Confinement-Induced Resonances in Cold Atomic and Atom-Ion Systems

V S Melezhik[1] and A Negretti[2]

[1] *Bogolubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, Russia*
[2] *Zentrum für Optische Quantentechnologien, and Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Hamburg, Germany*
Contact Email: melezhik@theor.jinr.ru

We have investigated confinement-induced resonances (CIR)s in a system composed by a tightly trapped ion and a moving atom in a waveguide [1]. The conditions for the appearance of such resonances were determined for a broad region – from the "long-wavelength" limit to the opposite case when the typical length scale of the atom-ion interaction R^* essentially exceeds the transverse waveguide width $a_\perp$. We have found considerable dependence of the resonance position on the atomic mass which, however, disappears in the "long-wavelength" limit, where the well known result [2] for the atom-atom CIR is reproduced. We have also derived an analytic formula for the CIR position in the "long-wavelength zero-energy" limit.

Our results can be used in current experiments for searching atom-ion CIRs with the aim of measuring the atom-ion scattering length, determining the temperature of the atomic gas in the presence of an ion impurity, manipulating the effective atom-ion interaction in confined systems. In particular, the control of the atom-ion interaction could be exploited to control the atom-phonon coupling in a solid-state quantum simulator [3], to investigate more exotic quantum phases in low dimensional systems, where the trap width $a_\perp$ is tuned in such a way that simultaneously an atom-atom and an atom-ion CIR are generated and a strongly correlated atom-atom and the atom-ion system is created, or, by exploiting the effect of the complete reflection of the confined atom from the ion in the CIR, to realise a device for triggering the confined atom flow, similarly to a single atom transistor [4].

References

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