Ozaki, Tezuka, and Kawakami: arXiv:1107.0774

Cluster-cluster collision of one-dimensional fermions

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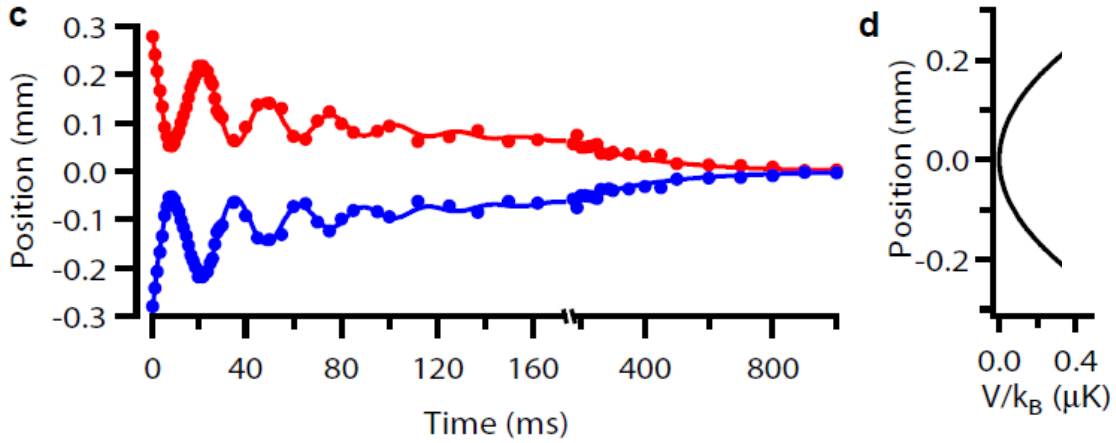
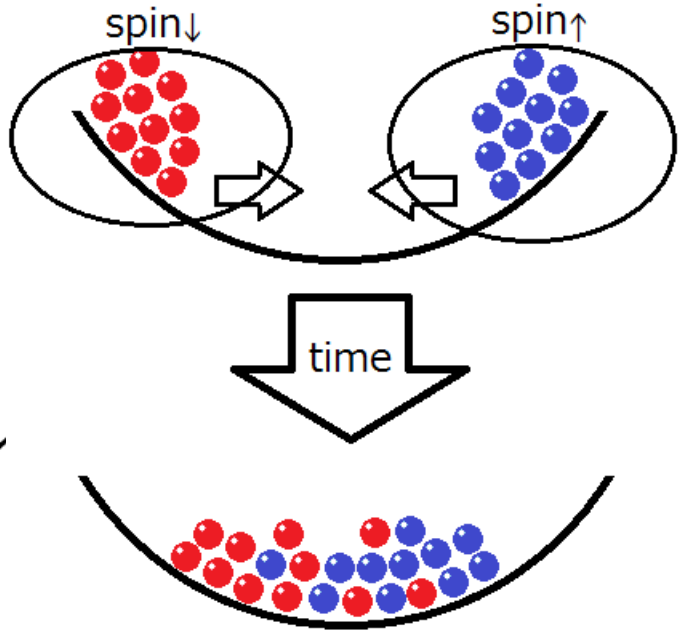
Motivation

Experiment of spin mixing
by MIT group

[A. Sommer et al., *Nature* **472** 201 (2011)]





Our question is :

What kind of many-body effects are observed during one collision between two 1-dimensional fermion clusters?

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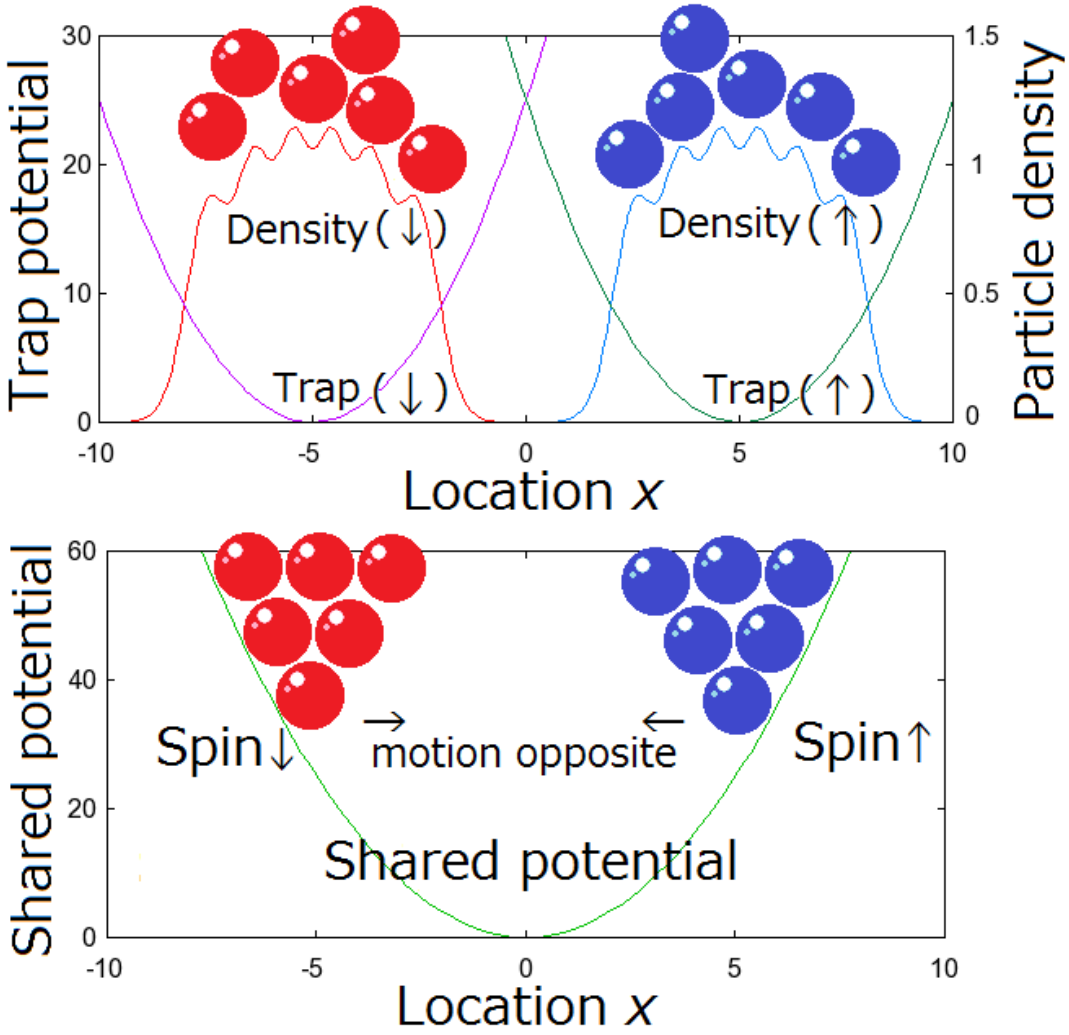
Simulated system

- 1-dimensional spin ½ Fermi system
- Particle-particle contact interaction

- *n* particles initially trapped by separate trap potentials
- Change to shared potential

➢ Collision at the center of the trap



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Method and results

- We adopt 201 sites Fermi-Hubbard model and apply t-DMRG

- The system parameters:
  u : contact interaction strength
  n : particle number per spin
- We focus on the limits of $u \to 0$ and $u \to \infty$, and calculate reflectance R_n and transmittance T_n (= 1 - R_n)

- The calculation results are :

When $u \to 0$, $R_n \propto u^2$ $R_n = nR_1$

When $u \to \infty$, $T_n \propto u^{-2}$ $T_n = nT_1$

Same dependence on u
as single-particle case for all n

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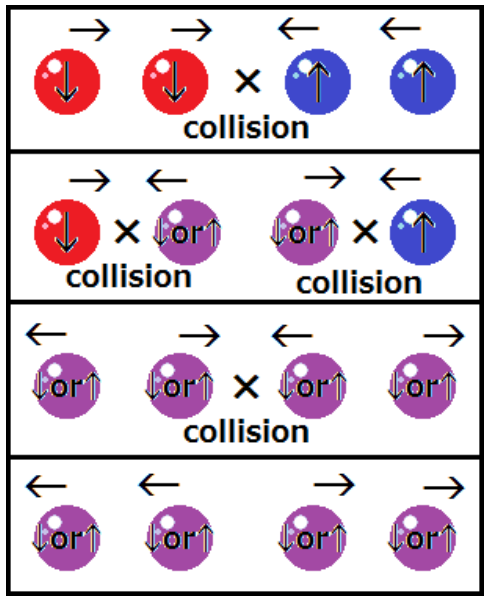
Discussion and conclusion



Quasi-classical collision model :

- Cluster ⇒ independent particles
- Cluster-cluster collision

⇒ a series of independent particle-particle collisions

In this model, $R_n = nR_1$ $(u \to 0)$ and $u \to \infty$, $T_n = T_1$ $(u \to \infty)$

⇒ When $u \to \infty$, n times more particles transmit

Our results are NOT consistent with quasi-classical model

⇒ Dynamically emerging quantum many-body effects!