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Education

2019 – 2025 **PhD, Physics**, University of California, Berkeley (*expected May 2025*).

Dissertation Quantum Sensing and Dark Matter Detection via Topological Order and Collective Excitations

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

- Designing novel quantum sensing schemes that combine exotic condensed phases and conventional material tuning knobs such as strain, pressure, and doping. My work leverages a diverse range of quantum materials—such as topological insulators, frustrated magnets, and Dirac semimetals—for applications in dark matter detection and high-energy particle physics.
- Using *ab initio* calculations to elucidate the electronic, magnetic, vibrational, and topological properties of the newly discovered altermagnetic materials, often in collaboration with experimentalists.
- Developing hybrid classical-quantum algorithms for strongly correlated systems, with a focus on quantum embedding schemes that integrate first-principles methods and quantum computation to study interactions between solid-state spin-defect qubits.

Publications and Preprints

Cited 230 times, *h*-index: 8 (as of October 3rd, 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) [\[arXiv:2401.12345\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (2022).
- 2021 **Omar A. Ashour**[†]. NonlinearSchrodinger: higher-order algorithms and Darboux transformations for nonlinear Schrödinger equations (2021). [\[arXiv:2103.14469\]](#) [\[arXiv:2103.14469\]](#)
- 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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (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 [\[arXiv:2103.14469\]](#) (2015).

Manuscripts in Preparation

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

Nicholas Dale*, **Omar A. Ashour***, ..., and Sinéad M. Griffin. Directly probing g -wave alternating magnetism below and above the Fermi level.

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 (LBL) and Norman Tubman (NASA QuAIL)

Topics Development of VQE variants with DFT- and RDMFT-based cost functions (with NASA)
Quantum simulation of the Kibble-Zurek mechanism in 1D neutral atom chains (with QuEra)

2021 – **Molecular Foundry and Materials Sciences Division, Berkeley 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 two-dimensional materials

2017 – 2018 **NSF Nanoscale Science & Engineering Center, UC Berkeley**, Berkeley, CA.

PI Xiang Zhang

Topic Ultrafast spectroscopy of monolayer transition metal dichalcogenides

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

May 2024 **NERSC Quantum PhD Internship**, awarded through a competitive application process

March 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], sole developer and maintainer.
Parallel, high-throughput package for calculating phonon and magnon interactions with general dark matter models, using on first-principles calculations, model Hamiltonians, and effective field theory.
- (Releasing Oct. 2024) **pymatgen.io.espresso** [Python], sole developer and maintainer.
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], sole developer and maintainer.
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 patches.

Service and Outreach

- Aug. 2024 **Symposium Organization:** I proposed and organized a symposium, *Next-Generation Quantum Materials for Quantum Computing and Sensing*  at the annual Molecular Foundry User Meeting, featuring invited and contributed talks from across the U.S.
- 2021, '22, '23 **Griffin Group MVP:** voted by peers in my research group as the “most valuable physicist” of the year for fostering a collaborative and supportive environment.
- 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 academic topics. The site also includes tutorials and practical guides on several aspects of computational solid-state physics, attracting over 60,000 monthly visits.
- 2021 – **Undergraduate Mentoring:** I am involved in mentoring several undergraduate students, and have trained and lectured to 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.