DYNAMICS OF VORTEX PINNING IN A TWO-DIMENSIONAL SUPERFLUID FLOW

Stockdale, O. R.[1*], Reeves, M. T.[1], Davis, M. J.[1]

[1] Australian Research Council Centre of Excellence in Future Low-Energy Electronics Technologies, School of Mathematics and Physics, University of Queensland, St Lucia, QLD 4072, Australia.
**e-mail: o.stockdale@uq.edu.au*

An understanding of the turbulent behaviour of superfluid flow is important for their future development for devices such as exciton transistors. Therefore, an understanding of the dynamics of vortices and their pinning behaviour is essential. While vortex pinning is reasonably well-understood in superconductors, an understanding of the dynamics of vortex pinning is not as well developed in superfluids [1, 2]. Here we simulate the scattering of a quantised vortex off a pinning obstacle in a two-dimensional atomic superfluid using the Gross-Pitaevskii equation. We provide a framework for interpreting the numerical simulations by mapping the mean-field description of the superfluid to classical electrostatics. We show that our simulations are consistent with analytical solutions of an analogue system of a free charge interacting with a dielectric medium in regimes when the flow velocity is small (see Fig. 1). By building a phase portrait of vortex pinning we elucidate the physical mechanisms that lead to vortex pinning, as well as calculating the superfluid velocity required to unpin a vortex. We find that larger pinning sites are not always the most efficient way to pin a vortex. We will also present results for vortex pinning in driven-dissipative polariton superfluid flows.

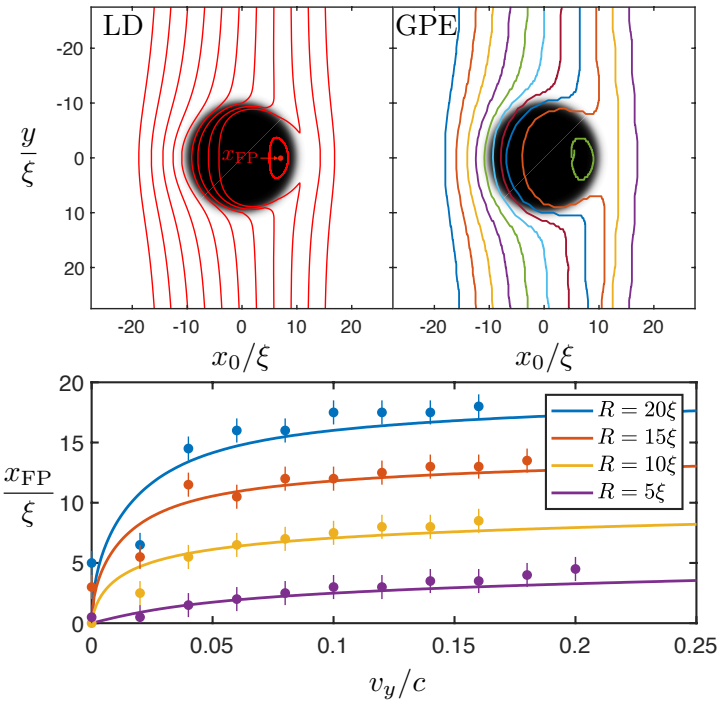

Fig. 1. Top: Comparison between linear dielectrics (LD) and the Gross-Pitaevskii equation (GPE) of vortex trajectories past a soft pinning potential in a uniform superfluid flow. **Bottom:** Position of the vortex fixed point, as shown in the upper left panel, between LD (solid line) and GPE (data points) as a function of superfluid velocity.

References

[1] K. Schwarz. Physical Review Letters **47**(4), 251 (1981).

[2] G. Blatter *et al.,* Reviews of Modern Physics **66**, 1125 (1994).