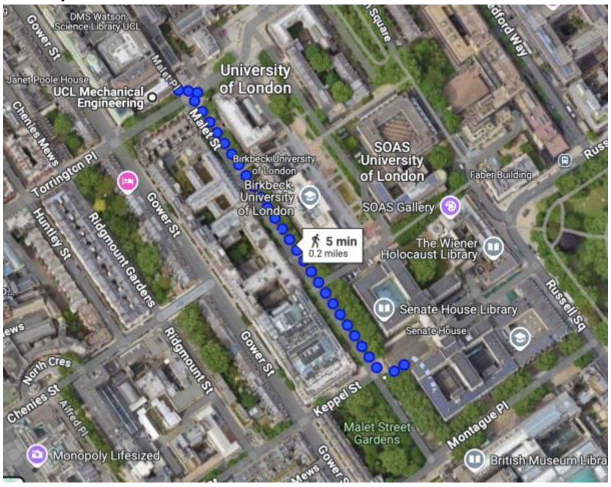
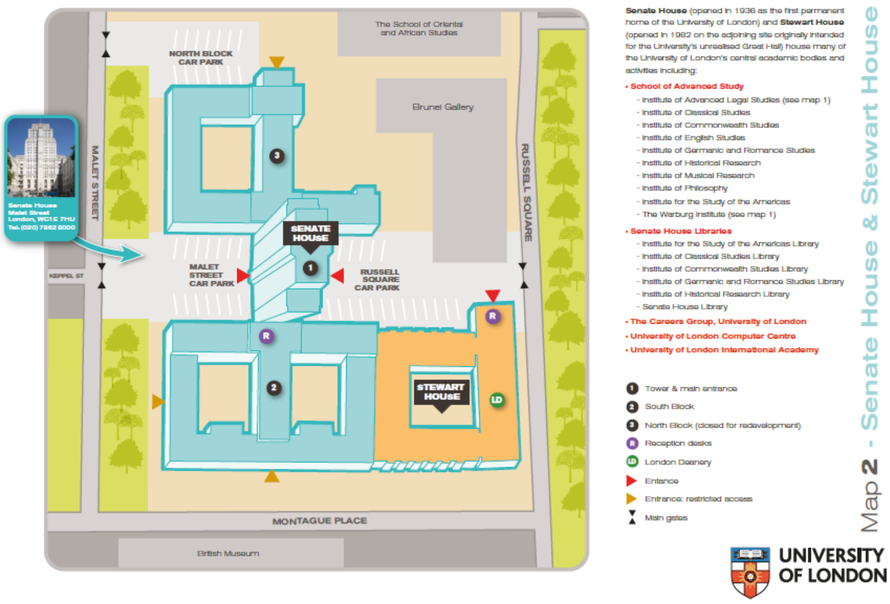
Poster Abstracts for:
Condensed Matter Physics in the City 2025

Poster session: Tuesday 17th June 2025, 6pm -8pm
[Stewart House, Room 1, University of, 32 Russell Sq, London WC1B 5DN](#)

Directions:

The poster venue is a short walk down Malet Street from the Roberts building:





How to access the venue entering through Senate House: Start from Malet Street, Go to Senate House main entrance, turn right for the South block which has the Reception (which you will see on the right soon after you enter), and if needed ask them for further directions. Take the grand central staircase, at the top (first floor) turn left, go through the double doors and go straight to the end, you should see some newly refurbished rooms with RHUL logo etc.

Osama Alsaiari (University of Cambridge): Non-periodic Boundary Conditions for Euler Class and Dynamical Signatures of Obstruction

While the landscape of free-fermion phases has drastically been expanded in the last decades, recently novel multi-gap topological phases were proposed where groups of bands can acquire new invariants such as Euler class. As in conventional single-gap topologies obstruction plays an inher- ent role that so far has been only incidentally addressed. We here systematically investigate the nuances of the relation between the non-Bravais lattice configurations and the Brillouin zone bound- ary conditions (BZBCs) for any number of dimensions. Clarifying the nomenclature, we provide a general periodictization recipe to obtain a gauge with an almost Brillouin-zone-periodic Bloch Hamiltonian both generally and upon imposing a reality condition on Hamiltonians for Euler class. Focusing on three-band C2 symmetric Euler systems in two dimensions as a guiding example, we present a procedure to enumerate the possible lattice configurations, and thus the unique BZBCs possibilities. We establish a comprehensive classification for the identified BZBC patterns according to the parity constraints they impose on the Euler invariant, highlighting how it extends to more bands and higher dimensions. Moreover, by building upon previous work utilizing Hopf maps, we illustrate physical consequences of non-trivial BZBCs in the quench dynamics of non-Bravais lattice Euler systems, reflecting the parity of the Euler invariant. We numerically confirm our results and corresponding observable signatures, and discuss possible experimental implementations. Our work presents a general framework to study the role of non-trivial boundary conditions and obstructions on multi-gap topology that can be employed for arbitrary number bands or in higher dimensions.

Joseph Jones (University of Birmingham): A new, exact perturbation theory for classical statistical mechanics

Co-authors: Martin W. Long, University of Birmingham

We have developed a new, exact mathematical technique that we call statistical physics perturbation theory [1]. Our method supersedes the high-temperature series expansion and is also competitive with Monte Carlo simulations. Indeed, we do not require the assumption of a phase transition to predict one! Our perturbation theory is for operators related by the Baker-Campbell-Hausdorff (BCH) identity, exp(C)=exp(A)exp(B) [2], rather than by addition, C=A+B, as in quantum mechanics. We use the transfer matrix approach to classical statistical mechanics [3] which leads directly to the BCH identity and we must find the operator C. Our perturbation theory is almost verbatim the quantum case, save that the denominators, 1/x, are replaced by hyperbolic functions, coth(x), and corrections! We also present predictions for the correlation length as a function of temperature and the associated critical exponent for the Ising model on the square, cubic and hypercubic lattices. Surprisingly, for the square lattice, we find the exact correlation length at first order with all higher order contributions vanishing!

[1] J. M. Jones and M. W. Long, in preparation [2] J. C. Moodie and M. W. Long, 2021 J. Phys. A: Math. Theor. 54 015208 [3] T. D. Schultz, D. C. Mattis and E. H. Lieb, Rev. Mod. Phys. 36, 85

Orazio Scarlatella (University of Cambridge): Subwavelength arrays of quantum emitters: nonlinearities enter the weak-drive regime, leading to correlated subradiant states

Co-authors: Nigel Cooper, University of Cambridge

Quantum emitters arrays have emerged as important platforms in which strong light-matter interactions can be achieved and precisely controlled. In subwavelength regimes, they are characterized by a manifold of subradiant eigenstates, which can host novel quantum many-body states and are promising for several applications. Nevertheless, their excitation under a weak far-field driving is typically prevented by their subradiant nature. As an important consequence, the weak-drive regime has been regarded as a linear regime described by classical equations of motion. Here we point out that this regime is instead strongly non-linear for regular geometries, due to the important contribution of non-linear momentum-conserving driving processes. Using a Dynamical Mean-Field Theory (DMFT), we show that these processes lead to a steady state of interacting subradiant excitations, with correlations of two-mode squeezing and long-range character, realising a novel strongly-correlated driven-dissipative state. These results might be relevant for applications in non-linear optics, quantum metrology and quantum computing.

Yona Soh (Paul Scherrer Institute): Untangling twin domains and discovery of unconventional quasiparticles in Fe3Sn2

It is widely thought that flat-bands as well as Dirac and Weyl crossings can be supported in a kagome layer. One model kagome system is Fe3Sn2, a ferromagnet with a high (~600 K) Curie temperature, which undergoes a first order spin reorientation around 120 K [1,2]. Our density functional theory (DFT) calculations predict Weyl nodes near the Fermi level EF and electron pockets at the zone center[3]. Magnetotransport of Fe3Sn2 displays anomalous behaviour at temperatures below 80 K, where the spin reorientation is complete, such as tunability of the carrier density via magnetization[4] and a 3-fold antisymmetric planar Hall effect[5]. Using micro-focused ARPES, we discover a sharp band, appearing only below 80 K, which cannot be reproduced by our DFT calculations suggesting that its origin is from strong correlations[6]. In addition, analysis of the spectral weight suggests fractionalization of charge.

[1] “Magnetotransport as diagnostic of spin reorientation: kagome ferromagnet as a case study”, Neeraj Kumar et al., Phys. Rev. B 100, 214420 (2019) [2] “Images of a first-order spin-reorientation phase transition in a metallic kagome ferromagnet”, Kevin Heritage et al., Adv. Funct. Mater. 2020, 1909163 [3] “Switchable Weyl nodes in topological Kagome ferromagnet Fe3Sn2”, M. Yao et al,, arXiv:1810.01514 [4] “Tuning the electronic band structure in a kagome ferromagnetic metal via magnetization”, Neeraj Kumar et al., Phys. Rev. B 106, 045120 (2022) [5] “Anomalous planar Hall effect in a kagome ferromagnet”, Neeraj Kumar, et al., arXiv:2005.14237 [6] “Anomalous electrons in a metallic kagome ferromagnet”, S. A. Ekahana et al., Nature 627, 67-72 (2024)

Yu-Chin Tzeng (National Yang ming Chiao Tung University): Entanglement Hamiltonian and effective temperature of non-Hermitian quantum spin ladders

Co-authors: Pei-Yun Yang, National Taiwan University

Quantum entanglement plays a crucial role not only in understanding Hermitian many-body systems but also in offering valuable insights into non-Hermitian quantum systems. In this paper, we analytically investigate the entanglement Hamiltonian and entanglement energy spectrum of a non-Hermitian spin ladder using perturbation theory in the biorthogonal basis. Specifically, we examine the entanglement properties between coupled non-Hermitian quantum spin chains. In the strong coupling limit ($J\ r\ u\ n\ g \gg 1$), first-order perturbation theory reveals that the entanglement Hamiltonian closely resembles the single-chain Hamiltonian with renormalized coupling strengths, allowing for the definition of an ad hoc temperature. Our findings provide new insights into quantum entanglement in non-Hermitian systems and offer a foundation for developing novel approaches for studying finite temperature properties in non-Hermitian quantum many-body systems. [SciPost Phys. Core 7, 074 (2024)].