

a completely different field of science, namely radiative thermal transport in the near-field, in which recently rapid progress has recently been made<sup>2</sup>. The work of Yildiz et al. should inspire theorists working on radiation to think about friction and, likewise,

motivate experimentalists to measure heat transport in topological insulators.

Bernd Gotsmann 

IBM Research — Zurich, Zurich, Switzerland.  
e-mail: [bgo@zurich.ibm.com](mailto:bgo@zurich.ibm.com)

Published online: 14 October 2019  
<https://doi.org/10.1038/s41563-019-0509-y>

#### References

1. Yildiz, D., Kiesel, M., Gysin, U., Gürlü, O. & Meyer, E. *Nat. Mater.* <https://doi.org/10.1038/s41563-019-0492-3> (2019).
2. Song, B., Fiorino, A., Meyhofer, E. & Reddy, P. *AIP Adv.* **5**, 053503 (2015).

## Knot a crystal

Tie a knot in a rope and hold both ends pinned, and you have a topologically protected structure: you can't get rid of the knot without cutting the rope. That's what makes knots so fascinating for physics: they are quasiparticles created and sustained by topology alone.

He would not have used those terms, but Lord Kelvin surely had something of that kind in mind when he proposed his vortex theory of the atom in 1867<sup>1</sup>. He had just witnessed the stability of colliding smoke rings blown by his friend Peter Guthrie Tait, leading him to suppose that atoms might be composed of vortex rings in the ether.

It was a classic example of how to be productively wrong. Knotted quasiparticles called skyrmions formed in the quantum field that describes pions have been proposed as a model of nucleons, and two-dimensional analogues have been reported in magnetic materials<sup>2,3</sup>. Knotted molecules can be created by prearranging open strands using coordination chemistry<sup>4</sup>, while microscopic knots can be tied in materials 'by hand' using laser tweezers, as demonstrated for polymers<sup>5</sup> and liquid crystals<sup>6</sup>.

In the last of these cases, the liquid crystals were chiral nematics, where the molecules have an orientational twist, ripe for topological

manipulation, that was locally altered with suspended colloidal microparticles. Tai and Smalyukh now describe another technique for producing knots in this class of material without any need for micromanipulation<sup>7</sup>. Rather, their soliton defects, constituted from knotted vortex lines within the helical liquid-crystal background, form spontaneously as the material switches from an isotropic (non-oriented) to a chiral nematic phase in a confined film in the presence of a weak electrical field. Many knots (which Tai and Smalyukh call heliknotons) appear throughout the material, and are directly visible in polarized-light microscopy.

The resulting elastic deformations of the liquid-crystal lattice induce an effective long-ranged interaction that can make the heliknotons self-organize into a crystalline superlattice, as if they were indeed so many packed atoms. At low defect concentration the knots no longer feel one another and act more like a random gas, diffusing freely within the liquid-crystal matrix like a loose knot moving along a string.

Because of their electrical dipoles, the knotted structures can be influenced by electrical fields, altering their interactions (from attractive to repulsive) and the symmetry of the quasiparticle lattices they form. What's more, the preparation procedure



Philip Ball

can also generate topologically more complex knots — one might loosely call them 'double' and 'triple' knots, or within the quasiparticle picture, different species of 'atom'. That establishes a very rich set of elements for producing binary or ternary heliknoton crystals, and perhaps even for exploring the formation of discrete 'molecules': a topological chemistry set that would surely have delighted Lord Kelvin.

Published online: 23 October 2019  
<https://doi.org/10.1038/s41563-019-0528-8>

#### References

1. Kelvin, *Lord Proc. R. Soc. Edin.* **6**, 94–105 (1867).
2. Mühlbauer, S. et al. *Science* **323**, 915–919 (2009).
3. Yu, X. Z. et al. *Nature* **465**, 901–904 (2010).
4. Dietrich-Buchecker, C. O. & Sauvage, J.-P. *Angew. Chem. Int. Ed.* **28**, 189–192 (1989).
5. Arai, Y. et al. *Nature* **399**, 446–448 (1999).
6. Tkalec, U., Ravnik, M., Čopar, S., Žumer, S. & Mušević, I. *Science* **333**, 62–65 (2011).
7. Tai, J.-S. B. & Smalyukh, I. I. *Science* **365**, 1449–1453 (2019).