Marko Cetina
(Massachusetts Institute of Technology (MIT), Cambridge, USA)

Hybrid Approaches to Quantum Information using Ions, Atoms and Photons

I will present two hybrid systems with applications to quantum information processing: one combining trapped ions with laser-cooled atoms and another interfacing a collection of ions with photons.

Yb^+ ions are trapped in a radio-frequency surface-electrode Paul trap and overlapped with Yb atoms trapped in a magneto-optical trap. Interactions between trapped cold atoms and cold ions were observed for the first time via near-resonant charge-exchange collisions at energies between 3 μeV and 4 meV ($k_{B \times 35\ mK}$ - $k_{B \times 47\ K}$), limited by the trap-driven micromotion of the ions [1].

The coupling of ions to photons can be enhanced by employing collective superradiant effects. To realize collective ion-photon coupling in a system compatible with trapped-ion quantum logic, linear chains of ions are trapped inside the mode of a medium-finesse optical resonator using an array of microfabricated surface-electrode Paul traps. The interaction of the ions with the optical resonator is observed by using the resonator to analyze the spectrum of the ions' near-resonance fluorescence. Preliminary results show the capability of this system to store photonic information in the collective states of individually-addressable ions, with application to efficient ion-photon interfaces [2].

[1] A. Grier, M. Cetina, F. Orucevic, and V. Vuletic, Phys. Rev. Lett. 102, 223201 (2009)
[2] Lamata et al, arXiv:1102.4141v1 [quant-ph]

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Universität Ulm, Raum 45.2.304 (Uni West)
Albert-Einstein-Allee 45, 89081 Ulm

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