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Controlling trapped ions without lasers[1]

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Quantum computing using trapped atomic ions relies on manipulation of the ions quantum states and the creation of entanglement between ions, both of which are typically accomplished using laser beams. However, there are drawbacks to this approach, including errors due to photon scattering and the complexity of the required laser sources. Our group performs quantum state control using oscillating rf and microwave-frequency magnetic and electric fields, and their near-field gradients, instead of laser beams. We use low-power resonant laser beams for cooling, optical pumping, and readout. A critical element is the use of a microfabricated surface-electrode ion trap, which holds the ions roughly 30 μm above the electrodes generating the control fields. I will describe several of our recent results, including the creation of high-fidelity entangled states of two ions using only microwave and rf control fields, and the use of rf electric fields to generate squeezed states of ion motion for sensing applications and to amplify phonon-mediated ion-ion interactions.

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