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Universal coarsening in 2D and 3D Bose gases

Tuesday 3 September 2024 12:00 (20 minutes)

Coarsening of an isolated far-from-equilibrium quantum system is a paradigmatic many-body phenomenon, relevant from subnuclear to cosmological lengthscales, and predicted to feature universal dynamic scaling. It is hypothesised that the associated scaling exponents would allow for the classification of nonequilibrium phenomena into an out-of-equilibrium analogue of equilibrium universality classes. In this talk, I will present our recent observations of universal scaling in the coarsening of isolated homogenous two- and three-dimensional Bose gases.

We start by preparing a degenerate gas in a far-from-equilibrium state, and then observe the relaxation towards an equilibrium condensate. We reveal universal scaling in the experimentally accessible finite-time dynamics by elucidating and accounting for initial-state-dependent prescaling effects. The observed scaling exponents match analytical predictions, and are independent of both the initial state and the strength of interparticle interactions. The methods we introduce establish a direct comparison between cold-atom experiments and non-equilibrium field theory, and are applicable to any study of universality far from equilibrium.

Finally, we also investigate the timescales associated with coarsening. While stronger interactions generally speed up the thermalisation dynamics, we find that at sufficiently high interactions the coarsening dynamics becomes interaction-independent, hinting at the existence of a universal 'speed limit' for coarsening.

References

Short bio (50 words) or link to website

2016 –2020: University of Cambridge, MSci in Natural Sciences
2020 –now: University of Cambridge, PhD at Zoran Hadzibabic group

Relevant publications (optional)

1. Gazo, Martin, Andrey Karailiev, Tanish Satoor, Christoph Eigen, Maciej Gałka, and Zoran Hadzibabic. "Universal Coarsening in a Homogeneous Two-Dimensional Bose Gas." arXiv preprint arXiv:2312.09248 (2023). https://arxiv.org/abs/2312.09248
2. Karailiev, Andrey, Martin Gazo, Maciej Gałka, Christoph Eigen, Tanish Satoor, and Zoran Hadzibabic. "Observation of an inverse turbulent-wave cascade in a driven quantum gas." arXiv preprint arXiv:2405.01537 (2024). https://arxiv.org/abs/2405.01537
3. Gałka, Maciej, Panagiotis Christodoulou, Martin Gazo, Andrey Karailiev, Nishant Dogra, Julian Schmitt, and Zoran Hadzibabic. "Emergence of isotropy and dynamic scaling in 2D wave turbulence in a homogeneous Bose gas." Physical Review Letters 129, no. 19 (2022): 190402. https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.12

Career stage

Student

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Presenter: GAZO, Martin

Track Classification: FINESS