Designer Quantum Materials, atom-by-atom.

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Although scanning tunneling microscopy (STM) first gave us a real-space atomic-scale image of the silicon surface over 30 years ago, the ability to make electrically useful devices atom-by-atom has just recently advanced to the point where it can start being used as a tool to address basic science questions and engineering challenges. We have recently directed our ability to make atomically precise donor structures in silicon to fabricating tunable arrays that hold promise for mimicking the underlying behavior of quantum materials, providing an engineered approach to their study. This talk will focus both on the promise of realizing tunable donor arrays that serve as analog quantum simulations (AQS) of important quantum many body problems, and on our technical progress towards that goal.

The promise of using AQSs to simulate interesting quantum many body problems has two origins. These highly tunable arrays could be made to replicate the physics of entire families of materials, including those which haven't been made yet, thus helping to predict what materials are worth synthesizing and purifying. AQSs could also be used to benchmark modeling approaches on small arrays before those approaches are applied to complicated real materials.

Experimental data and modeling results will be used to support our view that donor arrays provide a complementary approach to trapped atoms and ions to understanding quantum many body effects. The motivation for pursuing AQS with donors specifically stem from the relatively large energy scales for donors, providing materials parameters that can be tuned over a wide range, in comparison to trapped atoms and ions. Conversely, the stochastic nature of the donor chemistry ensures comparatively small arrays with significant levels of disorder.

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