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报告

Control of Spin-Exchange Interaction between Alkali-Earth Atoms via Confinement-Induced Resonances in a Quasi 1+0 Dimensional System

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Research Interest:

1. Few-body problems in ultracold atom physics.
2. Quantum optics.

报告摘要 Abstract

A nuclear-spin exchange interaction exists between two ultracold fermionic alkali-earth (like) atoms in the electronic $^{1}{\rm S}_{0}$ state (g-state) and $^{3}{\rm P}_{0}$ state (e-state), and is an essential ingredient for the quantum simulation of Kondo effect. We study the control of this spin-exchange interaction for two atoms simultaneously confined in a quasi-one-dimensional (quasi-1D) tube, where the g-atom is freely moving in the axial direction while the e-atom is further localized by an additional axial trap and behaves as a quasi-zero-dimensional (quasi-0D) impurity. In this system, the two atoms experience effective-1D spin-exchange interactions in both even and odd partial wave channels, whose intensities can be controlled by the characteristic lengths of the confinements via the confinement-induced-resonances (CIRs). In a previous work, we and our collaborators have studied this problem with a simplified pure-1D model (Phys. Rev. A {\bf 96}, 063605 (2017)). In current work, we go beyond that pure-1D approximation. We model the transverse and axial confinements by harmonic traps with finite characteristic lengths $a_\perp$ and a_z, respectively, and exactly solve the ``quasi-1D + quasi-0D" scattering problem between these two atoms. Using the solutions we derive the effective 1D spin-exchange interaction and investigate the locations and widths of the even/odd wave CIRs for our system. It is found that when the ratio $a_z/a_\perp$ is larger, the CIRs can be induced by weaker confinements, which are easier to be realized experimentally. The comparison between our results and the recent experiment by L. Riegger {\it et.al.} (Phys. Rev. Lett. {\bf 120}, 143601 (2018)) implies that the two experimentally observed resonance branches of the spin-exchange effect are due to an even-wave CIR and an odd-wave CIR, respectively. Our results are advantageous for the control and description of either the effective spin-exchange interaction or other types of interactions between ultracold atoms in quasi 1+0 dimensional systems.