Ultracold atomic and atom-ion processes in confined geometry of waveguide-like traps *

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Impressive progress of the physics of ultracold quantum gases has stimulated the necessity of detailed and comprehensive investigations of collisional processes in the confined geometry of atomic and ionic traps. The traditional free-space scattering theory is no longer valid here and the development of the quantum scattering theory including the influence of the confinement is needed. In our works we have developed quantitative models [1-4] for pair collisions in tight atomic waveguides and have found several novel effects in its application: the confinement-induced resonances (CIRs) in multimode regimes including effects of transverse excitations and deexcitations [2], the so-called dual CIR yielding a complete suppression of quantum scattering [1], and resonant molecule formation with a transferred energy to center-of-mass excitation while forming molecules [5]. Last effect was confirmed experimentally in [6]. Our calculations have also been used for planning and interpretation of the Innsbruck experiment where CIRs in ultracold Cs gas were observed [7]. Mention also the calculation of the Feshbach resonance shifts and widths induced by atomic waveguides [8]. In the frame of our approach we have predicted dipolar CIRs [9] which may pave the way for the experimental realization of, e.g., Tonks-Girardeau-like or super-Tonks-Girardeau-like phases in effective one-dimensional dipolar gases.

Recently, we have predicted the atom-ion CIRs [10] which are important for a hot problem of control of the confined hybrid atom-ion systems having many promising applications [11]. We plan to present our new results, particulary, a calculation of the ion micromotion effect in the atom-ion systems confined in waveguide-like traps [10,11].

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