# The single-atom box

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The Cooper-pair box, a small superconducting island coupled by a Josephson junction to the outside world, is one of the most well-known model systems of single-electron physics. It shows a step-wise increase of the excess Cooper-pair number with the junction bias that corresponds to successive transfers of Cooper pairs one by one through the junction. We have developed a theory of the analogue of a Cooper-pair box for ultracold atoms [1]: a Josephson junction formed by two tunnel-coupled Bose-Einstein condensates in a double-well potential in the regime of strong atom-atom interaction for an arbitrary total number $N$ of bosons in the condensates. The tunnel resonances in the junction are shown to be periodically spaced by the interaction energy, forming a single-atom staircase sensitive to the parity of $N$ even for large $N$. Such staircase structures have been experimentally observed in optical lattices of double-well potentials [2]. A different, e.g. fermionic, additional particle in the junction is predicted to lead to non-trivial modifications of the staircase.

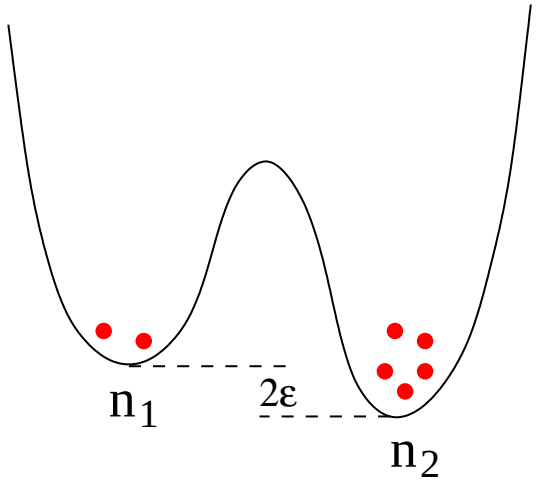


Fig.1: $N = n_1 + n_2$ bosons in a double-well potential

[1] D. V. Averin, T. Bergeman, P. R. Hosur, and C. Bruder, Phys. Rev. A **78**, 031601(R) (2008).

[2] P. Cheinet, S. Trotzky, M. Feld, U. Schnorrberger, M. Moreno-Cardoner, S. Fölling, and I. Bloch, Phys. Rev. Lett. **101**, 090404 (2008).