School of Physics
Trinity College Dublin

Research project in **Photonics**

Research project in **Theoretical & Computational Solid State**

Quantum computing with knots of light

Research supervisor: Prof. Paul Eastham

Quantum computers are hypothetical devices that exploit quantum effects to perform calculations beyond the reach of existing classical machines. They store information not in bits - switches which are either "on" or "off" - but in qubits - quantum-mechanical switches which can be in a superposition of "on" and "off". The problem with building quantum computers is that such superpositions are fragile. Topological quantum computers would circumvent this problem by storing information inside knotted wavefunctions, where it cannot be destroyed without untying the knot.

We aim to show theoretically that topological quantum computing could be achieved using photons in nanophotonic structures.

Knots in the electromagnetic field are common (Figs. 1,2), with the most common being the optical vortices used to stir particles: such vortices can be created using structured wave-plates, and occur spontaneously in the emission from polariton lasers. We will (a)design nonlinear photonic nanostructures to fix the topology of the field, and (b)calculate spectra of these nanostructures, to identify topologies with low-energy subspaces suitable for quantum computing. Beyond this we could explore the extent to which the subspaces are decoherence free, and look at how states within the low-energy subspace can be manipulated, for example using quantum control techniques.

The project would involve a mixture of analytical and computational work, and would provide an opportunity to interact with experimentalists as well as other theorists both locally and internationally.

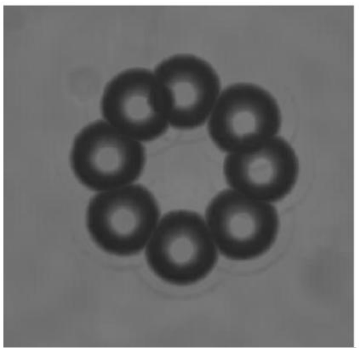

Fig 1: Particles trapped around a vortex beam created by conical diffraction, from Opt. Express. 18 27319 (2010)

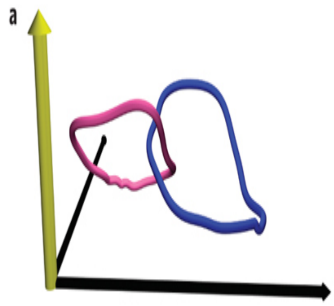

Fig 2: Experimental formation of vortex knots in light, from M. Dennis et al., Nat. Phys. 6 118 (2010)

Funding

Applicants should apply for funding from the following sources: TCD PG Scholarship and School of Physics Studentship schemes.

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For more information

Drop me an email to arrange an informal discussion.