From Mott or Kondo Semiconductor to Unconventional Superconductor: Emergence of Strongly Correlated Quantum Matter on Examples

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The research on magnetic, superconducting, and semiconducting materials prospered as separate disciplines throughout most of the second half of the XX century. Furthermore, the conventional magnetic superconductors and (semi)magnetic (semi)conductors have gained a proper recognition [1,2], in addition to a later discovery of non-Fermi (*non-Landau*) quantum liquids and *topological order* [3]. On the conceptual side, the first Wilson division of materials into metals, semiconductors, and insulators [4] has been updated subsequently to include *strongly correlated materials,* for which quantum phase transitions between the aforementioned states can take place under controllable changes of pressure, temperature, composition, etc.

In my talk, after singling out unique character of strongly correlated systems I concentrate on two concrete topics: *(i)* universal properties of high temperature superconductors [5,6] as they evolve from the Mott-semiconducting (insulating) to the high-T_c state, and *(ii)* heavy-fermion systems, in which the original magnetic-semiconducting state evolves into either (magnetic) superconductor or (magnetic) *Kondo insulator* [7]. Those two systems have common basic features, such as the correlation-driven (non-BCS) origin of superconducting pairing or competition/cooperation of magnetism and superconductivity. They exhibit also quite specific features. For example, in the latter systems we observe there metamagnetism, explicit spin-dependence of very heavy masses [8], and most importantly, the *quantum critical behavior* [9].

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