Nematic microfluidics reveals topological tête-à-tête across disparate material fields

Luca Giomi[1], Žiga Kos[2], Miha Ravnik[2,3], and Anupam Sengupta*

[1]*Instituut-Lorentz for Theoretical Physics, Leiden University, Leiden (NL)*

[2]*Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana (SI)*

[3]*Condensed Matter Physics Department, Jožef Stefan Institute, Ljubljana (SI)*

[4]*Institute for Environmental Engineering, ETH Zürich, Zürich (CH)*

Topological defects are singularities in material fields that play a defining role across range of systems: from cosmic microwave background polarization to superconductors, and living matter. Despite significant advances in our understanding of topological defects and their mutual interactions, little is known about the formation and interaction of defects across different material fields embedded within the same system. Using nematic microfluidics as a test bed, we report how topological defects in two different material fields – the hydrodynamic flow field, and the nematic orientational field – co-emerge and cross-talk with each other [1]. To do so, we generate hydrodynamic stagnation points of different topological charges at the center of star-shaped microfluidic junctions, as shown in Figure 1, which then interact with emergent topological defects in the orientational field of the nematic director. Supported by analytical and numerical calculations, these experiments demonstrate that a hydrodynamic singularity of given topological charge can nucleate a nematic defect of equal topological charge, which we corroborate by creating -1, -2, and -3 topological defects in 4-, 6-, and 8- arm junctions. Finally, we characterize the coupling between the orientation and the flow fields, and propose this as tunable parameter for designing multi-field topology in nematic microfluidic systems. Our work is an attempt toward describing materials that are governed by distinctly multi-field topology, and although discussed in a nematofluidic context, has potential ramifications on both equilibrium and non-equilibrium systems.

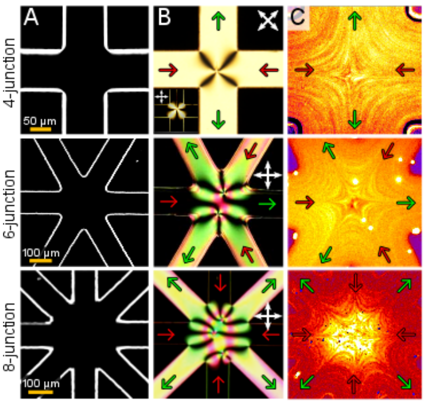

Figure 2: Emergence of nematic defects and hydrodynamic singularities at microfluidic junctions. (A) Star-shaped microfluidic junctions, with 4- 6- and 8- arms (from top to bottom). (B) Emergent topological defects at the microfluidic junction visualized using polarization optical microscopy. (C) Concomitant fluorescent imaging of flowing tracers reveal hydrodynamic stagnation points at the geometric center of each microfluidic junction.

References

[1] L. Giomi, Ž. Kos, M. Ravnik, and A. Sengupta, PNAS **114**, E5771 (2017).

**Corresponding author e-mail: anupams@ethz.ch*