Mahmoud Jalali Mehrabad (US Permanent Resident)

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Research Profile

Chiral, topological and correlated quantum optics and integrated photonics: Integrated harmonic generation and frequency combs; many-body dynamics; quantum nanophotonics circtuits. I build **photonic integrated circuits** that use **chiral and topological characters of light and matter** and **quantum control** to realize **turnkey robust nonlinear and quantum devices** with wafer-scale reproducibility.

Appointments

2025– **Research Scientist**
Massachusetts Institute of Technology (MIT), USA

2025 **Assistant Research Scientist**
Joint Quantum Institute (JQI), University of Maryland, USA

2022–2025 **Postdoctoral Research Associate**
Hafezi Lab, Joint Quantum Institute (JQI), University of Maryland, USA

2021–2022 **Postdoctoral Researcher**
Skolnick Lab, University of Sheffield, UK

Education

2021 **Ph.D. Physics**, University of Sheffield (UK) — Thesis: *Integrated Topological Quantum Optics*; Advisors: M. Skolnick (FRS), M. Fox; Prize Scholarship Fellow; Rank Prize Awardee 2021

2015 **B.Sc. Physics**, UoS (Iran) — GPA 89/100 (ranked first); Faculty Award for Research Excellence

Grants & Roles

1. Co-PI on **NSF RQS-5240322** grant "Robust Quantum Simulation" (2023).
2. Co-Staff-PI on **ONR DURIP 6000016748 GRA** grant "Nonlinear topological photonics" (2024).
3. Entrepreneurial Lead PI on **NSF I-Corps** grant "Integrated Metasurface-Enhanced Light-Induced Phenomena" (2025).
4. Co-Staff-PI on **ONR DURIP GRA** grant "Topological harmonic and squeezing" (Under Review).
5. Co-Staff-PI on **NSF** grant "Coherence and phase locking in topological combs" (Under Review).
6. Co-PI on **Maryland Innovation Infinitive: technology assessment** grant "Nested-FPM: High-Yield Integrated Nonlinear Photonic Devices" (Submitted 2025).

Publications & Preprints (*Equal contribution)

Books

1. *A Guide on Data Analysis in Origin*, M. H. Ehsani, **M. J. Mehrabad**. Semnan University Press, ISBN 978-600-7065-8-4 (2016).

Patents

1. *Active Nanoplasmonic Platform for Controllable Light–Matter Interaction.* S. Sarkar, **M. J. Mehrabad**, Y. Zhou, M. Hafezi. Provisional US Patent 63/814,919 (2025).
2. *TOPAI: Topological Photonics Architectures for Optical Computing and Artificial Intelligence.* **M. J. Mehrabad**, L. Xu, S. Sarkar, Z. Y. Wei, M. Hafezi. Provisional US Patent (Filed Aug 2025).
3. *Nested Frequency and Phase Matching.* **M. J. Mehrabad**, L. Xu, G. Moille, Y., K. Srinivasan, M. Hafezi. Provisional US Patent (Filed Aug 2025).
4. *Quantum Optical Metamorphosis.* **M. J. Mehrabad**, A. Parhizkar, L. Xu, M. Hafezi. US Patent (Filed Aug 2025).
5. *System of vapor flux controlling in thermal evaporation method using magnetic quadrupole and magnetic lens.* M. H. Ehsani, **M. J. Mehrabad**. Iran Patent No. 87925 (2016).

Papers—In preparation

1. *Quantum metamorphosis: Emergence and the breakdown of bulk-edge dichotomy in multiscale systems.* **M. J. Mehrabad*** , A. Parhizkar* , L. Xu*, D. Leykam, M. Hafezi.
2. *Waveguide-geometry-agnostic integrated nonlinear optics.* L. Xu* , **M. J. Mehrabad*** , A. Padhye* , K. Srinivasan, M. Hafezi.

Papers—Submitted / Under Review

1. *Bosonic quantum many-body simulation with interacting photons.* X. Zheng* , **M. J. Mehrabad*** , A. Dutt, N. Schine, E. Waks. ***Physical Review X*** (submitted, arXiv:2504.15441, 2025).

Papers—Accepted / Under Revision

1. *Multi-timescale Frequency–Phase Matching for High-Yield Nonlinear Photonics.* **M. J. Mehrabad***, L. Xu*, G. Moille, K. Srinivasan, M. Hafezi. (In Press in ***Science***, arXiv: 2506.15016, 2025).
2. *Giant enhancement of exciton diffusion near an electronic Mott insulator.* P. Upadhyay* , D. G. S. Forero* , T. S. Huang* , **M. J. Mehrabad**, B. Gao, S. Sarkar, D. Session, K. Watanabe, T. Taniguchi, Y. Zhou, M. Knap, M. Hafezi. (In Press in ***Science***, arXiv:2409.18357, 2025).
3. *Probing Quantum Anomalous Hall States in Twisted Bilayer WSe_2 via Attractive Polaron Spectroscopy.* B. Gao, M. Ghafariasl* , **M. J. Mehrabad*** , T. S. Huang* , L. Zhang, D. Session, P. Upadhyay, R. Ma, G. Alshalan, DGS. Forero, S. Sarkar, S. Park, H. Jang, K. Watanabe, T. Taniguchi, M. Xie, Y. Zhou, M. Hafezi. ***Physical Review X*** (under revision, arXiv:2504.11530, 2025).

Papers—Published

1. *Optical pumping of electronic quantum Hall states with vortex light.* D. Session* , **M. J. Mehrabad*** , N. Paithanker* , T. Grass, C. Eckhardt, B. Cao, D. G. S. Forero, K. Li, M. S. Alam, G. S. Solomon, N. Schine, J. Sau, R. Sordan, M. Hafezi. ***Nature Photonics*** 19 (2), 156–161 (2025).
2. *On-chip multi-timescale spatiotemporal optical synchronization.* L. Xu* , **M. J. Mehrabad*** , C. Flower* , G. Moille, Y. Chembo, K. Srinivasan, S. Mittal, M. Hafezi. ***Science Advances*** 11, eadw7696 (2025).
3. *Sub-wavelength optical lattice in 2D materials.* S. Sarkar* , **M. J. Mehrabad*** , D. G. S. Forero* , L. Gu* , C. J. Flower, L. Xu, K. Watanabe, T. Taniguchi, S. Park, H. Jang, Y. Zhou, M. Hafezi. ***Science Advances*** 11, eadv2023 (2025).
4. *Chiral quantum optics: recent developments, and future directions.* D. G. S. Forero* , **M. J. Mehrabad*** , C. Vega Garcia, A. González-Tudela, M. Hafezi. ***PRX Quantum*** 6, 020101 (2025).
5. *Nonlinear Quantum Optics at a Topological Interface Enabled by Defect Engineering.* L. Hallacy, N. J. Martin, **M. J. Mehrabad**, D. Hallett, R. Dost, A. Fenzl, L. Brunswick, M. S. Skolnick, L. R. Wilson. ***npj Nanophotonics*** 2(1): 9 (2025).
6. *Observation of topological frequency combs.* C. J. Flower* , **M. J. Mehrabad*** , L. Xu* , G. Moille, D. G. S. Forero, Y. Chembo, K. Srinivasan, S. Mittal, M. Hafezi. ***Science*** 384(6702): 1356–1361 (2024).
7. *Strain-Induced Landau Levels in Photonic Crystals.* **M. J. Mehrabad**, M. Hafezi. ***Nature Photonics*** 18(6): 527–528 (2024).
8. *Dynamic control of 2D non-Hermitian photonic corner states in synthetic dimensions.* X. Zheng* , **M. J. Mehrabad*** , J. Vannucci, K. Li, A. Dutt, M. Hafezi, S. Mittal, E. Waks. ***Nature Communications*** 15: 10881 (2024).
9. *Topological and conventional nano-photonic waveguides for chiral integrated quantum optics.* N. J. Martin, **M. J. Mehrabad**, A. P. Foster, R. Dost, E. Clarke, P. K. Patil, A. M. Fox, M. S. Skolnick, L. R. Wilson. ***Physical Review Research*** 6(2): L022065 (2024).
10. *Near-Visible Topological Edge States in a Silicon Nitride Platform.* D. Sharp, C. Flower, **M. J. Mehrabad**, A. Manna, H. Rarick, R. Chen, M. Hafezi, A. Majumdar. ***Optical Materials Express*** 14(6): 1596–1602 (2024).
11. *Excitonic Mott insulator in a Bose–Fermi–Hubbard system of moiré WS_2/WSe_2 heterobilayer.* B. Gao, D. D. Suarez, S. Sarkar, T. Huang, D. Session, Ma. J. Mehrabad, R. Ni, M. Xie, P. Upadhyay, J. Vannucci, S. Mittal, K. Watanabe, T. Taniguchi, A. Imamoglu, Y. Zhou, M. Hafezi. ***Nature Communications*** 15: 2305 (2024).
12. *Spin-selective strong light–matter coupling in a 2D hole gas microcavity.* D. G. Suárez, D. Session, **M. J. Mehrabad**, P. Knüppel, S. Faelt, W. Wegscheider, M. Hafezi. ***Nature Photonics*** 17: 912–916 (2023).
13. *A chiral topological add–drop filter for integrated quantum photonic circuits.* **M. J. Mehrabad**, A. P. Foster, R. Dost, E. Clarke, P. K. Patil, A. M. Fox, M. S. Skolnick, L. R. Wilson. ***Optica*** 10(3): 415–421 (2023).
14. *Topological Edge Mode Tapering.* C. J. Flower, S. Barik, **M. J. Mehrabad**, N. Martins, S. Mittal, M. Hafezi. ***ACS Photonics*** 10: 3502–3507 (2023).
15. *Topological photonics: fundamental concepts, recent developments, and future directions.* **M. J. Mehrabad**, S. Mittal, M. Hafezi. ***Physical Review A*** 108: 040101 (2023).
16. *Chiral topological photonics with an embedded quantum emitter.* **M. J. Mehrabad**, A. P. Foster, R. Dost, E. Clarke, P. K. Patil, A. M. Fox, M. S. Skolnick, L. R. Wilson. ***Optica*** 7(12): 1690–1696 (2020).
17. *A semiconductor topological photonic ring resonator.* **M. J. Mehrabad**, A. P. Foster, R. Dost, E. Clarke, P. K. Patil, I. Farrer, J. Heffernan, M. S. Skolnick, L. R. Wilson. ***Applied Physics Letters*** 116: 061102 (2020).
18. *Substrate-temperature effects on surface reaction kinetics in CVD GaAs.* **M. J. Mehrabad**, M. H. Ehsani, A. Javadian. ***Ir. Journal of Applied Physics*** 7(1): 5–22 (2017).
19. *Fabrication of Co thin films using pulsed laser deposition with/without magnetic field.* M. H. Ehsani, **M. J. Mehrabad**, P. Kameli. ***Journal of Magnetism and Magnetic Materials*** 417: 117–121 (2016).

20. *Low-temperature electrical resistivity of bilayered $LaSr_2Mn_2O_7$ manganite.* M. H. Ehsani, **M. J. Mehrabad**, P. Kameli, M. E. Ghazi, F. S. Razavi. ***Journal of Low Temperature Physics*** 183: 359–370 (2016).
21. *High-performance hetero-junction silicon solar cells via AMPS-1D.* N. Memarian, M. Minbashi, **M. J. Mehrabad**. ***Journal of Nano Electron. and Physics*** 8(4): 04058 (2016).
22. *Source-temperature effects in Au thin-film growth.* **M. J. Mehrabad**, M. H. Ehsani. ***Ir. Journal of Applied Physics*** 6(1): 5–26 (2016).
23. *Transition temperature and magnetoresistance prediction of $LaSr_2Mn_2O_7$.* M. H. Ehsani, **M. J. Mehrabad**. ***Engineering Sciences*** 30(4): 339–344 (2016).
24. *Eddy current, solid loss, induced voltage and magnetic torque in thin conductors (FEM).* **M. J. Mehrabad**, M. H. Ehsani. ***Procedia Materials Science*** 11: 412–417 (2015).

Talks & Conferences (selected)

Recent invited/oral (2023–2025)

- PQE, Snowbird, UT *(Invited)*; SPIE Photonics West, San Francisco *(Invited)*; PQE, Snowbird *(Invited)*; RQS, Maryland *(Invited)*; NIST Boulder *(Invited)*; WINDS, Hawaii *(Oral)*; DAMOP, Spokane *(Oral)*; IMOD, Seattle *(Oral)* — **2023–2025**.

Earlier conferences & schools (pre-2023)

Participated in ∼15 conferences and summer schools including MURI (2022–2023), Topological Photonics Summer School (2019), Quantum Dots (2018–2020), UK Semiconductors (2018–2019), ICPS (2018), and thematic workshops across the UK and EU. Full list on request.

Selected Service & Outreach

Discovery Night "Quantum Light" (2018); Cheltenham Science Festival "Communication with Light" (2019); Facilitator, Research Professionalism/Integrity training (2021).

Teaching & Mentoring

- JQI/UMD (2022–2025): led experiments and supervised >10 trainees across cryogenic and room-temperature photonics; managed >8 experimental setups (spectroscopy, HBT, dilution fridge).
- University of Sheffield (2018–2022): GTA (Quantum Information Lab), MSc/PhD supervision in topological and chiral photonics.

Research & Technical Skills

Simulation: Lumerical FDTD (advanced), Ansys Maxwell (intermediate), COMSOL (intermediate)
Design & fabrication: GDS Voyager, nanophotonics design, EBL, RIE/ICP, SEM
Lab: mK dilution fridge / cryogenics, photoluminescence, HBT, quantum optical spectroscopy
Programming: Python, MATLAB **Markup:** LaTeX **Graphics:** Inkscape, Blender 3D
Languages: English, Spanish, French, Persian

Awards, Scholarships, and Funding

Academic

Ranked 1st among B.Sc. Physics students, Semnan University (2012–2015); Top B.Sc. Student Award, Faculty of Science, Semnan University (2015); Faculty of Physics M.Sc. Scholarship as an Exceptional Student, Semnan University (2015).

Scholarships and Grants

ONR DURIP; NSF Robust Quantum Simulation (RQS); University of Sheffield University Prize Scholarship; Rank Prize Foundation Award; Full Cover Grant for Book Publication (Semnan University); Grant Award for Book Publication (Semnan University); Grant for Topical Paper in Nano (Nano Research Organization of Iran); Grant Award for Industrial Patent (Semnan University).

Non-Academic

Ranked 3rd in UK national Dota 2 e-sport tournament (2018); Winner, University of Sheffield bake-off tournament (2020).

References

Prof. Mohammad Hafezi — postdoctoral supervisor
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Prof. Kartik Srinivasan — postdoctoral co-advisor
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Prof. Maurice Skolnick (FRS) — PhD supervisor
m.skolnick@sheffield.ac.uk

Prof. Dirk Englund — Research PI
englund@mit.edu