Insights on the Many-Body Physics of Tunneling from Numerically Exact Solutions of the Time-Dependent Schrödinger Equation for Ultracold Bosons

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Abstract

The scope of the talk is to deliver recent insights on the process of many-body tunneling of initially-coherent ultracold one-dimensional many-boson systems with repulsive interactions to open space [1]. The multiconfigurational time-dependent Hartree method for bosons (MCTDHB), see [2, 3] and http://MCTDHB.org, was used to solve the underlying many-boson time-dependent Schrödinger equation *numerically exactly* and will be introduced in the talk. It is shown that the emission of the bosons to open space is accompanied by fragmentation – a dynamical loss of the coherence. The source bosons remain coherent while the emitted ones do not. The mechanism of the dynamical fragmentation is *many simultaneously happening* single-particle processes. The characteristic momneta associated with these processes are a manifestation of the chemical potentials of all the subsystems with particle numbers $N, N-1, ...$ See the Figure and Ref. [1] for more details.

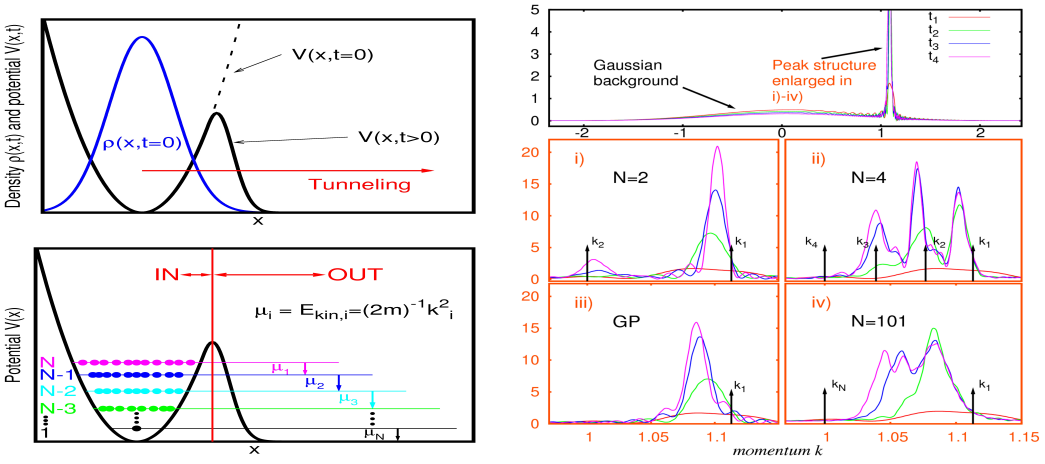

Figure 1: **Illustration of the Many-Boson Tunneling Process.** Left upper panel: Schematic plot of the studied tunneling process. Bottom left panel: The single-boson processes involved in the dynamics and the chemical potentials μ_i which are converted to kinetic energies $E_{kin,i}$. Right top: Overall momentum distributions. Right panels i),ii),iv): *All* the momenta corresponding to the chemical potentials $k_i = \sqrt{2mE_{kin,i}} = \sqrt{2m\mu_i}; i = N, N-1, ..., 1$ show up in the the spectra of momentum distributions (see the black arrows). Right panel iii) The respective Gross-Pitaevskii solutions reveal only a single peak for all times.

References

[1] Axel U. J. Lode, Alexej I. Streltsov, Kaspar Sakmann, Ofir E. Alon, and Lorenz S. Cederbaum, arXiv:1202.3447v1 [cond-mat.quant-gas] (2012)

[2] A. I. Streltsov, O. E. Alon, and L. S. Cederbaum, Phys. Rev. Lett **99**, 030402 (2007).

[3] O. E. Alon, A. I. Streltsov, and L. S. Cederbaum, Phys. Rev. A **77**, 033613 (2008).