Collisions and chemistry in hybrid systems of cold molecular ions and ultracold atoms: experiment and theory

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We review recent results on the characterisation of the prevalent cold collisions and chemical reactions occurring between molecular ions and ultracold atoms in ion-atom hybrid trapping experiments [1]. Focussing on the prototypical N_2^+ + Rb and O_2^+ + Rb systems, we have used a combination of experiment and theory to unravel the details of charge-exchange, radiative, inelastic and elastic collisions in the cold regime. In N_2^+ + Rb, non-adiabatic charge exchange was observed to be the dominant process the dynamics and kinetics of which are governed by a subtle interplay between long-range and short-range intermolecular interactions [2]. By contrast, radiative charge exchange and molecule formation [3] as well as rotationally inelastic collisions [4] were calculated to play only minor roles under typical experimental conditions. We also briefly review recent developments on the quantum control and non-destructive state readout of single molecular ions [5,6] and discuss prospects for the application of these techniques in studies of cold collisions of molecular ions with hyperfine-Zeeman state resolution.

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