Contribution ID: **17** Type: **Poster**

A charged impurity in an ultracold gas: observations of cold chemistry

Monday 2 September 2024 17:00 (2 hours)

Hybrid ion-atom systems combine the benefits of a single, well-controlled ion with those of a many-body quantum gas, offering prospects for quantum simulation, ultracold chemistry, and charged impurity physics [1, 2]. For the latter, the longer range of the atom-ion interaction, compared to that between two neutrals, is expected to give rise to interesting behaviour, for example the formation of a much larger polaron than in studies of neutral impurities. Furthermore, the excellent degree of control available over a single charged impurity has prospects for its use as a sensitive probe to give information about the bath in which it is immersed. It has been suggested that studies of few-body chemical processes in atom-ion experiments could provide valuable insight into the many-body behaviour of this system [3]. In this talk, I will present recent observations of chemical reactions between a single Yb+ ion and Li_2 dimers in an ultracold cloud, leading to the formation of a LiYb+ molecular ion [4]. We find this to be an unexpected example of the ion probing the atom cloud for trace quantities of dimers. Furthermore, I will outline recent experimental upgrades used to manipulate our atom cloud, increasing its density and preparing a new mixture of spin states. These upgrades have prospects for future studies of a single ionic impurity in a bath cooled to degeneracy, in particular one that is in the BEC-BCS crossover regime.

References

[1] M. Tomza et al., Rev. Mod. Phys. 91, 035001 (2019).
[2] R. S. Lous and R. Gerritsma, Adv. At. Mol. Opt. Phys. 71 (2022).
[3] J. Pérez-Ríos, Mol. Phys. 119, 8 (2021).
[4] H. Hirzler et al., Phys. Rev. Lett. 128, 103401 (2022).

Short bio (50 words) or link to website

For my PhD, I work on experiments in which a single trapped ion is immersed in a cloud of ultracold neutral atoms. My focus is on optimized cooling of the system to energies in which quantum effects begin to dominate, as well as observations of cold chemistry.

Relevant publications (optional)

Observation of chemical reactions between a trapped ion and ultracold Feshbach dimers, H. Hirzler, R.S. Lous, E. Trimby, J. Pérez-Ríos, A. Safavi-Naini and R. Gerritsma, Phys. Rev. Lett. 128, 103401 (2022). https://doi.org/10.1103/PhysRevLett.128.103

Buffer gas cooling of ions in time-dependent traps using ultracold atoms, E. Trimby, H. Hirzler, H. Fürst, A. Safavi-Naini, R. Gerritsma and R. S. Lous, New Journal of Physics 24, 035004 (2022). https://doi.org/10.1088/1367-2630/ac5759

Trap-assisted complexes in cold atom-ion collisions, H. Hirzler, E. Trimby, R. Gerritsma, A. Safavi-Naini and J. Pérez-Ríos, Phys. Rev. Lett. 130, 143003 (2023). https://doi.org/10.1103/PhysRevLett.130.143003

Career stage

Student

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Session Classification: Posters I

Track Classification: FINESS