Center for Artificial Low D Electronic Systems

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“Single-shot readout of the nuclear spin in a single atom using ESR-STM”

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Individual nuclear spins have attracted research interest as promising candidates for the building blocks for quantum memory because they have longer lifetime and coherence time compared to electronic spin states. Most studies on individual nuclear spins have focused on the nuclear spins embedded in solids such as nitrogen-vacancy centers in diamond and single-molecule magnets, which have limited controllability due to their environment. Scanning tunneling microscopy with electron spin resonance (ESR-STM), which allows for precise placement of individual magnetic atoms on a crystal surface, recently observed the nuclear spin state through the hyperfine interaction. However, time-resolved measurements for its relevant timescales have not been reported. In this work, we achieve single-shot measurements of the nuclear spin state of 49Ti atom, which has S=1/2 (electronic) and I=7/2 (nuclear) spins, adsorbed on MgO/Ag(001) using ESR-STM. We apply the pulsed radio-frequency electric field at the fixed frequency, which can drive ESR only when the atom has a certain nuclear spin state and observe whether ESR is driven or not by measuring tunneling conductance. This new approach enables time-resolved measurement of the nuclear spin, and we measure its intrinsic lifetime to be 5 sec, which is 7 orders of magnitude longer than the electronic spin in the same atom. Moreover, we reveal the nuclear spin pumping and relaxation process by sending DC or AC field between the pulses. This long lifetime of the nuclear spin together with the ability of atom manipulation offers a new platform to investigate quantum coherence and entanglement of atomic nuclear spins on surfaces.