Ching-Yao Lai

Lamont Doherty Earth Observatory, Columbia University
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Research Interests

Fluid Mechanics, Soft Matter Physics, Climate Science, Machine Learning

Education

Ph.D. in Mechanical and Aerospace Engineering, Princeton University (2013-2018)

Advisor: Howard A. Stone

Thesis title: *Fluid-structure interactions for energy and the environment*

B.S. in Physics, National Taiwan University (2009-2013)

Research Experience

Columbia University, Lamont-Doherty Earth Observatory (Fall 2018-Present)

Lamont Postdoctoral Fellow, Mentors: Jonathan Kingslake, Timothy Creyts, and Roger Buck

- Coupling data-driven models with physics-based models to study the hydrofractures on ice-shelves. (analytic modeling/observation)
- Development of deep convolutional neural network models to identify fracture patterns in observations. (machine learning)
- Relaxation of ice-sheets on a porous bed. (analytic modeling/observation/experiment)

Princeton University, Complex Fluids Group (2013-2018)

PhD Student, Advisor: Howard A. Stone

- Interactions between fluid flow and elastic boundaries, motivated by hydraulic fracturing (experiment/mathematical modeling)
- Fracturing driven by two-phase flow of compressible foam (experiment/mathematical modeling)
- Flows in poroelastic medium (experiment)

Princeton University, The Deike Group (2017-2018)

Visiting PhD Student, Advisor: Luc Deike

- Direct numerical simulation of bubble bursting at the air-sea interface (computation/analytic modeling)

National Taiwan University, Theoretical Nonlinear Physics Group (2012-2013)

Undergraduate Researcher, Advisor: Yih-Yuh Chen

- Interfacial instabilities in torsional flows

Institute of Physics, Academia Sinica (2011-2013)

Undergraduate Researcher, Advisor: Jih-Chiang Tsai

- Interfacial morphology and instabilities in rotating flows, with applications to the air-sea interface (experiment)

Honors

Lamont Doherty Postdoctoral Fellowship (September 2018-Present)

Competitive institutional postdoctoral fellowship awarded by Lamont-Doherty Earth Observatory, Columbia University.

Maeder Graduate Fellowship in Energy and the Environment (June 2017 - June 2018)

Honorific fellowship awarded by the Andlinger Center for Energy and the Environment, Princeton University, in recognition of research accomplishments in energy-related and environmental studies.

Mary and Randall Hack '69 Graduate Award (July 2016 - July 2017)

Awarded by the Princeton Environmental Institute, Princeton University, in support of innovative research on water and water-related topics with implications for the environment.

First Place Award for Achievements in Energy Research (December 2016)

Awarded at the 5th International Education Forum on Environment and Energy Science, San Diego, CA.

Princeton Energy and Climate Scholars (PECS) (June 2016 - May 2018)

An honor society composed of selected Princeton Ph.D. students with research expertise related to the science and policy of energy and climate.

Publications

Under Review

C. Y. Lai, L. A. Stevens, D. L. Chase, T. T. Creyts, M. D. Behn, S. B. Das, H. A. Stone, *"Seasonally evolving bed permeability of the Greenland Ice Sheet"*

Peer Reviewed Articles

C. Y. Lai, J. Kingslake, M. Wearing, P.-H. Cameron Chen, P. Gentine, H. Li, J. Spergel, J. M. van Wessem, *"Vulnerability of Antarctica's ice shelves to meltwater-driven fracture,"* Nature, accepted (2020)

C. Y. Lai, J. Eggers, and L. Deike, *"Bubble bursting: universal cavity and jet profiles,"* Phys. Rev. Lett., **121**, 144501 (2018). doi: 10.1103/PhysRevLett.121.144501

C. Y. Lai, B. Rallabandi, A. Perazzo, Z. Zheng, S. Smiddy, and H. A. Stone *"Foam-driven fracture,"* Proc. Natl. Acad. Sci., 201808068 (2018). doi: 10.1073/pnas.1808068115

H. S. Rabbani, D. Or, Y. Liu, **C. Y. Lai**, N. Lu, S. S. Datta, H. A. Stone, and N. Shokri, *"Suppressing viscous fingering in structured porous media,"* Proc. Natl. Acad. Sci., 201800729 (2018). doi: 10.1073/pnas.1800729115

C. Y. Lai, Z. Zheng, E. Dressaire, G. Ramon, H. E. Huppert, H. A. Stone, *"Elastic relaxation of fluid-driven cracks and the resulting backflow,"* Phys. Rev. Lett., **117**, 268001 (2016). doi: 10.1103/PhysRevLett.117.268001

C. Y. Lai, Z. Zheng, E. Dressaire, H. A. Stone, *"Fluid-driven crack in an elastic matrix in the toughness-dominated limit,"* Invited paper to Philos. Trans. R. Soc. A, **374**, 20150425 (2016). doi: 10.1098/rsta.2015.0425

C. Y. Lai, Z. Zheng, E. Dressaire, J. Wexler, H. A. Stone, *"Experimental study on penny-shaped fluid-driven cracks in an elastic matrix,"* Proc. R. Soc. A, **471**, 20150255 (2015). doi: 10.1098/rspa.2015.0255

J. C. Tsai, C. Y. Tao, Y. C. Sun, **C. Y. Lai**, K. H. Huang, W. T. Juan, and J. R. Huang, *"Vortex-induced morphology on a two-fluid interface and the transitions,"* Phys. Rev. E, **92**, 031002(R) (2015). doi: 10.1103/PhysRevE.92.031002

Energy Policy

G. Davies*, R. Edwards*, **C. Y. Lai***, B. Perry*, and K. Spokas*, *"Institutional Emissions and Energy Planning: Understanding the interactions between carbon accounting, institutional goal setting, and energy procurement,"* published by the Princeton Environmental Institute at Princeton University (2019). *Equally Contributed (report available online)

Presentations

Invited Talks

"How does ice flow and crack in a warming climate?" Climate Seminar Series, Princeton University, NJ (March 2020).

"Fluid-structure interactions for energy and climate," Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, MA (March 2020).

"Fluid-structure interactions for energy and climate," Department of Physics and Astronomy, University of Pennsylvania, PA (February 2020).

"Hydrofractures: How meltwater impacts ice sheets and ice shelves," The School of Earth and Atmospheric Sciences, Georgia Institute of Technology, GA (February 2020).

"Fluid-structure interactions for energy and climate," The Rowland Institute at Harvard, Harvard University, MA (September 2019).

"The physics of fluid-driven fractures with applications in hydrofracturing and calving," Division of Marine Geology and Geophysics, Lamont-Doherty Earth Observatory, Columbia University, NY (November 2017).

"A laboratory-scale model of hydraulic fracturing and the resulting flowback," The 5th International Education Forum on Environment and Energy Science, San Diego, CA (December 2016).

"An experimental model of hydraulic fracturing in a homogeneous elastic reservoir," Society of Engineering Science 53rd Annual Technical Meeting, College Park, MD (October 2016).

"Experimental study on fluid-driven cracks and backflow in an elastic matrix," School of Mechanical Engineering, Purdue University, West Lafayette, IN (May 2016).

Seminar Talks

"Physics of hydrofracturing and its impact on ice-shelf vulnerability," Division of Marine Geology and Geophysics, Lamont-Doherty Earth Observatory, Columbia University, NY (March 2019).

"The simplicity in complexity: The simple scaling laws for hydraulic fractures," Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, NJ (May 2015).

Conference Talks

C. Y. Lai, J. Kingslake, M. Wearing, P.-H. Cameron Chen, P. Gentine, H. Li, J. Spergel, J. M. van Wessem, *"Vulnerability of Antarctica's ice shelves to meltwater-driven fracture"* American Geophysical Union Fall Meeting, San Francisco, CA (December 2019)

C. Y. Lai, D. L. Chase, L. A. Stevens, T. T. Creyts, H. A. Stone, *"Relaxation of ice-sheet uplift on a porous bed"* 72th Annual Meeting of the American Physical Society's Division of Fluid Dynamics, Seattle, CA (November 2019).

C. Y. Lai, J. Kingslake, M. Wearing, P.-H. Cameron Chen, P. Gentine, H. Li, J. Spergel, J. M. van Wessem, *"Vulnerability of Antarctica's ice shelves to meltwater-driven fracture"* West Antarctica Ice Sheet Workshop, Julian, CA (October 2019)

C. Y. Lai, J. Eggers, L. Deike, *"Bubble bursting: universal cavity and jet profiles"* 71th Annual Meeting of the American Physical Society's Division of Fluid Dynamics, Atlanta, GA (November 2018).

C. Y. Lai, B. Rallabandi, A. Perazzo, S. Hilgenfeldt, S. Smiddy, H. A. Stone, *"Foam relaxation in fractures and narrow channels"* 70th Annual Meeting of the American Physical Society's Division of Fluid Dynamics, Denver, CO (November 2017).

C. Y. Lai, Z. Zheng, E. Dressaire, G. Ramon, H. E. Huppert, H. A. Stone, *"Elasticity-driven backflow of fluid-driven cracks"* 69th Annual Meeting of the American Physical Society's Division of Fluid Dynamics, Portland, OR (November 2016).

C. Y. Lai, S. Smiddy, H. A. Stone, *"Foam-driven fractures of an elastic matrix"* 68th Annual Meeting of the American Physical Society's Division of Fluid Dynamics, Boston, MA (November 2015).

C. Y. Lai, Z. Zheng, E. Dressaire, J. Wexler, H. A. Stone, *"Fluid-driven fracture of elastic reservoirs followed by viscous backflow"* 67th Annual Meeting of the American Physical Society's Division of Fluid Dynamics, San Francisco, CA (November 2014).

C. Y. Lai, Y. T. Sun, C. C. Chang, Y. Y. Chen, P. Arratia, J. C. Tsai, *"Interfacial Instabilities in Torsional Flows"* 65th Annual Meeting of the American Physical Society's Division of Fluid Dynamics, San Diego, CA (November 2012).

Poster Presentations

C. Y. Lai, J. Kingslake, H. Li, P. Gentine, *"Using convolutional neural networks to identify fracture patterns in satellite imagery of Antarctica,"* 2019 New York Scientific Data Summit, Columbia University, New York, NY (June 2019).

C. Y. Lai, Z. Zheng, B. Rallabandi, S. Smiddy, E. Dressaire, H. A. Stone, *"Fluid-driven fracture: scaling, flowback, and foams,"* 7th Northeast Complex Fluids and Soft Matter workshop, Princeton University, Princeton, NJ (May 2017).

C. Y. Lai, Z. Zheng, K. Hyoungsoo, H. A. Stone, *"Experimental study on fluid-driven cracks and backflow in an elastic matrix,"* 8th International Conference on Porous Media Annual Meeting, Cincinnati, OH (May 2016).

C. Y. Lai, Z. Zheng, E. Dressaire, J. Wexler, H. A. Stone, *"Fluid-driven Fracture of Elastic Matrix Followed by Backflow,"* 14th Carbon Mitigation Initiative Annual Meeting, Princeton University, Princeton, NJ (April 2015).

C. Y. Lai, Y. T. Sun, C. C. Chang, Y. C. Lin, and J. C. Tsai, *"Morphology and Pattern Formation at a Rotating Fluid-fluid Interface."* Conference of Nonlinear Dynamics and Fluid Instabilities in the 21st Century (a conference in honor of Jerry Gollub), Haverford College, Haverford, PA (May 2011).

Grant Writing Experience

Lead PI of NSF proposal *"Predicting and mapping surface crevasses using physics-based models and neural networks"*, submitted in April 2019

PI of proposal *"Flowback dynamics and reduction of water use in hydraulic fracturing"* funded by the Princeton Environmental Institute, Princeton University (2016-2017)

Outreach

Prison Teaching Initiative, Garden State Youth Correctional Facility, Crosswicks, NJ

An initiative aiming to reduce incarceration rates in New Jersey by increasing access to post-secondary education in state prisons.

Volunteer Instructor - “Elementary algebra" (Spring 2017)

Climate Education, Princeton Day School, Princeton, NJ

Strengthen climate education in a local high school via discussions on policies and technologies for mitigating climate change, led by Princeton PhD students.

Volunteer Speaker - “Technological solutions for climate change" (Spring and Fall 2017)

Teaching

Princeton University

Teaching Assistant - “Mathematics in Engineering". Teaching evaluation score: 4.6/5 (Fall 2017)

Teaching Assistant - “Mechanics of Fluids". (Spring 2015 and 2016)

Mentoring

Complex Fluids Group, Princeton University

Mentored PhD student Danielle Chase with her first PhD project (Summer 2018)

Mentored undergraduate student Samuel Smiddy with his senior thesis research (2015 - 2018)

Mentored visiting master’s student Minh Pham from Ecole Polytechnique, France. (Summer 2016)

Leadership Experience

Sustainability Chair (2016 - 2018)
Department of Mechanical and Aerospace Engineering, Princeton University

Initiate a composting pilot program and promote waste reduction for departmental events.

Speaker Coordinator (2017 - 2018)
Princeton Energy and Climate Scholars, Princeton University

Organize seminars and invite faculty speakers from multidisciplinary backgrounds across engineering, science, history, art, and public policy to present their research related to energy and climate.

Graduate Student Committee (2014 - 2018)
Department of Mechanical and Aerospace Engineering, Princeton University

Serve as a liaison between graduate students and the department.

Vice President (2015 - 2016)
Princeton Association of Taiwanese Students, Princeton University

President (2012 - 2013)
Association of Non-Linear Science, National Taiwan University

Developed traffic and disease spreading models.