

Theresa Saxton-Fox

PERSONAL DATA

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EDUCATION

OCTOBER 2017 Doctor of Philosophy in Mechanical Engineering
California Institute of Technology, Pasadena, CA

JUNE 2013 Master of Science in Mechanical Engineering
California Institute of Technology, Pasadena, CA

JUNE 2012 Bachelor of Science in Mechanical Engineering
Massachusetts Institute of Technology, Cambridge, MA

THESIS

CALTECH 2017	Coherent structures, their interactions, and their influence on passive scalar transport in wall-bounded turbulent flows
ADVISOR	<i>Dr. Beverley McKeon, Theodore von Karman Professor of Aeronautics</i>
COMMITTEE	<i>Dr. Tim Colonius, Frank and Ora Lee Marble Professor of Mechanical Engineering</i> <i>Dr. Guillaume Blanquart, Professor of Mechanical Engineering</i> <i>Dr. Anthony Leonard, Theodore von Karman Professor of Aeronautics, Emeritus</i>

The thesis focused on the characterization of coherent structures and their interactions in a turbulent boundary layer, with application to improved understanding and modeling of canonical wall-bounded turbulent flows, as well as to passive scalar transport and the distortion of an optical beam passing through variable-density flow. First, connections were identified between instantaneous and statistical descriptions of coherent velocity structures through the study of experimental velocity data of a turbulent boundary layer and an analysis of representative models for energetic turbulent structures. The representative models were used in a novel conditional averaging technique to identify the average behavior of small scales about variations in the large-scale streamwise velocity field in experimental and computational data. Based upon the results of this analysis, a hypothesis for a scale interaction mechanism was proposed involving three-dimensional critical layers. The modeling and analysis methods were then applied to the aero-optic problem in which optical beams are distorted after passing through variable-density turbulent flows. A conditional averaging analysis of simultaneous velocity and aero-optic experimental data identified that the nonlinear interaction of two turbulent scales was most correlated to the aero-optic distortion. The modeling of this interaction using a linear superposition of coherent structure models led to new insights regarding the instantaneous relationship between the velocity and scalar fields over a range of Prandtl numbers.

HONORS

- 2013 – 2016 National Defense Science and Engineering Graduate (NDSEG) Fellow
- 2013 National Science Foundation (NSF) Graduate Research Fellowship Awardee (Declined)
- 2012 & 2011 Patriot League Rowing Scholar Athlete of the Year
- 2011 Rhodes Scholarship Finalist
- 2011 Supported by Lockheed Martin Foundation UROP Fund
- 2010 MIT Public Service Center Summer Fellowship Awardee

PUBLICATIONS

- Nonlinear interactions and aero-optical distortions in a mildly-heated turbulent boundary layer**
T. Saxton-Fox and B. McKeon. *In preparation.*
- The spatial organization of small scales by energetic, coherent structures in turbulent boundary layers**
T. Saxton-Fox and B. McKeon. *In preparation.*
- 2017 **Coherent structures, uniform momentum zones, and the streamwise energy spectrum in wall-bounded turbulent flows**
T. Saxton-Fox and B. McKeon. *Journal of Fluid Mechanics, Rapids.*
- 2017 **Modeling momentum and scalar transport in a wall-bounded turbulent flow**
T. Saxton-Fox and B. McKeon. *International Symposium on Turbulence and Shear Flow Phenomena Proceedings.*
- 2016 **Scale interactions and 3D critical layers in wall-bounded turbulent flows**
T. Saxton-Fox and B. McKeon. *International Congress of Theoretical and Applied Mechanics Proceedings.*
- 2016 **Toward low order models of wall turbulence using resolvent analysis**
K. Rosenberg, T. Saxton-Fox, A. Lozano-Duran, A. Towne, and B. McKeon. *Proceedings of the 2016 Center for Turbulence Research Summer Program.*
- 2015 **Aero-optical distortion as a marker of turbulent structure**
T. Saxton-Fox, B. McKeon, S. Gordeyev, and A. Smith. *International Symposium on Particle Image Velocimetry Conference Proceedings.*
- 2015 **Studies of the large-scale structure in adiabatic and moderately-wall-heated subsonic boundary layers**
S. Gordeyev, A. Smith, T. Saxton-Fox, and B. McKeon. *International Symposium on Turbulence and Shear Flow Phenomena Proceedings.*
- 2014 **Subsonic boundary-layer wavefront spectra for a range of Reynolds numbers**
A. Smith, S. Gordeyev, T. Saxton-Fox, and B. McKeon. *AIAA Conference Proceedings.*

CONFERENCE TALKS

- JULY 2017 **Modeling momentum and scalar transport in a wall-bounded turbulent flow**
T. Saxton-Fox and B. McKeon. *International Symposium on Turbulence and Shear Flow Phenomena*.
- NOVEMBER 2016 **3D critical layers in fully developed turbulent flows**
T. Saxton-Fox and B. McKeon. *American Physical Society: Division of Fluid Dynamics*.
- AUGUST 2016 **Scale interactions and 3D critical layers in wall-bounded turbulent flows**
T. Saxton-Fox and B. McKeon. *International Congress of Theoretical and Applied Mechanics*.
- APRIL 2016 **Relating statistical and instantaneous descriptions of wall turbulence**
T. Saxton-Fox and B. McKeon. *Southern California Flow Physics Symposium*.
- NOVEMBER 2015 **Connections between density, wall-normal velocity, and coherent structure in a heated turbulent boundary layer**
T. Saxton-Fox, B. McKeon, S. Gordeyev, and A. Smith. *American Physical Society: Division of Fluid Dynamics*.
- APRIL 2015 **Aero-optical distortion as a marker of turbulent structure**
T. Saxton-Fox and B. McKeon. *Southern California Flow Physics Symposium*.
- SEPTEMBER 2015 **Aero-optical distortion as a marker of coherent structure**
International Symposium on Particle Image Velocimetry.
- NOVEMBER 2014 **Simultaneous measurements of aero-optical distortion and turbulent structure in a heated turbulent boundary layer**
T. Saxton-Fox, B. McKeon, A. Smith, and S. Gordeyev. *American Physical Society: Division of Fluid Dynamics*.
- APRIL 2014 **Aero-optical distortions in a low-speed, heated turbulent boundary layer**
T. Saxton-Fox and B. McKeon. *Southern California Flow Physics Symposium*.

OTHER RESEARCH AND PROFESSIONAL EXPERIENCE

- DECEMBER 2017 – **Fluid Mechanics Transport Phenomena**
AUGUST 2018 *Postdoctoral researcher*
PRINCETON Will design and execute new experiments for the Superpipe, a very high-Reynolds number pipe flow facility, in Professor Marcus Hultmark's laboratory. The experiments will focus on adding non-equilibrium pressure gradients and curvature effects, and increasing the experimental flexibility of the facility, to allow for the implementation of complex flow conditions and modern measurement techniques.
- JUNE 2016 – **Center for Turbulence Research Summer Program**
JULY 2016 *Visiting researcher*
STANFORD Studied the instantaneous interaction of velocity features in a turbulent boundary layer. Analyzed and visualized three-dimensional data from a direct numerical simulation of a turbulent boundary layer from Professor Xiaohua Wu of the Royal Military College of Canada. Collaborated with members of the Stanford community towards incorporating scale interaction physics in wall-models for large-eddy simulations of turbulent boundary layers.
- SEPTEMBER 2011 – **Underwater Autonomous Vehicle Recharging System**
JUNE 2012 *Fuel System Team Manager*
MIT Part of the 2.013 and 2.014 engineering systems design class funded by MIT Lincoln Laboratory. Helped create a working prototype of an AUV recharging section that surfaced to run a gasoline engine and recharge batteries. Specifically led the fuel system team, designing a fuel storage and delivery system that maintained neutral buoyancy and moment by taking on water as fuel was used.
- JUNE – AUGUST **777 Engine Control**
2012 *Engineering Intern*
BOEING Certified new software for 777 Rolls Royce engines by performing flight trials on a flight simulator. Supported in-service 777 engines through analysis of engine failure data. Reported findings back to engine companies and customers. Improved and streamlined engine functional tests to reduce costs and pre-delivery time.
- JANUARY 2011 – **PHUMP Heat Transfer Laboratory**
APRIL 2012 *Undergraduate researcher*
MIT Aided in the development and testing of a high power pumped heat exchanger in Professor John Brisson's laboratory. Compiled matrix of copper and monel sinter characteristics, and measured heat transfer properties of fan blades and condenser plates under variable fan speed conditions.
- JUNE – AUGUST **Commercial Operations for Energy Technology**
2011 *Intern*
GENERAL ELECTRIC Developed a project management tool to coordinate and monitor the proposal process for the sale of gas and steam turbines in the Americas, the Middle East, and India. Created a report card to evaluate the cycle time and level of accuracy in the proposal generation process for the sale of power plants globally.
- MAY – JULY **Support Technology for Wind Energy**
2010 *Summer employee*
NRG SYSTEMS Designed packaging for a solar remote power unite using SolidWorks. Evaluated the moments on 80 and 60 meter tilt-up towers that arise during the lifting process. Optically and mechanically measured end-play variation in anemometer components.

MENTORSHIP

MAY – SEPTEMBER 2014 & 2015 CALTECH	SURF Program <i>Mentor of undergraduate researchers</i> Led one undergraduate researcher per summer for two summers. Students worked on a heat transfer experiment funded by Lockheed Martin. Met daily with the students and aided in their development of independence and confidence in choosing parts, building an experimental setup, and running experiments. Also gave guidance on scientific writing and presenting, culminating in the students writing a final report and presenting to employees of Lockheed Martin.
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TEACHING

SEPTEMBER 2016 – JUNE 2017 CALTECH	Experimental Methods (Graduate Level Course) <i>Teaching assistant</i> This course consisted of three terms: a lecture term, a ‘canned’ experimental term, and a free-form project term. Responsibilities included holding office hours, contributing problems to homework assignments, and grading homework and exams (lecture term); setting up and overseeing laboratory experiments and grading laboratory reports (canned experimental term); mentoring two students in a short research project and grading laboratory reports (free-form project term).
OCTOBER – MAY 2012 – 2017 CALTECH Y	Rise Tutoring Program <i>Tutor</i> A volunteer tutoring program for local high school students that are struggling in math and science. I tutored one to two students for two hours a week each academic year, totaling eight students over five years. Responsibilities included tutoring the appropriate level of high school math, physics, chemistry, and biology, in addition to providing mentorship and training students in better study habits.
JANUARY – MARCH 2015 CALTECH	Fluid Mechanics (Undergraduate Level Course) <i>Teaching assistant</i> An introductory course on fluid mechanics for undergraduates in Mechanical Engineering. Responsibilities included a weekly recitation, creating homework solutions, grading homework sets, and grading exams.
SEPTEMBER – JUNE 2009 - 2012 CAMBRIDGE, MA	Tutoring Plus <i>Tutor</i> A volunteer tutoring program for students living in public housing in Cambridge, Massachusetts. I tutored one high school student for three years and provided mentorship.

LEADERSHIP

2013 – 2017 CALTECH Y	Social Activism Speaker Series (SASS) Organizing Committee <i>Chair (2015-2016), Member (2013-2017)</i> Chose, invited, and hosted speakers to discuss a variety of topics from science policy to social justice at Caltech. Organized between one and two speaker events a month, with an average of roughly 40 people per event. Speakers in the 2016-2017 school year included Dr. Rush Holt, CEO of the American Association for the Advancement of Science (AAAS) and Dr. France Cordova, Director of the National Science Foundation (NSF).
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- 2016 – 2017 **Rise Tutoring Advisory Committee**
 CALTECH Y *Member*
 Advised staff at the Caltech Y on methods to improve the Rise tutoring program. Suggested new tools to improve and evaluate student learning, helped identify invited speakers to train the tutors, and aided in reviewing yearly surveys of program participants.
- 2010 – 2012 **Engineers Without Borders, MIT Chapter**
 MIT & *Chapter President 2010-2011, Travel Team Project Manager 2010*
 UGANDA Led efforts to implement solar panels and a battery system in a health care clinic in rural Uganda. Traveled to Uganda as part of this effort as project manager with three other MIT undergraduate students. Coordinated the shipping and importing of the solar panels. The following year, raised \$12,000 to send students back to Uganda to implement a rainwater catchment system.