Continuous media and metamaterials with a near-zero refractive index (NZI media) provide alternative pathways for the control and manipulation of light-matter interactions. The exotic behavior of NZI media is rooted in the fact that the wavelength gets effectively stretched as the refractive index vanishes. This allows for pathological solutions to the wave equation, including spatially static fields distributions which nevertheless dynamically oscillate in time. This paradoxical behavior gives access to a regime of qualitatively different wave dynamics, where the importance of the geometry is lessened, and certain observables are invariant with respect to geometrical deformations, even including changes in the topology of the system.

In this talk, I’ll review and discuss some of the geometry-invariant phenomena related to near-zero-index media. Examples will include: (i) transmission (tunneling) of waves through deformed waveguides. (ii) Unconventional resonators supporting modes whose eigenfrequency is independent of the geometry of their external boundary. (iii) Violation of effective medium theory geometrical restrictions, enabling, for example, single unit-cell metamaterials. (iv) Existence of bound states in open 3D compact resonators with arbitrarily shaped boundaries.

Different technological applications and implementations of these concepts will be
large variety of computationally intractable systems can be mapped into certain universal classical spin models such as an Ising, XY or Heisenberg models that are characterised by given degrees of freedom, “spins”, their interactions, “couplings” and their associated cost function, “Hamiltonian”. Various physical platforms have been proposed to simulate such models using superconducting qubits, optical lattices, coupled lasers etc.

We introduce polariton lattices as a new platform for analogue simulation; based on well-established semiconductor and optical control technologies polariton simulators allow for rapid scalability, ease of tunability and effortless readability. Polariton condensates can be imprinted into any twodimensional lattices either by spatial modulation of the pumping laser or by lithographic techniques during the growth process, offering straightforward scalability. In the case of optically imprinted polariton lattices with freely propagating polariton condensates, we recently demonstrated that
the phasecon configuration acquired in a polariton dyad or triad is chosen so as to maximise polariton occupancy [1], while by expanding to square, and rhombic lattices as well as to arbitrary polariton graphs we simulated annealing of the XY Hamiltonian through bosonic stimulation [2]. The bottom-up approach of bosonic stimulation is achieved here by gradually increasing the excitation density to condensation threshold. This is an advantage over classical or quantum annealing techniques, where the global ground state is reached through transitions over metastable excited states with an increase of the cost of the search with the size of the system. By controlling the separation distance, in-plane wavevector, and spin of the injected condensates in polariton graphs, we acquire several degrees of freedom in the tunability of inter-site interactions, whilst the continuous coupling of polaritons to free photons offers effortless readability of all the characteristics of the polariton condensates such as energy, momentum, spin, and most critically their phase. The above constitute a unique toolbox for realising intriguing discrete giant vortices, controllable next nearest neighbour interactions, dynamic phase transitions and simulating artificial solids.

References

Charge and Energy Noise in ac-driven Conductors and their Detection from Frequency-resolved Potential and Temperature Fluctuations
The time-dependent driving of nanoscale conductors allows for the controlled creation of single-electron excitations. This effect has been demonstrated experimentally both by application of time-dependent driving to gates coupled to confined systems, such as quantum dots [1], and by specifically shaped ac-driving of two-dimensional conductors [2,3].

However, the spectral properties of the injected signal are in general not known; moreover, the particle emission goes along with the excitation of electron-hole pairs with some unknown energy distribution. These issues can be addressed by studying fluctuations in the detected currents: not only do such fluctuations provide more insight into how to increase the precision of the single-particle emission, but also they allow for obtaining more information about the character of the emitted signal.

Here, I will present a theoretical study of charge and energy currents and their fluctuations in coherent conductors driven by different types of time-periodic bias voltages, based on a scattering matrix approach [4,5]. Specifically, we investigate the role of electron-like and hole-like excitations created by the driving in the charge current noise, where they only contribute separately. In contrast, additional features due to electron-hole correlations appear in the energy noise.

We then compare two different types of driving schemes [6], that is for a driven mesoscopic capacitor [1] as well as for a Lorentzian-shaped bias voltage [3], which do not differ in the number of injected particles, but only in their energetic properties.

Finally, I will discuss proposals for the detection of charge and energy noise, either through power fluctuations [4], or via frequency-dependent temperature and electrochemical-potential fluctuations in a probe reservoir [7].

References