Ultracold collisional processes in atomic traps

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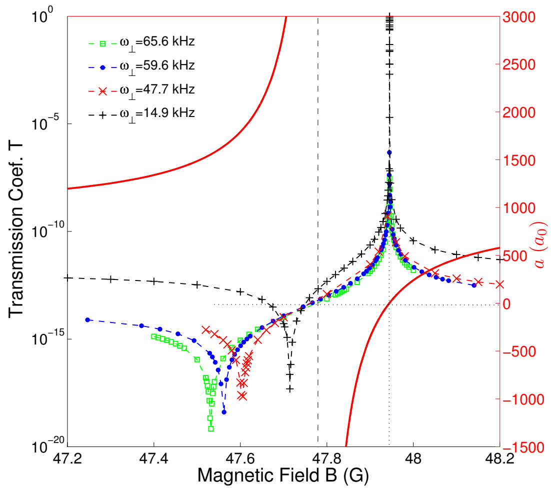
Impressive progress of the physics of ultracold quantum gases has stimulated the necessity of detailed and comprehensive investigations of collisional processes in the confined geometry of atomic traps. Here the free-space scattering theory is no longer valid and the development of the low-dimensional theory including the influence of the confinement is needed. In our works we have developed a computational method [1-3] 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 [4]. Our calculations have also been used for planning and interpretation of the Innsbruck experiment on investigation of CIRs in ultracold Cs gas [5].

In the past two years we develop a theoretical model for Feshbach resonance shift and width induced by an atomic waveguide [6]. The Feshbach resonances of different tensorial structure have been used for experimental creation of the CIRs [5], however the modeling of CIRs was limited by the single-channel s-wave potentials [7]. We have calculated the shifts and widths of s-, d- and g-wave magnetic Feshbach resonances of Cs atoms in harmonic waveguides. In Figure the calculated transmission coefficient T as a function of magnetic field B and the waveguide frequency $\omega_\perp$ is given near the d-wave Feshbach resonance 47.8G in Cs, where the free-space scattering length $a(B)$ (solid curves in the Figure) diverges. We have found that $a = 0.68a_\perp = 0.68\sqrt{\hbar/(\mu\omega_\perp)}$ is fulfilled at the positions of the CIR (minimums of T in the Figure) for the Feshbach resonances of different tensorial structure. It holds in spite of the fact that this law was originally obtained in the framework of s-wave single-channel pseudopotential [7].We have also found the linear dependence of the width of the resonance enhancement of the T-coefficient (at the point 47.95G in the Figure) on the atomic momentum and quadratic dependence on the trap width $a_\perp$. The found effect could potentially be used experimentally.



Recently, we have predicted [8] the dipolar confinement-induced resonances (DCIRs) at ultracold dipolar collisions in harmonic waveguides and quantitatively investigated the conditions for appearance of such resonances. Our model opens novel possibilities, which we plan to discuss briefly, for quantitative studies of anisotropic quantum scattering in the plane [9] and modeling quasi-2D scattering of polar molecules in "pancake" traps.

References

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