

# Emerging inverse energy transfer mechanism in coupled helium-4 vortex reconnections

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## INTRODUCTION

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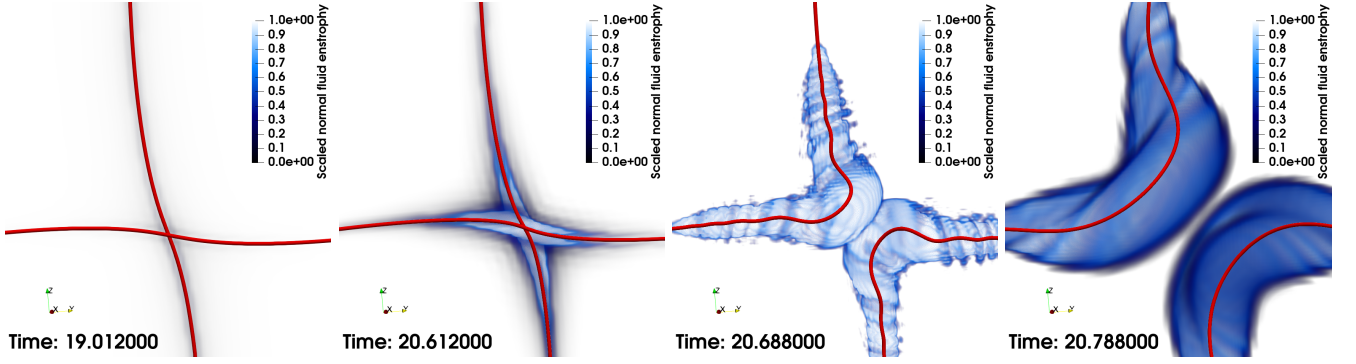


FIG. 1: 3D rendering of an orthogonal vortex configuration, undergoing a vortex reconnection. The red tube represents a superfluid vortex, where the radius has been greatly exaggerated for visual purposes, and the blue volume rendering represents the scaled normal fluid enstrophy  $\omega^2/\omega_{max}^2$ .

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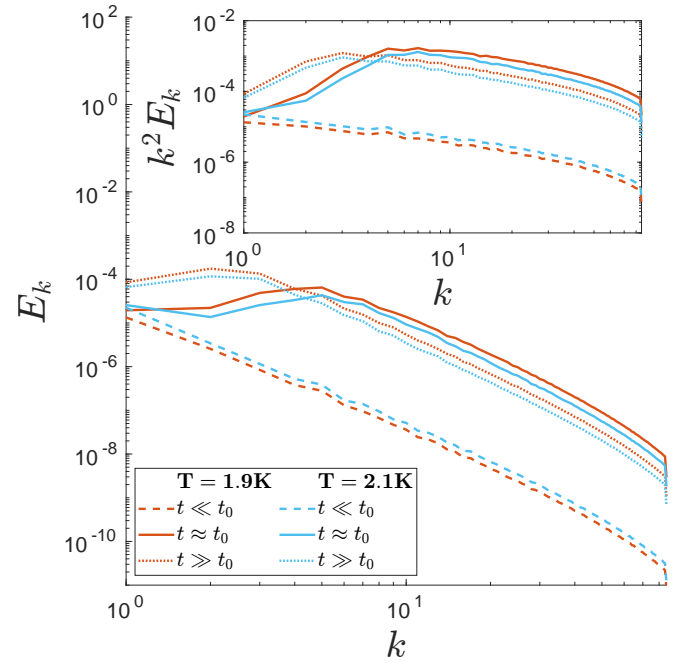
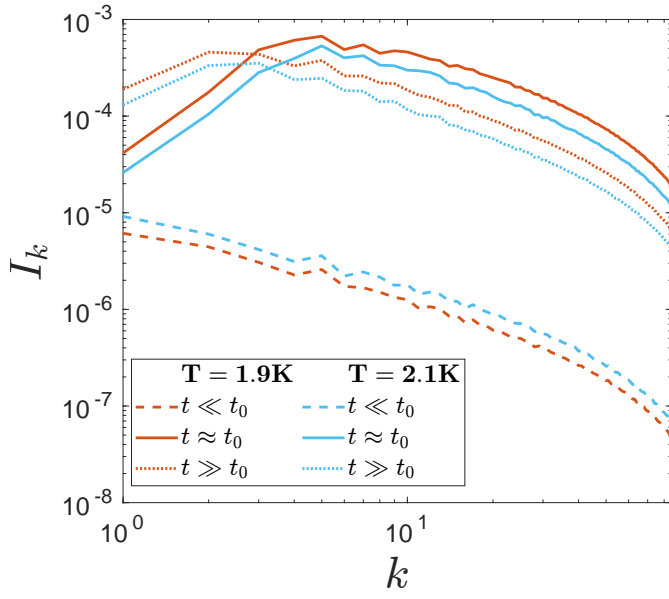


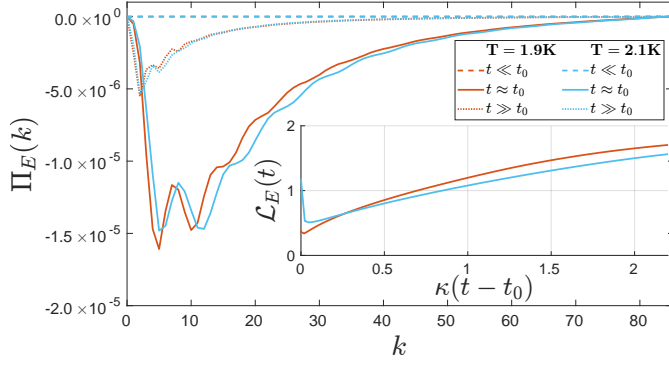
FIG. 2: Normal fluid kinetic energy spectrum  $E_k$  before reconnection (dashed lines), at reconnection (solid lines) and after reconnection (dotted lines) for  $T = 1.9K$  and  $T = 2.1K$ . *Inset*: Dissipation spectrum  $D_k/\nu_n = k^2 E_k$  at the same snapshots in time.

*Main results.*— In this Letter, we use the Schwarz model to evolve vortex filaments  $\mathbf{s}(\xi, t)$ , where  $\xi$  is the natural parametrisation of vortex lines, also known as the arclength. The normal fluid is coupled via the mutual friction force  $\mathbf{f}_{ns}$  in a self-consistent manner using a recently developed technique in Ref. [1]. Further details of the method are outlined in Ref. [2] and the corresponding Supplementary Materials.

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- [1] L. Galantucci, A. W. Baggaley, C. F. Barenghi, and G. Krstulovic, A new self-consistent approach of quantum turbulence in superfluid helium, *Eur. Phys. J. Plus* **135**, 547 (2020).
  - [2] Punctuated energy injection in superfluid helium-4 vortex reconnections.



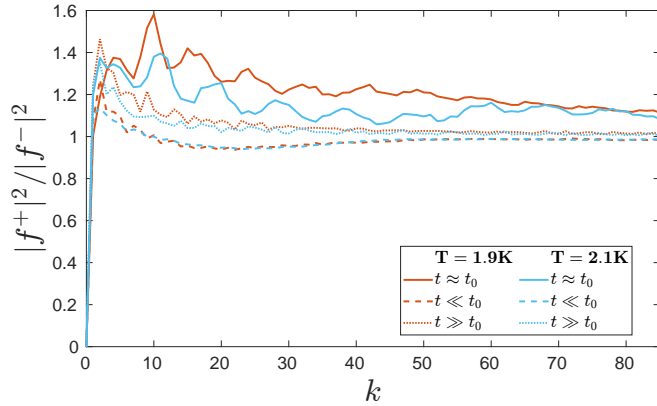
(a)



(b)

FIG. 3: *Top*: Mutual friction injection spectrum  $I_k$ .

*Bottom*: Spectral normal fluid kinetic energy flux  $\Pi_E = \int_k^\infty T(k)dk$ , where  $T(k)$  is the energy transfer function. *Inset*: Post reconnection evolution of the integral length scale  $\mathcal{L}_E = \pi/2 \langle \mathbf{u}^2 \rangle \int_0^\infty dk E_k/k$ .

FIG. 4: Spectrum ratio of helical mutual friction modes  $f^+(k)$  and  $f^-(k)$  for  $T = 1.9K$  and  $T = 2.1K$ .

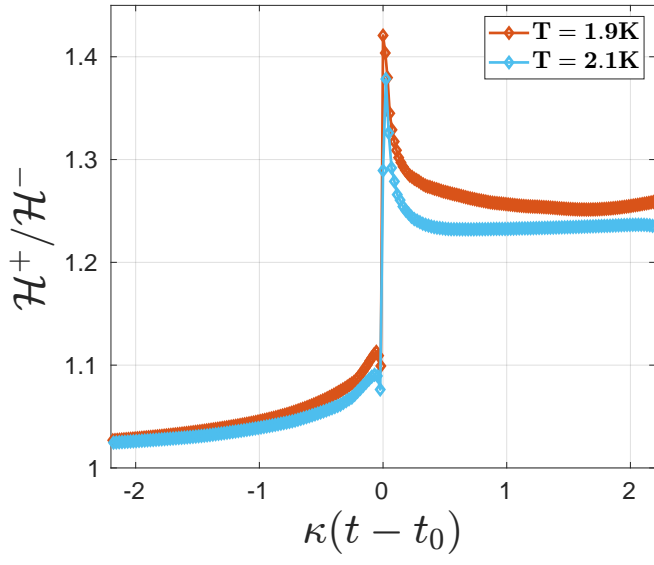


FIG. 5: Balance of helical helicity modes  $\mathcal{H}^+$  and  $\mathcal{H}^-$ .