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Apparent Low-Energy Scale Invariance in Two-Dimensional Fermi Gases[1]

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Strongly-interacting systems in two dimensions have occupied a central position in the study of quantum materials. From high temperature superconductors to the Hall effect in two-dimensional electron gases, strong quantum and thermal fluctuations conspire to make this an extremely rich yet poorly-understood regime to work in. Several remarkable and surprising recent experiments in ultracold atomic gases show us that there are puzzles to be understood even in the simplest nontrivial two-dimensional system: a dilute quantum gas with strong s-wave interactions. Amongst these is an experiment that finds an undamped breathing mode oscillating at twice the trap frequency over a wide range of parameters [1], behaviour nominally associated with scale invariance, even though scale invariance is strictly broken in this system by a finite s-wave scattering length. This apparent scale symmetry is all the more remarkable given that the mean-field BCS theory for the 2D gas predicts an exact low-energy scale invariance, relevant to the low-energy breathing mode, meaning that only quantum and thermal fluctuations can break this low-energy scale symmetry [2]. Understanding why the symmetry breaking is so weak may give insight into how to make reliable theoretical predictions in systems with strong fluctuation effects, where there is no obvious small parameter from which a perturbation expansion can be formulated.

[1] E. Vogt, M. Feld, B. Frohlich, D. Pertot, M. Koschorreck, and M. Kohl, Phys. Rev. Lett. 108, 070404 (2012).
[2] E. Taylor and M. Randeria, Phys. Rev. Lett. 109, 135301 (2012).

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