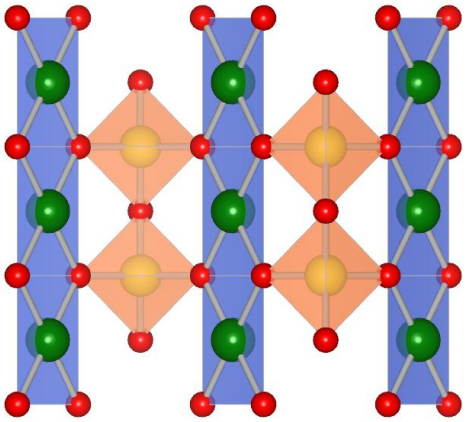
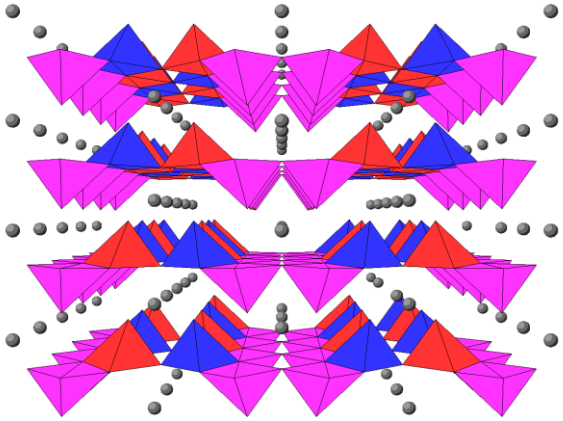
Peculiar low dimensional magnetism and superconductivity

The basic concepts of superconductivity and magnetism are both complimentary and contradictory. There are several insulating magnetic systems which exhibit properties paradoxically similar to behavior of type II superconductors.

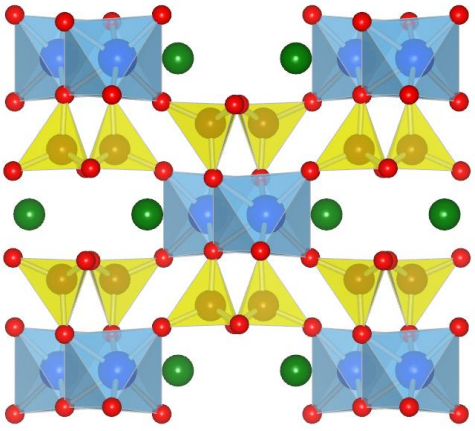
The spin-Peierls compounds are able to develop an energy gap between singlet ground state and triplet excited state. These systems possess first and second critical magnetic fields and are able to create self-accomodating network of magnetic excitations. The essence of spin-Peierls transition is the dimerization of uniform half-integer spin chain. In copper germanate $CuGeO_3$ the transition takes place at about 14 K.





The first magnetic field of about 12 T destroys the spin gap induced by dimerization while the second magnetic field of about 250 T transforms this compound into fully magnetized state. There are several physical mechanisms leading low dimensional magnetic systems into ground state protected by an energy gap.

The sodium vanadate NaV_2O_5 is characterized by mixed valence of transition metal. At elevated temperatures, the formal valence of vanadium is +4.5. At about 34 K the charge ordering phenomena result in formation of two different valence states +4 and +5.



The spin gap appears due to dimerization of magnetically active vanadium ions. Finally, the spin gap may result from the orbital ordering as it occurs in sodium titanium silicate $NaTiSi_2O_6$. At elevated temperatures, the only electron on d shell of trivalent titanium in this compound is shared by two orbitals of similar energy. At 230 K the structural transition of Jahn-Teller origin lifts the degeneracy. The electrons on magnetically active orbitals constitute dimers possessing the spin gap. The role of magnetic interactions leading to spin singled ground states should be taken into account considering physical mechanisms of unconventional superconductivity.

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