Relativistic Quantum Materials

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Quantum materials – as a direct consequence of many-body electronic interactions – manifest a wide range of astonishing electronic and magnetic phenomena, which embody the central scientific questions challenging the field of condensed matter physics. Recently, it was discovered that completely new phases of matter can be induced also by the relativistic effects stemming from the interaction between the electron's spin with its own motion. While spin-orbit coupling underlies the description of atomic energy levels, its most spectacular consequences are found in the low-energy electronic structure of solids, which is ushering us in the era of 'relativistic quantum materials'. In this talk I will show how spin and angle-resolved photoemission spectroscopy, in combination with in-situ doping techniques, can be used to unveil the interplay of many-body and/or relativistic effects in the emergence of non-Fermi liquid behavior in high-T_c cuprates, unconventional superconductivity in Sr_2RuO_4, and relativistic Mott insulating behavior in Na_2IrO_3. Highlights from emerging ultrafast spectroscopies will also be discussed, with emphasis on the possibility to disentangle in the time-domain the degrees of freedom underlying the elementary excitations; this offers a new approach to understand and control the properties of these intriguing systems.