Advanced quantum simulator design for unconventional superconductors and other quantum materials

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**Description:**

Unconventional superconductors could lead to major advances in areas as diverse as medical imaging, transport and synchrotron colliders. Yet the description of such superconductors remains a huge challenge for theorists. Diverse interactions can be found within these fascinating quantum materials: Interactions between both the spin and charge of electrons sitting within multiple electronic bands are further complicated by interactions between electrons and lattice vibrations (phonons).

It would be of high interest to introduce these complex effects into quantum simulators. A quantum simulator is essentially an analogue quantum computer that emulates quantum processes in a controlled way. An advantage of quantum simulators over conventional experimental systems is that interactions can be tuned or even turned off to understand their roles in complex systems. For example optical lattices filled with cold atoms can emulate simplified models of the interactions between electrons in materials [1,2]. The physics of unconventional superconductors is typically more complex than these simplified models. The purpose of this project is to develop quantum simulators that can handle the large diversity of interactions found in unconventional superconductors. This will build on our previous work in this area [3-6]. A combination of advanced simulation techniques (quantum Monte Carlo / diagrammatic Monte Carlo) and analytic calculations will be used to examine and develop quantum simulators. These will be combined with computational intelligence techniques to develop a toolbox for quantum simulator design. Strong mathematical skills are essential and prior computer programming experience would be useful.

**References:**

**Qualifications required:** Good first degree in physics or possibly related subject where quantum mechanics has been studied (e.g. applied mathematics, chemistry), preferably at master’s level.