MATTHEW C. PHARR

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Graduating doctoral student interested in plasma physics, fusion reactor design, and scientific computing.

EDUCATION

Columbia University, New York, NY
Ph.D. Plasma Physics, Expected 2026
M.Phil. Plasma Physics, 2025
M.S. Applied Physics, 2023

Rensselaer Polytechnic Institute, Troy, NY
B.S. Physics & Mathematics, 2021
Summa Cum Laude.

PUBLICATIONS

- **M. Pharr**, N. C. Logan, J. K. Park, and C. Paz-Soldan, *Metrics for quantifying resonant drive in ideal and extended MHD*, Planned for submission 2025.
- **M. Pharr**, N. C. Logan, J. K. Park, and C. Paz-Soldan, *Quantifying resonant drive in kinetically relaxed tokamak perturbed equilibria*, Planned for submission 2025.
- **M. Pharr**, N. C. Logan, C. Paz-Soldan, J. K. Park, and C. Hansen, *Error field predictability and consequences for ITER*, Nucl. Fusion 64, 126025 (2024).
- F. Ebrahimi and **M. Pharr**, *A Nonlocal Magneto-curvature Instability in a Differentially Rotating Disk*, ApJ 936, 145 (2022).

- N. Logan et al., *SPARC Tokamak Error Field Expectations and Physics-Based Correction Coil Design*, Planned for submission to Nuclear Fusion, 2025.
- X. Bai et al., *Time variation of error field correction in ITER*, submitted to Plasma Physics and Controlled Fusion (2025).
- The MANTA Collaboration et al., *MANTA: a negative-triangularity NASEM-compliant fusion pilot plant*, Plasma Phys. Control. Fusion 66, 105006 (2024).
- C. J. Hansen et al., *TokaMaker: An open-source time-dependent Grad-Shafranov tool for the design and modeling of axisymmetric fusion devices*, Computer Physics Communications 298, 109111 (2024).
- C. Paz-Soldan et al., *Simultaneous access to high normalized density, current, pressure, and confinement in strongly-shaped diverted negative triangularity plasmas*, Nucl. Fusion 64, 094002 (2024).
- C. T. Holcomb et al., *DIII-D research to provide solutions for ITER and fusion energy*, Nucl. Fusion 64, 112003 (2024).
- S. Guizzo et al, *Electromagnetic System Conceptual Design for a Negative Triangularity Tokamak*, ArXiv, submitted to Fusion Engineering and Design (2024).

RESEARCH & PROJECTS

Graduate Research Assistant, Columbia University August 2021 - Present
Department of Applied Physics and Applied Mathematics, New York, NY
Advisor: Dr. Carlos Paz-Soldan, Dr. Nikolas Logan.

- Research in theoretical and computational plasma physics, focusing 3D perturbations of tokamak equilibria, error field effects and its induced risk, and MHD stability.
- Created error field source model for ITER, and used it to predict the risk of error field penetration in ITER's baseline scenario. Used this model to propose a novel method for ensuring extrapolability of error field measurements from low to high beta.
- Contributions to the MANTA project, a joint Columbia/MIT negative triangularity pilot plant design study. Worked on integrated modeling of plasma equilibria, transport, and 0D systems modeling.
- Development and application of computational tools, including: GPEC, a fast linear perturbed equilibrium suite, including sub-modules DCON and its asymptotic matching code, RDCON/RMATCH, as well as an in-progress Julia-based modernization; Tokamaker, a flexible, open-source Grad-Shafranov

solver for Tokamak and Dipole equilibria; OpenPOPCON, an open-source 0D tokamak systems code that has been used for scoping the MANTA and CENTUAR tokamak designs, as well as in consultation with fusion startups.

- Work for the SPARC MHD team, including maintaining and developing its total error field source model, giving feedback on iterative coil design, and predicting time-dependent risk of error field penetration. Developed a module for the POPSIM code, a plasma control system simulator, to include effects of time-dependent error fields and their driven tearing modes and penetration risks.
- Attended MIT CPS-FR Computational Summer School, 2023.

SULI Intern, Princeton Plasma Physics Laboratory Fall 2020 - Summer 2021
Theory Department, Princeton, NJ
Supervisor: Dr. Fatima Ebrahimi.

- Studied large-scale magnetic field growth and stability in Hall-MHD simulations of quasi-Keplerian plasma flows, with applications to astrophysical accretion disks.
- Used the extended MHD code NIMROD to perform linear and nonlinear simulations of magnetized plasmas in cylindrical geometry.
- Discovered a new family of more global solutions to the flow-driven Magneto-Rotational Instability (MRI) through a higherarchy of models, from a new fast linear eigenvalue solver to full 3D nonlinear simulations on large-scale computing clusters.

Undergraduate Research Assistant, Rensselaer Polytechnic Institute Summer 2020 - Spring 2021
Department of Mathematical Sciences, Troy, NY
Supervisors: Dr. Peter Kramer, Dr. Scott Forth.

- Studied the application of stochastic methods to the modeling of complex biological systems, including meiotic spindle assembly.
- Used python to implement a computational statistical model of microtubule dynamics, and performed data analysis and visualization.

PRESENTATIONS & CONFERENCE PROCEEDINGS

- M. Pharr et al. *Quantifying the Resonant Drive for Magnetic Islands in Perturbed Ideal, Resistive, and Kinetic MHD Equilibria.* American Physical Society, Division of Plasma Physics 2025 Annual Meeting: Long Beach, CA. Section GO05.00007: MFE: MHD.
- M. Pharr et al. *Quantifying the Resonant Drive for Magnetic Islands in Perturbed Ideal, Resistive, and Kinetic MHD Equilibria.* 29th US-Japan Joint Workshop on MHD Stability Control: Princeton, NJ, 2025.
- M. Pharr et al. *Expected Error Fields in ITER: A full-device source model and strategies for stable operation.* ITER International Summer School 2025: Aix-en-Provence, France.
- M. Pharr et al. *Expected Error Fields in ITER: A full-device source model and strategies for stable operation.* American Physical Society, Division of Plasma Physics 2024 Annual Meeting: Atlanta, GA. Section PP11.00050: Research in Support of ITER.
- M. Pharr et al. *Error Field Predictability and Consequences for ITER.* American Physical Society, Division of Plasma Physics 2023 Annual Meeting: Denver, Co. Section PP11.00050: Poster Session VI: MHD and Stability.
- M. Pharr, F. Ebrahimi, *A nonlocal Curvature-Driven Flow-Shear Instability in Low-Field Plasmas* Sherwood Fusion Theory 2023 Conference: Knoxville, TN.
- M. Pharr et al. *Error field source identification in early ITER plasmas.* American Physical Society, Division of Plasma Physics 2022 Annual Meeting: Spokane, Wa. Section PP11.00044: Poster Session VI: Diagnostics; Edge and Pedestal; Stability; Heating; Transport, Turbulence.
- M. Pharr, F. Ebrahimi, E. Blackman, *Large Scale Magnetic Field Growth and Stability in Hall-MHD Simulations of Quasi-Keplerian Flows.* American Physical Society, Division of Plasma Physics 2021 Annual Meeting: Pittsburgh, PA. Section UO06.00014: Astrophysical Turbulence and Dynamos.

HONORS & AWARDS

ORFEAS Fusion Design Contest Award; Columbia University 2022
For contributions to the Columbia/MIT team's project on negative triangularity reactor pilot plant design scoping. Awarded $22,000 as a group.

Max Hirsch Prize in Mathematics; Rensselaer Polytechnic Institute 2021
This prize is awarded to a Senior in the Department of Mathematical Sciences who has demonstrated outstanding ability in his or her academic work and also gives promise of outstanding success in a career in mathematical sciences.

J. Lawrence and Gertrude Katz Award in Physics; Rensselaer Polytechnic Institute 2021
This award is presented to the student selected as the outstanding graduating senior receiving a Bachelor of Science in Physics.

ΣΠΣ, Undergraduate Physics Honor Society 2021
Honorable Mention for Research Paper, Mathematical Competition in Modeling 2020
Rensselaer Archimedian Society (4.0/4.0 GPA award) 2019
Rensselaer Leadership Award 2018

PEDAGOGY

Graduate Teaching Assistant, Intro Physics Lab Sequence Fall 2022 - Present
Barnard College of Columbia University, Physics and Astronomy, New York, NY

Senior Graduate Mentor, Fusion Reactor Design Fall 2024
Columbia University, Applied Physics and Applied Mathematics, New York, NY

Graduate Teaching Assistant, Complex Analysis/Linear Algebra Fall 2021 - Spring 2022
Columbia University, Applied Physics and Applied Mathematics, New York, NY

Undergraduate Facilitator Fall 2019 - Summer 2020, Spring 2021
Rensselaer Polytechnic Institute, Physics Department, Troy, NY

I-PERSIST Mentor Fall 2019
Rensselaer Polytechnic Institute, Physics Department, Troy, NY

ALAC Introductory Physics Tutor Fall 2019 - Spring 2020
Rensselaer Polytechnic Institute, Physics Department, Troy, NY

Private Tutor, Math/Physics Spring 2018 - Spring 2020
Self-employed. Took 2-4 hours per week of university-level tutoring.

SKILLS

Languages and tools:
Python, Julia, Fortran 77/90/95, Matlab, Linux, git, LaTeX, OpenMP, MPI parallel computing
Amazon Web Services, Oracle Cloud, Google Cloud
Fortran and C++ graphical / memory debugging tools
Linear/nonlinear MHD simulation and analysis with DCON, GPEC, NIMROD

General/Practical Skills:
High Performance Computing
IT and Computer Networking
Application of Neural Networks and Machine Learning to Physics Problems
Use of vacuum technology and other plasma physics related lab equipment
Use of high voltage lab equipment
Native English, B2 French