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Invitation

Mesoscopic Physics with Ultracold Atoms: From Correlated Few-Boson Systems to One-Dimensional Rydberg Gases

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We explore three examples of mesocopic physics with ultracold atoms in three very different regimes of interactions. (1) Few-boson tunneling in a one-dimensional double well, covering the full crossover from weak interactions to the fermionization limit of strong correlations. It is found that the tunneling dynamics of two atoms evolves from Rabi oscillations to correlated pair tunneling as we increase the interaction strength. Near the fermionization limit, fragmented-pair tunneling is observed. (2) We demonstrate that scattering of particles strongly interacting in three dimensions (3D) can be suppressed at low energies in a quasi-one dimensional (1D) confinement. The underlying mechanism is the interference of the s- and p-wave scattering contributions with large s- and p-wave 3D scattering lengths being a necessary prerequisite. This low-dimensional quantum scattering effect might not only be useful in *"interacting"* quasi-1D ultracold atomic gases and guided atom interferometry but also for impurity scattering in strongly confined quantum wire-based electronic devices. (3) We study the quantum properties of Rydberg atoms in a magnetic Ioffe-Pritchard trap which is superimposed by a homogeneous electric field. Trapped Rydberg atoms can be created in long-lived electronic states exhibiting a *permanent* electric dipole moment of several hundred Debye. The resulting dipole-dipole interaction in conjunction with the radial confinement is demonstrated to give rise to an effectively one-dimensional ultracold quantum Rydberg gas with a macroscopic interparticle distance. We derive analytical expressions for the electric dipole moment and the required linear density of Rydberg atoms.

Donnerstag, 26. Juni 2008
16h15

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