Dynamics of vortices in strongly interacting Fermi gases

Nicola Grani[1,2,3], Diego Hernandez-Rajkov[2,3], Cyprien Daix[1,2], Giulia Del Pace[1], and Giacomo Roati[2,3]

[1]*Department of Physics and Astronomy, University of Florence, 50019 Sesto Fiorentino, Italy*
[2]*European Laboratory for Nonlinear Spectroscopy (LENS), University of Florence, 50019 Sesto Fiorentino, Italy*
[3]*Istituto Nazionale di Ottica del Consiglio Nazionale delle Ricerche (CNR-INO), University of Florence, 50019 Sesto Fiorentino, Italy*

At T=0, vortex dynamics is considered dissipationless and vortices move together with the surronding superfluid. At finite temperature, the presence of both a normal and superfluid componets changes this scenario. Vortex acts as a medium for momentum exchange between the normal and superfluid components, and the dynamics of the vortex is modified [1]. In this framework, vortex dynamics can be described by the dissipative Point Vortex Model (PVM), in which the dissipation effects are described by the dissipative coefficients α and α' [1].

In Fermi superfluids, the vortex core can host so-called Andreev bound states, introducing additional mechanisms for dissipation respect to bosonic superfluids and the theoretical microscopic undestanding of these coefficients is still an open problem in gas superfluids [1,2]. In our experiment, we probe the dissipative vortex dynamics in a homogeneous oblate unitary Fermi gas by creating a single vortex dipole [3]. Owning to our exquisite control of single-vortex position, we study the dynamics by tracking the single-vortex trajectories for different temperatures of the system. We analized the trajectories using the PVM and measure the dissipative coefficients as a function of temperature.

We also observe the time evolution of regular arrays of vortices created by the contact of two counter rotating superfluids, that break into vortex clusters [4]. The observed instability grow rates follow universal scaling relations, predicted by both classical hydrodynamics and PVM, suggesting that the observed vortex dynamics is a manifestation of the underlying unstable flow.

[1] N B Kopnin, Rep. Prog. Phys. 65 (2002) 1633

[2] Y.A. Sergeev, J Low Temp Phys 212 (2023) 251-305

[3] W. J. Kwon, Nature 600 (2021) 64-69

[4] D. Hernandez-Rajkov, Nature Physics (2024) 1-6