Non-adiabatic transition in a mass-imbalance few-fermion mixture

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Abstract:

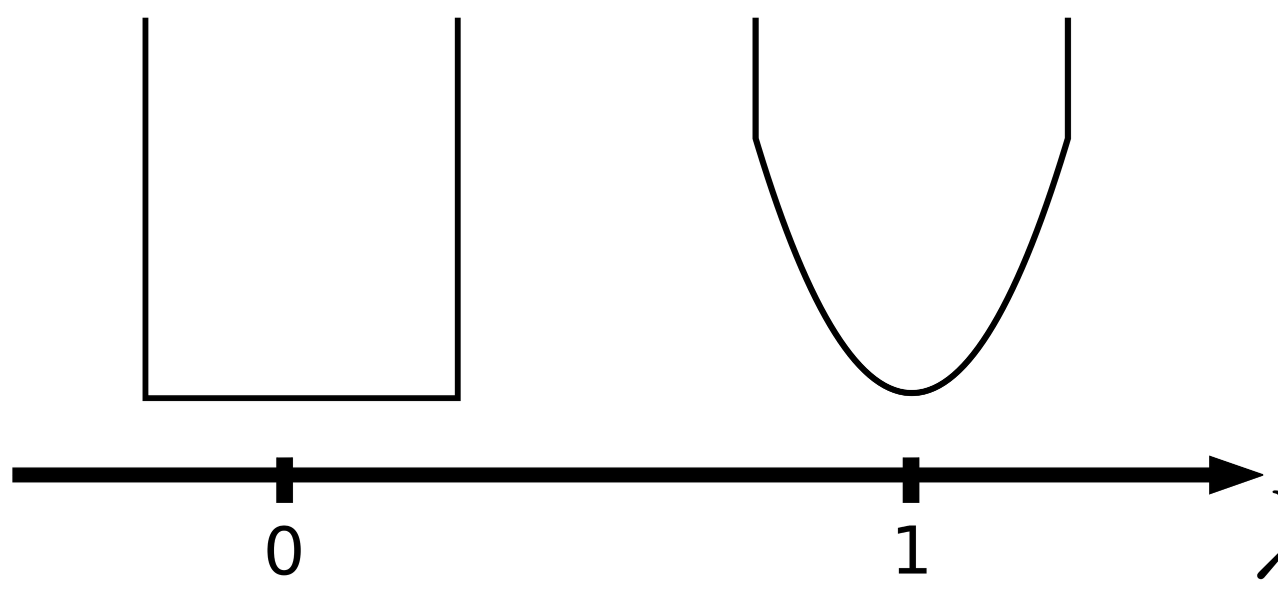
In a mass-imbalance mixture of a few ultracold fermionic atoms with repulsive interactions, a spatial arrangement of the components depends on a shape of the external confinement. When the mixture is initially prepared in a one-dimensional box trap and then the harmonic potential is slowly turned on, the system undergoes structural transition. Finite-time quench through this transition is analyzed.

Hamiltonian of the system:

$$\hat{\mathcal{H}} = \sum_{\sigma\in\{A,B\}} \int \mathrm{d}x\, \hat{\Psi}^\dagger_\sigma(x)\left[-\frac{\hbar^2}{2m_\sigma}\frac{\mathrm{d}^2}{\mathrm{d}x^2} + V_\sigma(x)\right]\hat{\Psi}_\sigma(x) + g\int \mathrm{d}x\, \hat{\Psi}^\dagger_A(x)\hat{\Psi}^\dagger_B(x)\hat{\Psi}_B(x)\hat{\Psi}_A(x)$$

Confinement:

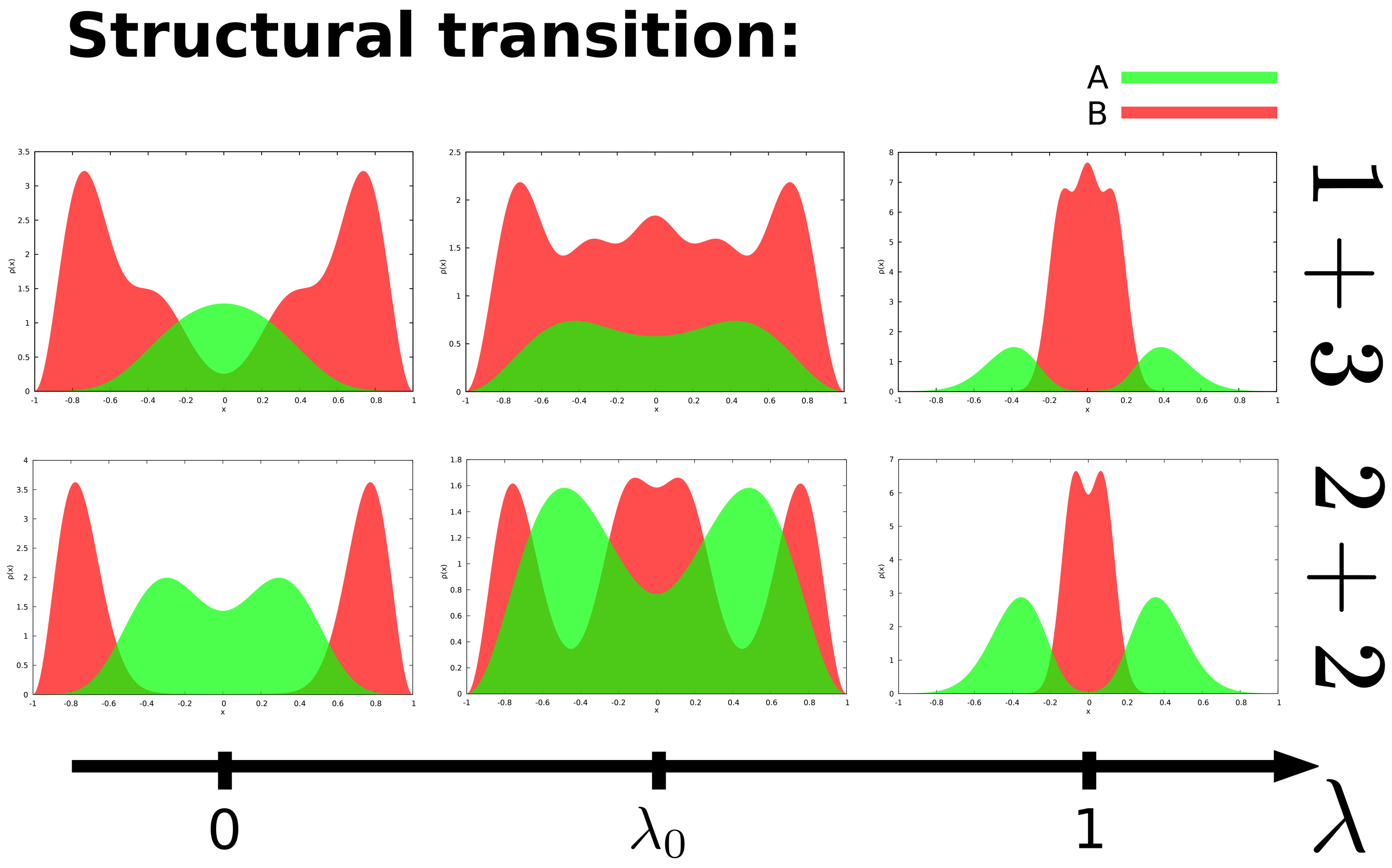
$$V_\sigma(x) = \begin{cases} \frac{1}{2}\lambda m_\sigma \Omega^2 x^2, & |x| < L \\ \infty, & |x| \geq L \end{cases}$$



Properties of the system:

- few-fermion mixture ($N_A + N_B = 4$)
- mass imbalance $\left(\frac{m_B}{m_A} = \frac{40}{6}\right)$
- strong interactions $\left(g = 20\frac{\hbar^2}{m_A L}\right)$

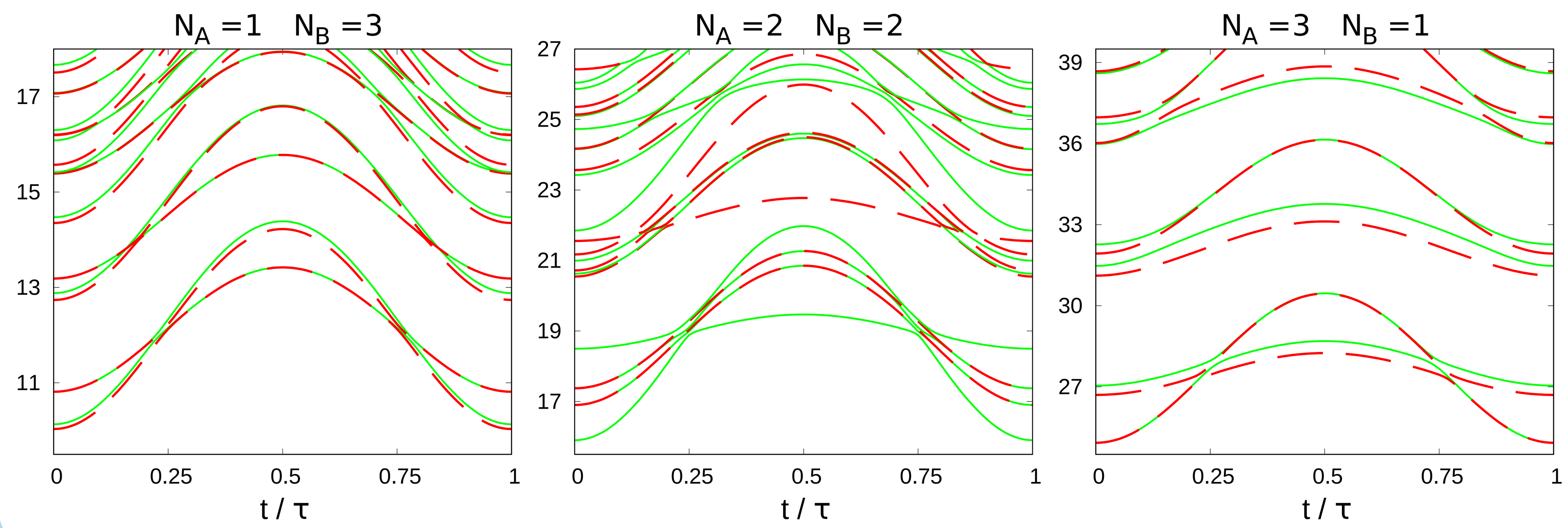
Structural transition:



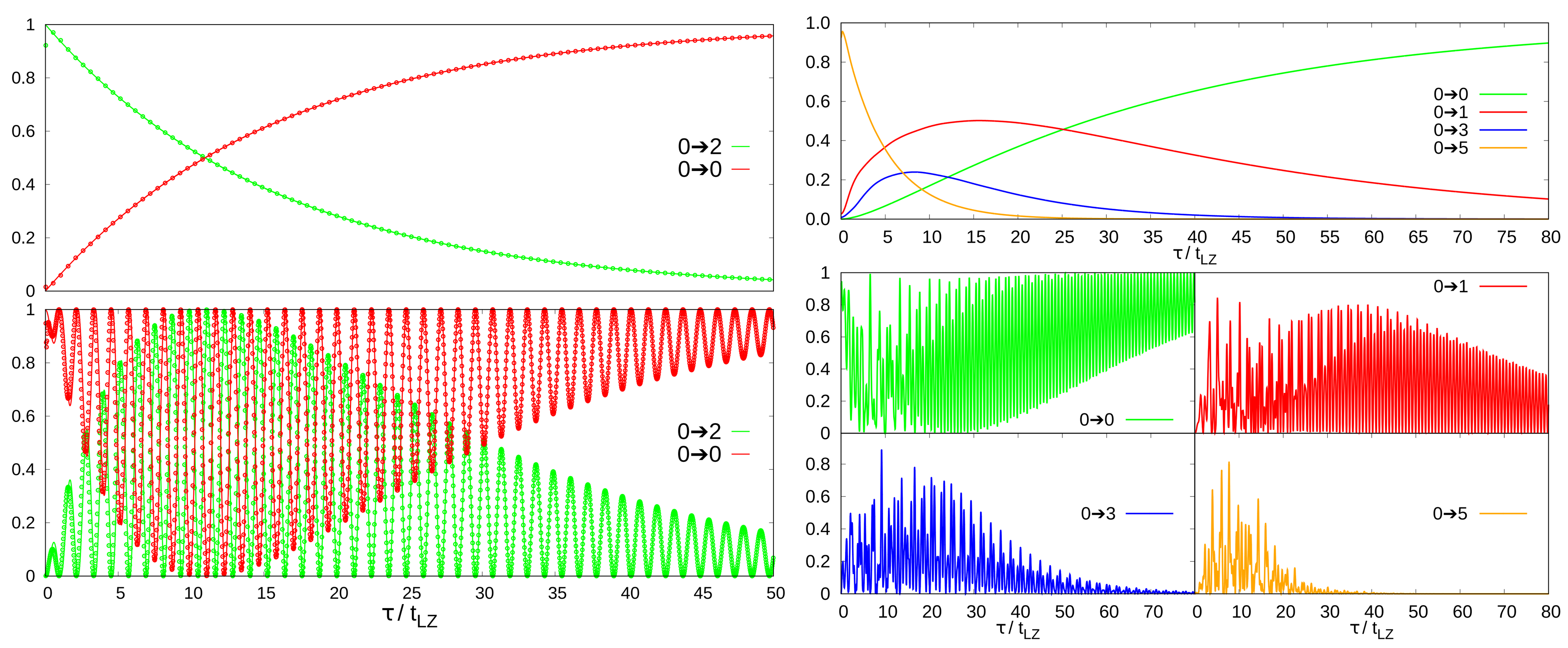
Time dependence:

$$\lambda(t) = 2\lambda_0 \sin^2\left(\pi\frac{t}{\tau}\right)$$

Temporary energy spectra:



Transitions probabilities:



$1+3$ $\qquad$ $2+2$

For 1+3 system - Landau-Zener model:

$$\hat{\mathcal{H}} = \begin{bmatrix} \epsilon_1 & \epsilon_{12} \\ \epsilon_{12} & \epsilon_2 \end{bmatrix}$$

$(\epsilon_1 - \epsilon_2)$ - linear in time

ϵ_{12} - constant coupling

References:

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