Norman M. Cao

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EDUCATION

Ph.D. in Applied Plasma Physics from Nuclear Science and Engineering Dept *June 2020*
- Massachusetts Institute of Technology, Cambridge, MA
- Graduate GPA of 4.9 out of 5.0

Bachelor of Science in Aerospace Engineering and Physics, Minor in Mathematics *June 2015*
- Massachusetts Institute of Technology, Cambridge, MA
- Undergraduate GPA of 4.9 out of 5.0

RESEARCH EXPERIENCE

Research Assistant at MIT Plasma Science and Fusion Center *August 2016 – Current*
- Member of the core transport group working to understand turbulence at Alcator C-Mod and other facilities
- Help maintain and develop software for HIREXSR, an x-ray imaging crystal spectrometer

Student Festival Fellow at 9th Festival de Théorie in Aix-en-Provence, France *June – July 2017*
- Attended two-part festival featuring interdisciplinary lectures focused on magnetized plasmas
- Worked on festival project under guidance from attending research faculty member, on *Wave Kinetic Approach to Turbulence Spreading in Hasegawa-Mima*

MIT 16.62x Experimental Projects *Sep. 2014 – May 2015*
- *Project Title:* "Smart Camera Setting Control for Stable Successful Feature Tracking"
- Worked with one other undergraduate in a student-driven research project for this capstone class
- Designed a machine learning algorithm for improved visual navigation in changing light conditions
- Experimentally validated the algorithm through indoor/outdoor lighting transitions
- Awarded **Best Undergraduate Research Project in Computer Science in AeroAstro** department (2015)

SELECTED PUBLICATIONS

Cao N M, Rice J E, Diamond P H, White A E, Chilenski M A, Ennever P C, Hughes J W, Irby J, Reinke M L and Rodriguez-Fernandez P 2020 Evidence and modeling of turbulence bifurcation in L-mode confinement transitions on Alcator C-Mod *Phys. Plasmas* **27** 052303

Cao N M and Sciortino F 2020 Bayesian Spectral Moment Estimation and Uncertainty Quantification *IEEE Trans. Plasma Sci.* **48** 22–30

Cao N M, Rice J E, Diamond P H, White A E, Baek S G, Chilenski M A, Hughes J W, Irby J, Reinke M L and Rodriguez-Fernandez P 2019 Hysteresis as a probe of turbulent bifurcation in intrinsic rotation reversals on Alcator C-Mod *Nucl. Fusion* **59** 104001

SELECTED CONFERENCE PRESENTATIONS

Invited Talk: "Hysteresis as a Probe of Turbulent Bifurcation in Intrinsic Rotation Reversals on Alcator C-Mod", 61st APS-DPP Meeting; October 21-25, 2019; Fort Lauderdale, Florida

Best Student Poster Prize Winner: "Observation and Quasilinear Modeling of Rotation Reversal Hysteresis in Alcator C-Mod Plasmas", 24th Joint US-EU Transport Task Force Meeting; March 18-21, 2019; Austin, Texas

Invited Talk: "Observation and Quasilinear Modeling of Rotation Reversal Hysteresis in Alcator C-Mod Plasmas", 2nd Asia-Pacific Conference on Plasma Physics; November 12-17, 2018; Kanazawa, Japan

HONORS AND AWARDS

- Promising Young Scientist Prize at 10th Festival de Théorie in Aix-en-Provence *Jul. 2019*
- Best Student Poster Prize at 24th Joint US-EU Transport Trask Force Meeting *Mar. 2019*
- Student Festival Fellow at 9th Festival de Théorie in Aix-en-Provence *Jul. 2017*
- U.S. NRC Nuclear Education Graduate Fellowship Recipient *Sep. 2016*
- Inducted into Sigma Pi Sigma and Phi Beta Kappa Society *Jun. 2015*
- Best Undergraduate Research Project in Computer Science in AeroAstro *Jun. 2015*

RELEVANT COURSEWORK

Plasma Physics II, Plasma Waves, Engineering Principles for Fusion Reactors, Introduction to Lie Groups, Advanced PDE with Applications, Statistics for Applications, Introduction to Functional Analysis

TEACHING EXPERIENCE

Teaching Assistant for MIT 22.63 Engineering Principles for Fusion Reactors *Sept. 2018 – Dec. 2018*
- Provided mentorship and feedback for students in upper-level graduate course on design for fusion systems

Teaching Assistant for MIT 22.611 Intro to Plasma Physics I *Sept. 2016 – Dec. 2016*
- Held office hours and graded problem sets for graduate level introductory plasma physics

MIT Plasma Science and Fusion Center Outreach *Sept. 2015 – Current*
- Regularly lead tours and engage in other fusion energy outreach activities

Teacher for MIT Educational Studies Program *Jan. 2012 – Current*
- Taught one- to two-hour courses on different topics in physics and math to middle and high schoolers

ENGINEERING EXPERIENCE

Project Engineer for KitCube, MIT 16.83 Space Systems Engineering *Feb. – May 2015*
- Designed a $2 million CubeSat capable of entering and sending transmissions from lunar orbit
- Acted as primary technical liaison between subsystems as project engineer
- KitCube later won **2nd place out of 13 teams** at NASA CubeSat Challenge Ground Tournament 1

Mission Assurance Intern at SpaceX *June – Aug. 2014*
- Developed integrated probabilistic risk analyses (PRA) for Crew Dragon systems
- Assisted in investigations of major F9 anomalies
- Designed and implemented metrics for tracking component and system reliability

MIT MASLAB Robotics Competition *Jan. 2014*
- Built and coded fully autonomous robot on team of five students to complete various ball-based challenges
- Lead coding efforts for complex project involving computer vision, SLAM, and decision making
- **3rd place out of 18 teams**; selected for additional sponsor award

COMMUNITY ACTIVITIES

MIT Mystery Hunt *Jan. 2012 – Current*
- Help organize a team every January for MIT's famously challenging mystery hunt

Judicial Committee Chair for Next House *June – Aug. 2014*
- Elected to mediate dormitory-level dispute and ensure bylaws were being properly followed
- Assisted executive board in planning and running events for the dorm

BIBLIOGRAPHY

[1] **Cao N M**, Mier Valdivia A M and Rice J E 2016 Applying X-ray Imaging Crystal Spectroscopy for Use as a High Temperature Plasma Diagnostic *J. Vis. Exp.* **2016**

[2] Creely A J, Howard N T, Rodriguez-Fernandez P, **Cao N**, Hubbard A E, Hughes J W, Rice J E, White A E, Candy J, Staebler G M, Conway G D, Freethy S J and Sung C 2017 Validation of nonlinear gyrokinetic simulations of L- and I-mode plasmas on Alcator C-Mod *Phys. Plasmas* **24** 056104

[3] Rice J E, Hughes J W, Diamond P H, **Cao N**, Chilenski M A, Hubbard A E, Irby J H, Kosuga Y, Lin Y, Metcalf I W, Reinke M L, Tolman E A, Victora M M, Wolfe S M and Wukitch S J 2017 On the $\rho_* \nabla$ scaling of intrinsic rotation in C-Mod plasmas with edge transport barriers *Nucl. Fusion* **57** 116004

[4] Rodriguez-Fernandez P, Rice J E, **Cao N M**, Creely A J, Howard N T, Hubbard A E, Irby J H and White A E 2017 On the correlation between 'non-local' effects and intrinsic rotation reversals in Alcator C-Mod *Nucl. Fusion* **57** 074001

[5] Kuang A Q, **Cao N M**, Creely A J, Dennett C A, Hecla J, LaBombard B, Tinguely R A, Tolman E A, Hoffman H, Major M, Ruiz Ruiz J, Brunner D, Grover P, Laughman C, Sorbom B N and Whyte D G 2018 Conceptual design study for heat exhaust management in the ARC fusion pilot plant *Fusion Eng. Des.* **137** 221–42

[6] Rodriguez-Fernandez P, White A E, Howard N T, Grierson B A, Staebler G M, Rice J E, Yuan X, **Cao N M**, Creely A J, Greenwald M J, Hubbard A E, Hughes J W, Irby J H and Sciortino F 2018 Explaining Cold-Pulse Dynamics in Tokamak Plasmas Using Local Turbulent Transport Models *Phys. Rev. Lett.* **120** 075001

[7] Rice J E, Reinke M L, **Cao N**, Hughes J W, Ashbourn J M A, Ernst D R, Hubbard A E and Irby J H 2018 Up/down impurity density asymmetries in C-Mod plasmas *Nucl. Fusion* **58** 126008

[8] Schmidtmayr M, Hughes J W, Ryter F, Wolfrum E, **Cao N**, Creely A J, Howard N, Hubbard A E, Lin Y, Reinke M L, Rice J E, Tolman E A, Wukitch S and Ma Y 2018 Investigation of the critical edge ion heat flux for L-H transitions in Alcator C-Mod and its dependence on B T *Nucl. Fusion* **58** 056003

[9] Rice J E, Rosmej F B, **Cao N**, Chilenski M, Howard N T, Hubbard A E, Hughes J W, Irby J H, Lin Y, Rodriguez-Fernandez P, Wolfe S M, Wukitch S J, Bitter M, Delgado-Aparicio L, Hill K and Reinke M L 2018 X-ray observations of ${{\rm{K}}}_{\beta }$ emission from medium Z He-like ions in C-Mod tokamak plasmas *J. Phys. B At. Mol. Opt. Phys.* **51** 035702

[10] Houshmandyar S, Hatch D R, Horton C W, Liao K T, Phillips P E, Rowan W L, Zhao B, **Cao N M**, Ernst D R, Greenwald M, Howard N T, Hubbard A E, Hughes J W and Rice J E 2018 Electron critical gradient scale length measurements of ICRF heated L-mode plasmas at Alcator C-Mod tokamak *Phys. Plasmas* **25** 042305

[11] Rodriguez-Fernandez P, White A E, Howard N T, Grierson B A, Yuan X, Staebler G M, Rice J E, Angioni C, **Cao N** M, Creely A J, Fable E, Greenwald M J, Hubbard A E, Hughes J W, Irby J H and Sciortino F 2019 Perturbative transport modeling of cold-pulse dynamics in Alcator C-Mod Ohmic plasmas *Nucl. Fusion* **59** 066017

[12] **Cao N M**, Rice J E, Diamond P H, White A E, Baek S G, Chilenski M A, Hughes J W, Irby J, Reinke M L and Rodriguez-Fernandez P 2019 Hysteresis as a probe of turbulent bifurcation in intrinsic rotation reversals on Alcator C-Mod *Nucl. Fusion* **59** 104001

[13] Wilks T M, Wolfe S, Hughes J W, Hubbard A E, Greenwald M, **Cao N**, Rice J E and Reinke M 2019 Experimental energy confinement time scaling with dimensionless parameters in C-Mod I-mode plasmas *Nucl. Fusion* **59** 126023

[14] **Cao N M** and Sciortino F 2020 Bayesian Spectral Moment Estimation and Uncertainty Quantification *IEEE Trans. Plasma Sci.* **48** 22–30

[15] **Cao N M**, Rice J E, Diamond P H, White A E, Chilenski M A, Ennever P C, Hughes J W, Irby J, Reinke M L and Rodriguez-Fernandez P 2020 Evidence and modeling of turbulence bifurcation in L-mode confinement transitions on Alcator C-Mod *Phys. Plasmas* **27** 052303