Detecting quantum phase transitions in U1.xThxTe2 under extreme conditions of high hydrostatic pressure and magnetic field

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UTe2 is a novel highly correlated superconductor which exhibits up to three field induced unconventional superconducting phases in high magnetic fields up to 70 T [1]. In this talk I will report investigations of the high pressure phase diagram of pristine UTe2 at room temperature and the high magnetic field phase diagram of disordered UTe2. Results from high pressure x-ray diffraction studies in UTe2 up to 30 GPa at room temperature revealed an orthorhombic to tetragonal phase transition between 5 and 7 GPa [2,3,4], with a large volume collapse of nearly 10% and a nearest U-U distance increase by about 4% [2]. Resonant x-ray emission spectroscopy and partial fluorescence yield x-ray absorption studies clearly demonstrate a U intermediate valence of nearly +3.74 at 1.8 GPa and room temperature. With increasing pressure, the U valence shifts towards 4+, passes through a peak at 2.8 GPa, and then decreases towards 3+ and settles to nearly a constant value above 15 GPa and up to 52 GPa [2]. This lower to higher symmetry transition suggests less 5*f* electron participation in bonding when the weakly correlated superconducting phase in the tetragonal structure of UTe2 appears. In addition, high magnetic field measurements on the effect of disorder on the superconducting phases from substituting Th ions to disrupt U-dimers, and weaken electronic correlations, revealed the suppression of the field polarized superconducting and high field superconducting phase at Th ion concentrations [5]. Interestingly, the low field superconducting phase persisted in samples with Th ion concentrations up to 4.7 %, suggesting that the 3 ambient pressure superconducting phases originate from separate superconducting pairing symmetries.

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Additionally, high pressure x-ray diffraction spectra in UFe2Si2 exhibit new peaks at P > 20 GPa – signaling a possible phase transition. UFe2Si2 resonant x-ray emission spectra are consistent with a valence of 3.7 at 1.5 GPa which steadily decreases to 3.6 up to 7 GPa, while data collected at 32 and 54 GPa indicates an increase in valence back to 3.7.