Kristian Tyn Kai Chung

(510)589-8243
ktchung@pks.mpg.de

Ph.D. Physics

My research focuses on frustrated magnetism, lattice gauge theory, generalized symmetries, and their interplay in the descriptions of spin liquid phases of matter. My interests are particularly focused on gauge fields and topology in condensed matter systems, particularly in the context of spin liquids and frustrated quantum magnets, and in the use of higher-form and generalized symmetries in guiding our understanding of such exotic phases of matter. Towards that end I run a journal club on generalized symmetries. My Ph.D. research centered on frustrated magnetism in pyrochlore rare earth insulators, focusing especially on the physics of the 1-form U(1) spin liquids known as quantum spin ices, and the use of polarized neutron scattering as a probe of spin liquidity. This work motivated me to study Hodge theory and differential forms applied to spin liquid phases, the topic of my Ph.D. dissertation. Using insights from Hodge theory led me to construct and study models for a new class of spin liquids, naturally dubbed 2-form U(1) spin liquids. More recently my research has focused on lattice gauge theory, the nature of Higgs phases, and their interplay with generalized symmetries and symmetry breaking. This work has thus far culminated in the demonstration that Higgs phases exhibit boundary symmetry breaking under appropriate boundary conditions in Abelian, non-Abelian, and higher-form gauge theories coupled to Higgs fields. Currently I am very interested in non-invertible symmetries and their spontaneous breaking in a class of G-qudit toy models.

Academic Experience

Postdoctoral Researcher *Max Planck Institute for the Physics of Complex Systems (MPI-PKS)* (2023 – present)
◇ **Project Title**: Lattice field theory approaches to frustrated magnetism
◇ **Group**: Condensed Matter Division

Ph.D. Physics *University of Waterloo* (2017 – 2023)
◇ **Thesis**: Hodge Theory for Geometrically Frustrated Magnetism
◇ **Advisor**: Prof. Michel Gingras

M.Sc. Physics *San Francisco State University* (2014 – 2017)
◇ **Thesis**: Investigation of the Color-Coulomb Flux Tube
◇ **Advisor**: Prof. Jeff Greensite

B.Sc. Physics *University of the Pacific* (2008 – 2013)
◇ **Research Project**: Observables in the Hamiltonian (ADM) Formulation of General Relativity and Quantum Gravity
◇ **Advisor**: Prof. Sayandeb Basu

Research Expertise

Topics
- ◇ Frustrated Magnetism and Spin Liquids
  - ○ Pyrochlore Magnetic Insulators
  - ○ Classical & Quantum Spin Ice
  - ○ Emergent Gauge Fields: Higher-form (“stringy”) & Higher-rank (“fractonic”)
- ◇ Generalized Symmetries
  - ○ Lattice gauge theory: Abelian, non-Abelian, and higher-form
  - ○ Higgs phases & boundary symmetry breaking
  - ○ Higher-form symmetry breaking & topological order
  - ○ Non-invertible & Rep(G) symmetries

Methods
- ◇ Markov Chain Monte Carlo
- ◇ Field Theory, Differential Geometry, & Hodge Theory — Continuum + Discrete
- ◇ Group Theory & Group Representations
- ◇ Linear Spin Wave Theory & Classical Low-Temperature Expansion
- ◇ Large-N Expansion & Self-Consistent Gaussian Approximation (SCGA)
- ◇ Neutron Scattering — Dynamical Spin Structure Factors and Polarization Analysis

Primary References

1. Michel J. P. Gingras *University of Waterloo*
◇ Position: Professor, Canada Research Chair in Condensed Matter Physics & Statistical Mechanics
◇ Email: gingras@uwaterloo.ca
◇ Website: https://uwaterloo.ca/physics-astronomy/profile/gingras

2. Sergej Moroz *Karlstad University*
◇ Position: Associate Professor of Physics
◇ Email: sergej.moroz@kau.se
◇ Website: https://www.kau.se/en/researchers/sergej-moroz

3. Paul McClarty *Laboratoire Léon Brillouin Saclay*
◇ Position: CNRS Researcher (DR2)
◇ Email: paul.mcclarty@cea.fr
◇ Website: https://scholar.google.com/citations?user=VRBh43gAAAAJ

Additional References

4. Chistopher Hooley *Coventry University*
◇ Position: Professor, Group lead: Statistical Physics Group
◇ Email: ae4620@coventry.ac.uk
◇ Website: https://pureportal.coventry.ac.uk/en/persons/chris-hooley

5. Andriy Nevidomskyy *Rice University*
◇ Position: Professor, Physics and Astronomy
◇ Email: nevidomskyy@rice.edu
◇ Website: https://profiles.rice.edu/faculty/andriy-nevidomskyy

6. Johannes Reuther *Freie Universität Berlin*
◇ Position: Professor
◇ Email: johannes.reuther@fu-berlin.de
◇ Website: https://www.physik.fu-berlin.de/einrichtungen/ag/ag-reuther/index.html

Publications

Mapping the Phase Diagram of a Frustrated Magnet: Degeneracies, Flat Bands, and Canting Cycles on the Pyrochlore Lattice (2024)
◇ K. Chung
◇ arXiv: 2411.03429 (in review)

Higgs Phases and Boundary Criticality (2024)
◇ K. Chung, R. Flores-Calderon, R. Carreira, P. Riberiro, S. Moroz, P. McClarty
◇ arXiv: 2404.17001 (in review).

2-Form U(1) Spin Liquids: Classical Model and Quantum Aspects (2023)
◇ K. Chung, M. Gingras
◇ arXiv: 2310.17607 (in press - Physical Review B).

Probing Flat Band Physics in Spin Ice Systems via Polarized Neutron Scattering (2022)
◇ K. Chung, J. Goh, A. Mukherjee, W. Jin, D. Lozano-Gómez, M. Gingras
◇ Physical Review Letters **128**, 107201 (2022).

Coulomb Flux Tube on the Lattice (2017)
◇ K. Chung, J. Greensite
◇ Physical Review D **96**, 034512 (2017).

Activities

Generalized Symmetries Journal Club (Founder & Organizer) *MPI-PKS* (2023 – present)
◇ A journal club dedicated to exploring topics in generalized symmetries.
◇ Website: generalized-symmetries-journal-club.github.io.

Quantum Matters Grad Talks (Cofounder & Organizer) *University of Waterloo* (2019 – 2022)
◇ A condensed matter seminar series by and for graduate students to discuss their research.
◇ Website: sites.google.com/view/qmgradtalks.

Awards

Best Poster Award *International Center for Theoretical Physics (ICTP)* (2023)
◇ Venue: Conference on Fractionalization and Emergent Gauge Fields in Quantum Matter
◇ Title: 2-Form U(1) Spin Liquids: Classical Model and Quantum Aspects

W.B. Pearson Medal *University of Waterloo* (2022)
◇ Description: "In recognition of creative research as presented in the student's thesis."

Robert W. Maxwell Memorial Scholarship *San Francisco State University* (2016)

Additional Education

International Summer School on Computational Quantum Materials *University of Sherbrooke* (2022)

Online School on Ultra Quantum Matter *Perimeter Institute for Theoretical Physics* (2020)