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

C. N. Varney<sup>1</sup> V. G. Rousseau<sup>2</sup> R. T. Scalettar<sup>1</sup>

<sup>1</sup>Department of Physics University of California, Davis

> <sup>2</sup>Instituut-Lorentz Universiteit Leiden

#### 2008 APS March Meeting

イロト イポト イヨト イヨト

## Outline

#### Introduction

Motivation Model and Method

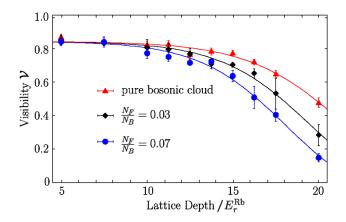
#### Results

Mott Behavior Visibility / Energy

#### Summary

< 同 > < 国 > < 国 >

#### 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

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

Visibility:

 $\mathcal{V} = \frac{\textit{S}_{\text{max}} - \textit{S}_{\text{min}}}{\textit{S}_{\text{max}} + \textit{S}_{\text{min}}}$ 

Parameters:

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

<ロ> (日) (日) (日) (日) (日)

э

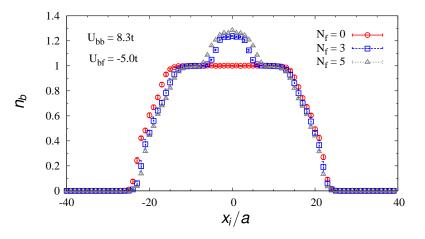
## Algorithm

Continuous time canonical 'worm' algorithm:

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

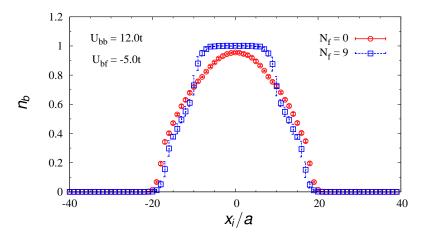
< 同 > < 国 > < 国 >

### Density



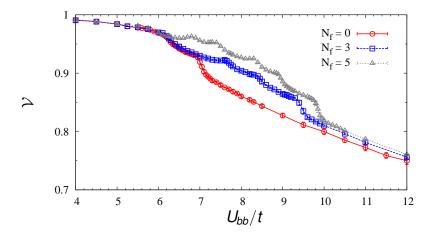
< ロ > < 回 > < 回 > < 回 > < 回 >

### Density



< ロ > < 回 > < 回 > < 回 > < 回 >

## Visibility

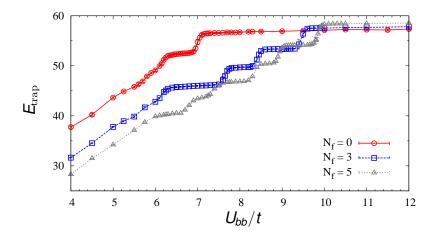


Varney, Rousseau, Scalettar QMC study of the visibility of 1D BF mixtures

< ロ > < 回 > < 回 > < 回 > < 回 >

э

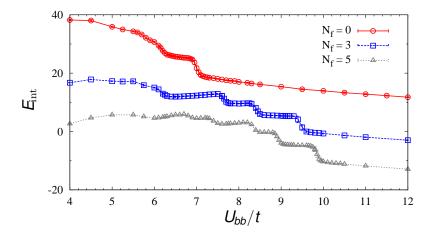
### Energy



Varney, Rousseau, Scalettar QMC study of the visibility of 1D BF mixtures

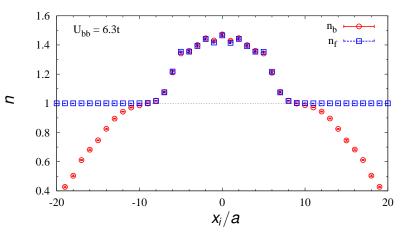
< ロ > < 回 > < 回 > < 回 > < 回 >

## Energy



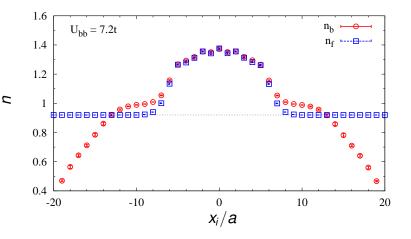
Varney, Rousseau, Scalettar QMC study of the visibility of 1D BF mixtures

< ロ > < 回 > < 回 > < 回 > < 回 >



Varney, Rousseau, Scalettar QMC study of the visibility of 1D BF mixtures

æ

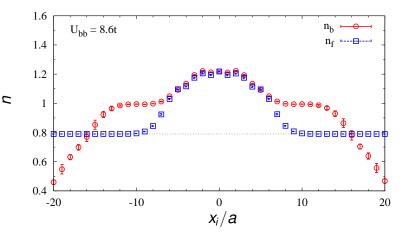


Varney, Rousseau, Scalettar QMC study of the visibility of 1D BF mixtures

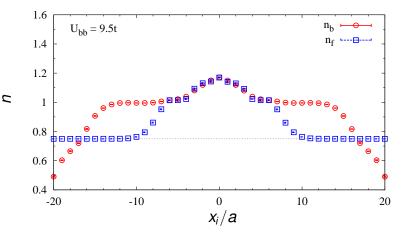
< 6 N

3

æ



Varney, Rousseau, Scalettar QMC study of the visibility of 1D BF mixtures



# 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).

イロト イボト イヨト イヨト