

## TRAPPING COLD ATOMS BY QUANTUM REFLECTION

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Quantum reflection is a process, where atoms are reflected, e.g., by an attractive potential without reaching a classical turning point. Especially in the case of atom-surface interactions, the description of low-energy scattering of atoms, molecules and Bose-Einstein condensates has found considerable interest in the recent past, theoretically and experimentally. Improved cooling techniques have made it possible to experimentally observe the behaviour of cold atoms interacting with a surface.

Pasquini et. al. [1] observed quantum reflection of a Bose-Einstein condensate of sodium atoms from a silicon surface. At normal incidence and without the use of auxiliary fields, the reflection probabilities achieved values around fifty percent and more. These experimental results raised the question if quantum reflection can be used as a tool to trap atoms. In [2], we developed a simple but realistic model for a quantum reflection trap: the atom surface potential between two plates is modeled by a step-potential, because atom-surface potentials for quantum reflection behave as a step-potential in the near threshold region. Under conditions comparable to the experiment [1], we achieved an enhancement of the surviving particle fractions inside the trap by up to two orders of magnitude for times near the half of a second. Very recently, it was shown by Madronero et. al. [3], that modeling the true atom-surface interaction by a step-potential gives indeed most reliable results. So far, all dynamics have been described by the Schroedinger equation, but for a more realistic description of the behaviour of cold atoms, the Gross-Pitaevskii-dynamics must be studied. When particle interaction is included into the trapping system, the scale invariance of the system is broken. Only in the third spatial dimension the trapping system conserves scale invariance and allows easy examination. Thus, the quantum reflection trap is best modeled as a sphere.

The effect of the particle interaction is twofold:

– for repulsive particle interaction, the decay of the particle fraction inside the trap is slightly accelerated, because the additional repulsive potential formed by the density-profile itself adds energy to the system and thus reduces the influence of the trapping potential.

– for attractive particle interaction, the surviving particle fraction inside the trap is strongly enhanced, because the additional attractive potential can store even higher energetic fractions of the wave-packet inside the trap, which would be driven to the outside without this additional potential. Thus, when attractive particle interaction is taken into account, the storage capacities of the quantum reflection trap can be increased largely. But, as is the case for harmonic oscillator traps, all good must come to an end when the scaled particle interaction  $g$  reaches a critical value. For our system, we found that the region for a strongly enhanced particle density is given for  $-0.63 < g < 0$ . For more attractive self-interaction, the system breaks down at some point; along with the break-down, the system suffers a sudden loss of particle density.

In conclusion, we have found, that cold atoms can be trapped by quantum reflection in a feasible, realistic and rather simple manner, because the trapping atom-surface potential is naturally present in nature.

[1] T. A. Pasquini et. al., Phys. Rev. Lett. **93**, 223201 (2004)

[2] A. Jurisch, H. Friedrich, Phys. Lett. A **349**, 230 (2006)

[3] J. Madronero, H. Friedrich, Phys. Rev. A **75**, 022902 (2007)