Properties of super-Tonks-Girardeau gases

Shu Chen[1,*]

[1] *Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China*

I shall give an introduction to our recent theoretical works on the super-Tonks-Girardeau gases, which are related to the recently experimentally observed super-Tonks-Girardeau state of bosonic Cesium atoms [Science **325**, 1224 (2009)]. By solving exact dynamics of the integrable Lieb-Liniger Bose gas, we demonstrate that such an excited gas state can be a very stable dynamic state. Furthermore we calculate the breathing mode of the super Tonks-Girardeau gas which is found to be in good agreement with experimental observation. Our results show that the highly excited super Tonks-Girardeau gas phase can be well understood from the fundamental theory of the solvable Bose gas [1]. More general, we demonstrate that a stable excited state with no pairing between attractive fermionic atoms can be also realized by a sudden switch of interaction from strongly repulsive regime to the strongly attractive regime. Such a state is an exact fermionic analog of the experimentally observed bosonic super-Tonks-Girardeau state and should be possible to be observed by the experiment [2]. Alternatively, we also show that the strongly attractive Fermi gas can be effectively described by the super-Tonks-Girardeau gas composed of bosonic bound Fermi pairs with attractive interaction, instead of the Tonks-Girardeau gas composed of unbreakable Fermi pairs with strongly repulsive interaction [3]. We also show that the super-Tonks-Girardeau state can be realized in the multi-component Fermi gas [4]. The similar phenomena in the optical lattice is also studied [5].

PACS numbers:

*Electronic address: schen@iphy.ac.cn

---

[1] S. Chen, L. Guan, X.Yin, Y. Hao, and X.-W. Guan, Phys. Rev. A **81**, 031609(R) (2010).
[2] L. Guan and S. Chen, Phys. Rev. Lett. **105**, 175301 (2010).
[3] S. Chen, X.-W.Guan, X. Yin, L. Guan, and M. T. Batchelor, Phys. Rev. A **81**, 031608(R) (2010).
[4] X. Yin, X.-W.Guan, M. T. Batchelor, and S. Chen,Phys. Rev. A **83**, 013612 (2011).
[5] L. Wang, Y. Hao, and and S. Chen, Phys. Rev. A **81**, 063617 (2010).