Wide-scale adoption of quantum computing requires understanding complex materials and functional systems in which fragile quantum states are both protected from their noisy environments and coherently driven out-of-equilibrium. The emerging lightwave supercurrent and topological current control offer promise of realizing nearly dissipationless coherent transport against impurity scattering at terahertz (THz) speed with negligible energy cost.

In this talk, I will discuss strategic advantages, with help of some recent examples from our research, of implementing this control concept to measure, manipulate and harvest exceptional photocurrent transport, pseudo-spin quantum entanglement and dynamic symmetry switches in some model coherent states of matter in topological materials and superconductors.

I will also present the emerging THz coherent spectroscopy and microscopy tools at space-time limits of nanometre and femtosecond that facilitate reaching such a fundamental understanding and control of quantum states by light.*

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