Emergent Universal Drag Law in a Model of Superflow

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Dimensionless numbers, such as the Reynolds number, Strouhal number and the drag coefficient are powerful quantities to understand the dynamical behaviour of fluids. For example, the Reynolds number quantitifies the ratio of intertial to viscous forces. Furthermore, these numbers govern the dynamical similarities between fluids. This implies that qualitatively, one would observe the same fluid phenomena inside a garden pond as in the ocean upon proper scaling.

The presence of viscosity in classical fluids allows for energy dissipation and establishes drag due to viscous friction. In contrast, zero-temperature superfluids are known for their characteristic absence of viscosity. Despite this aspect, drag is indeed observed in superfluids and is due to energy dissipation facilitated by nucleation of vortices [1]. In earlier work, the superfluid Reynolds and Strouhal number were shown to be connected through a universal relation identical to that of a classical fluid [2]. In this work, we instead study the behaviour of drag inside a superfluid and establish the presence of the universal relation between the Reynolds number and the drag coefficient, known from classical hydrodynamics.

To observe this relation, we numerically investigate vortex shedding by obstacles of various shapes, ranging from streamlined to blunt bodies. The drag force can be extracted from the induced wake, leading to the drag coefficient. Through adjustment of the superfluid velocity and barrier size, the universal relation between the Reynolds number and the drag coefficient is obtained. The presence of this relation shows that – while the origin of superflow is vastly different – scale invariance extends into the limit of a quantum fluid.

[1] T. Frisch et al., *Phys. Rev. Lett.*, **69**, 1644 (1992).

[2] M.T. Reeves et al., *Phys. Rev. Lett.*, **114**, 155302 (2015).