A high-resolution source of single ions using correlated feedback

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The cold atom ion source (CAIS)[1], based on photoionization of laser-cooled atoms, has been shown to possess a brightness which surpasses conventional liquid metal and gas field ion sources[2]. The CAIS offers high resolution, a broad range of atomic species with associated choice of imaging and etching contrast, and competitively high beam current. Here we investigate the application of cold-atom ion sources to deterministic production of single ions with high spatial and temporal resolution.

In one approach we exploit the correlation between electrons and their associated ions following ionization of cold atoms[3]. Coincident detection and feedback in combination with Coulomb-driven particle selection allows for high-fidelity heralding of ions at a high repetition rate. We have used detection of coincident electrons to gate the ion beam and enhance the ion heralding rate.

Extension of the scheme beyond time-correlated to position/momentum-correlated feedback provides a general and powerful means to optimize the ion beam brightness for the development of next-generation focused ion beam technologies[4]. We will show experimental results and the results of detailed calculations of a momentum-feedback scheme for a high brightness quasi-single-ion source.

We have also investigated Rydberg blockade for isolating single ions. We use STIRAP[5] to efficiently ionize atoms and Doppler velocity selection to reduce the ion beam energy spread. Rydberg excitation and field ionization then produce widely separated ions which are again heralded, and potentially gated, by detection of the correlated electrons.

We are combining these techniques and using a commercial ion beam microscope column to create a powerful tool for characterization and fabrication of materials at the nanoscale.

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