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Abstract

The development of next-generation functional quantum systems requires the exploration of a variety of novel quantum materials. Topological materials hold strong promise, hosting topologically protected or otherwise long-lived quasiparticles that potentially enable novel routes to quantum functionality. Most topological materials identified thus far contain strong spin-orbit coupling but are weakly correlated. Exploring effects of topology in such weakly correlated settings has led to the identification of fundamentally new quantum phases and phenomena, including the topological insulators and topological semimetals.

This Vannevar Bush Faculty Fellowship project is paradigm-shifting in its advancement of a new theoretical framework. We will use strong electron correlations to create and control novel topological states of matter. The proposed research is two-pronged. We will pursue Weyl-Kondo semimetals in theoretical models containing strong correlations for heavy fermion and related quantum materials, building on our recent work along this direction. Equally important, we will sustain and expand experimental collaborations to validate the proposed framework in a carefully chosen set of materials. The support of experimental collaborators is essential in forming a dialogue between theory and experiment to refine and establish the framework.

The proposed research is expected to realize extreme quantum materials, which may serve as novel platforms for DoD capabilities of interest, such as quantum sensing and quantum computation. It will impact on a large group of new graduate students and postdoctoral fellows, who will be engaged in the multifaceted research that will be enabled by the VBFF program.