Yu-Hsin Melissa Chen

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Education

National Taiwan Normal University (Taipei, Taiwan) **Sept. 2021 – Jan. 2025**
Bachelor of Science in Physics (Early-graduated)
Courses hightlight: Introduction to Solid state physics, Application of Group Theory in Condensed matter physics

Research Interest

○ **Primary Focus**: Condensed Matter Theory, Topological Phases of Matter.
○ **Related Background**: High Energy Physics (e.g. Neutrino Physics, Dark matter).

Research Experience

Institute of Physics, Academia Sinica (Taipei, Taiwan) **Aug. 2025 – Now**
Undergraduate Research Assistant (full-time), Quantum Matter Theory Group
Advisor: Professor Chen-Hsuan Hsu
○ Conducted theoretical-numerical investigations on topological density wave , including realization and detection, and the analysis of external-field effects. Computed Berry curvature and Chern numbers to characterize topological properties, studied edge states under external fields, and collaborated on RG flow simulations to explore interaction behaviors.

Key project:

- **topological density wave model:**
  - Analyzed a theoritical model with momentum and angular parameters, connecting with Floquet system to find the detection. Designed numerical simulations to study how varying model parameters influences the system.
- **External-field analysis in topological density wave model:**
  - Added external fields into existing Hamiltonians, performing numerical to compute energy spectra.
  - Conducted systematic parameter sweeps and visualized edge-state localization and bulk-gap behavior under different field configurations.
- **Numerical RG flow analysis in collaboration with postdoc:**
  - Implemented Python-based RG flow solvers for couplings and Luttinger parameters, and visualized trajectories to analyze energy scales and interaction competition.

○ **Other project:** Supported team members in running codes on high-performance computing clusters and resolved issues.

Institute of Physics, Academia Sinica (Taipei, Taiwan) **Sept. 2024 – June. 2025**
Undergraduate Researcher, High Energy Theory Group
Advisor: Professor Meng-Ru Wu
○ Conducted undergraduate research on neutrino oscillations, deriving theoretical models and performing numerical simulations of solar neutrino, while exploring potential resonance phenomena in dark photon fields. Independently identified research directions and solved most technical challenges, receiving guidance mainly through email correspondence.

Projects:

- **Numerical simulations of neutrino oscillations:**
  - Derived neutrino oscillation probabilities from the Schrödinger equation, and also designed a Python-based numerical framework to compute solar neutrino survival probabilities as functions of propagation distance.

  - Structured the python program into modular components—electron potential, Hamiltonian, Schrödinger equation, probability—while ensuring dimensional consistency when converting quantities and transforming the Schrödinger equation from time to spatial form.
  - Resources: https://github.com/yhmchen/2-flavor-solar-neutrino-oscillation.
    The code can also be found on my personal website and is also listed at the top of my CV.

- **Exploration research directions:**
  - Conducted a literature survey on MSW and parametric resonances, reviewed solar neutrino papers, and identified dark photon as a potential mechanism for investigation, upon which I independently proposed a preliminary framework describing neutrino interactions with time-dependent dark photon fields and presented it as a written proposal.

Institute of Physics, Academia Sinica (Taipei, Taiwan) **Summer 2024**
Summer Intern, High Energy Experiment Group
Advisor: Professor Henry Tsz-King Wong
○ Conducted a project analyzing LIGO public data to search for dark-matter mirror interactions via a Yukawa potential. Explored parameter dependencies in simulated strain signals and investigated potential physical meaning for LIGO's mirror.

Project:

- **Parameter-space scanning and computational implementation:**
  - Modeled dark-matter mirror interactions using a Yukawa potential based on published literature, and implemented numerical simulations to explore parameter dependencies.
  - Automated systematic scans over force ranges and incident angles, extracting key trends in simulated strain signals.
  - Visualized and interpreted results to identify patterns and correlations in the data.

Academic Activities

National Taiwan Normal University (Taipei, Taiwan) **March. 2023 – Dec. 2023**
Undergraduate Student , High Energy Theory Group
Advisor: Professor Chuan-ren Chen
○ Learned basic concepts in particle physics, studied the thesis and used Python to reproduce the figures from the article.

National Taiwan Normal University (Taipei, Taiwan) **Sept. 2023 – Dec. 2023**
Member, Black hole Group
Advisor: Professor Hung-yi Pu
○ Presented and discussed key concepts in black hole physics as part of our group's reading seminar.

TIDC Summer School of Experimental High Energy Physics **June 24 – June 29, 2024**
○ Completed lectures and hands-on sessions in theory and experiment, and delivered a final presentation on the topic.

Publication

One in preparation (Condensed matter theory, ongoing)
Studied topological density wave models to characterize their topological properties. Contributed to numerical modeling, computation of topological invariants, and verification across parameter regimes.

Skills

○ **Programming language**: Python, Mathematica

Community Service

Digital Companions for Learning program **Sept. – Dec. 2023**

○ Provided online math tutoring to a rural junior-high student, helping learners with limited resources grasp abstract concepts.