A New Mechanism for Sympathetic Cooling of Atoms and Ions in Atomic and Ion-Atomic Traps

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Sympathetic cooling of a Fermi gas with a buffer gas of bosonic atoms is an effective way to achieve quantum degeneracy in Fermi systems. However, all attempts to use this method for cooling ions until recently were ineffective because of the unremovable ion "micromotion" in electromagnetic Paul traps, which prevents the realization of a number of hot projects with cold atom-ion systems.

In this regard, we propose a new efficient method for sympathetic cooling of ions: the use for this purpose of cold buffer atoms in the region of atom-ion confinement-induced resonances (CIRs) [1]. We show that the destructive effect of ion "micromotion" on its sympathetic cooling can, however, be suppressed in the vicinity of the atom-ion CIR. Here, the resonant blocking of the complete approach of an atom with an ion during a collision also blocks the enhancement of its "micromotion". We investigate the effect of sympathetic cooling around CIRs in atom-ion, and atom-atom confined collisions within the quasiclassical-quantum approach using the Li-Yb^+ and Li-Yb confined systems as an example. In this approach, the Schrödinger equation for a cold light atom is integrated simultaneously with the classical Hamilton equations for a hotter heavy-ion or atom during a collision. We have found the region near the atom-ion CIR where the sympathetic cooling of the ion by cold atoms is possible in a hybrid atom-ion trap. We also show that it is possible to improve the efficiency of sympathetic cooling in atomic traps by using atomic CIRs.

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References

[1] V S Melezhik, Phys. Rev. A **103**, 053109 (2021)