# Owen M. Dugan

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## EDUCATION

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY | CLASS OF 2025 (expected graduation 2023)**
- Double major in computer science and physics; current courses include 8.321 Quantum Theory 1 (graduate level), 18.701 Algebra 1 (abstract algebra), 7.015 Biology, and 21L.001 Foundations of Western Literature: Homer to Dante. Received credit for eight MIT classes (passed the final exams of eight MIT courses in August 2021, prior to starting freshman year at MIT) including: 6.0001 (Computer Science and Python), 5.111 (Chemistry), 18.01 (Calculus), 18.02 (Multivariable Calculus), 18.03 (Differential. Equations), 8.02 (Electricity & Magnetism), 8.03 (Waves), 8.04 (Quantum Physics 1).
- Undergraduate Research Opportunities Program - research on interpretable neural networks and symbolic regression with Professor Marin Soljačić's group (since June 2020).

**UNIVERSITY LEVEL CLASSES TAKEN PRIOR TO COLLEGE | 2012 - 2021**
- Mechanics, Electricity & Magnetism, Light & Heat, Modern Physics, Quantum Computing, Intermediate Number Theory, Intermediate Algebra, Intermediate Counting & Probability, Calculus BC, Multivariable Calculus, Linear Algebra, Differential Equations, Real & Complex Analysis, Tensor Calculus (self-study with Theoretical Physics Club); Advanced Python Programming, AP Computer Science in Java, Algorithms, Deep Convolutional Neural Networks for Computer Vision, Automata Theory & Properties of Languages, Data Structures.

## PUBLICATIONS

- Paper 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).
- Costa, A., Dangovski, R., **Dugan, O.**, Kim, S., Goyal, P., Soljačić, M., and Jacobson, J., "Fast Neural Models for Symbolic Regression at Scale," arXiv e-prints, 2021, being submitted to Nature Machine Intelligence. First three authors noted as equal contributors.
- **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," submitted for publication in *Mythlore*, 2021.
- Acknowledged in: Costa, A., Dangovski, R., Kim, S., Goyal, P., Soljačić, M., and Jacobson, J., "Interpretable Neuroevolutionary Models for Learning Non-Differentiable Functions and Programs," arXiv e-prints, 2020.
- **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.

## RESEARCH

**PROFESSOR MARIN SOLJAČIĆ'S RESEARCH GROUP (MIT) | 2020-PRESENT**
- **Coded neural network to successfully fit implicit equations that cannot be fit by the state-of-the-art AI.**
- Independently reprogrammed and generalized team's interpretable neural network.

- Developed new algorithms adding features previously attempted but not achieved, including constant fitting; improved network initialization and function selection.
- Developed regularization terms that fit implicit functions which had never been fit before by any neural network.
- Identified techniques to increase processing speed by as much as 128%.
- Benchmarked network against other methods on 15 real-world datasets (600+ hours compute time).
- Invited to join Professor Marin Soljačić's MIT research group.
- Named equal contributor with PhD candidates on paper describing the team's interpretable neural network and its applicability for high-risk applications and physics simulations.

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

- **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. Determined whether kilonova neutrinos can be detected by the Deep Underground Neutrino Experiment and what information can be gained from such detections. Paper in preparation with Professor Karagiorgi.
- Self-studied quantum mechanics, magnetohydrodynamics, tensor calculus, supernova and kilonova physics, and particle physics to master material needed to complete project.
- Coded a muon detector to be displayed at Nevis Labs lecture hall.
- Invited to attend Columbia University Research Experiences for Undergraduates (REU) program lectures (Summers 2018 & 2019).

**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**
- Uses platesolving, recursive sizing, area/cubic interpolation, piecewise bivariate cubic fits, curvilinear transformations, Gaussian cross correlations, modified Fast Fourier Transformations, Fourier synthesis, trail wobble fitting (to compensate for atmospheric effects), & Gaussian brightness profiles.
- Mean percent error in photometry was improved by a factor of 9. Coded algorithms reduced photometric error to intrinsic error level.

**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 sponsored by the Open Humans Foundation, the Center for Research & Interdisciplinarity, and Just One Giant Lab.

**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.
- Identified possibly misclassified star system and with teammates successfully re-classified it.


## INTERNATIONAL AWARDS

**RESEARCH SCIENCE INSTITUTE (RSI) SCHOLAR | 2020**

- One of 84 students selected from around the world and one of two selected from New York State (acceptance rate < 3%)

**REGENERON INTERNATIONAL SCIENCE AND ENGINEERING FAIR (ISEF) FINALIST | 2020**

- Satellite trail removal project (top 0.03% worldwide)

**PURPLE COMET MATH TEAM MEMBER | 2019-2021**

- 2nd in the World (2018); 5th in the World (2019, 2020 & 2021)

# NATIONAL AWARDS

**DAVIDSON FELLOW | 2021**
**US PRESIDENTIAL SCHOLAR | 2021**
**REGENERON SCIENCE TALENT SEARCH SCHOLAR | 2021**
**NATIONAL MERIT SCHOLAR | 2021**
**CAROLINE D. BRADLEY SCHOLAR | 2016 – 2021** - one of 30 high school students selected nationwide
**UNITED STATES NATIONAL PHYSICS OLYMPIAD (USAPHO) | 2019, 2020 & 2021**
- One of approximately 400 students who qualified to take the US National Physics Olympiad exam
  - USAPhO 2021 – Honorable Mention – F=MA score of 19/25 (~Top 0.5%) in 2021
  - USAPhO 2020 cancelled due to pandemic – F=MA score of 24/25 (~Top 0.1%) in 2020
  - USAPhO 2019 - Honorable Mention – F=MA score of 17/25 (~Top 5%) in 2019

**DEPARTMENT OF DEFENSE SCHOLAR | 2020**
**SAT PERFECT SCORE | 2019**
**NATIONAL AP SCHOLAR AND AP SCHOLAR WITH DISTINCTION | 2019 & 2020**
**AMERICAN INVITATIONAL MATHEMATICS EXAM | 2015 & 2017-2020** – Five-time Qualifier
**AMERICAN MATHEMATICS COMPETITIONS (AMC) AWARDS | (partial list)**
- Top 0.3% - AMC 12 Distinguished Honor Roll (2020), Top 0.2% - 1% - AMC 10 Distinguished Honor Roll (2017-2019), AMC 10 Honor Roll – top 2.5% (2015), AMC 10 Achievement Roll – Score ≥ 90 while in 8th grade or lower (2015-2017)

**PATENTS PENDING** – Two U.S. Patent Applications pending relating to removing satellite trails from images and identifying and removing satellite trail wobble. Sole inventor.

# CONFERENCES

**RESEARCH PRESENTER | 2018 – PRESENT**
- New York State Science & Engineering Fair – neural network research (2021)
- Regeneron Westchester Science & Engineering Fair – neural network research (2021)
- MIT Physics Group - interpretable neural networks (2020 & 2021)
- Research Science Institute (RSI) - interpretable neural networks (2020)
- Society of Astronomical Sciences Telescope Science Symposium (Featured Presenter) - satellite trail removal (2020)
- Regeneron International Science & Engineering Fair – satellite trail removal research (2020)
- New York State Science & Engineering Fair - satellite trail removal research (2020)
- Northeastern Astroimaging Conference - double star research (2019)
- Columbia University Neutrino Group - neutrino emissions from kilonovae research (2019)
- Westchester Amateur Astronomers meeting - double star research (2019)
- Stanford Online High School Colloquium – double star research (2019)
- Maine Astronomy Retreat - neutrino research and double star research (2018)
- Global Sphere Network - double star research (2018)

**INVITED ATTENDEE – NATIONAL SCIENCE FOUNDATION COMMISSIONED WORKSHOP | 2020**
- Invited by Dr. Jeffrey Hall, Director of Lowell Observatory, to attend an invitation-only multi-day conference of professional astronomers including representatives from NASA and SpaceX discussing mitigation strategies for the SpaceX Starlink Satellite Network (invited based on my satellite trail removal research).