Owen M. Dugan

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EDUCATION

MASSACHUSETTS INSTITUTE OF TECHNOLOGY | CLASS OF 2025 (*expected graduation 2023*)

- Courses Taken: (GPA = 5.0/5.0 – A+ in first & second year graduate-level physics classes)
  - 8.223 Classical Mechancs II (Lagrangian/Hamiltonian Mechanics), 8.321 (Graduate) Quantum Theory 1 (Schrödinger & Heisenberg Pictures, Angular Momentum, Perturbation Theory, etc.), 8.324 (Graduate) Quantum Field Theory 1 (Scalar, Spinor, and Vector Field Theories, Feynman Diagrams, Perturbation Theory, etc.), 18.701 Algebra 1 (group theory and linear algebra), 18.702 Algebra 2 (representation theory, ring theory, modules, field theory, and Galois theory), 7.015 Biology, 21L.001 Foundations of Western Literature: Homer to Dante, 21L.003 Reading Fiction (British Novels), 21M.361 Electronic Music Composition 1.
- Placement credit for eight MIT classes (passed MIT's final exams):
  - 6.0001 Intro to CS Programming in Python, 5.111 Principles of Chemical Science, 18.01 Calculus (Single-Variable Calculus), 18.02 Calculus (Multivariable Calculus), 18.03 Differential Equations, 8.02 Physics 2 (Electricity & Magnetism), 8.03 Physics 3 (Waves), 8.04 Quantum Physics 1.
- Undergraduate Research Opportunities Program with Professor Marin Soljačić's group:
  - Interpretable neural networks for symbolic regression (2020-Present).
  - Neural network applications to social science (2021-Present).
  - Neural networks for simulating open quantum systems (2022).
  - Neural network applications in optical systems (2002).

PUBLICATIONS

- Published:
  - **Dugan, O.**, Dangovski, R., Costa, A., Kim, S., Goyal, P., Jacobson, J., and Soljačić, M., "Fast Neural Models for Symbolic Regression at Scale," arXiv e-prints, 2022.
  - **Dugan, O**., "QiskiFT Quantum Error Correction and Quantum Fault Tolerance Development Kit," https://druidowm.github.io/qiskift/, 2021.
  - **Dugan, O**. and Krasner, J., "Soup, Bones, and Shakespeare: Literary Authorship and Allusion in Middle Earth," *Mythlore*, 2022.
  - **Dugan, O.**, "Astronomy Will Not Trail Off: Novel Methods for Removing Satellite Trails From Celestial Images," *J. of the American Association of Variable Star Observers (JAAVSO)*, vol. 48, no. 2, p. 262, 2020.
  - Robertson, P., Espenshade, C., Sarva, J., **Dugan, O.**, Tock, K., "An Automated Approach to Modeling Jupiter's Synchrotron Radiation from Radio Telescope Observations," Astronomy Theory, Observations & Methods, vol. 1, no. 1, pp. 24-33, 2020.
  - **Dugan, O.**, Robinson, T., Carmeci, F., and Tock, K., "CCD Measurements and Reclassification of WDS 07106 +1543 to an Optical Double," *J. of Double Star Observations*, vol. 15, no. 1, pp. 119–129, 2019.
- In preparation:
  - **Dugan, O.** and Karagiorgi, G., "Determination of the Expected Neutrino Signal from Kilonovae in the Deep Underground Neutrino Experiment Using Data from Simulations Employing M1 and Monte Carlo Schemes," (Columbia University/Nevis Labs).
  - **Dugan, O.**, Dangovski, R., Costa, A., Kim, S., Goyal, P., Jacobson, J., and Soljačić, M., "Fast Neural Models for Symbolic Regression at Scale," being submitted to Nature Machine Intelligence, 2022.

RESEARCH

PROFESSOR MARIN SOLJAČIĆ'S RESEARCH GROUP (MIT) | 2020-PRESENT

- **Neurosymbolic Regression**

  - Independently reprogrammed and generalized team's interpretable neural network; Developed algorithms for: Constant fitting (previously attempted by group but not achieved), Implicit function fitting (outperforms other symbolic regression approaches), and Regularization terms to identify trivial functions; Improved network initialization and Function selection (dynamic programming); Identified techniques to reduce the number of calculations by up to 8X; Benchmarked network against other methods on 15 real-world datasets (1000+ hours compute time); Used Neural Differential Equations to perform symbolic regression of time-series data.
- **Neural Network applications for Open Quantum Systems**
  - Using neural network models to simulate open quantum systems in NetKet.
- **Neural Network Applications to Social Science**
  - Using Neurosymbolic regression to discover laws governing various social science datasets.
- **Neural Network Applications in Optical Systems**

PARTICLE PHYSICS RESEARCH – COLUMBIA UNIVERSITY/NEVIS LABS | 2017-2021

- **Developed software for Physics Professor Georgia Karagiorgi to efficiently compute the expected neutrino signal from an astrophysical source** taking into account viewing angle using data from kilonova models that employ a fully-general-relativistic Boltzmann equation or approximations with two moment formalisms or Monte Carlo schemes.

QUANTUM ERROR CORRECTION & FAULT TOLERANCE - INDEPENDENT RESEARCH | 2021

- **Developed code to automatically implement error correction and fault tolerance for Qiskit quantum circuits.** (Created and published development kit (QiskiFT), documentation, and website.)

SATELLITE TRAIL REMOVAL - INDEPENDENT RESEARCH | 2019-2021

- **Developed novel algorithms/code to identify and remove satellite trails from night sky images.**

COVID-19 DETECTION SOFTWARE – QUANTIFIEDFLU INITIATIVE | 2020-2021

- **Developed and trained neural network to identify illnesses** based on patterns of biometric data collected from wearables for the not-for-profit QuantifiedFlu.org Initiative.

DOUBLE STAR RECLASSIFICATION RESEARCH – STANFORD ONLINE HIGH SCHOOL | 2018

- **Developed and coded a gradient descent algorithm** to determine the best fit linear solution for a misclassified double star system. Re-classified misclassified star system.

AWARDS

RSI SCHOLAR (2020)	NATIONAL MERIT SCHOLAR (2021)	UNITED STATES NATIONAL PHYSICS OLYMPIAD (USAPHO) (2019, 2020 & 2021)
REGENERON ISEF FINALIST (2020)	DEPARTMENT OF DEFENSE SCHOLAR (2020)	PURPLE COMET MATH TEAM (2018-2021 – 2nd & 5th in World)
DAVIDSON FELLOW (2021)	SAT PERFECT SCORE (2019)	NATIONAL AP SCHOLAR & AP SCHOLAR WITH DISTINCTION (2019 & 2020)
US PRESIDENTIAL SCHOLAR (2021)	MULTIPLE PATENTS PENDING	AMERICAN INVITATIONAL MATHEMATICS EXAM (2015 & 2017-2020)
REGENERON STS SCHOLAR (2021)	CAROLINE D. BRADLEY SCHOLAR (2016–2021)	

OTHER PROJECTS

MIT Artificial Intelligence Club – AIMS Labs (2021-2022)

- **Developed a directions app for MIT campus (in progress).** Programmed a React Native app displaying a map of MIT, allowing input of a current location and destination, and identifying and displaying the shortest path using A* search. Also developed a number of tools for parsing map data from building blueprints.

Independent Food Waste Reduction Project (2021-2022)