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Investigation of a hybrid quantum system of ultracold atoms and trapped ions LOTHAR RATSCHBACHER, JONATHAN SILVER, LEONARDO CARCAGNI, CHRISTOPH ZIPKES, CARLO SIAS, MICHAEL KÖHL, University of Cambridge — Hybrid quantum experiments with single ions immersed in quantum gases are starting to be used as versatile systems for experiments in quantum information science, atomic physics and cold chemistry. We deterministically position radio-frequency trapped $^{174}\text{Yb}^+$ ions inside a Bose Einstein condensate of ^{87}Rb atoms and achieve independent control on the motional and internal states of both species. We investigate the fundamental atom-ion interactions by characterizing elastic and inelastic collisions and measure their energy-dependent collision rates. In the presence of near resonant light interactions between both species are strongly modified, leading to inelastic scattering rates that are more than three orders of magnitude higher compared to collisions in the ground states. We analyze the process at the single particle level with ion trap mass spectroscopy to identify the underlying interaction channels. The emerging understanding of the state-dependent interactions between the two quantum systems paves the way for applications in quantum information science and cold-matter research.

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