Orbitals, reduced dimensionality and spin gaps in correlated oxides

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Due to directional character of orbitals very often orbital ordering leads to an effective dimensionality reduction. Especially strong are these effects in systems with triply-degenerate $t_{2g}$ electrons. One of the striking consequences thereof is the possibility to form spin-gap states instead of long-range magnetic ordering. Such spin gap states may be formed on dimers, on trimers, on bigger clusters and even on chains. In the talk I will review this question, discuss different situations and different mechanisms of spin gap formation, and illustrate these general ideas on several examples (perovskite KCuF$_3$; spinels MgTi$_2$O$_4$ and CuIr$_2$S$_4$ [1]; pyroxene NaTiSi$_2$O$_6$ [2]; layered systems La$_4$Ru$_2$O$_{10}$ with square [3], LiVO$_2$ with triangular [4], Li$_2$RuO$_3$ with honeycomb lattices [5], pyrochlore Tl$_2$Ru$_2$O$_7$ [6])