Recently, the ability to drive electron spin resonance (ESR) of individual atoms using a scanning tunneling microscope (STM) provided a major step forward in sensing and manipulating magnetism at the atomic scale. In the first part, I will describe the implementation of continuous-wave ESR in STM [1]. The ultrahigh energy resolution of ESR has allowed the measurement of the magnetic interaction between two atoms [2–4], the detection of nuclear spins [5, 6], as well as the exploration of quantum fluctuations in designed spin arrays. Next, I will talk about coherent spin control using all-electric pulsed ESR [7]. By modulating the atomically-confined magnetic interaction between the STM tip and surface atoms, we drive quantum Rabi oscillations of single spins in as little as ~20 nanoseconds. Ramsey fringes and spin echo signals allow us to improve quantum coherence. I will also show the coherent operations on engineered atomic dimers. Coherent control of spins arranged with atomic precision thus provides a solid-state platform for quantum simulation of many-body systems.

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