Inelastic Confinement-Induced Resonances in Ultracold Atom-Ion Systems

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Over the last years, several different systems have been studied as promising candidates for quantum simulation and quantum computation [1], such as photonic systems, ultracold atomic clouds, ionic setups or quantum dots, among others.

Single trapped ions are arguably the best controlled single particle quantum system. However, scaling them to large numbers remains a challenge due to the strong Coulombic repulsion. Contrary, ultracold systems formed by neutral alkaline atoms can be easily scaled up to thousands or millions of particles. Thus, the construction of mixed systems formed by ultracold neutral atoms and ions may exploit the advantages of both individual setups because of their complementary properties.

In this work, we have extended a numerical approach, originally designed for two ultracold atoms confined in a finite three-dimensional optical lattice [2], to study an atom-ion system. The atom-ion interaction is treated in a realistic *ab initio* fashion using numerical Born-Oppenheimer curves. We demonstrate that the inelastic confinement-induced resonances (ICIR) shown to occur for ultracold neutral atoms [3], dipolar systems quantum gases [4], and quantum-dot systems [5] are also present in the atom-ion system, if there is a coupling of center of mass and relative motions due to the confining potentials (see Fig. 2). The ICIR offers an alternative means to control the atom-ion interaction even in the absence of magnetic Feshbach reso-

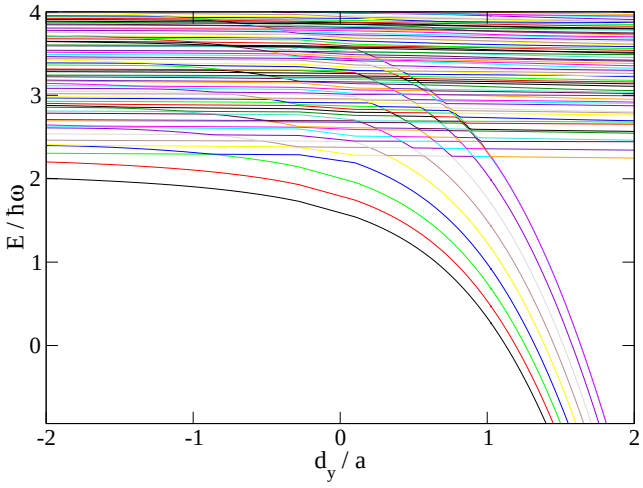

Figure 1: *Ab initio* eigenenergy spectrum of Li_2^+ confined in a quasi-one dimensional harmonic trap with $\omega_{\rm ion} = 1.4\,\omega_{\rm atom}$, and $\omega_x/\omega_z = \omega_y/\omega_z = 10$, as a function of the ratio between the transversal characteristic size, d_y, and the scattering lenght, a.

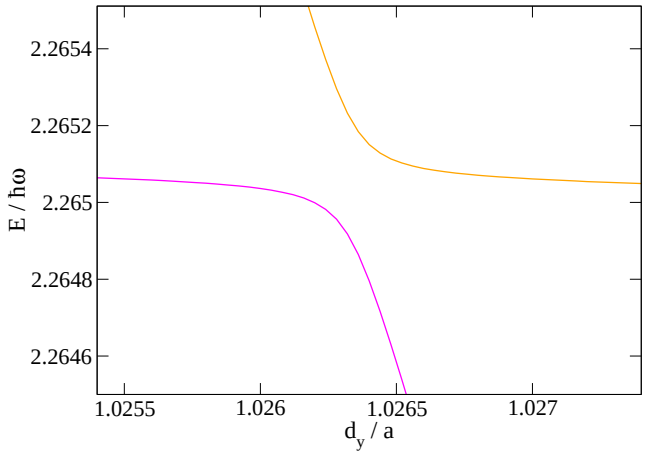

Figure 2: Enlarged view of one of the avoided crossings shown in Fig. 1 responsible for an inelastic confinement-induced resonance due to the coupling of the relative motion and center of mass at $d_y/a \approx 1.0263$.

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