Award Achievements

The 4th Heinrich Rohrer Medal –Rising Medal–

Prof. Yi Chen

"For the pioneering contributions that have pushed the boundaries of scanning tunneling microscopy along two directions which are the creation of the first atomic scale multi-qubit platform and the innovative visualization of exotic excitations in a quantum spin liquid."

Prof. Yi Chen has extended the capability of scanning tunneling microscopy (STM) to two unexpected yet important domains, i.e., studies of spin qubits and spin liquids.

Recent technological developments have made the following question no longer a fantasy: can one construct a qubit platform, one atom at a time, with an STM? Together with colleagues, Chen has used and developed an arsenal of cutting-edge surface-science techniques to make this happen. Using STM-based atom manipulation, spin qubits can be constructed with Å precision. The biggest remaining question, however, is how to detect and control the spin qubits lying outside the tunnel junction, a task that seemingly violates the basic principle of STM. Chen and colleagues have realized that this is possible in the coherent regime —the spin under the tip can act as a sensor qubit that detects state populations of other spin qubits around it. With additional microwave control methods, fast gate operations such as CNOT and CCNOT are thereby demonstrated. This first atomic-scale multi-qubit platform promises a variety of simulation and sensing schemes with sub-nm precision.

Chen's second contribution concerns the use of STM to hunt for elusive quasiparticles called spinons. Long predicted in exotic states of matter called spin liquids, spinons carry no charge and are notoriously difficult to identify via conventional probes. In certain cases, however, spinons become itinerant, hence the material can be seen as a "charge-neutral metal". The question then becomes how to detect metallic behavior with an STM, a task that many STM pioneers have beautifully demonstrated. Using surface-science techniques (e.g., spectroscopic imaging and atom deposition), Chen and coworkers have made a series of discoveries, including imaging of spinon Fermi-surface ordering as well as spinon-induced Kondo screening of magnetic impurities. This methodology has carved out a new area of research for STM, where other types of exotic fractionalized quasiparticles such as Majorana fermions may now be visualized.