Quantum Monte Carlo study of the visibility of one-dimensional Bose-Fermi mixtures

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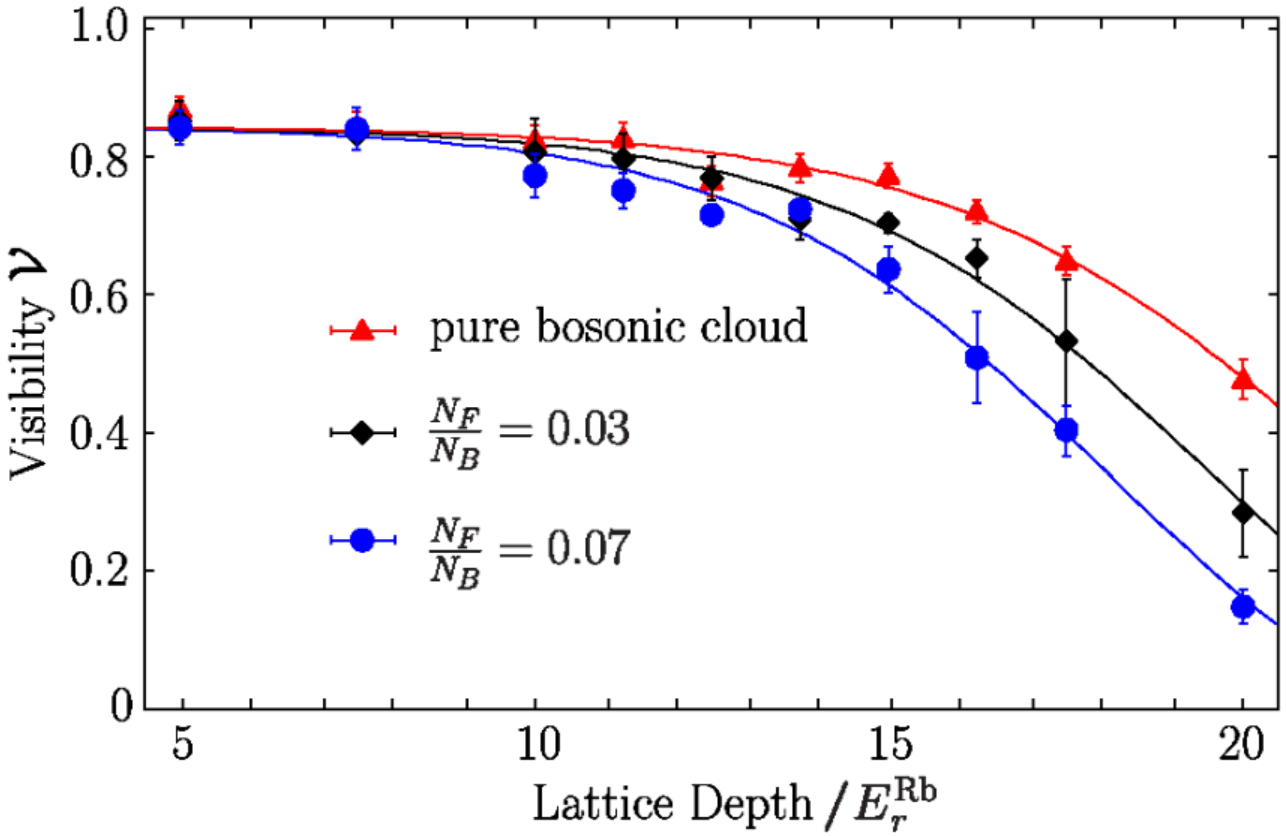
Outline

Experimental Motivation



PRL 96, 180403 (2006).

Theoretical Motivation

- "Defect free" systems.
- Exotic phase transitions.
- What changes in multi-component systems?
  - PRL 95, 220402: Kinks in visibility for bosonic system.
- PRA 77, 023608: Why does visibility increase?

Hamiltonian

$$H = -t_b \sum_i \left(\hat{b}_i^\dagger \hat{b}_{i+1} + \text{H.c.} \right) - t_f \sum_i \left(\hat{f}_i^\dagger \hat{f}_{i+1} + \text{H.c.} \right)$$
$$+ W \sum_i x_i^2 \left(\hat{n}_b^{(i)} + \hat{n}_f^{(i)} \right)$$
$$+ \frac{U_{bb}}{2} \sum_i \hat{n}_b^{(i)} \left(\hat{n}_b^{(i)} - 1 \right) + U_{bf} \sum_i \hat{n}_b^{(i)} \hat{n}_f^{(i)}$$

Visibility:

$$\mathcal{V} = \frac{S_{\max} - S_{\min}}{S_{\max} + S_{\min}}$$

Parameters:

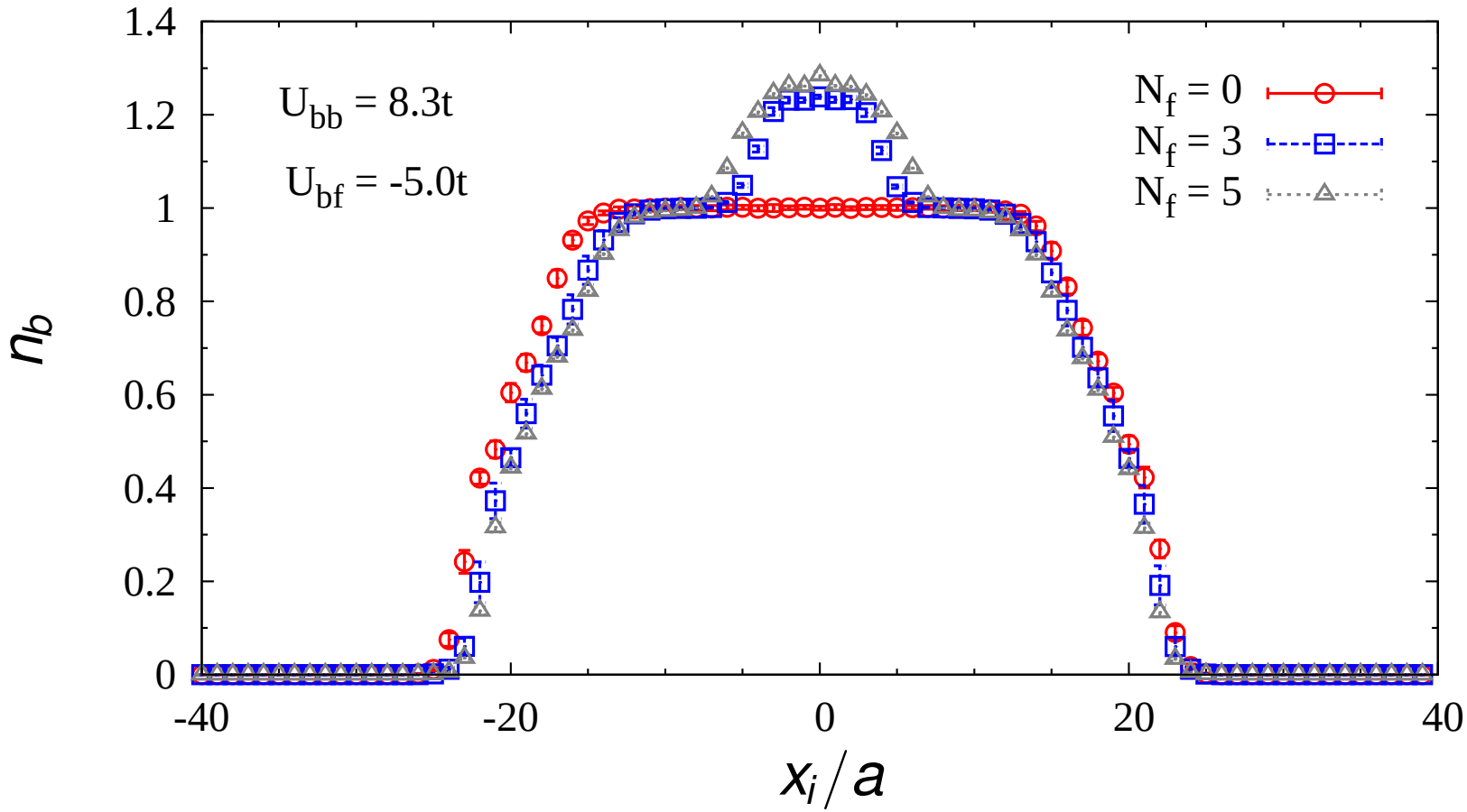
$$t = t_b = t_f = 1$$
$$W = 0.01t$$

Algorithm

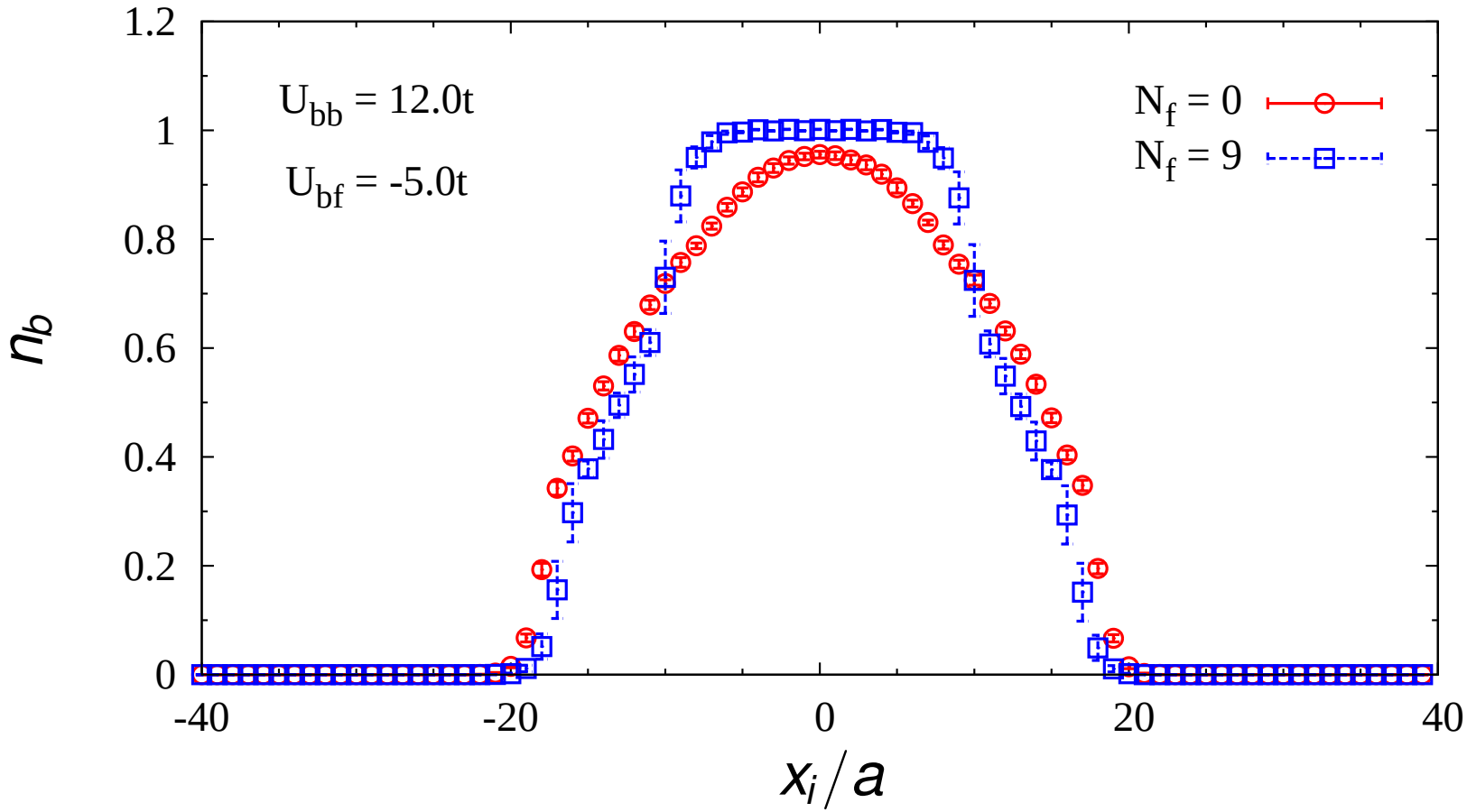
Continuous time canonical 'worm' algorithm:

- No Trotter error.
- Constant particle number.
- Short correlation times.
- Non-local Greens functions.

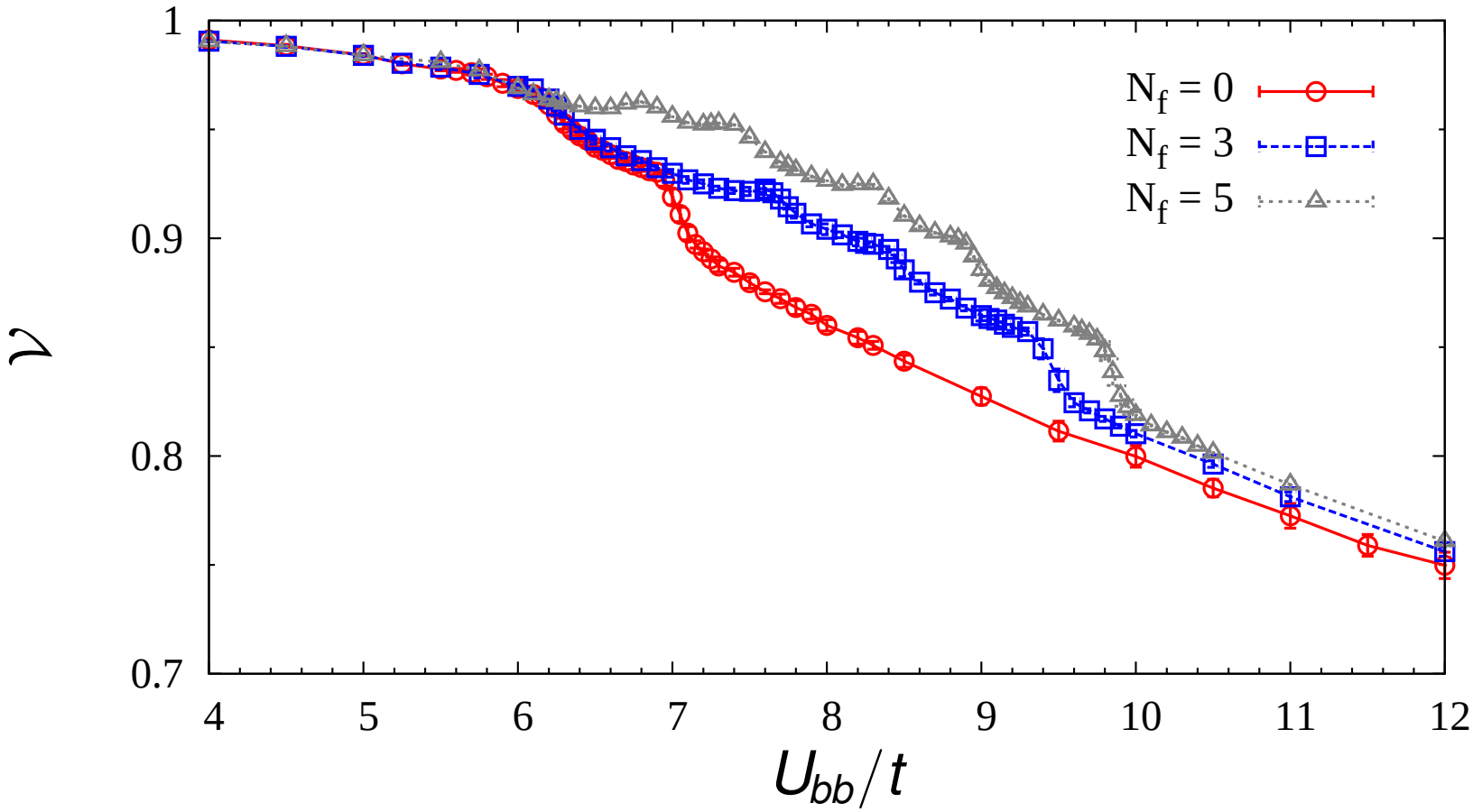
Density



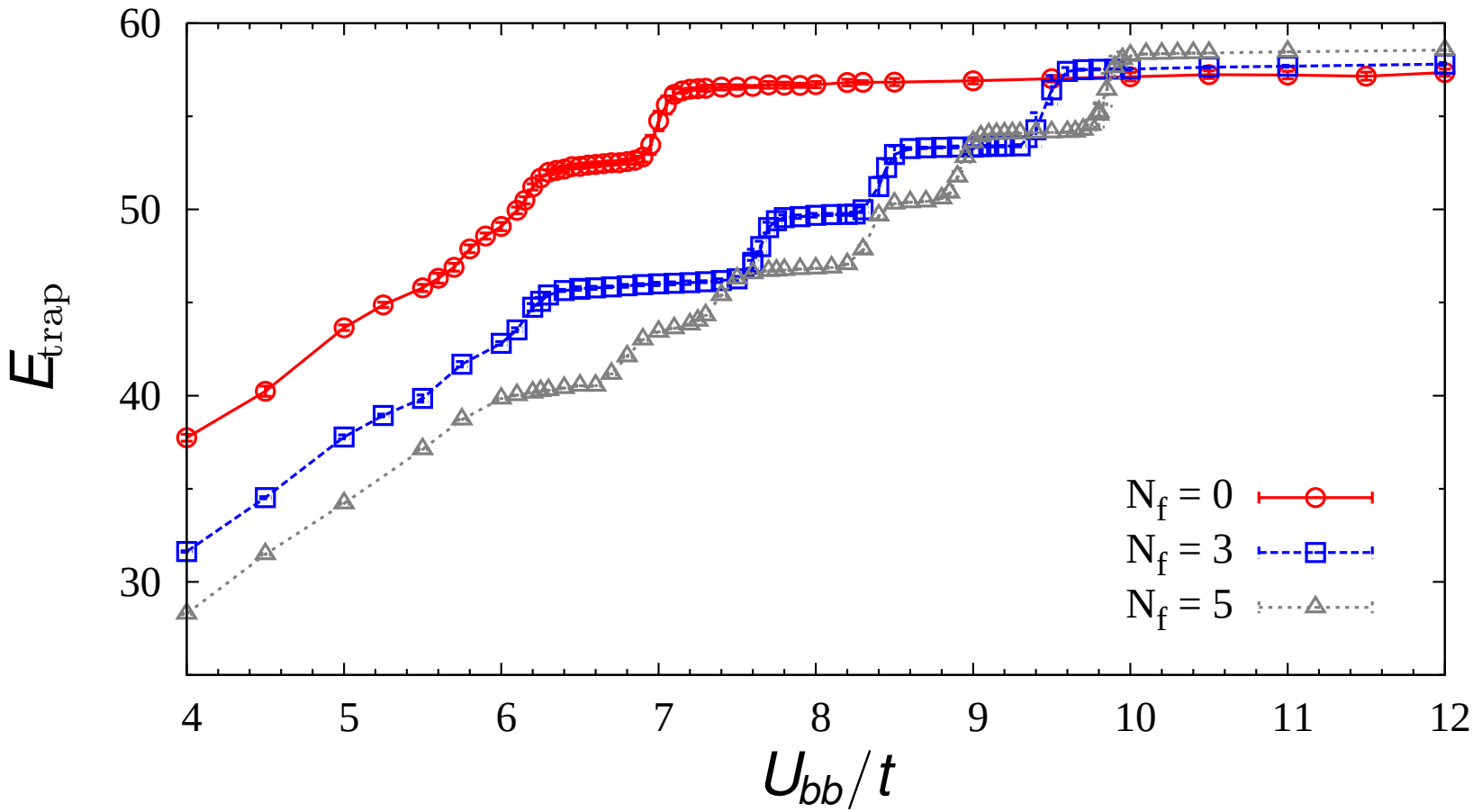
Density



Visibility



Energy



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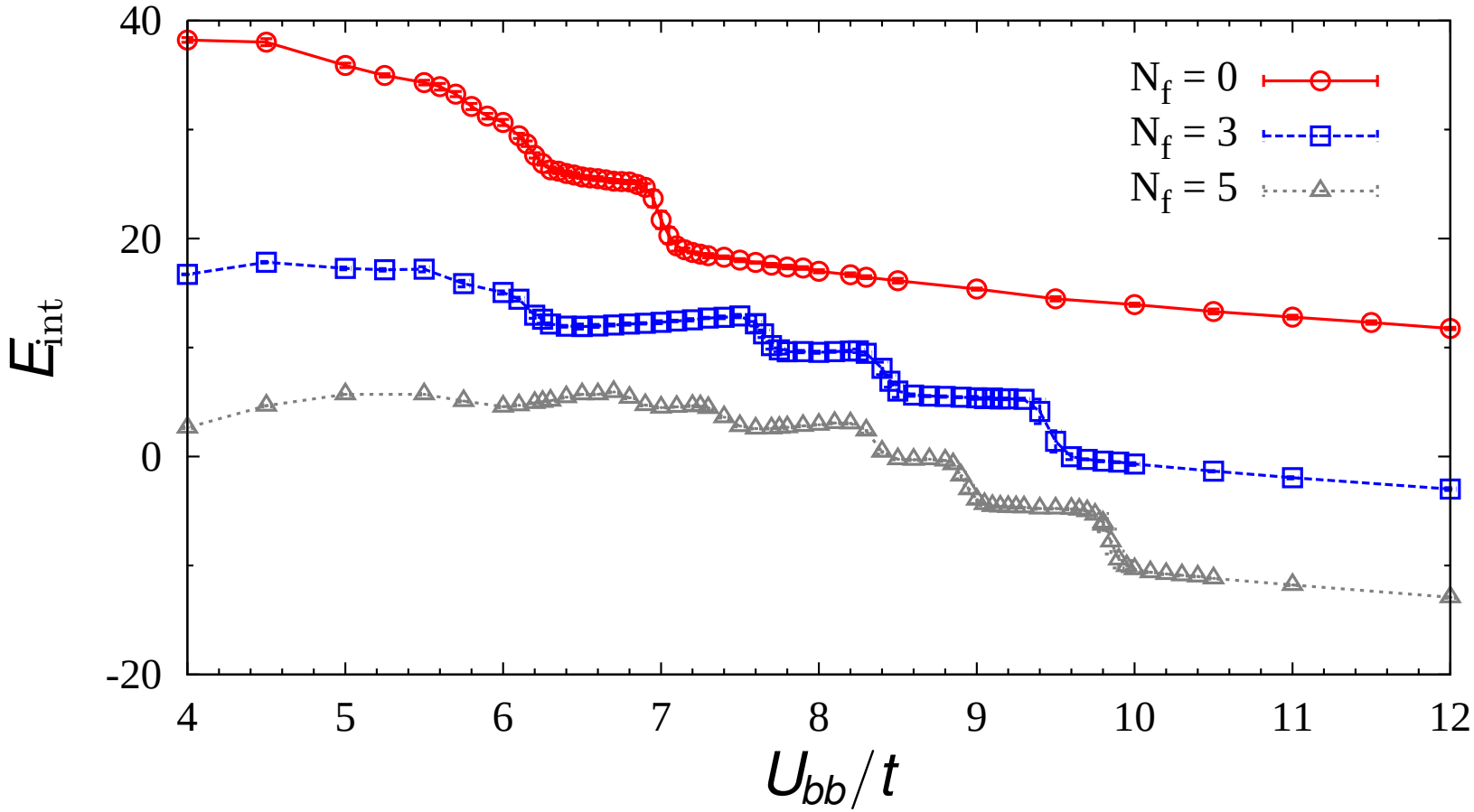
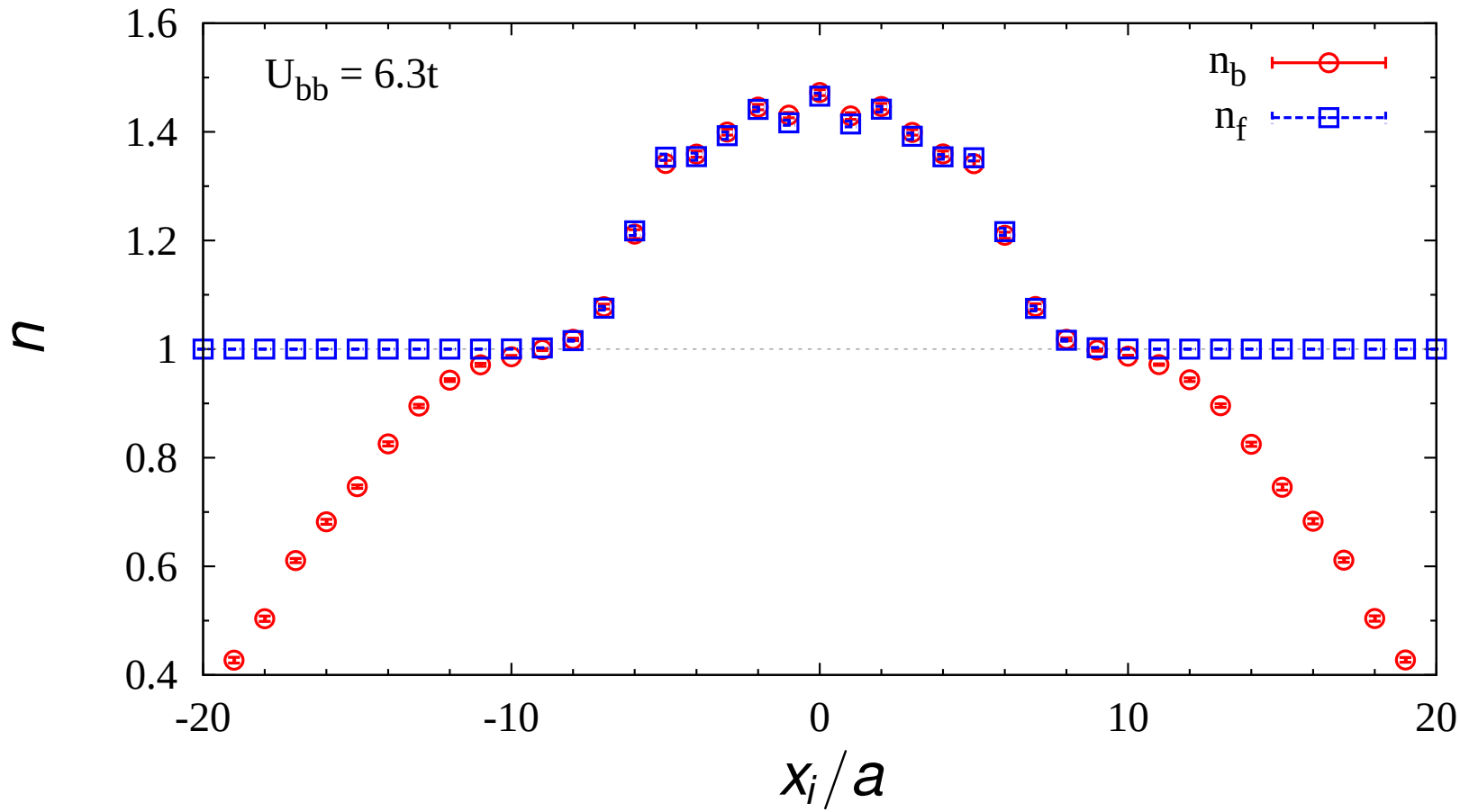
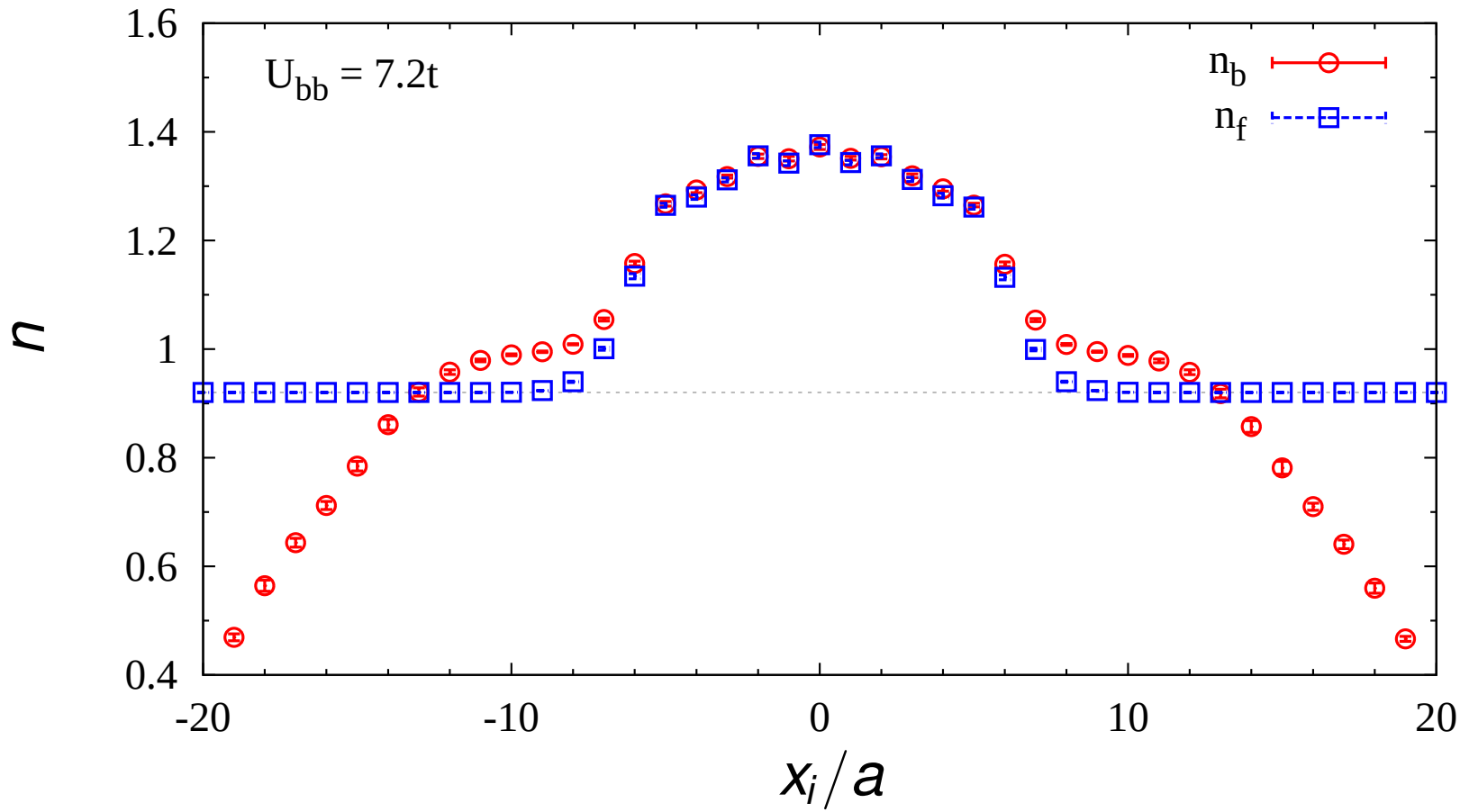


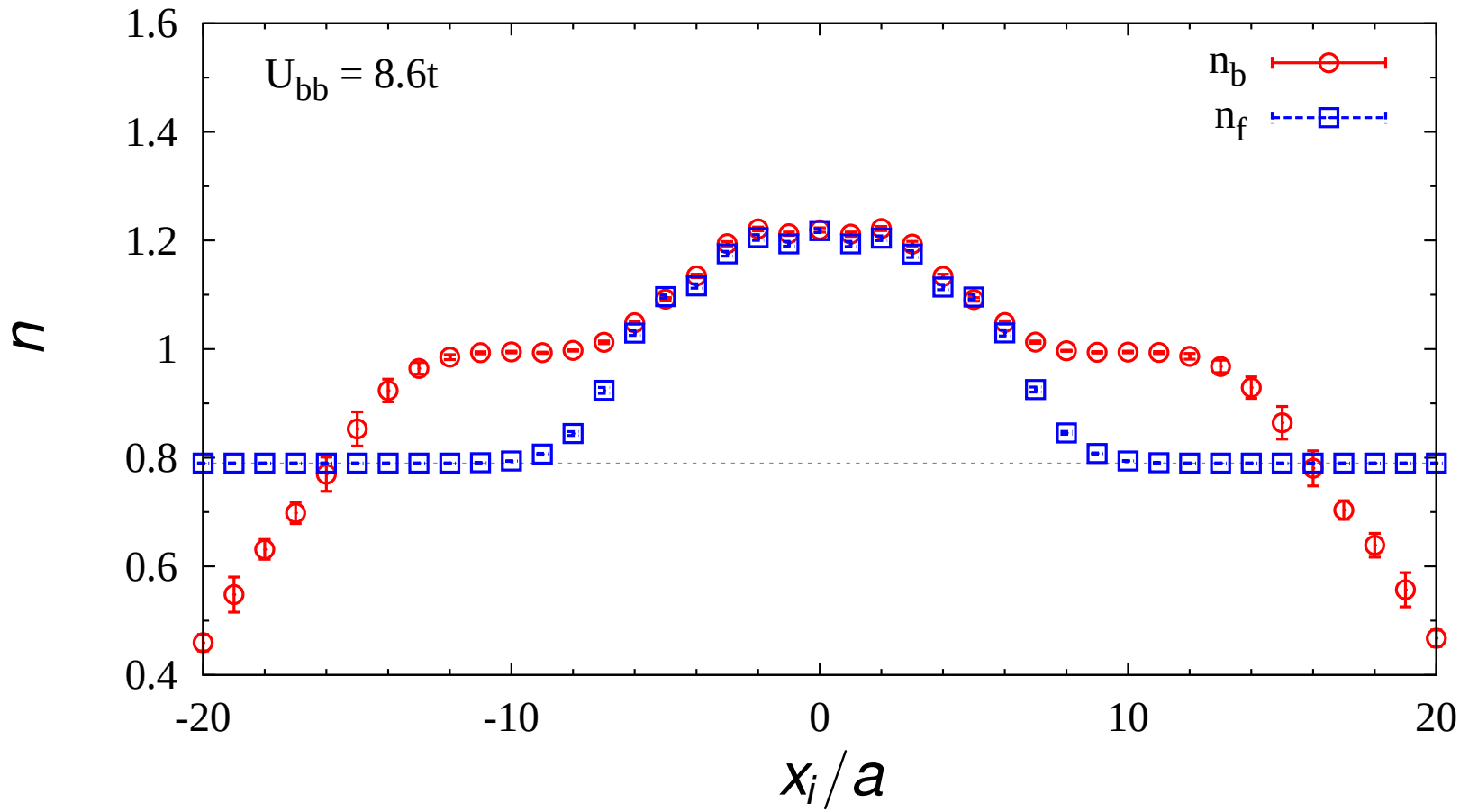
Origin of Kinks



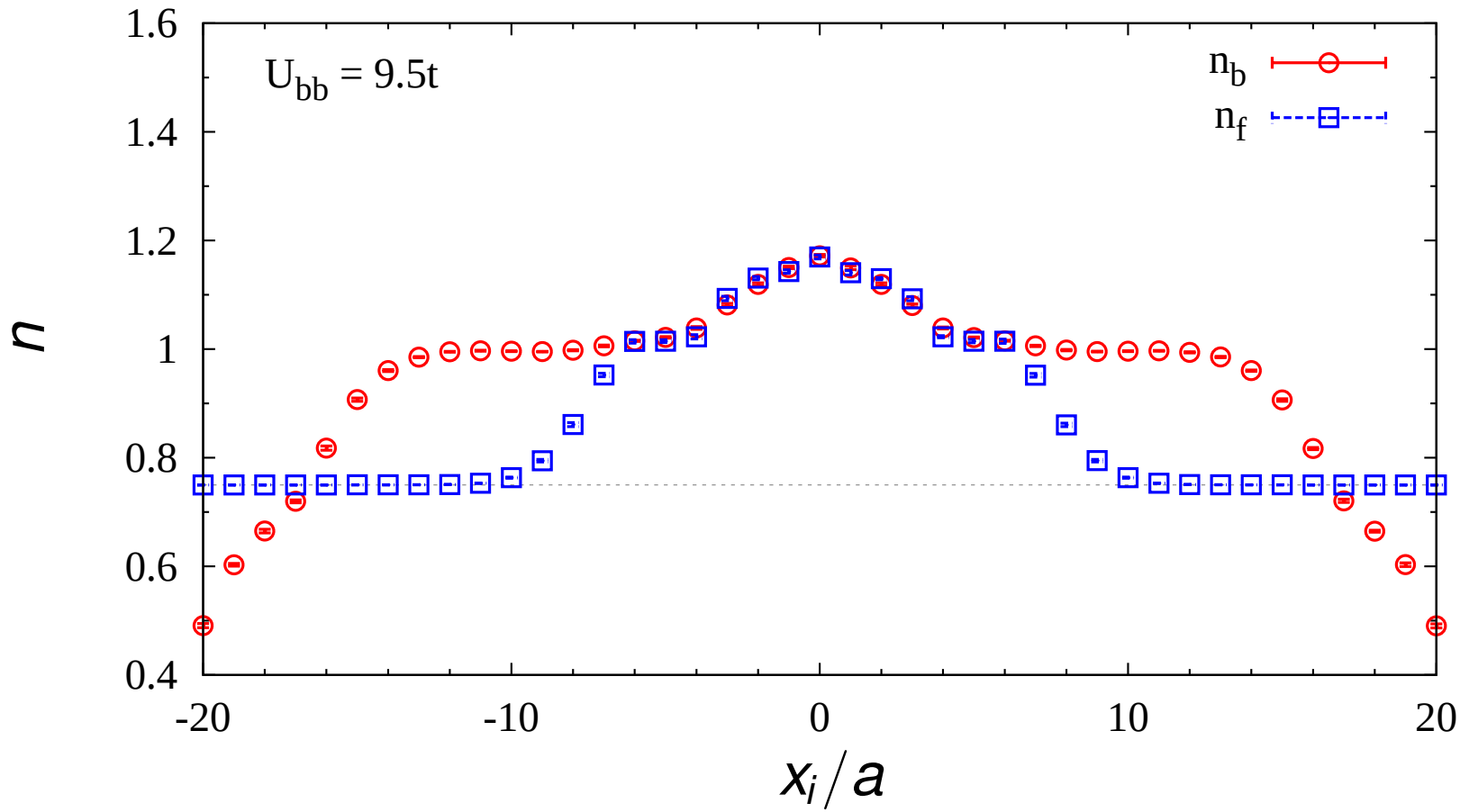
Origin of Kinks



Origin of Kinks



Origin of Kinks



Summary

- Fermions can cause or destroy Mott insulator.
- Kinks in visibility / energy.
- Center of trap populated by molecular superfluid.

Additional reading:

- PRL 96, 180402 & 180403 (2006).
- PRA 77, 023608 (2008).