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False vacuum decay in an ultracold spin-1 Bose gas

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Cold atomic gases offer multiple prospects for simulating the physics of the very early universe in the laboratory, and an ultracold atom analogue of early universe false vacuum decay was recently observed in a ferromagnetic superfluid [1]. In this talk I will discuss theoretical modelling of false vacuum decay analogues using c-field methods [2]. Specifically, I will describe truncated-Wigner and stochastic projected Gross-Pitaevskii simulations of false vacuum decay, modelling zero and finite temperatures respectively, in a spin-1 Bose gas analogue [3, 4]. I discuss the comparison of these simulations to the bubble nucleation rates predicted by the non-perturbative instanton method, and areas of potential future work to refine stochastic simulations of these non-equilibrium superfluid systems.

References

[1] Observation of false vacuum decay via bubble formation in ferromagnetic superfluids, A. Zenesini, A. Berti, R. Cominotti, C. Rogora, I. G. Moss, T. P. Billam, I. Carusotto, G. Lamporesi, A. Recati, and G. Ferrari, Nature Physics 20, 558 (2024).

[2] P.B. Blakie, A.S. Bradley, M.J. Davis, R.J. Ballagh, and C.W. Gardiner, Dynamics and statistical mechanics of ultra-cold Bose gases using c-field techniques, Advances in Physics 57:5, 363 (2008).

[3] False-vacuum decay in an ultracold spin-1 Bose gas, T.P. Billam, K. Brown, and I.G. Moss, Physical Review A 105, L041301 (2022).

[4] Bubble nucleation in a cold spin 1 gas, T.P. Billam, K. Brown, and I.G. Moss, New Journal of Physics 25, 043028 (2023).

Short bio (50 words) or link to website

https://www.ncl.ac.uk/maths-physics/people/profile/thomasbillam.html

Relevant publications (optional)

Career stage

Professor

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