Knotted disclinations

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Ever since Kelvin's famously unsuccessful vortex model of the atom, the prospect of using knotted configurations of a continuous field to encode information, model fundamental states of matter, or sculpt and manipulate the properties of materials, has been too alluring to let go of. Tying a knot in a shoe-lace or a piece of string is (relatively) easy, but tying a knot in a continuous field – such as the vorticity of a fluid, the phase field of light, or the director of a liquid crystal – is a different matter, as the whole rest of the material must conform to the knotted core. Recent advances, both in optics (knotted light) [1] and in liquid crystalline materials doped with colloidal particles [2, 3], have opened the door to experimental realisations of such knotted field configurations and the longer term possibility that they may find uses in novel metamaterials.

In nematic liquid crystals, anisotropic particles align in a state of preferred orientation. Defects, known as disclination lines, are places where this alignment is ill-defined and the orientation 'winds around'. In the Ljubljana group's experiments [2, 3] disclinations are induced by placing colloidal particles in the liquid crystal, and their shape, and knottedness, controlled through the application of targeted pulses of laser light, allowing all types of knots up to crossing number seven to be produced.

This project will address basic issues concerning the formation, control, stability and switching of textures of knotted and linked disclination loops in cholesterics and twisted nematic cells, as well as exploring potential applications for such textures in novel devices and metamaterials. The project will involve a mix of analytic and numerical techniques, with the numerical work involving the development of an existing c++ code.

The project opens broadly into the burgeoning area of applied topology and the design and control of metamaterials. There is considerable scope for a student interested in this field to carry on as part of a PhD.

References

[1] M. R. Dennis *et al.*, Nat. Phys. **6**, 1–4 (2010); W. T. M. Irvine, J. Phys. A: Math. Theor. **43**, 385203 (2010).

[2] U. Tkalec, M. Ravnik, S. Čopar, S. Žumer, and I. Muševič, Science **333**, 62–65 (2011); R. D. Kamien, *ibid.*, 46–47 (2011).

[3] V. S. Jampani *et al.*, Phys. Rev. E **84**, 031703 (2011).