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**Orbital Superstructures in Spinels**

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Orbital degrees of freedom often lead to specific types of orbital and spin ordering. Complicated and interesting superstructures are observed in B-sublattice of spinels. This is connected with the geometric frustration of this lattice and with the interconnection of edge-sharing $MO_6$ octahedra, which is especially important for transition metals with partially-filled $t_{2g}$ levels. In some such systems ($MgTi_2O4$, $CuIr_2S_4$, $AlV_2O_4$) there appears strange superstructures with the formation of spin gap states. In other cases ($ZnV_2O_4$) structural transitions, apparently connected with orbital ordering, are followed by long-range magnetic ordering. Last but not least, the famous Verwey transition in magnetite $Fe_3O_4$ leads to a very complicated structural pattern, accompanied by the appearance of ferroelectricity. In this talk I will discuss all these examples, paying main attention to an interplay of charge, spin and orbital degrees of freedom. In particular, for $MgTi_2O4$, and $CuIr_2S_4$ we proposed the picture of orbitally-driven Peierls state [1]. Similar phenomenon can also explain situation in $ZnV_2O_4$[2], although the corresponding superstructure has not yet been observed experimentally. Finally, I propose the model of charge and orbital ordering in magnetite [3], which uses the idea of an interplay of site- and bond-centered ordering [4] and which seems to explain both the structural data and the presence of ferroelectricity in $Fe_3O_4$ below Verwey transition.

[1] D.I.Khomskii and T.Mizokawa, Phys.Rev.Lett. **94**, 156402 (2005);
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[4] D.V.Efremov, J.van den Brink and D.I.Khomskii, Nature Mater. **3**, 853 (2004)