Mahmoud Jalali Mehrabad (US Permanent Resident)

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Last updated: May 18, 2026

Research Profile

Chiral, topological and correlated quantum optics and integrated photonics: Integrated harmonic generation and frequency combs; many-body dynamics; quantum nanophotonics circuits. I develop agentic reasoning frameworks and physics-informed AI methods to accelerate discovery and control in complex quantum photonic systems. 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, systematically exploring vast parameter spaces in nonlinear optics and many-body quantum phases through AI-driven design and optimization.

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 seed grant "Robust Quantum Simulation" (2023).
2. Co-Staff-PI on ONR DURIP 6000016748 GRA grant "Nonlinear topological photonics" (2024).
3. Co-Team Lead on NSF I-Corps grant "Multi-time scale topological light sources" (2026).
4. Co-PI on DARPA DSO PA-26-01 grant "Nested on-chip multi-harmonic generation" (2026).
5. Co-PI on Maryland Innovation Initiative grant "Nested-FPM: High-Yield Integrated Nonlinear Photonic Devices" (Under Review 2026).

Publications & Preprints (*Equal contribution)

Papers—Published

1. *Science* **390**(6773), 612–616 (2025). **M. J. Mehrabad***, L. Xu*, G. Moille, C. J. Flower, S. Sarkar, A. Padhye, S.-C. Ou, D. G. Suárez-Forero, M. Ghafariasl, Y. Chembo, K. Srinivasan, M. Hafezi. Multi-timescale frequency-phase matching for high-yield nonlinear photonics.
2. *Science* **384**(6702), 1356–1361 (2024). C. J. Flower*, **M. J. Mehrabad***, L. Xu*, G. Moille, D. G. Suárez-Forero, O. Örsel, G. Bahl, Y. Chembo, K. Srinivasan, S. Mittal, M. Hafezi. Observation of topological frequency combs.
3. *Science* **391**(6783), 394–398 (2026). P. Upadhyay*, D. G. Suárez-Forero*, T.-S. Huang*, **M. J. Mehrabad**, B. Gao, S. Sarkar, D. Session, K. Watanabe, T. Taniguchi, Y. Zhou, M. Knap, M. Hafezi. Giant enhancement of exciton diffusion near an electronic Mott insulator.
4. *Physical Review X* **16**, 021037 (2026). B. Gao, M. Ghafariasl*, **M. J. Mehrabad***, T.-S. Huang*, L. Zhang, D. Session, P. Upadhyay, R. Ma, G. Alshalan, D. G. Suárez-Forero, S. Sarkar, S. Park, H. Jang, K. Watanabe, T. Taniguchi, M. Xie, Y. Zhou, M. Hafezi. Probing Quantum Anomalous Hall States in Twisted Bilayer WSe_2 via Attractive Polaron Spectroscopy.

5. *Nature Photonics* **19**(2), 156–161 (2025). D. Session*, **M. J. Mehrabad***, N. Paithanker*, T. Grass, C. Eckhardt, B. Cao, D. G. Suárez-Forero, K. Li, M. Alam, G. Solomon, N. Schine, J. Sau, R. Sordan, M. Hafezi. Optical pumping of electronic quantum Hall states with vortex light.

6. *Nature Photonics* **18**(6), 527–528 (2024). **M. J. Mehrabad**, M. Hafezi. Strain-induced Landau levels in photonic crystals. *[Invited News & Views]*

7. *Nature Photonics* **17**, 912–916 (2023). D. G. Suárez-Forero, D. Session, **M. J. Mehrabad**, P. Knüppel, S. Fält, W. Wegscheider, M. Hafezi. Spin-selective strong light–matter coupling in a 2D hole gas microcavity.

8. *Science Advances* **11**, eadw7696 (2025). L. Xu*, **M. J. Mehrabad***, C. J. Flower*, G. Moille, Y. Chembo, K. Srinivasan, S. Mittal, M. Hafezi. On-chip multi-timescale spatiotemporal optical synchronization.

9. *Science Advances* **11**, eadv2023 (2025). S. Sarkar*, **M. J. Mehrabad***, D. G. Suárez-Forero*, L. Gu*, C. J. Flower, L. Xu, K. Watanabe, T. Taniguchi, S. Park, H. Jang, Y. Zhou, M. Hafezi. Sub-wavelength optical lattice in 2D materials.

10. *Science Advances* **10**(51), eadr5904 (2024). D. G. Suárez-Forero*, R. Ni*, S. Sarkar*, **M. J. Mehrabad***, E. Mechtel, V. Simonyan, A. Grankin, K. Watanabe, T. Taniguchi, S. Park, H. Jang, M. Hafezi, Y. Zhou. Chiral flat-band optical cavity with atomically thin mirrors.

11. *Nature Communications* **15**, 10881 (2024). X. Zheng*, **M. J. Mehrabad***, J. Vannucci, K. Li, A. Dutt, M. Hafezi, S. Mittal, E. Waks. Dynamic control of 2D non-Hermitian photonic corner states in synthetic dimensions.

12. *Nature Communications* **15**, 2305 (2024). B. Gao, D. G. Suárez-Forero, S. Sarkar, T.-S. Huang, D. Session, **M. J. Mehrabad**, R. Ni, M. Xie, P. Upadhyay, J. Vannucci, S. Mittal, K. Watanabe, T. Taniguchi, A. Imamoğlu, Y. Zhou, M. Hafezi. Excitonic Mott insulator in a Bose–Fermi–Hubbard system of moiré WS_2/WSe_2 heterobilayer.

13. *npj Nanophotonics* **2**(1), 9 (2025). L. Hallacy, N. J. Martin, **M. J. Mehrabad**, D. Hallett, R. Dost, A. Fenzl, L. Brunswick, M. S. Skolnick, L. R. Wilson. Nonlinear quantum optics at a topological interface enabled by defect engineering.

14. *Optica* **10**(3), 415–421 (2023). **M. J. Mehrabad**, A. P. Foster, R. Dost, E. Clarke, P. K. Patil, A. M. Fox, M. S. Skolnick, L. R. Wilson. A chiral topological add–drop filter for integrated quantum photonic circuits.

15. *Optica* **7**(12), 1690–1696 (2020). **M. J. Mehrabad**, A. P. Foster, R. Dost, E. Clarke, P. K. Patil, A. M. Fox, M. S. Skolnick, L. R. Wilson. Chiral topological photonics with an embedded quantum emitter.

16. *PRX Quantum* **6**, 020101 (2025). D. G. Suárez-Forero*, **M. J. Mehrabad***, C. Vega Garcia, A. González-Tudela, M. Hafezi. Chiral quantum optics: recent developments and future directions. *[Invited perspective]*

17. *Physical Review Research* **6**(2), L022065 (2024). 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. Topological and conventional nano-photonic waveguides for chiral integrated quantum optics.

18. *Physical Review A* **108**, 040101 (2023). **M. J. Mehrabad**, S. Mittal, M. Hafezi. Topological photonics: fundamental concepts, recent developments, and future directions. *[Invited perspective]*

19. *Applied Physics Letters* **116**, 061102 (2020). **M. J. Mehrabad**, A. P. Foster, R. Dost, E. Clarke, P. K. Patil, I. Farrer, J. Heffernan, M. S. Skolnick, L. R. Wilson. A semiconductor topological photonic ring resonator.

20. *Optical Materials Express* **14**(6), 1596–1602 (2024). D. Sharp, C. J. Flower, **M. J. Mehrabad**, A. Manna, H. Rarick, R. Chen, M. Hafezi, A. Majumdar. Near-visible topological edge states in a silicon nitride platform.

21. *ACS Photonics* **10**, 3502–3507 (2023). C. J. Flower, S. Barik, **M. J. Mehrabad**, N. Martins, S. Mittal, M. Hafezi. Topological edge mode tapering.

22. *Iranian Journal of Applied Physics* **7**(1), 5–22 (2017). **M. J. Mehrabad**, M. H. Ehsani, A. Javadian. Substrate-temperature effects on surface reaction kinetics in CVD GaAs.

23. *Journal of Magnetism and Magnetic Materials* **417**, 117–121 (2016). M. H. Ehsani, **M. J. Mehrabad**, P. Kameli. Fabrication of Co thin films using pulsed laser deposition with/without magnetic field.

24. *Journal of Low Temperature Physics* **183**, 359–370 (2016). M. H. Ehsani, **M. J. Mehrabad**, P. Kameli, M. E. Ghazi, F. S. Razavi. Low-temperature electrical resistivity of bilayered $LaSr_2Mn_2O_7$ manganite.

25. *Journal of Nano- and Electronic Physics* **8**(4), 04058 (2016). N. Memarian, M. Minbashi, **M. J. Mehrabad**. High-performance hetero-junction silicon solar cells via AMPS-1D.

26. *Iranian Journal of Applied Physics* **6**(1), 5–26 (2016). **M. J. Mehrabad**, M. H. Ehsani. Source-temperature effects in Au thin-film growth.

27. *Engineering Sciences* **30**(4), 339–344 (2016). M. H. Ehsani, **M. J. Mehrabad**. Transition temperature and magnetoresistance of $LaSr_2Mn_2O_7$.

28. *Procedia Materials Science* **11**, 412–417 (2015). **M. J. Mehrabad**, M. H. Ehsani. Eddy current, solid loss, induced voltage and magnetic torque in thin conductors (FEM).

Papers—Submitted/Under Review

1. arXiv:2511.13831 (2025). **M. J. Mehrabad***, A. Parhizkar*, L. Xu*, G. Moille, A. Dutt, D. Englund, K. Srinivasan, D. Leykam, M. Hafezi. Quantum Metamorphosis: Programmable Emergence and the Breakdown of Bulk-Edge Dichotomy in Multiscale Systems.

2. (2025). L. Xu*, A. Padhye*, S. Sarkar, A. Parhizkar, G. Moille, K. Srinivasan, M. Hafezi, **M. J. Mehrabad***. Single-Shot Realization of 10,000-Mode Octave-Spanning Artificial Gauge Fields.

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

4. arXiv:2510.13110 (2025). B. Wu, **M. J. Mehrabad**, D. Englund. Bidirectional nonlinear optical tomography: unbiased characterization of off- and on-chip coupling efficiencies.

5. arXiv:2512.10045 (2025). H. Flores, **M. J. Mehrabad**, S. Mirzaei, R. Camacho, D. Englund. Broadband spatio-spectral mode conversion via four-wave mixing.

6. arXiv:2512.10140 (2025). S. Mirzaei, **M. J. Mehrabad**, H. Flores, R. Camacho, D. Englund. Programmable quantum photonic interfaces for quantum networking.

7. arXiv:2603.23815 (2026). Y. M. Goh, C. Li, Y. Hwang, **M. J. Mehrabad**, J. Fujimoto, D. Englund. Visible spectral-domain optical coherence tomography for photonic integrated circuits.

8. arXiv:2504.16119 (2026). B.-H. Wu, S.-Y. Ma, **M. J. Mehrabad**, S. K. Vadlamani, H. Choi, D. Englund. Microring perceptron sensing for low-power radio-frequency detection with quantum-compatible photonic preprocessing.

9. (2026). S.-Y. Ma, X. Bai, R. Hamerly, **M. J. Mehrabad**. Optical neural networks should be evaluated by function, not only physics.

Books

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

Patents

1. Y. M. Goh, C. Li, Y. Hwang, **M. J. Mehrabad**, J. Fujimoto, D. Englund. Visible Spectral-Domain Optical Coherence Tomography for Photonic Integrated Circuits (2026).

2. **M. J. Mehrabad**, L. Xu, G. Moille, K. Srinivasan, M. Hafezi. Nested Frequency and Phase Matching. Provisional US Patent 63/944,606 (2025). *First-named inventor.*

3. S. Sarkar, **M. J. Mehrabad**, Y. Zhou, M. Hafezi. Active Nanoplasmonic Platform for Controllable Light–Matter Interaction. Provisional US Patent 63/814,919 (2025).

4. **M. J. Mehrabad**, L. Xu, A. Padhye, S. Sarkar, M. Hafezi. Systems of Ultrabroadband Multi-Modal Artificial Gauge Fields. Provisional US Patent (filed Dec 2025). *First-named inventor.*

5. **M. J. Mehrabad**, L. Xu, S. Sarkar, Z. Y. Wei, M. Hafezi. TOPAI: Topological Photonics Architectures for Optical Computing and Artificial Intelligence. Provisional US Patent 63/964,690 (2026). *First-named inventor; recognized by UM Ventures as Outstanding Invention of 2025.*

6. **M. J. Mehrabad**, A. Parhizkar, L. Xu, M. Hafezi. Quantum Optical Metamorphosis. US Patent (filed Aug 2025). *First-named inventor.*

7. M. H. Ehsani, **M. J. Mehrabad**. System of vapor flux controlling in thermal evaporation method using magnetic quadrupole and magnetic lens. Iran Patent No. 87925 (2016).

Talks & Conferences (selected)

Recent invited/oral (2023–2026)

- 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); CLEO (Oral) — 2023–2026.

Earlier conferences & schools (pre-2023)

- Participated in ∼15 conferences and summer schools, including 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

- MIT (2025–): led projects and supervised >10 trainees across integrated quantum and nonlinear photonics and agentic exploration of scientific discovery; managed >5 projects. Mentored multiple UGs.
- 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 (2017–2022): GTA (Quantum Information Lab), MSc/PhD supervision in topological and chiral photonics.

Research & Technical Skills

Simulation: Lumerical/Tidy3D FDTD (advanced), LLE (advanced), Ansys Maxwell (intermediate), COMSOL (intermediate). **Design & fabrication:** Nanophotonics design, GDS Voyager, Beamer, 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, Persian.

Awards, Scholarships, and Funding

Academic awards

- **UM Ventures Outstanding Invention of 2025 Award** — TOPAI: Topological Photonics Architecture for Optical Computing and AI (project lead and first-named inventor).
- Rank Prize Foundation Award (2021) — PhD work on semiconductor topological quantum photonic integrated circuits.
- University of Sheffield University Prize Scholarship (2017–2021).
- 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).

Grants and scholarships

- ONR DURIP, NSF Robust Quantum Simulation (RQS), Maryland Innovation Initiative (under review).
- 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).

Selected Press Highlights

1. Phys.org / JQI, 2026, "Sudden breakups of monogamous quantum couples surprise researchers."
2. Phys.org / Optics.org, 2025, "New photonic chips passively convert laser light into multiple colors on demand."
3. Phys.org / JQI, 2024, "Twisted light gives electrons a spinning kick."

4. Phys.org, 2024, “New photonic chip spawns nested topological frequency comb.”

References

Prof. Mohammad Hafezi — Postdoctoral advisor
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Prof. Maurice Skolnick (FRS) — PhD advisor
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Prof. Kartik Srinivasan — Postdoctoral co-advisor
kartiks@nist.gov