CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

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Hybrid atom-ion Quantum Systems
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(Guest of Prof. Dr. Klemens Hammerer)

Leibniz Universität Hannover
Welfengarten 1, 30167 Hannover
(building 1101)
Seminar room D326
at the Institute of Quantum Optics
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"Studying the quantum physics of interacting atoms and ions"

In recent years, a novel field of physics and chemistry has developed in which trapped ions and ultracold atomic gases are made to interact with each other. These systems find applications in studying ultracold chemistry and collisions [1], and a number of quantum applications are envisioned such as ultracold buffergas cooling of the trapped ion quantum computer and quantum simulation of fermion-phonon coupling [2]. Up until now, however, the ultracold temperatures required for these applications have not been reached. This is because the electric traps used to hold the ions can cause heating during atom-ion collisions [3]. In my talk, I will present recent experimental results on Yb+ ions interacting with ultracold 6Li atoms. The large mass ratio of this combination supresses the heating, bringing the quantum regime within reach [3,4]. We measure the dynamics of single Yb+ spin-qubits in a cold Li cloud [5]. The observed large spin-exchange rates suggest the existence of broad magneto-molecular (Feshbach) resonances between atoms and ions at lower temperatures. We study the effect of experimental imperfections that limit attainable temperatures in our setup and conclude that the required temperatures should be in reach after minor improvements [4]. Finally, I show how we can tune the interactions between the atoms and ions in our experiment, by laser-coupling to Rydberg states [6]. These techniques may allow to create spin-spin interactions between atoms and ions, or phonon-mediated atom-atom interactions [7] and to eliminate heating due to the electric field of the ion trap altogether [8].

[1] M Tomza et al., arXiv:1708.07832 (2017).
[2] U. Bissbort et al., Phys. Rev. Lett. 111, 080501 (2013).
[3] M. Cetina et al., Phys. Rev. Lett. 109, 253201 (2012).
[4] H. A. Fürst et al., J. Phys. B: At. Mol. Opt. Phys. 51 195001 (2018).
[5] H. A. Fürst et al., Phys. Rev. A 98, 012713 (2017).
[6] N. V. Ewald et al., arXiv:1809.03987 (2018).
[7] T. Secker et al., Phys. Rev. A 94, 013420 (2016).
[8] T. Secker et al., Phys. Rev. Lett. 118, 263201 (2017).

All DQ-mat members and all interested are cordially invited to attend.