Unconventional phases of matter from strong electron-electron interaction

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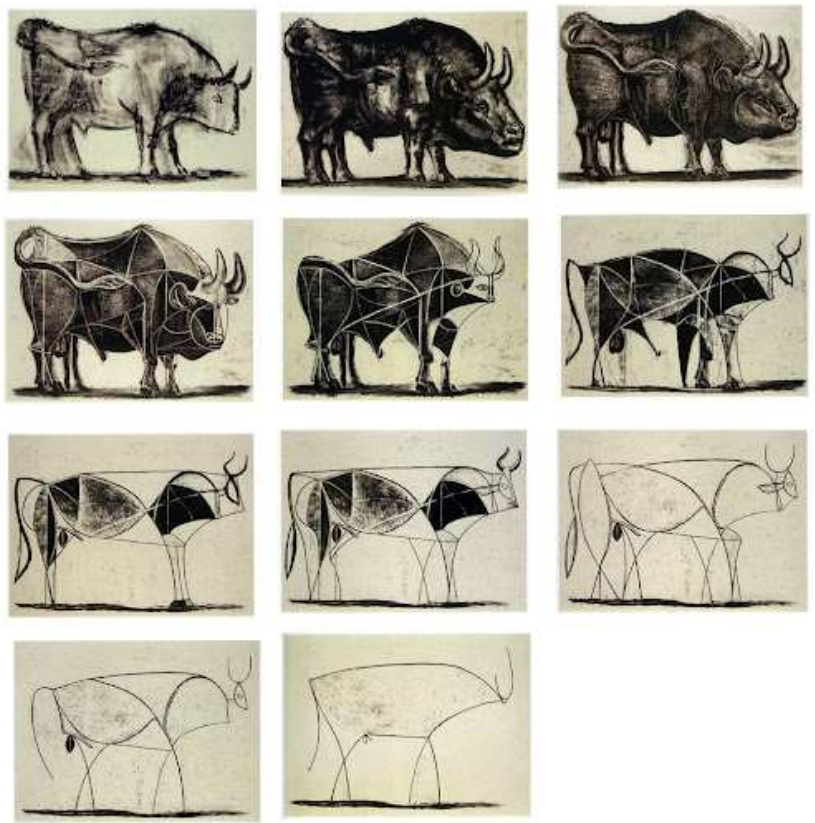
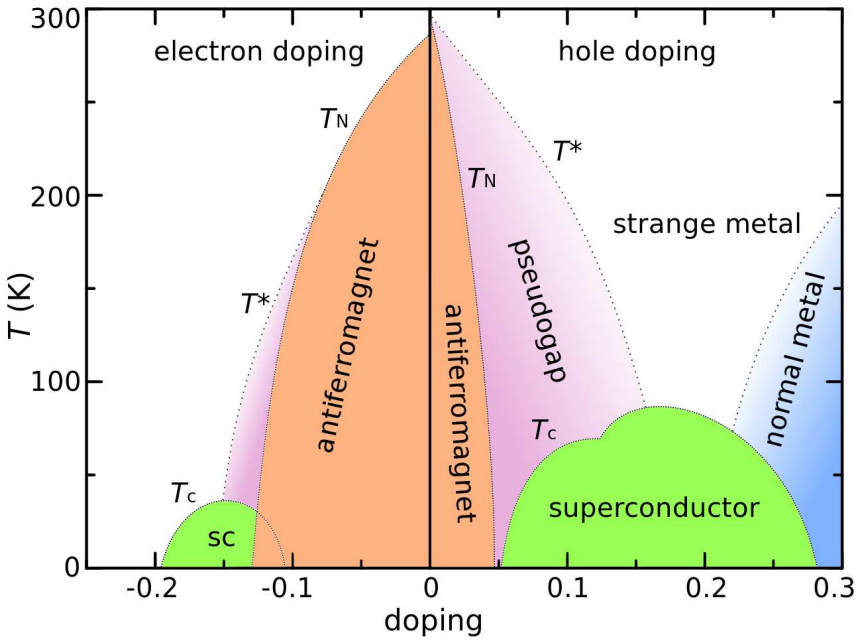
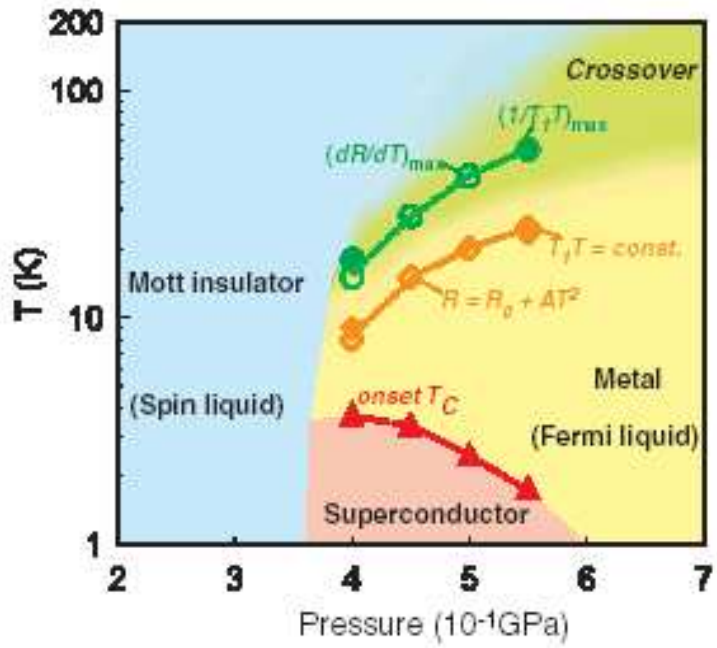


- **Electrons and nuclei in solids...**

$$\mathcal{H} = \sum_i \left(-\frac{\hbar^2}{2m}\right)\nabla_i^2 + \sum_I \left(-\frac{\hbar^2}{2M_I}\right)\nabla_I^2 + \frac{1}{2}\sum_{i\neq j}\frac{e^2}{|r_i - r_j|} + \frac{1}{2}\sum_{I\neq J}\frac{Z_I Z_J e^2}{|R_I - R_J|} - \sum_{i,J}\frac{Z_J e^2}{|r_i - R_J|}$$

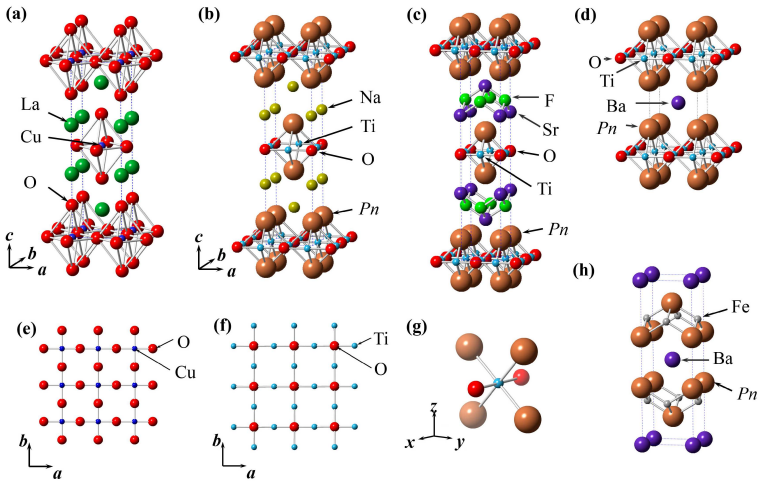
- **...may give rise to a variety of phases of matter**

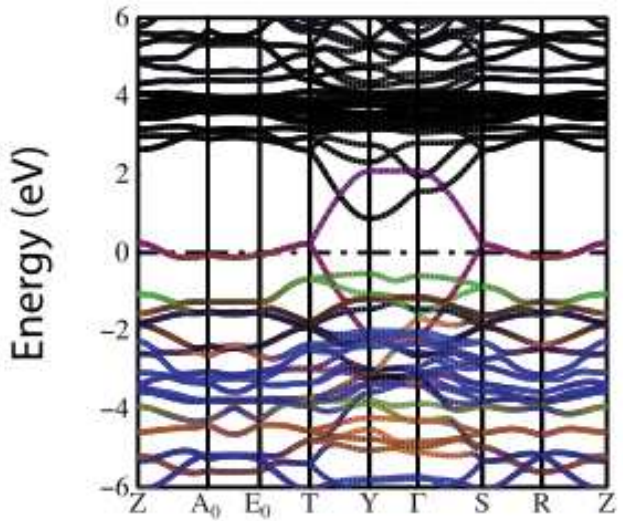




Stripping the many-body problem to its basics

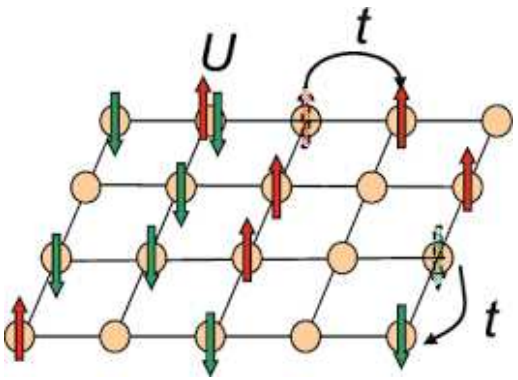
- **Very complicated systems with many atoms and many electronic bands**





- **The e-e interaction plays a relevant role, but it is hard to be treated**

$\Longrightarrow$ **Simpler models for "relevant" degrees of freedom**



e.g., the Hubbard model

(Similar to the Ising model for classical magnetism)

It's still a complicated model to be solved

- **Numerical calculations for many-body systems**

  Mainly quantum Monte Carlo and exact diagonalizations...

  ...but also keen to other numerical approaches