Abstract Submitted
for the DAMOP14 Meeting of
The American Physical Society

Breakdown of the scale invariance in a near-Tonks-Girardeau gas: some exact results and beyond ZHEDONG ZHANG, Stony Brook University, GREGORY ASTRAKHARCHIK, Universitat Politècnica de Catalunya, DAVID AVELINE, California Institute of Technology, STEVEN CHOI, University of Massachusetts Boston, HÉLÈNE PERRIN, Université Paris 13, THOMAS BERGEMAN, Stony Brook University, MAXIM OLSHANII, University of Massachusetts Boston — In this Letter, we consider the elementary monopole excitations of the harmonically trapped Bose gas in the vicinity of Tonks-Girardeau limit. Using Girardeau's Fermi-Bose duality and subsequently, an effective fermion-fermion odd-wave interaction, we obtain the dominant correction to the scaleinvariance- protected value of the excitation frequency. We produce a series of diffusion Monte Carlo results that confirm our analytic perturbative value for three particles. And less expectedly, our result stands in an excellent agreement with the result of a hydrodynamic simulation of the collective excitations in the limit of a large number of atoms (with the Lieb-Liniger equation of state as an input). The sub-leading term in the near-Tonks-Girardeau expansion of the sum rule upper bound to the monopole frequency, by Menotti and Stringari [Phys. Rev. A 66, 043610 (2002)], also gives the same number. Surprisingly it was found that the usually successful hydrodynamic perturbation theory predicts a shift that is 9/4 higher than its ab initio numerical counterpart. We conjecture that the sharp boundary of the cloud in local density approximation-characterized by an infinite density gradient-renders the perturbation theory for the collective excitation frequencies inapplicable.

Zhedong Zhang
Stony Brook University

Date submitted: 31 Jan 2014 Electronic form version 1.4