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Information in quantum field theory simulators: Thin-film superfluid helium

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Experimental studies of information in continuous—variable quantum systems have thus far been highly limited due to the difficulty of accessing the full state of the system. Recently, novel reconstruction methods for Gaussian states —those fully characterised by mean and covariance —have been utilised, enabling the verification of the area-law scaling of mutual information in a one-dimensional quantum field theory (QFT) simulator [1]. Advances in the control of quantum systems now open new avenues for the development and use of (2+1)-dimensional QFT simulators. Here, we show a procedure for analysis of information-theoretic quantities in various simulator systems. We then motivate the use of superfluid helium–4 thin-film QFT simulators [2] for this purpose. Finally, we discuss remaining technical challenges and recent progress, arguing that experimental measurements of information in (2+1) dimensional, finite-size, field theory simulators may soon be within reach. **References** [1] Bunney, C. R. D., Barroso, V. S., Biermann, S., Geelmuyden, A. et al. (2024), 'Third sound detectors in accelerated motion', New J. Phys. 26, 065001. [2] Tajik, M., Kukuljan, I., Sotiriadis, S., Rauer, B. et al. (2023), 'Verification of the area law of mutual information in a quantum field simulator', Nature Physics 19(7), 175–2481.

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