CHEMICAL AND SPECTROSCOPIC APPLICATIONS OF ULTRACOLD IONS IN ION TRAPS

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Over the past years, ultracold ($T < 10$ mK) atomic and molecular ions prepared by laser and sympathetic cooling in ion traps have found an increasing number of applications in molecular physics[a], chemistry[b] and spectroscopy[c]. At low temperatures the ions undergo a phase transition from a "gaseous" state to an ordered structure in the trap. Owing to their strong localisation single ions can be observed, addressed and manipulated opening up perspectives for new gas-phase experiments with single-particle sensitivity. In this talk, novel experimental schemes for reactive-scattering studies and high-resolution spectroscopy based on ultracold ions will be discussed. A new method to investigate reactive collisions between laser-cooled ions and velocity-selected neutral molecules will be introduced. The technique is particularly suited to measure ion-molecule reaction rates as a function of temperature down to ≈ 1 K. First results on the $Ca^+ + CH_3F \rightarrow CaF^+ + CH_3$ reaction will be presented. In the second part of the talk, prospects for the state-selected generation of cold molecular ions and their application in high-resolution spectroscopic experiments will be explored.

[a] M. Drewsen, I. Jensen, J. Lindballe, N. Nissen, R. Martinussen, A. Mortensen, P. Staanum and D. Voigt, *Int. J. Mass Spectrom.* **229** (2003), 203

[b] S. Willitsch, M. T. Bell, A. D. Gingell, S. R. Procter and T. P. Softley, *Phys. Rev. Lett.* **100** (2008), 043203

[c] P. O. Schmidt, T. Rosenband, C. Langer, W. M. Itano, J. C. Bergquist and D. J. Wineland, *Science* **309** (2005), 749