ANDREA KOUTA DAGNINO

Website: `https://koutadagnino.netlify.app/` ◇ Email : akd95@ou.ac.uk ◇ Birth date: October 2004

EDUCATION

The University of Cambridge 2022 - present
MASt in Physics

- Major options: Theory of Quantum Matter, Advanced Quantum Condensed Matter Physics, Quantum Field Theory.
- Minor options: Phase Transitions, Superconductivity and Quantum Coherence, Quantum Simulation with synthetic many-body systems.

The Open University 2017 - 2022
BSc (Honours) in Mathematics

- Degree classification: First class
- Relevant modules: Mathematical models and modelling, Quantum mechanics, Electromagnetism, Fluid dynamics and mathematical methods, Deterministic and stochastic dynamics, Final year project.
- Completed 30 ECTS credits more than required from degree regulations.

RESEARCH EXPERIENCE

Topological quantum systems November 2021- present
Independent

- Developed source code to calculate properties such as the Berry connection/curvature, Chern number and band structure of quantum systems in Python, and applied it to study toy models such as the Haldane model.
- Analytically and numerically analysed properties of edge states in finite Chern insulators.
- Benchmarked my results against the existing literature with excellent agreement.
- Wrote an expository essay on the Berry phase and its connection to the Quantum Hall effect and Topological insulators, which includes several plots made with my code.

Undergraduate research project May 2021 - Present
Research student

- Employed the QuSpin Python library to simulate finite quantum systems on lattices using both exact and approximate diagonalisation techniques (e.g. block-diagonalisation and Lanczos).
- Investigated the phase properties of extended Bose Hubbard models (EBHM) in one dimension.
- Identified two EBHMs which exhibit signatures of weak ergodicity breaking, and performed both numerical and analytical tests to probe for the presence of rare states in their spectrum.
- Utilised the computing cluster at the School of Physical Sciences to perform intensive computational tasks.
- Performed a novel analytic calculation of the energy spectrum of repulsively bound boson pairs on a ladder.
- Developed a perturbative approach to producing scarred states in models with Hilbert space fragmentation.
- Currently finalising research results in the form of a paper (manuscript in preparation).

OUTREACH

Fisika lectures July 2020 - present
Content creator

- Produced over than 25 lecture videos on Linear algebra, Statistical mechanics, Special relativity and other miscellaneous topics free to view for other undergraduate and graduate students.
- Total: 23k views

WRITTEN WORKS

Many-body quantum scarring and repulsively bound states in the Bose-Hubbard ladder April 2022 - present
Manuscript in preparation

- Reviewed the properties of an extended Bose-Hubbard model (EBHM) of spinless bosons on a ladder.
- Demonstrated that the model hosts a family of rare states which avoid thermalisation and have out-of-equilibrium dynamics consistent with many-body scarring.

- These rare states are well-characterised by Fock states resembling repulsively bound states.
- Developed a perturbative argument to qualitatively understand the properties of these rare states.
- Performed a novel calculation of the energy spectrum of repulsively bound pairs on ladders.

The use of Josephson junctions in constructing qubits with long decoherence times — February 2022 - August 2022
Final year project

- Provided a general overview of the physics behind superconductivity and the Josephson effect.
- Explained how Josephson junctions can be used to create three families of superconducting qubits.
- Surveyed the coherence properties of superconducting qubits, describing possible sources of decoherence and mitigation .
- Concluded with a discussion on the possible directions for future research in superconducting quantum computation and the predicted time-scales for these improvements to be implemented.

Simulating Extended Bose-Hubbard Models — May 2021 - September 2021
Research report (available upon request)

- Presented an ab-initio derivation of the Extended Hubbard model (EBHM) from the Born-Oppenheimer approximation, an overview of the Eigenstate Thermalisation Hypothesis and its relation to random matrix theory.
- Showed that in the attractive Hubbard potential regime the 1D EBHM presents atypical states which can be readily observed by looking at the infinite time averaged eigenstate expectation values (EEV) of certain local operators. When viewed from a post-quench perspective however these states rapidly relaxed to thermal equilibrium.
- Developed a model of two disconnected EBH chains interacting through an intersite potential which presents a family of rare states with anomalous EEVs.

Berry phase, the Quantum Hall effect and Topological order — November 2021 - present
Expository essay

- Starting from the Adiabatic theorem, the concept of Berry curvature as a magnetic field in phase space is developed, which leads to the introduction of the first Chern class as a topological invariant in tight-binding models.
- Discussed the integer quantisation of the Hall conductance and related it to the Chern number via the Thouless-Kohmoto-Nightingale-den Nijs invariant.
- Introduced the Haldane model as an elementary example of a Chern insulator, constructed its topological phase diagram both analytically and numerically, and analysed the resulting emergence of chiral edge states by computing the band structure of graphene nanoribbons.
- Explored the path integral formalism for spin systems and its implication of topological theta terms arising in Heisenberg antiferromagnets.

The Undergraduate Companion to Theoretical Physics — September 2020 - present
Lecture notes

- Typeset a series of lecture notes on foundational courses in theoretical physics at an advanced undergraduate level:

1. Classical physics
2. Electromagnetism
3. Quantum mechanics
4. Thermal and statistical physics
5. Modern physics
6. Mathematical methods

TECHNICAL SKILLS

LaTeX, Python, Maxima, Adobe Illustrator

CONFERENCES ATTENDED

SQP Autumn School 2021
GSSI Statistical and Quantum Mechanics 2021