Orbital Ordering and Spin-Singlet Clusters in Triangular-Based Vanadates

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Orbital ordering on geometrically frustrated lattices has attracted great interests in strongly correlated electron system. However, the microscopic observation of the orbital ordering texture remains to be an intriguing issue. We report rare examples of the orbital order and spin-singlet formation in the triangular based vanadates, $A\mathrm{V_{10}O_{15}}$, $A\mathrm{V_{13}O_{18}}$, and $A\mathrm{V_{13}O_{22}}$ (A = Ba, Sr), probed by ^{51}V NMR. These componds have orbital degrees of freedom and itinerant electrons due to the partially occupied $3d$ t_{2g} orbitals. In $\mathrm{BaV_{10}O_{15}}$, the single-crystal ^{51}V NMR revealed the spin-singlet trimer and the antiferromagnetic tertramer formation accompanied by the orbital order. The result suggests the competition between charge ordering and Peierls instability to relieve completely the geometical frustration. The spin-singlet cluster and paramagnetic sites were also found via the local spin susceptibility measurements in $\mathrm{BaV_{13}O_{22}}$,[1] while only the spin-singlet V site was observed in $A\mathrm{V_{13}O_{18}}$ (A = Ba, Sr). These results highlight the orbital physics of the metal-insulator transition on the frustrated latticee.

[1]J. Miyazaki, K. Matsudaira, Y. Shimizu, M. Itoh, Y. Nagamine, S. Mori, J. E. Kim, K. Kato, M. Takata, and T. Katsufuji, Phys. Rev. Lett. **104**, 207201 (2010).