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Education

2019 – 2025 **PhD, Physics**, University of California, Berkeley.

Dissertation Topological Order and Collective Excitations for Light Dark Matter Direct Detection

Advisor Sinéad M. Griffin

2019 – 2020 **MA, Physics**, University of California, Berkeley.

2017 – 2019 **MS, Applied Physics**, University of California, Berkeley.

Thesis The Nonlinear Schrödinger Hierarchy: from Quasi Rogue Waves to Nonlinear Talbot Carpets

2013 – 2017 **BS, Electrical Engineering (Optics)**, Texas A&M University, *Summa Cum Laude*.

Thesis Maximal Intensity Higher-Order Breathers of the Nonlinear Schrödinger Equation

Primary Research Interests

- Leveraging exotic phases in condensed matter to develop novel quantum sensing schemes for applications such as dark matter detection and high-energy physics.
- Discovering new altermagnets and exploring their electronic, vibrational, magnetic, and topological properties using first-principles calculations.
- Designing multi-layered quantum embedding schemes by integrating *ab initio* methods with hybrid quantum algorithms to study spin-defect qubits in solid-state systems.

Publications and Preprints

Cited 230 times, *h*-index: 8 (as of September 29th, 2024)

★ Equal Contribution † Corresponding Author

2024 **Omar A. Ashour** and Sinéad M. Griffin. Pressure-tunable targets for light dark matter direct detection: the case of solid helium (2024). [[arXiv:2409.02439](#)]

2024 Na Hyun Jo^{*}, **Omar A. Ashour**^{*}, Zhixue Shu, Chris Jozwiak, Aaron Bostwick, Sae Hee Ryu, Kai Sun, Tai Kong, Sinéad M. Griffin, and Eli Rotenberg. Effects of strain, defects, and interactions on the topological properties of HfTe₅, *Phys. Rev. B*, **109**, 235122 (2024), *Editor's Suggestion*.

2024 Thomas F. Harrelson, Ibrahim Hajar, **Omar A. Ashour**, and Sinéad M. Griffin. Theoretical investigation of decoherence channels in athermal phonon sensors, *J. Phys. Condens. Matter*, (Accepted) (2024).

- 2022 Stanko N. Nikolić, Sarah Alwashahi, **Omar A. Ashour**, Siu A. Chin, Najdan B. Aleksić, and Milivoj R. Belić. Multi-elliptic rogue wave clusters of the nonlinear Schrödinger equation on different backgrounds, *Nonlinear Dynamics*, **108**, 479–490 [↗](#) (2022).
- 2022 **Omar A. Ashour**[†], Siu A. Chin, Stanko N. Nikolić, and Milivoj R. Belić. Higher-order breathers as quasi-rogue waves on a periodic background, *Nonlinear Dynamics*, **107**, 3819–3832 [↗](#) (2022).
- 2022 Thais Chagas*, **Omar A. Ashour***, Guilherme Ribeiro, Wendell Silva, Zhenglu Li, Rogério Magalhães-Paniago, Yves Petroff, and Steven G. Louie. Multiple strong topological gaps and hexagonal warping in Bi₄Te₃, *Physical Review B*, **105**, L081409 [↗](#) (2022).
- 2022 Milivoj R. Belić, Stanko N. Nikolić, **Omar A. Ashour**, and Najdan B. Aleksić. On different aspects of the optical rogue waves nature, *Nonlinear Dynamics*, **108**, 1655–1670 [↗](#) (2022).
- 2021 **Omar A. Ashour**[†]. NonlinearSchrödinger: higher-order algorithms and Darboux transformations for nonlinear Schrödinger equations (2021). [\[arXiv:2103.14469\]](#) [↗](#)
- 2019 Stanko N. Nikolić, **Omar A. Ashour**, Najdan B. Aleksić, Yiqi Zhang, Milivoj R. Belić, and Siu A. Chin. Talbot carpets by rogue waves of extended nonlinear Schrödinger equations, *Nonlinear Dynamics*, **97**, 1215–1225 [↗](#) (2019).
- 2019 Stanko N. Nikolić, **Omar A. Ashour**, Najdan B. Aleksić, Milivoj R. Belić, and Siu A. Chin. Breathers, solitons and rogue waves of the quintic nonlinear Schrödinger equation on various backgrounds, *Nonlinear Dynamics*, **95**, 2855–2865 [↗](#) (2019).
- 2017 Stanko N. Nikolić, Najdan B. Aleksić, **Omar A. Ashour**, Milivoj R. Belić, and Siu A. Chin. Systematic generation of higher-order solitons and breathers of the Hirota equation on different backgrounds, *Nonlinear Dynamics*, **89**, 1637–1649 [↗](#) (2017).
- 2017 Runze Li, **Omar A. Ashour**, Jie Chen, H. E. Elsayed-Ali, and Peter M. Rentzepis. Femtosecond laser induced structural dynamics and melting of Cu (111) single crystal: an ultrafast time-resolved x-ray diffraction study, *Journal of Applied Physics*, **121**, 055102 [↗](#) (2017).
- 2017 Siu A. Chin, **Omar A. Ashour**, Stanko N. Nikolić, and Milivoj R. Belić. Peak-height formula for higher-order breathers of the nonlinear Schrödinger equation on non-uniform backgrounds, *Physical Review E*, **95**, 012211 [↗](#) (2017).
- 2016 Siu A. Chin, **Omar A. Ashour**, Stanko N. Nikolić, and Milivoj R. Belić. Maximal intensity higher-order Akhmediev breathers of the nonlinear Schrödinger equation and their systematic generation, *Physics Letters A*, **380**, 3625–3629 [↗](#) (2016).
- 2015 Siu A. Chin, **Omar A. Ashour**, and Milivoj R. Belić. Anatomy of the Akhmediev breather: cascading instability, first formation time, and Fermi-Pasta-Ulam recurrence, *Physical Review E*, **92**, 063202 [↗](#) (2015).

Manuscripts in Preparation

Omar A. Ashour and Sinéad M. Griffin. Non-pair-breaking topological quantum sensing of collective excitations.

Omar A. Ashour and Sinéad M. Griffin. Antiferromagnetic topological insulators for light dark matter direct detection with magnons.

Omar A. Ashour and Sinéad M. Griffin. Topological crystalline insulators for light dark matter direct detection with phonons.

Research Experience

- 2024 **Quantum @ NERSC, Lawrence Berkeley National Lab**, Berkeley, CA.
PIs Katherine Klymko and Norman Tubman (NASA)
Topic Development of DFT-based hybrid quantum algorithms for molecules (with NASA QuAIL)
Studies of quantum phase transition using neutral atom quantum simulators (with QuEra)
- 2021 – **Molecular Foundry, Lawrence Berkeley National Lab**, Berkeley, CA.
PI Sinéad M. Griffin
Topic Dark matter interaction with collective excitations in quantum materials
- 2019 – 2021 **Physics Department, UC Berkeley**, Berkeley, CA.
PI Steven G. Louie
Topic DFT and GW calculations of topological insulators and low-dimensional systems
- 2017 – 2018 **NSF Nanoscale Science & Engineering Center, UC Berkeley**, Berkeley, CA.
PI Xiang Zhang
Topic Ultrafast spectroscopy of transition metal dichalcogenide monolayers
- 2014 – 2017 **Department of Physics and Astronomy, Texas A&M University**, College Station, TX.
PIs Siu A. Chin and Milivoj R. Belić
Topic Mathematical and computational studies of nonlinear Schrödinger equations
- 2016 – 2017 **Texas A&M Engineering Experiment Station (TEES)**, College Station, TX.
PI Peter M. Rentzepis
Topic Ultrafast X-ray studies of thin films, and ultrafast optical studies of bacteria
- 2015 **Institute of Electronic Structure and Laser (IESL-FORTH)**, Heraklion, Greece.
PI Stelios Tzortzakis
Topic Femtosecond laser machining of low-loss waveguides

Fellowships and Awards

- 2024 **Ovshinsky Travel Award**, Division of Materials Physics, American Physical Society
- 2018 – 2019 **Anselmo J. Macchi Graduate Fellowship**, UC Berkeley
- 2017 – 2019 **Berkeley Graduate Fellowship**, UC Berkeley
- 2017 – 2018 **Cornell Graduate Fellowship** (declined), Cornell University
- 2016 **Richard E. Ewing Award** for excellence in student research, Texas A&M University
- 2014, '15, '17 **Gathright Scholar Award** for outstanding academic achievement, Texas A&M University

Selected Software Packages

GitHub 

DarkMAGIC, [Python/MPI/Numba].

Parallel, high-throughput package for calculating phonon and magnon interactions with dark matter based on first-principles calculations.

(Releasing **pymatgen.io.espresso**, [Python].

Oct. 2024) Exploiting ducktyping, this package elevates Quantum ESPRESSO (QE) to a first-class citizen in the pymatgen ecosystem, enabling VASP-based packages to fully support QE with just two lines of code.

GitHub 

NonlinearSchrodinger.jl, [Julia].

arXiv 


Highly-performant package for solving nonlinear Schrödinger-type partial differential equations using numerical and analytical algorithms.

Contributions I have contributed to a variety of scientific packages in C/C++, FORTRAN, CUDA, MPI, OpenMP, and OpenACC. Examples include pymatgen, sumo, and VASP.

Service and Outreach

Aug. 2024 **Next-Generation Quantum Materials for Quantum Computing and Sensing** .

I proposed and organized a symposium at the annual Molecular Foundry User Meeting, featuring invited and contributed talks from across the U.S.

2021 – **Educational Resources:** I maintain a popular website, <https://ashour.dev> , which features my comprehensive notes on group theory, condensed matter physics, density functional theory, and other topics. The site also includes tutorials and practical guides on several aspects of DFT calculations, attracting over 60,000 monthly visits.

2021 – **Undergraduate Mentoring:** I am involved in mentoring several undergraduate students, and have given lectures to and trained summer intern cohorts at Berkeley Lab.

2020 **Scientist Ambassador:** I spent four weeks as an ambassador to a first-grade class, teaching them about the day-to-day life of a scientist.

2018 **Be A Scientist:** I worked with students at a local middle school for 6 weeks to design and conduct science experiments and foster critical thinking skills.