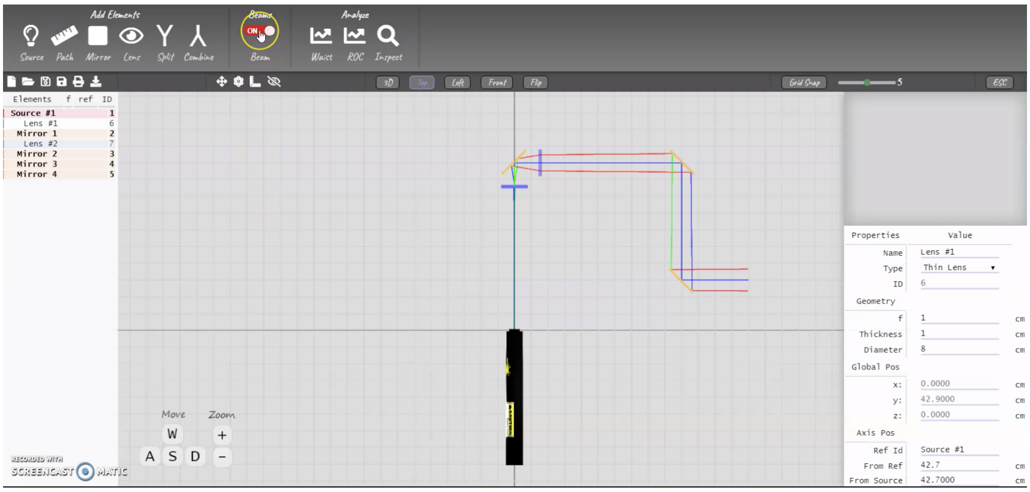
Optictool

The Intuitive Optical Design Platform for Research, Engineering, and Education



SUNY Technology Accelerator Fund
Class of 2020

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1 Non-confidential Description of the Technology

Built on the principle that design tools should be experienced as a nearly seamless extension of the creative process, Optictool brings new methods for optical system design to students, engineers, and scientists. In particular, Optictool aims to create a design experience similar to that of working with physical optics in a lab environment. By offloading cumbersome and tedious calculations to software, the mind of the designer is freed to focus on creative solutions and innovation. Built on the *threejs* open-source library, the Optictool platform is web-portable and allows the user to experience the optical design process in a 3D virtual environment.

2 Description of the Technology

Our product, Optictool, brings a new philosophy to the world of optical engineering design. It was built on the principle that design tools should be experienced as a nearly seamless extension of the creative process that leverages the intuition of the designer. In particular, our product takes the approach of a "path-first" philosophy wherein the user defines the desired optical path much as one would visualize it when physically placing optics on a table in a laboratory. By offloading cumbersome and tedious calculations to software, the mind of the designer is freed for higher-level analysis, such as consideration of alternate solutions and design optimization. The software products are planned to be developed and released in three tiers, each targeting a different audience. The first tier (free) will be geared toward educational institutions and will include a minimal tool set. The second tier will have an extensive materials library but limited geometrical options for design of simpler optical systems. The third tier will include a full range of design tools that can be used for innovative research and development of new optical devices and experimental systems.

This work should be contrasted with existing state-of-the-art design tools that feel as though they are based on 90's spreadsheet calculations where the user must define all positions and angles explicitly, often requiring a series of time-consuming calculations at each step of the process. This design approach presents numerous problems and inefficiencies to the user, not the least of which is the potential for error. More fundamentally, the focus on lengthy calculations is a distraction from the higher creative functions of design.

The path-first concept mimics the natural thought process, and therefore an intuitive design process, that would be the natural mode of work for an experimentalist. Our design process begins by placing a series of way points that define the desired optical path of the light from the source to destination. Each change in the direction of the path then defines the location of a mirror, whose properties can be defined and calculated automatically by the program. Following the definition of the optical path, the user can insert lenses that affect the shape of the light beam. A sophisticated and intuitive system of object placement allows lenses to be placed and moved along the optical path with the click of a mouse. This allows the user to see the effect on the beam shape much as one would do in a laboratory environment simply by moving a lens and observing the change in the light patterns at a reference point.

The user interface for this software is built on the *threejs* library that was developed as a basis for online 3D gaming. This set of tools allows the optical design, including the light source and lenses, to be rendered in 3D. This provides the user with the opportunity to evaluate the design much as one would in a lab, where the optics can be examined from different perspectives.

3 Summary of Market Analysis

The consumer electronics market is experiencing huge development of products lines and sophistication of devices, many with various degrees of feedback or autonomy. These devices range from simple doorbell cameras, to optical motion sensors, to camera systems on toy drones, to navigation cameras for self-driving cars. The growth of optical devices in a wide variety of consumer electronics means that there will necessarily be the need for additional optical engineering.

The free-distribution version of the software, intended for educational use, will provide widespread dissemination of the tool through high schools and colleges. This is effectively phase 1 of the advertising campaign to establish name recognition and testimonials. It is expected that the importance of STEM fields as a leader of the US economic engine, especially as a means of recovery from the recession, will create additional emphasis and incentive to study physics, and therefore optics. While this audience is not envisioned as a revenue stream for the company, it is important to consider as a substantial component of outreach and free advertising for the product.

Many of the optical systems for consumer electronics are not complex, and the cameras used in many devices have fixed or limited zoom which requires some, but not advanced, optical engineering. This speaks to the need for a range of tools that can target different audiences and different needs. The intermediate line of software that will be sold will be ideally targeted to much of the simpler engineering of these consumer devices, as well simpler engineering that occurs in many university-based research labs.

The higher-end (3^{rd} tier) optics design package will be targeted toward groups working on sophisticated imaging systems and cutting-sedge R&D experiments. It is likely that additional rounds of federal stimulus will be pumped into the economy, partly through the DOE's national lab system, as was done during the financial crisis of 2009-2010. Those funds were directed to be spent on advanced projects that often required the acquisition of advanced camera systems or were used to purchase optical equipment for new experimental devices, among other things.

Following the invention disclosure, the creators of Optictool have had several conversations with members of the SUNY RF office who have assisted with doing preliminary market research. The following information is largely derived from their analysis. A significant annual growth of over 6% is expected for sales of design software. Prior to effects from the recent recession, analysis placed expected growth at approximately 3.9 billion in 2018 to 4.2 billion in 2021.

4 Project Narrative

This section describes the technology and its relation to the outstanding problems with existing commercial products.

4.1 The problem

Existing optical design software, like OSLO and Zemax Opticstudio, have a user interface that works against intuitive design and research efficiency. The fundamental means of interaction with the design places far too much emphasis on lengthy mathematical calculations that distract the user from the process of creative design.

4.2 The technology solution

Our Optictool software brings efficient design to the user, based in a philosophy that design software should be simple enough so that it can be used by a high school student and sophisticated enough to enable the professional engineer to do quality design work.

4.3 Feasibility

A proof-of-principle code has been developed. This first product incorporates the essential elements of the envisioned commercial product, including the path-first design process, 3D graphical representation of the optics, and point-and-click lens placement. There are no expected barriers to development of the product outside of time commitment.

4.4 Intellectual property

An invention disclosure titled "Intuitive Optical Design with Web Technologies" was filed with SUNY RF on April 23, 2020 and was assigned invention ID 2020/033-170. Discussions are continuing to explore the patentability of the path-first design method.

4.5 Market opportunity

The fields of engineering and CAD-related systems design are expected to see substantial growth in the next decade. Competing software that is specific to optical engineering is outdated and expensive, typically with price tags in the $6k+ range. By introducing this software with a free distribution license to educational institutions we anticipate being able to develop a core following of users. Those that transition into scientific and engineering positions will then be in a position to continue with the fee-based versions of the codes.

4.6 Commercialization plan

The Optictool software will be developed in a three-tiered structure, with the first tier being free. The goal is to have the fist profitable product (tier 2) ready for market at the end of year 1. It is expected that full development of the tier 3 product will take 18 months.

Tier 1 - Educational package: This package will be freely distributed and will include a base set of tools to enable teachers and students to explore the fundamentals of optics. The intuitive design nature of Optictool will allow students to build their own optical systems to virtually develop tools like microscopes and telescopes, and will also allow them to create models of systems like the human eye and corrective lenses.

Tier 2 - Fundamental design package: The simple design package will build on the educational package with four main features that are important for engineering design: materials libraries for a wide range of optics, options for parabolic optics, lateral and rotational displacement of optics for sensitivity studies, and options for multiple path and multiple source systems.

Tier 3 - Professional design package: This all-encompassing package will contain all of the features of the previous two packages and include options for optics or arbitrary geometry (e.g. conical or hyperbolic surface), full-wave calculations with polarization effects for modeling of interference. This last package will allow Optictool to be used for design and modeling of a wide range of systems, including in research labs.

4.7 Milestones

Technology development is captured in 3 major milestones, corresponding to the three product lines envisioned as commercial products.

Technology Milestone 1: 3 months
The first milestone in the product development is delivery of a complete educational package. This milestone will require completion of only two additional elements:

- an image propagation tool to visualize image propagation and formation in optical systems like telescopes and microscopes,

- program file size reduction by keeping only the essential elements of the *threejs* library.

Technology Milestone 2: 9 months
The second milestone will bring the software to the a fully capable system that can be used for professional design of simpler optical systems. Three major additions are needed to bring this product to the point of commercial viability. These are:

- thick lens and parabolic optics options,
- implementation of a complete materials library that includes index of refraction curves to enable a modeling of a wide range of lenses,
- sensitivity tools that allow the user to examine the effect on beam propagation as optical elements are rotated and displaced from their ideal locations,
- option for multiple beam path propagation as may arise when using a beam splitter,
- option for multiple sources, such as objects at different positions or multiple lasers (with allowance for multiple wavelengths).

Technology Milestone 3: 6 months
The third technology milestone encompasses the development of the highest functions of the software that will be implemented in the professional version of the code. Some of these elements, like the multiple path and multiple source design aspects, have been envisioned from the outset such that the code architecture has been built with their eventual implementation in mind. The main elements that need to be developed for this final stage of the software are:

- arbitrary optical shape for advanced systems engineering,
- full-wave calculations that allow for calculation of interference effects,
- beam distortion calculations that present measures of beam quality along the optical path,
- implementation of CAD model import so that additional hardware, such as optical tables and optical mounts, can be added for more complete rendering and for collision detection.

4.8 Team

The core team for this work will be Dr. Eric Edlund as overall director and Mr. Nate Rose as head software engineer. The core team will be augmented by an additional programmer to assist with product development, and later a marketing & sales manager.

5 College Commitment to the Project

SUNY Cortland will provide support for the development of Optictool through the provision of office space and technology for the project team. The Research and Sponsored Programs Office will administer and oversee the fiscal operation of the project, including post-TAF operations. The Research and Sponsored Programs Office will also work with Dr. Edlund to seek and secure research development grant funding to further the project post-TAF development. In addition, the Research and Sponsored Programs Office will help in the search for potential investors through the Cortland College Foundation and Alumni Association.

6 Roles and Responsibilities of the Partners

This project was established by two members, the authors of this report: Dr. Eric Edlund and Mr. Nate Rose, who will continue to be the main developers and members of this project.

Dr. Eric Edlund: With over 15 years of experience working with laser systems, Dr. Eric Edlund brings to the table a deep understanding of optics and optical design. He is an assistant professor in the Physics Department, where he continues to do research with his colleagues in Germany at the Wendelstein 7-X (W7-X) stellarator facility. Dr. Edlund wrote a grant proposal in 2014 that was funded at over $1M by the US Department of Energy. It was during work on this project, using two commercial products for optical design, that Dr. Edlund realized that there is a better way to do design. He began work on this project as a summer project with a student. Dr. Edlund's work with the W7-X project continues and he is currently in the process of implementing new hardware that will greatly extend the frequency range of the detection system. Dr. Edlund will continue as the project director and external face of the commercialization venture. His expertise in optics will be essential in making big decisions about the future directions of the project development.

Mr. Nate Rose: A recent graduate of SUNY Cortland, Mr. Rose is looking for career opportunities and a big idea to pursue. Prior to studying at SUNY Cortland, he worked in various jobs including fields like logging, machining, and aircraft maintenance. The hands-on nature of these experiences have given Mr. Rose a good intuition for physical systems. He applied that intuition in his studies, being perhaps the only student to have taken every class offered by the Physics Department. Mr. Rose was also the president of the Physics and Engineering Club, and leader of the club's prosthetic hand project that spanned over two years of collaborative work with students from biology and chemistry. Mr. Rose's interest in programming makes him a natural fit for this project. Mr. Rose will continue with this project as head technology officer and the lead programmer for the Optictool development.

7 Survey of Possible Industry Partners

The project creators do not believe that industry partners are essential to help develop this product to the point of marketability. There are, however, a number of industry partners that could be useful either as beta testers, leading clients, or as licensees of the software to help boost their own product line. These are discussed below.

Beta testers

Dr. Edlund's professional contacts in diverse national labs and academic institutions, including colleagues who teach in high schools, will be the first stop for getting feedback on ways to improve the user experience and range of analytical tools. The first goal with this first round of interactions is to ensure that the user interface is clean, efficient, and intuitive. The second goal will be to establish an ongoing dialogue with users about what additional features they would like to have to assist with their work or educational objectives.

Leading clients

The number of industrial companies working with optics is large, and so it will be important to establish a few key supporters of Optictool to provide credibility and name recognition to the product. Reflecting the tiered development of the product, we envision a similarly-tiered approach to establishing leading clients by first beginning with partners in academia who can implement the software in physics courses, followed by establishing connections with core users at reputable research centers like Lawrence Livermore National Laboratory and the Princeton Plasma Physics Laboratory (both places in which Dr. Edlund has professional connections), followed lastly by early adoption of the software by a few respected industrial partners such as FLIR or GoPro.

Licensees

An additional revenue stream can come in the form of licensing the Optictool platform for commercial use by another company. In this case we are thinking of industrial partners like ThorLabs or Edmund Optics, manufacturers of physical optics and optical hardware. These companies are continually expanding their range of educational and support tools for engineers. We believe it likely that a company like ThorLabs may be interested in licensing the Optictool software to make these tools available, perhaps through a web-based interface, so that customers and potential customers can perform some variety of optical calculations as they shop for parts.

8 Additional documents

- Letter of support from the SUNY Cortland Research Foundation
- Scope of work
- Conflict of interest forms
- CV for Dr. Eric Edlund

SUNY Cortland
Research and
Sponsored Programs Office

July 1, 2020

SUNY Technology Accelerator Fund Class of 2020
c/o Research Foundation of SUNY
P.O. Box 9
Albany, NY 12201-0009

Dear Reviewers:

I am writing in support of Dr. Eric Edlund's application titled "*Optictool: The Intuitive Optical Design Platformfor Research, Engineering, and Education*" for the TAF Class of 2020 investment.

SUNY Cortland is supportive of this application and for the continuing development of the Optictool product and will provide all the necessary support and administrative operations should Dr. Edlund receive a TAF award. We have confidence in the validity of Optictool and believe that it has commercialization potential.

Sincerely,

Thomas H. Frank, Ph.D.
Director, Research and Sponsored Programs
Deputy Research Foundation Operations Manager
Director, Technology Transfer

TAF Class of 2020 Project Scope of Work

Project Milestones	Cost	Month 1	2	3	4	5	6	7	8	9	10	11	12
Milestone 1: Educational distribution													
1.1 Develop image propagation tool	$12,461												
1.2 Reduce program file size	(3 person-months of labor)												
Milestone 2: Fundamentals distribution													
2.1 Develop thick lens and paraboloc optics													
2.2 Multiple beam options													
2.3 Multiple source options	$37,382												
2.4 Create materials library	(9 person-months of labor)												
2.5 Impement sensitivity tools													
Milestone 3: Professional distribution													
3.1 Develop arbitrary optical shape													→
3.2 Full-wave calculations	$24,921												→
3.3 Beam-distortion calculations	(12 person-months of labor)												→
3.4 CAD model import													→

Payment 1. for completion of Milestone(s) __________

Payment 2. for completion of Milestone(s) ___________

Payment 3. for completion of Milestone(s) ___________

Note: Costs are for labor only - no other development costs are anticipated.
These figures come from an hourly wage of $18.00 for Nate Rose as lead programmer.
12 months of salary at this rate amounts to $35,100, plus benefits at 42% to give
a total annaul cost of $49,842.

SUNY TECHNOLOGY ACCELERATOR FUND
CONFLICT OF INTEREST DISCLOSURE FORM

TAF Project Title: Optictool: The Intuitive Optical Design Platform for Research, Engineering, and Education

TAF Project Team Member: Eric Edlund

Please answer the following questions.

1. Do you or any related party (spouse, domestic partner, significant other, dependent, member of household, family member, or business partner) have any financial or other interest that you believe may be relevant to the exercise of your duties in performing the project articulated in the TAF Class of 2019 proposal that you are involved with? If so, please detail below or enter N/A in the space provided.

No.

2. Is any technology that is related to the proposed TAF Class of 2019 project currently licensed or optioned to a for-profit entity? ___ Yes _X_ No

   If yes, are you performing any services to the licensee outside of SUNY (e.g., consulting, board service)?
   ___ Yes ___No

   If yes, please explain below.

I certify that the above information is true and correct to the best of my knowledge and that I have read and agree to be bound the RF's Conflict of Interest Policy. I further certify that I will advise the TAF Managing Director or delegate immediately upon any material change in circumstance that may occur during the period of performance of the proposed TAF Project, if funded.

Signature: [signature] — Date: June 30, 2020

Eric Matthias Edlund

Assistant Professor
SUNY Cortland, Department of Physics
eric.edlund@cortland.edu

EMPLOYMENT

Teaching Appointments

State University of New York at Cortland — Cortland, NY
Department of Physics — August 2017 - present
Assistant Professor

California Polytechnic University — San Luis Obispo, CA
Department of Physics — Winter & Spring quarters, 2013
Visting Lecturer

Princeton University — Princeton, NJ
Department of Physics — Fall, 2012
Preceptor

Rider University — Lawrenceville, NJ
Department of Chemistry and Physics — Fall 2010
Lecturer

Research Appointments

Max Planck Institut für Plasmaphysik — Greifswald, Germany
Turbulence and Transport Group — August 2015 - December 2017
Visiting Scientist

Massachusetts Institute of Technology — Cambridge, MA
Plasma Science and Fusion Center — August 2015 - December 2017
Staff Scientist
Project Lead for the W7-X PCI Collaboration

US Department of Energy — Germantown, MD
Office of Fusion Energy Sciences — April-May 2015
Temporary Interdepartmental Work Detail
Research Scientist

Princeton Plasma Physics Laboratory — Princeton, NJ
ITER and Domestic Tokamak Collaborations — March 2015 - August 2015
Research Physicist, RM-2

Princeton Plasma Physics Laboratory — Princeton, NJ
Plasma Science and Technology Division — September 2009 - March 2015
Associate Research Physicist, RM-1

EDUCATION

Massachusetts Institute of Technology — Cambridge, MA
Ph.D., Physics — 2009

California State University Chico — Chico, CA
B.S., Physics and Mathematics — 2003

COURSES TAUGHT

SUNY Cortland
PHY 201 - Principles of Physics I (calculus-based mechanics, lecture & lab)
PHY 202 - Principles of Physics II (calculus-based E&M, lecture & lab)
PHY 203 - Principles of Physics III (calculus-based, waves, optics, thermodynamics)
PHY 420 - Classical Mechanics
PHY 429 - Special Topics: Classical Mechanics II

Cal Poly
PHYS 121 - College Physics I (algebra-based mechanics)
PHYS 132 - General Physics II (calculus-based, waves, optics and thermodynamics, lecture & lab)

Princeton University
PHY 103 - General Physics I (calculus-based mechanics, precept)

Rider University
PHY 200 - General Physics I (algebra-based mechanics, lab only)

GRANTS, PATENTS & INVENTIONS

"Intuitive optical design with web technologies"

E. M. Edlund and N. Rose

SUNY Invention Disclosure (April 23, 2020)

“Advanced liquid centrifuge using differentially rotating cylinders and optimized boundary conditions, and methods for the separation of fluids”
H. Ji, A. Cohen, P. Efthimion, E. Edlund, and E. Gilson
US Patent No. 10,300,410 (May 28, 2019)

“Phase contrast imaging for Wendelstein 7-X” (renewal)
M. Porkolab (PI), MIT and E. M. Edlund (co-PI), SUNY Cortland
submitted to: US Department of Energy, Office of Science, Office of Fusion Energy Sciences (2017)
total award: $900k, August 2018 - August 2021

“Construction of a phase contrast imaging diagnostic for Wendelstein 7-X”
M. Porkolab (PI) and E. M. Edlund (author and key personnel), MIT
submitted to: US Department of Energy, Office of Science, Office of Fusion Energy Sciences (2014)
total award: $1.039M, August 2015 - August 2018

PUBLICATIONS

First Author

E. M. Edlund and S. Kadas, “Visual storytelling of scientific data: collaborations between physics and graphic design in the college classroom” *The SUNY Journal of the Scholarship of Engagement*, accepted for publication.

E. M. Edlund, M. Porkolab, Z. Huang, O. Grulke, L.-G. Böttger, C. von Sehren and A. von Stechow, “Overview of the Wendelstein 7-X phase contrast imaging diagnostic” *Review of Scientific Instruments* 89, 10E105 (2018).

E. M. Edlund, P. T. Bonoli, M. Porkolab and S. J. Wukitch, “Modeling of EAST ICRF heating with the full-wave code TORIC” *21st Topical Conference of Radio Frequency Power in Plasmas*, (2015).

E. M. Edlund and H. Ji, “Reynolds number scaling of the influence of boundary layers on the global behavior of laboratory quasi-Keplerian flows” *Physical Review E* 92, 043005 (2015).

E. M. Edlund and H. Ji, “Nonlinear stability of laboratory quasi-Keplerian flows” *Physical Review E* 89, 021004 (2014).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin, N. Tsujii and S. J. Wukitch, “Experimental study of reversed shear Alfvén eigenmodes during the current ramp in the Alcator C-Mod tokamak” *Plasma Physics and Controlled Fusion* 52, 115003 (2010).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin and S. J. Wukitch, “Phase contrast imaging measurements of reversed shear Alfvén eigenmodes during sawteeth in Alcator C-Mod” *Physics of Plasmas* 16, 056106 (2009).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin and S. J Wukitch, “Observation of RSAEs during sawteeth in Alcator C-Mod” *Phys. Rev. Lett.* 102, 165003 (2009).

E. M. Edlund, M. Porkolab, G. J. Kramer, L. Lin, Y. Lin and S. J. Wukitch, “Reversed shear Alfvén eigenmodes in Alcator C-Mod during ICRF minority heating and relationship to sawtooth crash phenomena” *Proceedings of the European Physics Society Plasma Physics Conference* (2008).

Contributing Author

Z. Huang, E. M. Edlund, M. Porkolab, A. von Stechow, J.-P. B ahner, L.-G. B ottger, C. von Sehren, and O. Grulke, “The Wendelstein 7-X phase contrast imaging diagnostic” submitted to *Review of Scientific Instruments*, (May 2020).

A. von Stechow, O. Grulke, T. Wegner, J. H. E. Proll, J. A. Alcusón H. M. Smith, J. Baldzuhn, C. D. Beidler, M. N. A. Beurskens, S. A. Bozhenkov, E. M. Edlund, B. Geiger, Z. Huang, O. P. Ford, G. Fuchert, A. Langenberg, N. Pablant, E. Pasch, M. Porkolab, K. Rahbania, J. Schilling, E. R. Scott, H. Thomsen, L. Vanó, G. Weir, and the W7-X Team, “Suppression of core turbulence by profile shaping in Wendelstein 7-X” submitted to *Physical Review Letters*, (April 2020).

M. J. Burin, K. J. Kaspary, E. M. Edlund, R. Ezeta, E. P. Gilson, H. Ji, M. McNulty, J. Squire and G. R. Tynan, “Turbulence and jet-driven zonal flows: Secondary circulation in rotating liquids due to asymmetric forcing” *Physical Review E* 99, 023018 (2019).

A. Marinoni, C. P. Moeller, M. Porkolab, J. C. Rost, E. M. Davis, and E. M. Edlund, “A wide frequency heterodyne detection method using the Pockels effect” *MIT Plasma Science and Fusion Center internal report*, PSFC/RR-18-3 (2018).

T. Golfinopoulos, B. LaBombard, D. Brunner, J. Terry, S.-G. Baek, P. Ennever, E. Edlund, W. Han, W. Burke, S. Wolfe, J. Irby, J. Hughes, E. Fitzgerald, R. Granetz, M. Greenwald, R. Leccacorvi, E. Marmar, S. Pierson, M. Porkolab, R. Vieira, S. Wukitch, Stephen, “Edge Transport and Mode Structure of a QCM-Like Fluctuation Driven by the Shoelace Antenna” *Nuclear Fusion* 58, 056018 (2018).

A. Creely, A. White, E. M. Edlund, N. Howard, A. Hubbard, “Perturbative thermal diffusivity from partial sawtooth crashes in Alcator C-Mod”, *Nuclear Fusion* 56, 036003 (2016).

J. L. Terry, M. L. Reinke, J. W. Hughes, B. LaBombard, C. Theiler, G. M. Wallace, S. G. Baek, D. Brunner, R. M. Churchill, E. M. Edlund, P. Ennever, I. Faust, T. Golfinopoulos, M. Greenwald, A. E. Hubbard, J. Irby, Y. Lin, R. R. Parker, J. E. Rice, S. Shiraiwa, J. R. Walk, S. J. Wukitch, P. Xu, ”Improved confinement in high-density H-modes via modification of the plasma boundary with lower hybrid waves” *Physics of Plasmas* 22, 056114 (2015).

J. H. Rhoads, E. M. Edlund and H. Ji, “Effects of magnetic field on the turbulent wake of a cylinder in MHD channel flow” *Journal of Fluid Mechanics* 742, 446 (2014).

S. E. Sharapov, B. Alper, H. L. Berk, D. N. Borba, B. N. Breizman, C. D. Challis, I. G. J. Classen, E. M. Edlund, J. Eriksson, A. Fasoli, "Energetic particle instabilities in fusion plasmas", *Nuclear Fusion* 53, 104022 (2013).

A. H. Roach, E. J. Spence, C. Gissinger, E. M. Edlund, P. Sloboda, J. Goodman and H. Ji, "Observation of a free-Shercliff-layer instability in cylindrical geometry" *Physical Review Letters* 108, 154502 (2012).

E. J. Spence, A. H. Roach, E. M. Edlund, P. Sloboda and H. Ji, "Free MHD shear layers in the presence of rotation and magnetic field" *Physics of Plasmas* 19, 056502 (2012).

L. Lin, M. Porkolab, E. M. Edlund, J. C. Rost, C. Fiore, M. Greenwald, Y. Lin, D. R. Mikkelsen, N. Tsujii and S. J. Wukitch, "Studies of turbulence in Alcator C-Mod H-Mode plasmas with phase contrast imaging and comparisons with GYRO" *Physics of Plasmas* 16, 012502 (2009).

L. Lin, M. Porkolab, E. M. Edlund, J. C. Rost, M. Greenwald, N. Tsujii, J. Candy, R. E. Waltz and D. R. Mikkelsen, "Studies of turbulence in Alcator C-Mod ohmic plasmas with phase contrast imaging and comparisons with GYRO" *Plasma Physics and Controlled Fusion* 51, 065006 (2009).

M. Porkolab, E. M. Edlund, L. Lin, R. Parker, C. Rost, J. Sears, J. A. Snipes, S. J. Wukitch, B. N. Breizman, N. N. Gorelenkov, G. J. Kramer, A. Fasoli and H. Smith, "Experimental studies and analysis of Alfvén eigenmodes in Alcator C-Mod" *Proceedings of the 21st IAEA Conference*, IAEA-CN 149 (2006).

L. Lin, E. M. Edlund, M. Porkolab, Y. Lin and S. J. Wukitch, "Vertical localization of phase contrast imaging diagnostic in Alcator C-Mod" *Review of Scientific Instruments* 77, 10E918 (2006).

M. Porkolab, C. Rost, N. Basse, J. Dorris, E. M. Edlund, L. Lin, Y. Lin and S. J. Wukitch, "Phase contrast imaging of waves and instabilities in high temperature magnetized fusion plasmas" *IEEE Transactions on Plasma Science* 34, 229 (2006).

N. P. Basse, E. M. Edlund, D. R. Ernst, C. L. Fiore, M. J. Greenwald, A. E. Hubbard, J. W. Hughes, J. H. Irby, G. J. Kramer, L. Lin, Y. Lin, E. S. Marmar, D. R. Mikkelsen, D. A. Mossessian, M. Porkolab, J. E. Rice, J. A. Snipes and J. A. Stillerman, "Characterization of core and edge turbulence in L- and enhanced D-alpha H-mode Alcator C-Mod plasmas" *Physics of Plasmas* 12, 052512 (2005).

E. Scime, R. Murphy, E. M. Edlund and G. Ganguli, "Electrostatic ion-cyclotron waves in a currentless, anisotropic plasma with inhomogeneous flow" *Physics of Plasmas* 10, 4609 (2003).

Publicity and Interviews

"Physics and graphic design students work together on COVID-19" *SUNY Cortland Bulletin* (May 19, 2020).

"SUNY Cortland's academic odd couples address real-world problems " *SUNY Cortland Bulletin* (May 21, 2019).

"Angular momentum transport in astrophysics and in the lab" *Physics Today* 66, 27 (August 2013).

PRESENTATIONS

Talks

"Scientists as writers: commonalities and distinctions of writing across different disciplines" Institute for College Teaching, SUNY Cortland (March 2020). Co-presenter with Professor Karen Downey (Chemistry).

"Visual storytelling of scientific data: collaborations between art and physics in the college classroom" SUNY Applied Learning Conference, Albany, NY (October 2019).

"Branches, paths, and junctions: what do electrons know of free-will?" Physics Department Colloquium, SUNY Cortland (September 2019).

"Comparison of sawtooth heat pulses across confinement regimes in Alcator C-Mod" 56th annual meeting of the APS-DPP, New Orleans, LA (2014).

"Boundary layers and global stability of laboratory quasi-Keplerian flow" 66th annual meeting of the APS-DFD, Pittsburgh, PA (2013).

"Experimental studies of turbulence lifetimes in differentially rotating flows" 65th annual meeting of the APS-DFD, San Diego, CA (2012).

"A new concept for an advanced liquid centrifuge" Savannah River National Laboratory, Director's Colloquium (October 2012).

"Searching for a subcritical transition in quasi-Keplerian flows" 64th annual meeting of the APS-DFD, Baltimore, Maryland (2011).

"Studies of Rossby waves and hydrodynamic turbulence in a Taylor-Couette device" 63rd annual meeting of the APS-DFD, Los Angeles, California (2010).

"A new experiment for the study of hydrodynamic waves and turbulence" 52nd annual meeting the APS-DPP, Chicago, Illinois (2010).

(invited) “Observation of revered shear Alfvén eigenmodes during the sawtooth cycle in Alcator C-Mod” 50th annual meeting of the APS-DPP, Dallas, Texas (2008).

(invited) “Phase contrast imaging diagnostics on the Alcator C-Mod and DIII-D tokamaks” 17th Topical Conference on High-Temperature Plasma Diagnostics, Albuquerque, New Mexico (2008).

Posters

“Upgrades to the Wendelstein 7-X phase contrast imaging diagnostic and plans for the OP2 campaign” European Physics Society Conference, (2020, cancelled).

“Observation of electron-driven Alfvén eigenmodes in Wendelstein 7-X” European Physics Society Conference, Prague, Czech Republic (2018).

“Overview of the phase contrast imaging diagnostic for Wendelstein 7-X” High Temperature Plasma Diagnostics conference, San Diego, California (2018).

“First results from the Wendelstein 7-X phase contrast imaging diagnostic” 59th annual meeting of the APS-DPP, Milwaukee, Minnesota (2017).

“Overview of the design of the phase contrast imaging diagnostic for Wendelstein 7-X” 58th annual meeting of the APS-DPP, San Jose, California (2016).

“Modeling of ICRF wave propagation and heating in EAST with the full-wave code TORIC” 57th annual meeting of the APS-DPP, Savannah, Georgia (2015).

“Recent results from the Princeton MRI and HTX experiments” 54th annual meeting of the APS-DPP, Providence, Rhode Island (2012).

“In search of a subcritical transition to turbulence in rotating hydrodynamic flows” 53rd annual meeting of the APS-DPP, Salt Lake City, Utah (2011).

“A method for minimizing secondary flows in Taylor-Couette experiments” 52nd annual meeting the APS-DPP, Chicago, Illinois (2010).

“Diagnostic systems of the Princeton MRI Experiment” 51st annual meeting of the APS-DPP, Atlanta, Georgia (2009).

“Experimental study of reversed shear Alfvén eigenmodes during ICRF minority heating and relationship to sawtooth crash phenomena in Alcator C-Mod” 21st Transport Taskforce Workshop, Boulder, Colorado (2008).

“Reversed shear Alfvén eigenmodes in Alcator C-Mod during ICRF minority heating and relationship to sawtooth crash phenomena” 35th European Physics Society Plasma Physics Conference, Crete, Greece (2008).

“Mode structure and stability analysis of RSAEs with NOVA-K” 49th annual meeting of the APS-DPP, Orlando, Florida (2007).

"Alfvén eigenmode activity during the sawtooth phase in Alcator C-Mod" 48th annual meeting of the APS-DPP, Philadelphia, Pennsylvania (2006).

"Observation of reverse shear Alfvén eigenmodes in Alcator C-Mod and their modeling with NOVA" 47th annual meeting of the APS-DPP, Denver, Colorado (2005).

"Measurement and modeling of Alfvén cascades in Alcator C-Mod" 46th annual meeting of the APS-DPP, Savannah, Georgia (2004).

"Effects of temperature anisotropy and shear flow on ion-cyclotron instability of a magnetized plasma" 44th annual meeting of the APS-DPP, Orlando, Florida (2002).

Workshops
Rubrics and Contract Grading, SUNY Cortland Writing in the Disciplines Fellows program, January, 2020 (presenter). Co-presenter with Professor Jessica Carrick-Hagenbarth (Economics).

CREATIVE ENDEAVORS

Binary Processes, art installation in the *Measured Confluence* exhibition at the Dowd Gallery, SUNY Cortland. January-February, 2020.

Forbidden Regions, with Jaroslava Prihodova, art installation in the *Measured Confluence* exhibition at the Dowd Gallery, SUNY Cortland. January-February, 2020.

SERVICE AND ASSOCIATIONS

Current Service

Alumni-Undergraduate Research Science Symposium

Educational Policy Committee

Physics Department Graduate Celebration Event Coordinator

Physics Department Assessment Committee (Chair)

Physics Department Curriculum Committee (Chair)

Physics Department Personnel Committee

Physics Department Scholarship Committee

Physics Department Faculty Search Committee

Physics Department colloquium coordinator (unofficial)

Physics Department orientation advisor for new students

UUP research group

Past Service

Director of the Dowd Art Gallery Search Committee (2018-2019), SUNY Cortland

Physics Department Faculty Search Committee (2018-2019), SUNY Cortland

Computational physics curriculum committee, Cal Poly (2013)

Referee for Physical Review Letters, Physics of Plasmas and Nuclear Fusion

Reviewer for High Energy Density Plasma grant proposals, Department of Energy

Plasma Science and Technology Division lecture coordinator, PPPL (2011-2013)

Griggstown Volunteer Fire Department, treasurer (2011-2012)

Griggstown Volunteer Fire Department, volunteer fire fighter (2010-2014)

MIT Club Sports Council, officer (2007-2009)

MIT Cycling Team, captain (2006-2007)

MIT Office of Minority Education, tutor (2006-2007)

CSU Chico chapter of the Society of Physics Students, vice president (2001-2003)

CSU Chico chapter of the Society of Physics Students, tutor (1999-2003)

Associations

American Physical Society

American Association of Physics Teachers

AWARDS AND HONORS

Recipient (3 times) of the Award for Excellence in Research and Scholarship (SUNY Cortland)

Writing in the Disciplines Fellow, SUNY Cortland (2019-2020)

Fine Teaching Award, SUNY Cortland (2019)

Men of Excellence and Value Award, SUNY Cortland (2018)

STUDENT RESEARCH

Summer 2020, SUNY Cortland
Student: Hunter Reid
Project: Experimental and theoretical study of a process to create ice in the desert

Spring-Summer 2020, SUNY Cortland
Students: Scott Blankenbaker and Tyler Edgar
Project: Measurements of wave dispersion in a coupled oscillator system

Spring 2019 - present, SUNY Cortland
Student: Karl Hipius
Project: Simulation of a coupled oscillator system
Presented at the 2020 SUNY Cortland Transformations event

Summer 2018 - present, SUNY Cortland
Student: Nathaniel Rose
Project: Development of a gaussian optics program for optical design iteration

Spring 2019, SUNY Cortland
Students: Karl Hipius and Nathaniel Rose
Project: Construction of a macroscopic model of quantum mechanical systems
Presented at the 2019 SUNY Cortland Transformations event

Fall 2016 & Winter 2017, MIT
Student: Jeannette Maisano-Brown
Project: Development and testing of an arrayed light source for W7-X PCI detector calibration

Summer 2011, Princeton Plasma Physics Laboratory
Student: Michael Pretko
Project: Theoretical analysis of surface waves in rotating flows
Presented at the 2011 APS DFD Conference in Baltimore, MD

Summer 2010, Princeton Plasma Physics Laboratory
Student: Zoe Yan
Project: Measurement of the vortex lifetime in rotating flows

Fall 2009, Princeton Plasma Physics Laboratory
Student: Peter Humanik
Project: Development of a line-laser scanner for measurement of surface waves in rotating flows