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Towards a two-dimensional ion crystal immersed in an ultracold atomic cloud

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In experiments with trapped ions, individual particles are separated due to the Coulomb force. This feature makes the system especially suitable for studying few-body systems. In contrast, a large number of neutral atoms can reach quantum degeneracy. In our laboratory, we are developing a hybrid system of trapped Barium ions and neutral Lithium atoms. In our previous work, we have investigated a rotational melting of a two-dimensional Coulomb crystals in a Paul trap [1]. Recently, we have developed a system which the rotational speed of a two-dimensional ion crystal can be controlled. What is more, by tuning the trap frequency ratio in the 2D trapping plane, we have experimentally observed that a two-dimensional ion crystal consisting of a specific number of particles have multiple stable configurations which enables us to create a bistable coulomb crystal [2]. In case of an ion crystal consisting of 6 ions, the two configurations can be expressed as a pentagon shape with one ion at the center and a hexagon shape with no ion at the center of the crystal. Eventually, we aim at placing a two-dimensional crystal of ions inside an ultracold background gas of neutral Lithium to observe these phenomena in the quantum regime. Our plan is to transfer ions from a Paul trap to an electro-optical trap [3] before mixing ions with neutral atoms to avoid any heating from micromotion, leading to an efficient sympathetic cooling of the ions by the atoms. At the conference, latest results of our research will be presented.

[1] L. Duca, N. Mizukami, E. Perego, M. Inguscio and C. Sias, Phys. Rev. Lett. 131, 083602 (2023).
[2] G. Pupillo et al., arXiv:0904.2735v1 (2009).
[3] E. Perego et al., Appl. Sci. 2020, 10(7), 2222 (2020).

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