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Metal-metal bonding and phase transitions in 5d transition-metal chalcogenides

VALERY KIRYUKHIN, Rutgers University

Metal-metal bond formation tendency is highly prominent in 5d compounds. It often defines their crystallographic structures, and provides the dominant mechanism for many unusual phase transitions. Herein, we discuss the role of metal-metal dimerization and bonding in the structural and electronic phase transitions in several iridium chalcogenides, concentrating on x-ray scattering studies. We present examples of the transitions with unconventional reconstructions of the Fermi surface in metals, as well as metal-insulator transitions. Temperature induced infinite-staircase-like reentrant transitions between spin-polarized and unpolarized electronic bands, formation and destruction of type-II Dirac points in the band structure, as well as unconventional superconducting states are discussed. A brief summary of the experimental and theoretical aspects of the nature of the metal-metal bond in the presence of large spin-orbit coupling characteristic to the 5d elements is also given.