## Materials 218/UCSB: Class XVI: High $T_C$ copper oxide superconductors:

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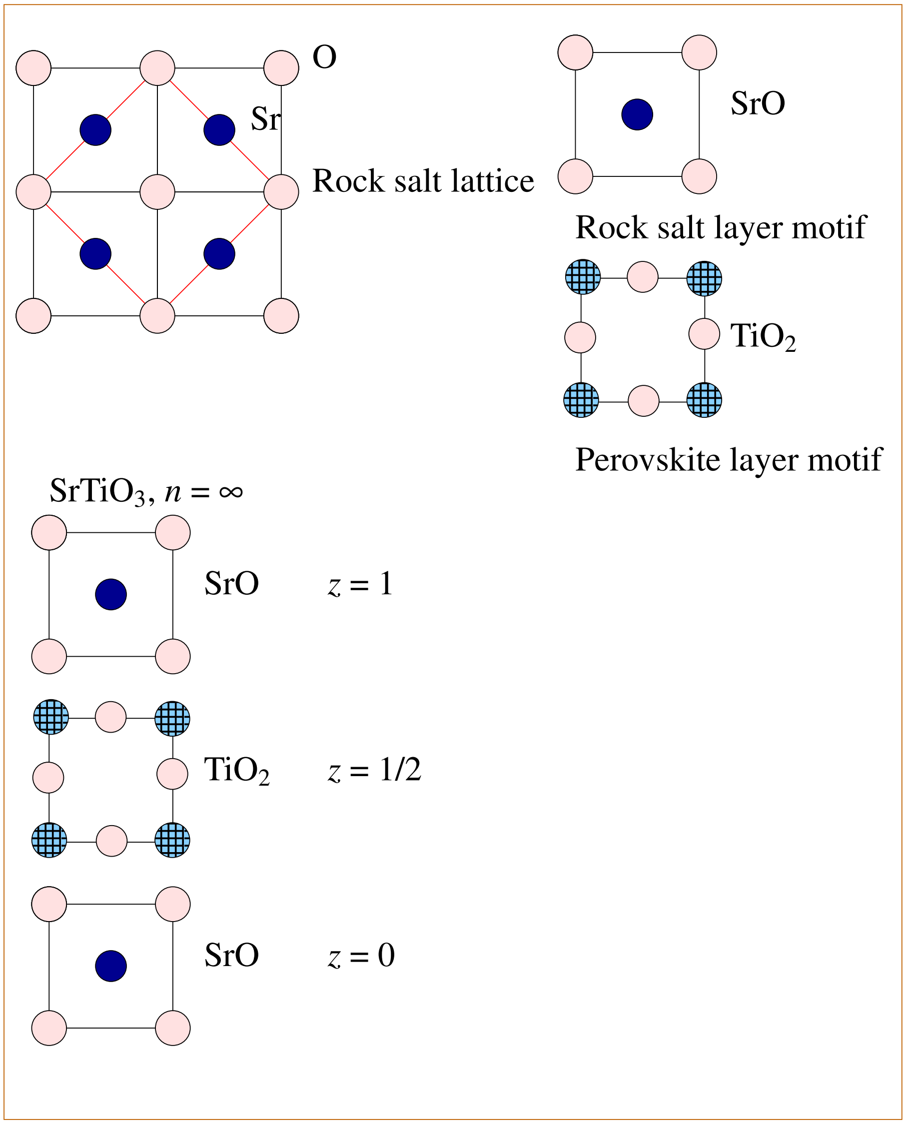
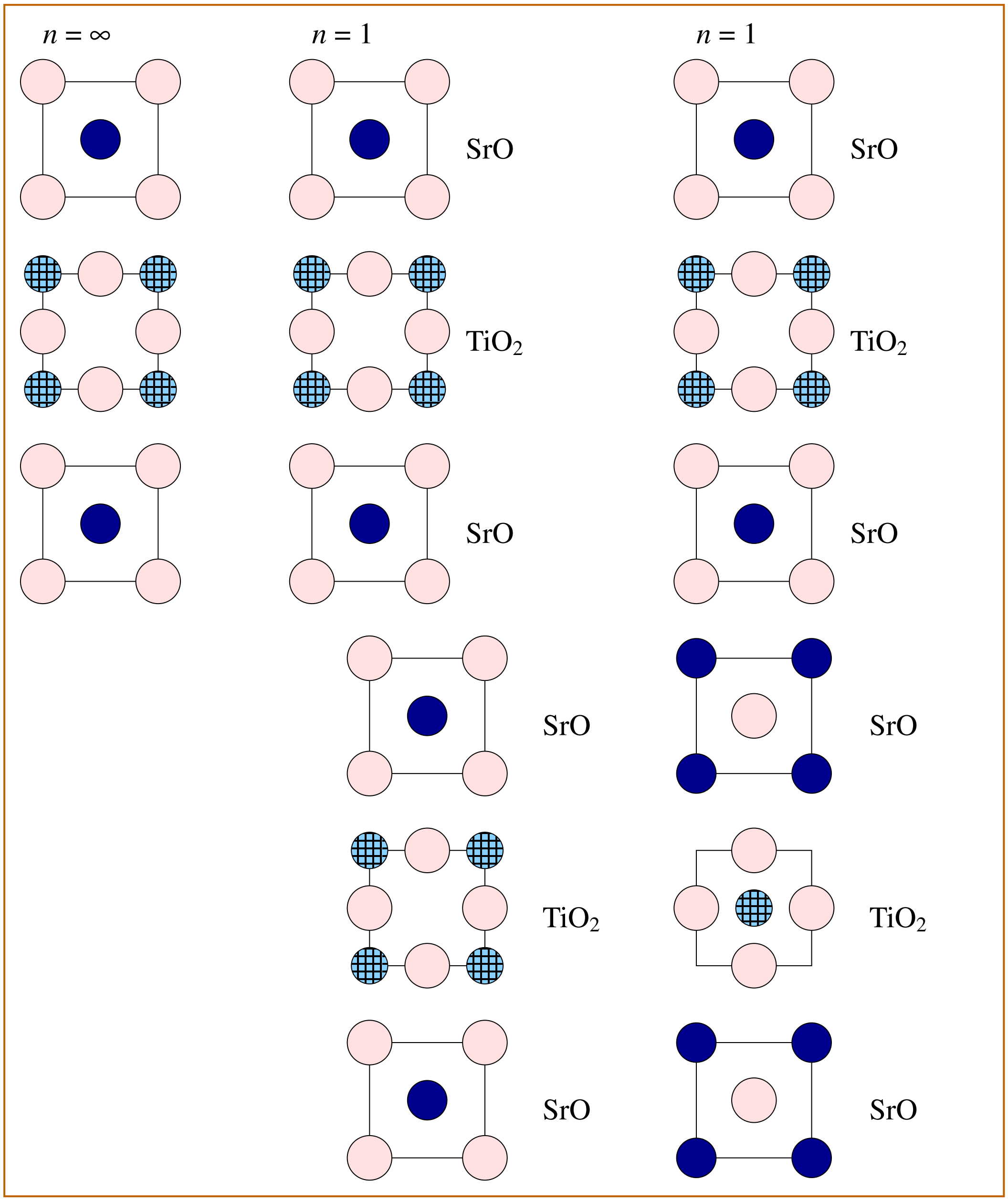
- The Ruddlesden-Popper phases:

  Ruddlesden-Popper phases are intergrowths of perovskite slabs with rock salt slabs. First described in the system Sr-Ti-O, the general formula of the the $n^{\text{th}}$ member of the phase is $(SrTiO_3)_n(SrO)$, and is also written, $Sr_{n+1}Ti_nO_{3n+1}$. The perovskite structure is one end-member of the R-P series ($n = \infty$) and the $K_2NiF_4$ structure is the other end-member ($n = 1$). The $n = 0$ member is rock-salt.

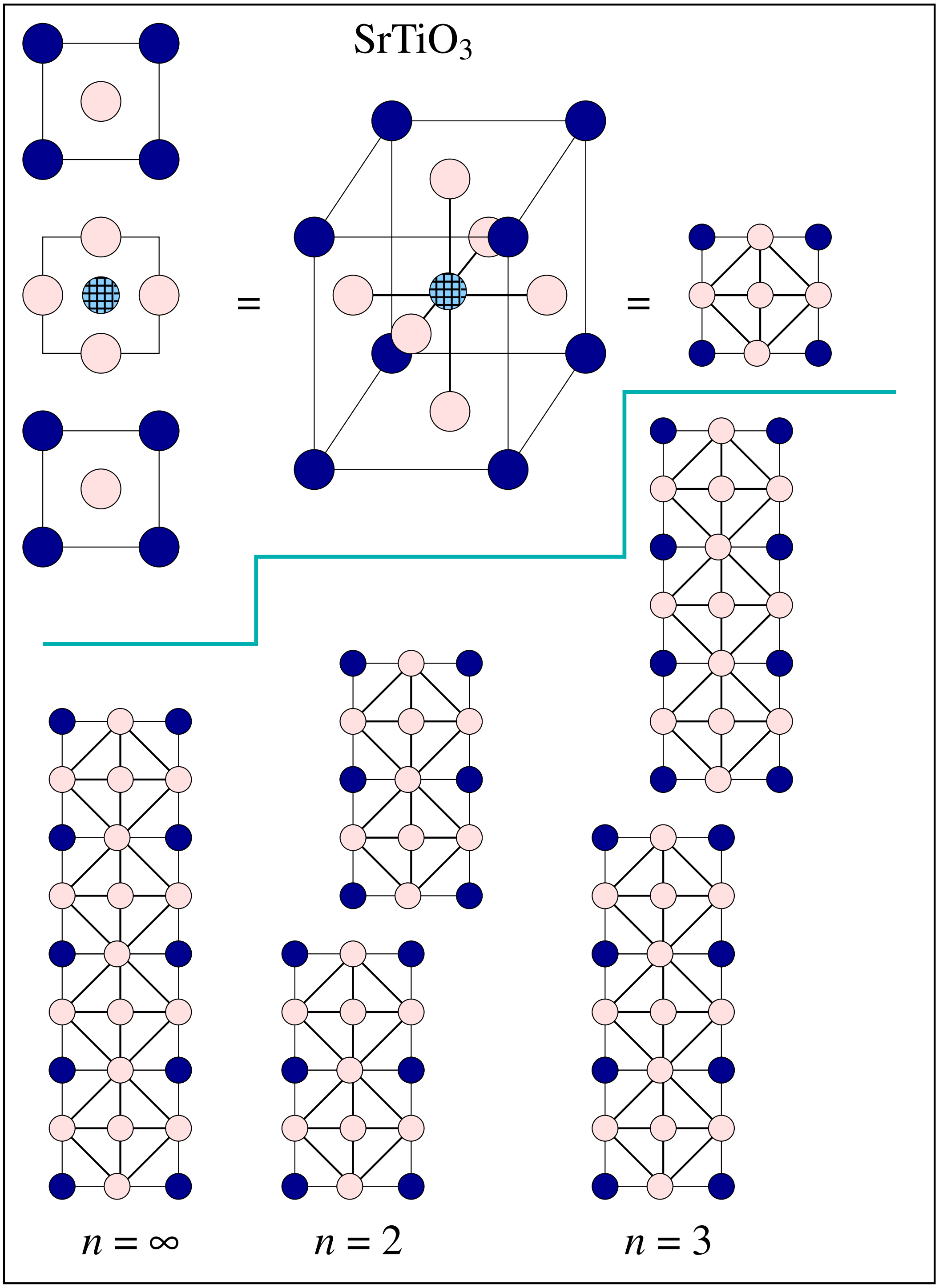
  We now consider different stacking depictions of the perovskite ($SrTiO_3$, $n = \infty$) phase and $K_2NiF_4$ ($Sr_2TiO_4$, $n = 1$) phases.





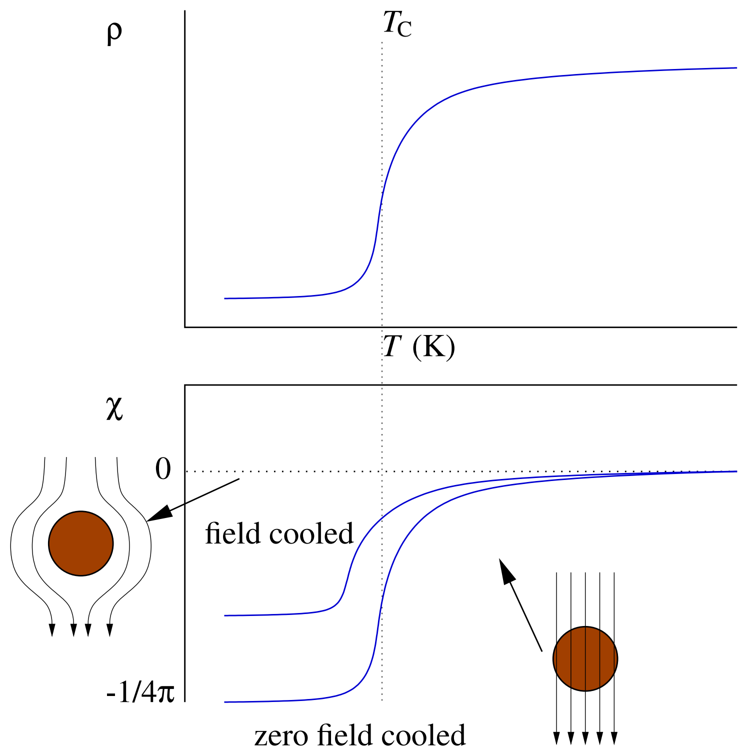

- Along the $c$ axis (the stacking direction), we notice for $SrTiO_3$ ($n = \infty$), the repeat sequence is $\ldots[SrO][TiO_2][Sr0][TiO_2]\ldots$
- Along the $c$ axis (the stacking direction), for $Sr_2TiO_4$ ($n = 1$), the repeat sequence is $\ldots[SrO][SrO][TiO_2][Sr0][SrO][TiO_2]\ldots$
- For $Sr_3Ti_2O_7$ ($n = 2$), the repeat sequence must be $\ldots[SrO][SrO][TiO_2][SrO][TiO_2][SrO][SrO][TiO_2][SrO][TiO_2][SrO][SrO]\ldots$

There is an alternate way of visualizing these structures, making use of octahedra:



## Superconductivity

- In 1908, Kamerlingh Onnes liquefied He for the first time, and in 1911 he used it to cool mercury to about 1.5 K. At 4.2 K, the resistance of his Hg specimen dropped suddenly from about 0.1 $\Omega$ to $10^{-5}$ $\Omega$, and by 3 K had dropped to $1/10^6$ its value at room $T$. This marked the discovery of superconductivity. Typical temperature dependence of the electrical resistivity and the magnetic susceptibility of a superconductor are shown below:




- Not only does the electrical resistivity go to zero, but because of the *Meissner effect* any magnetic lines of force are thrown out by the superconductor, making superconductors strong diamagnets (perfect, even, when the magnetic susceptibility becomes $\chi = -\frac{1}{4\pi}$).

- Uses of superconductors:
  - Used in electromagnetic coils in high field magnets in NMR, MRI *etc.*
  - Power transmission (high currents through thin wires)
  - Magnetic levitation

*to be continued*