Mohammad Javadi Balakan

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Research interests

Experimental condensed-matter physics of quantum materials and mesoscopic devices: topological superconductivity, flux quantization and phase-coherent transport for fault-tolerant quantum computing; earlier work on 2D-material and hybrid organic–silicon devices for optoelectronics and photovoltaics.

Appointments

2022 – 2026 **Research Scientist (2025 – 2026); Postdoctoral Fellow (2022 – 2024)**
College of Nanotechnology, Science, and Engineering (CNSE), State University of New York at Albany
Group of Prof. Ji Ung Lee · Topological superconductors for fault-tolerant quantum computation

- Electrical transport studies of topological superconductors in collaboration with Stony Brook University and BNL (Prof. Qiang Li and Prof. Genda Gu).
- Developed processes for end-to-end fabrication of nanoscale quantum devices.
- Upgraded a closed-cycle cryostat, designed and implemented cryogenic low-pass filters (LPFs) for precision electrical measurements, and developed Python scripts for instrument automation.
- Demonstrated half-integer flux quantization, intrinsic magnetization of the superconducting condensate, and Aharonov-Bohm oscillations of edge states in mesoscopic Fe(Te,Se) devices.

2019 – 2021 **Postdoctoral Associate**
Department of Physics, University of Tehran, Iran
Group of Prof. Yaser Abdi · CMOS-compatible solid-state devices based on 2D materials

- Investigated charge transport across graphene-silicon 2D/3D Schottky junctions.
- Developed a model for the fundamental efficiency of graphene-based solar cells.
- Fabricated and characterized infrared detectors based on 2D MoS_2 layers.
- Developed scalable position-sensitive detectors based on hybrid organic/inorganic PEDOT:PSS/Silicon heterojunctions (*APL Editor's Pick*).
- Pioneered a scalable method for synthesis of 2D borophene metallic layers using chemical vapor deposition.

Mar. – Sep. 2018 **Visiting Researcher**
Department of Physics, Sapienza Università di Roma, Italy
Supervisor: Prof. Giorgio Parisi · Statistical properties of harmonic spheres near jamming

2012 – 2019 **Graduate Researcher (MSc and PhD)**
University of Tehran and Tarbiat Modares University, Iran
Groups of Prof. Yaser Abdi, Prof. Ezatollah Arzi and Dr. Sara Darbari

Department of Physics, University of Tehran (Prof. Abdi's and Prof. Arzi's joint group)

- Fabrication and characterization of nanostructured solar cells based on dye-sensitized solar cells (solar simulator, IV, quantum efficiency, carrier lifetime and diffusion length measurement).
- Monte-Carlo simulation of charge transport in disordered wide band-gap semiconductors for photovoltaic and optoelectronic applications.
- Computer modeling for PECVD growth of single-standing carbon nanotubes.

Nanoelectronics Laboratory, Tarbiat Modares University, Iran (Dr. Sara Darbari's lab)

- Investigated sound-driven CNT-based tribo-electric nanogenerator in sonic array.
- Developed a piezo-phototronic device based on graphene/MoS2 heterostructure.

Education

2019 **PhD in Solid-State Physics, University of Tehran, Iran**
Thesis: *Charge Transport in Metal-Oxide Nano-Structures for Photovoltaic and Optoelectronic Applications*

2014 **MSc in Nanoscience and Nanotechnology, University of Tehran, Iran**
Thesis: *Electron Transport in Nano-Structured Solar Cells*

2012 **BSc in Physics, Urmia University, Iran**

Awards, fellowships and funding

2020 Chamran Postdoctoral Fellowship, Iran National Elites Foundation (INEF)

2019 Outstanding PhD Thesis in Physics (nationwide), Physical Society of Iran

2019 Outstanding PhD Dissertation in Physical Sciences, University of Tehran

2016–2018 INEF Graduate Scholarship

2014 Ranked 10th nationally in the PhD entrance examination

2014 Graduated with distinction, MSc

2012 Ranked 19th nationally in the MSc entrance examination

2012 Graduated with distinction, BSc

Publications

23 publications and preprints · 437 citations · h-index 13 (Google Scholar, October 2026)

Publications before 2022 appear under M. Javadi; since 2022 under M. J. Balakan.

Accepted

23. **M. J. Balakan**, S. Heidari, G. Gu, Q. Li, K. Watanabe, T. Taniguchi, and J. U. Lee, "Intrinsic magnetization of the superconducting condensate in Fe(Te,Se)," *Physical Review B* (Letter), accepted (2026). Editors' Suggestion · arXiv:2603.08891

Submitted and preprints

22. **M. J. Balakan**, G. Gu, Q. Li, K. Watanabe, T. Taniguchi, and J. U. Lee, "Half-integer winding of order parameter in an iron-based superconductor," submitted (2026). extended study of arXiv:2505.01522
21. **M. J. Balakan**, S. Heidari, G. Gu, Q. Li, D. Titcombe, Z. Xiao, H. Frost, E. Bhatia, C. Kow, P. Rao, K. Watanabe, T. Taniguchi, and J. U. Lee, "Aharonov–Bohm interference from coherent spin-polarized edge transport in Fe(Te,Se) superconducting rings," submitted (2025). arXiv:2508.05030
20. **M. J. Balakan**, G. Gu, Q. Li, K. Watanabe, T. Taniguchi, and J. U. Lee, "Observation of half-quantum vorticity in an iron-based superconductor," preprint (2025). arXiv:2505.01522
19. **M. Javadi**, "Graphene–semiconductor contact," preprint (2020). arXiv:2004.12313

Peer-reviewed journal articles

18. A. Mazaheri, **M. Javadi**, and Y. Abdi, "Chemical vapor deposition of two-dimensional boron sheets by thermal decomposition of diborane," *ACS Applied Materials & Interfaces* **13**(7), 8844-8850 (2021). doi:10.1021/acsami.0c22580
17. **M. Javadi**, AA. Noroozi, and Y. Abdi, "Kinetics of charge carriers across a graphene–silicon Schottky junction," *Physical Review Applied* **14**, 064048 (2020). doi:10.1103/PhysRevApplied.14.064048
16. AH. Mosaddegh, AA. Noroozi, **M. Javadi**, and Y. Abdi, "Ultrahigh photovoltage responsivity of PEDOT:PSS–silicon hybrid heterojunction photodiodes," *Applied Physics Letters* **117**, 073301 (2020). doi:10.1063/5.0007685
15. **M. Javadi**, "Theoretical efficiency limit of graphene–semiconductor solar cells," *Applied Physics Letters* **117**, 053902 (2020). doi:10.1063/5.0020080
14. **M. Javadi**, A. Mazaheri, H. Torbatiyan, Y. Abdi, "Mechanism of charge transport in hybrid organic–inorganic PEDOT:PSS/silicon heterojunctions," *Physical Review Applied* **12**, 034002 (2019). doi:10.1103/PhysRevApplied.12.034002
13. **M. Javadi**, AA. Noroozi, A. Mazaheri, Y. Abdi, "Sequentially assembled graphene layers on silicon, the role of uncertainty principles in graphene–silicon Schottky junctions," *Advanced Optical Materials* **7**, 1900470 (2019). doi:10.1002/adom.201900470
12. **M. Javadi**, Y. Abdi, "Frequency-driven bulk-to-surface transition of conductivity in ZnO nanowires," *Applied Physics Letters* **113**, 051603 (2018). doi:10.1063/1.5039474
11. **M. Javadi**, M. Gholami, H. Torbatiyan, Y. Abdi, "Hybrid organic/inorganic position-sensitive detectors based on PEDOT:PSS/n-Si," *Applied Physics Letters* **112**, 113302 (2018). Editor's Pick · doi:10.1063/1.5022758

10. **M. Javadi**, M. Gholami, Y. Abdi, "IR position-sensitive detectors based on double-junction asymmetric TiO_2/MoS_2/reduced graphene-oxide sandwiches," *Journal of Materials Chemistry C* **6**, 8444 (2018). doi:10.1039/c8tc02361a
9. **M. Javadi**, A. Heidari, S. Darbari, "Realization of enhanced sound-driven CNT-based triboelectric nanogenerator, utilizing sonic array configuration," *Current Applied Physics* **18**, 361 (2018). doi:10.1016/j.cap.2018.01.018
8. **M. Javadi**, H. Torbatiyan, Y. Abdi, "Ultra-low intensity UV detection using partitioned mesoporous TiO_2," *Applied Physics Letters* **111**, 063113 (2017). doi:10.1063/1.4994888
7. **M. Javadi**, Y. Abdi, "Kinetic Monte Carlo simulation of single-electron multiple-trapping transport in disordered media," *Computer Physics Communications* **221**, 282 (2017). doi:10.1016/j.cpc.2017.09.002
6. **M. Javadi**, Y. Abdi, "Nanopattern formation using localized plasma for growth of single-standing carbon nanotubes," *Journal of Nanoparticle Research* **19**, 17 (2017). doi:10.1007/s11051-016-3715-4
5. **M. Javadi**, S. Alizadeh, Y. Khosravi, Y. Abdi, "Electron transport in Q2D porous network of titania nanoparticles, incorporating electrical and optical advantages in dye-sensitized solar cells," *ChemPhysChem* **17**, 3542 (2016). doi:10.1002/cphc.201600609
4. **M. Javadi**, S. Darbari, Y. Abdi, F. Ghasemi, "Realization of a piezo-phototronic device based on reduced graphene-oxide/MoS_2 heterostructure," *IEEE Electron Device Letters* **37**, 677 (2016). doi:10.1109/LED.2016.2547993
3. **M. Javadi**, Y. Abdi, E. Arzi, "Local collection efficiency in nano-crystalline solar cells," *Solar Energy* **133**, 549 (2016). doi:10.1016/j.solener.2016.04.021
2. M. Sajedi Alvar, **M. Javadi**, Y. Abdi, E. Arzi, "Enhancing the electron lifetime and diffusion coefficient in dye-sensitized solar cells by patterning the layer of titanium dioxide nanoparticles," *Journal of Applied Physics* **119**, 114302 (2016). doi:10.1063/1.4943772
1. **M. Javadi**, and Y. Abdi, "Monte Carlo random walk simulation of electron transport in confined porous TiO_2 as a promising candidate for photo-electrode of nano-crystalline solar cells," *Journal of Applied Physics* **118**, 064304 (2015). doi:10.1063/1.4928328

Invited talks

- "*Half-integer winding of order parameter & intrinsic magnetization of superconducting condensate in Fe(Te,Se)*", GRC correlated electron systems, Mount Holyoke College, MA, USA (2026).
- "*Topological superconductivity in Fe(Te,Se)*", Laboratory for Physical Sciences (LPS), College Park, MD, USA (2025).
- "*Charge transport at graphene-silicon 2D/3D interface*", *TMU*, Tehran, Iran (2020).
- "*Negative photoconductivity in ZnO nanowires*", IPM, Tehran, Iran (2018).

Conference presentations

- **M. J. Balakan**, Half-integer winding of the order parameter and intrinsic magnetization of the superconducting condensate in mesoscopic Fe(Te,Se) devices, GRC Correlated Electron Systems (2026).
- **M. J. Balakan**, G. Gu, Q. Li, K. Watanabe, T. Taniguchi, and JU. Lee, Topological superconductivity in Fe(Te,Se) mesoscopic devices, APS Global Physics Summit (2026).

- Additional presentations at Iranian Physical Society meetings and nanostructured solar cell conferences (2014–2018).

Teaching and mentoring

Teaching Assistant, University of Tehran (2012–2018): Quantum Mechanics (undergraduate), Advanced Solid-State Physics & Laboratory (graduate), Advanced Quantum Mechanics (graduate)

- Mentored Ph.D. researcher Daniel Titcombe in experimental studies of topological superconductors (Prof. Lee's group).
- Mentored graduate researcher AliAkbar Noroozi in graphene-silicon optical detectors; work contributed to a Ph.D. thesis and two publications (Prof. Abdi's group).
- Mentored graduate student Mahdieh Gholami on CVD growth of two-dimensional MoS_2 for infrared detectors; work contributed to a master's thesis and a publication (Prof. Abdi's group).

Professional service

- Peer review for scientific journals including Physical Review Letters, 2D Materials, Applied Physics Letters, and Nanotechnology (ORCID).
- Served as a committee member for the Physical Society of Iran symposium, 2018.

Technical skills

Device fabrication and structural characterization: cleanroom nanofabrication, process development, electron-beam lithography (EBL), focused ion beam (FIB), scanning electron microscopy (SEM), atomic force microscopy (AFM), reactive ion etching (RIE), Raman and optical spectroscopy, thin film deposition (PVD, e-beam evaporation, CVD, PECVD), 2D materials, wide bandgap oxides, organic semiconductors, topological insulators, and topological superconductors.

Electrical characterization: DC/AC semiconductor parameter analysis (SMU, LCR, etc.), optoelectronic characterization tests (photovoltaic cells, optical detectors/sensors), low-noise/precision measurements (lock-in amplifiers, Atto-sense modules, low-temperature LPFs), cryogenic systems, quantum transport, phase-sensitive magnetic/flux measurements.

Computation, data analysis, and automation: Python, Mathematica, LabVIEW, KLayout (layout/mask design), statistical analysis, instrument automation.

References

Available upon request.