One-dimensional collision dynamics of fermion clusters

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Recent experiments with cold atomic gases have conducted from interest of the non-equilibrium dynamics of correlated quantum system. Of these experiments, the dynamics of the mixing of fermion clusters [1] is important as a simple system in which classical dynamics and quantum dynamics can be compared. Our motivation is to understand the difference between classical dynamics and quantum dynamics.

We use the time-dependent density matrix renormalization group method [2] and one-dimensional Fermi-Hubbard model. We simulate the collision dynamics of two fermion clusters. One of the clusters consists of spin-up fermions, and the other spin-down. Initially each cluster is separately trapped by a harmonic potential. Next we suddenly change the trapping potential into a shared symmetric harmonic potential. Then the clusters move towards each other, and collide at the bottom of the shared potential, and finally interpenetrate or get reflected depending on the interaction. Reflection rate of the clusters R is calculated changing particle number in one cluster and interaction between the two fermions. We have also evaluated the quasi-classical (independent collision) reflection rates R^{qc} to compare it with R. The quasi-classical picture is quantitatively valid in the limit of no interaction, but it is not valid when interaction is strong.

[1] A. Sommer, M. Ku, and M. W. Zwierlein, arXiv:1103.2337.
[2] S.R. White and A.E. Feiguin Phys. Rev. Lett. **93**, 076401 (2004).