Resonances in ultacold collisions confined by atomic traps

Vladimir Melezhik[1], Shahpoor Saeidian[2], Panagiotis Giannakeas[3], Peter Schmelcher[3]

[1]*Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna Moscow Region 141980, Russian Federation*
[2]*Optics and Photonic Research Center, Department of Physics, Institute for Advanced Studies in Basic Sciences (IASBS), Gava Zang, Zanjan 45137-66731, Iran*
[3]*Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany*
melezhik@theor.jinr.ru

By using our computational technique for ultracold scattering in low-dimensions [1,2] we have developed and analyzed a theoretical model which yields the shifts and widths of Feshbach resonances in atomic waveguides [3]. This model permits quantitative investigation of Feshbach resonances with different tensorial structure and having broad, narrow and overlapping character. We have calculated the shifts and widths of s-, d-, and g-wave magnetic Feshbach resonances of Cs atoms emerging in harmonic waveguides as confinement-induced resonances $T(B_r)=0$ at the field strengths B_r and resonant enhancement $T(B^*)=1$ of the transmission T(B) at zeros $a(B^*)=0$ of the free-space scattering length a. We have found the linear dependence of the width $\Gamma=\Delta k a_\perp^2/a_{bg}$ of the resonance at the magnetic field B* on the longitudinal atomic momentum k and quadratic dependence on the waveguide width $a_\perp$ (here $\Delta = B^*-B_{r0}$ is the width of the Feshbach resonance at B_{r0} and a_{bg} is the background scattering length in free-space).

The found effect could potentially be used experimentally. Actually, one can control the width $\Gamma=\Delta k a_\perp^2/a_{bg}$ of the resonance by varying the trap width $a_\perp$. From the other side, by measuring the width Γ one can extract from the obtained formulae the longitudinal colliding energy E ($k=\sqrt{2mE}/\hbar$) and estimate the temperature of the atomic cloud in the trap.

We have also found that the relationship $a = 0.68 a_\perp$ for the position of the confinement-induced resonance in a harmonic waveguide (where $T(B_r)=0$) is fulfilled with high accuracy for the Feshbach resonances of different tensorial structure which holds in spite of the fact that this property was originally obtained in the framework of the s-wave single-channel pseudopotential approach [4]. Note, that this property was recently experimentally confirmed for d-wave Feshbach resonances in a gas of Cs atoms transformed in atomic traps into confinement-induced resonances [5].

Our model opens novel possibilities, which we briefly discuss, for quantitative studies of the scattering processes in ultracold atomic gases in traps, particularly, the appearance of dipolar confinement-induced resonances [6].

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