, NMR, and optical measurement, we conclude that this V trimerization and the change of various properties can be attributed to the orbital ordering of V t_{2g} states with spin-singlet formation. The present result implies that such V trimers are local objects that are rather universally observed in a certain class of compounds ($3d^2$ ions on a fcc lattice), and can be regarded as “molecules of ions” in the crystal.

¹J. Miyazaki and T. Katsufuji *et al.*, Phys. Rev. Lett. **104**, 207201 (2010); T. Kajita and T. Katsufuji *et al.*, Phys. Rev. B **81**, 060405(R) (2010); M. Ikeda and T. Katsufuji *et al.*, Phys. Rev. B **82**, 104415 (2010); M. Ikeda and T. Katsufuji *et al.*, Phys. Rev. B **83**, 134417 (2011).