Pavel P. Popov, Ph.D.

Assistant Professor, Aerospace Engineering, San Diego State University

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EDUCATION

Ph. D., Aerospace Engineering
Cornell University, Jan. 2013
Concentrations in Aerospace Engineering, Fluid Mechanics, and Mathematics
Dissertation: "Advances in Particle/Finite Volume Algorithms for Turbulent Reactive Flows"
Advisor: Stephen B. Pope

M.S., Aerospace Engineering
Cornell University, Feb. 2010

B.S., Mechanical Engineering (summa cum laude)
Cornell University, Jan. 2007

RESEARCH EXPERIENCE

San Diego State University, Dept. of Aerospace Engineering

Assistant Professor, 2019-present

- I perform computational studies of plasma-coupled combustion processes. The research focus is on understanding the early time interactions between plasma and neutral chemistry in laser-induced breakdown ignition of a premixed reactant mixture. Additionally, I perform research in ignition identification criteria during the radical induction period of a given flow.

University of Illinois at Urbana-Champaign, Coordinated Science Laboratory

Research Scientist, 2016-2019

Plasma-Coupled Turbulent Combustion Simulations

Principal Investigator: Jonathan B. Freund

- I perform computational studies on plasma-stabilized turbulent reactive flows. I contribute to the development of a complex mesh, fourth-order multi-physics reacting flow solver. The research focus is on identifying the essential physical mechanisms in the ignition of a hydrogen jet in air cross-flow. A detailed chemical mechanism for hydrogen ignition is utilized, and uncertainty quantification of the effect of different chemical kinetic rates on the ignition characteristics of the flame is performed. Machine learning models are developed for the prediction of ignition at an early stage of the simulation.

UC – Irvine, Mechanical and Aerospace Engineering

Post-Doctoral Fellow, 2012-2016

Acoustic Instability in Liquid-Propellant Rocket Engines

Principal Investigator: William A. Sirignano

- I performed computational studies on the development and growth of acoustic instabilities in liquid-propellant rocket engines. Stochastic computational algorithms were employed to account for the randomness in the instability-generating disturbance. The project developed strategies for the prevention of acoustic instabilities, via active and/or passive control – a number of strategies for instability prevention were successfully identified. The computational algorithms used for this project were developed in-house during the project's initial stages – very good agreement between simulated results and existing experimental measurements was achieved.

Cornell University, Mechanical and Aerospace Engineering

Graduate Research Assistant, 2007-2012

Particle/Finite Volume Algorithms for Turbulent Reactive Flows

Principal Investigator: Stephen B. Pope

- I performed computational studies on the basic physical mechanisms of turbulent reactive flows, with special emphasis on turbulence-chemistry interactions. I developed original computational routines, which were then integrated into an overall code. The work was done as part of a group project which lead to the development of a highly-accurate particle/finite volume code. This code was then used to perform simulations of laboratory flames and examine the fundamental mechanisms of turbulent reactive flows. Very good agreement between simulated results and experiment was achieved.

TEACHING EXPERIENCE

San Diego State University, Aerospace Engineering

Assistant Professor, 2019-present

- I currently teach San Diego State University's course on Rocket and Space propulsion

University of Illinois at Urbana-Champaign, Coordinated Science Laboratory

Undergraduate Research Advisor

- I serve as the advisor for an undergraduate research project on the application of machine learning (ML) to computational combustion. As part of this role, I have weekly meetings with my advisee, provide him with data to train his models on, and suggest solutions to problems he may encounter.

UC – Irvine, Mechanical and Aerospace Engineering

Lecturer, 2014-2015

- I taught the Summer and Fall session offerings of Heat and Mass Transfer (ENGRMAE 120), and the Spring session offering of Viscous and Compressible Flow (ENGRMAE 130B). Both are 4-credit courses in the junior-level mechanical and aerospace engineering curriculum. The average

class size was 50 students. In addition to lecturing and the preparation of course materials, responsibilities included the supervision of teaching assistants for the respective courses.

Graduate Student Co-Advisor, 2013-2016

- I served as co-advisor to a graduate student in the department of Mechanical and Aerospace Engineering; the principal advisor was William Sirignano. Duties as co-advisor included guiding the student through the successful implementation of numerical algorithms required for his research, and assisting in the debugging stage of these algorithms.

Cornell University, Mechanical and Aerospace Engineering

Teaching Assistant, 2006-2009

- During my PhD program, and in my last semester as an undergraduate, I was a teaching assistant for junior-level Fluid Dynamics and Heat Transfer courses, and a senior level Fluids and Heat Transfer laboratory course. Duties included holding office hours, grading student work, and the instruction and supervision of students during lab experiments.

GRANTS AND AWARDS

- AFOSR grant FA9550-12-1-0156 (for the period 2015-2018): co-authored the successful grant continuation proposal
- Cornell Fluid Dynamics Seminar – Jayesh prize for outstanding presentation, 2011
- APSDFD Gallery of Fluid Motion Poster Award, 2016

PUBLICATIONS

Published in Peer-Reviewed Journals

1/ Popov, P.P., Buchta, D.A., Anderson, M.J., Massa, L., Capecelatro, J., Bodony, D.J. and Freund, J.B., *Machine Learning-Assisted Early Ignition Prediction in a Complex Flow, Combustion and Flame*, **206,** pp. 451-466, 2019

2/ Nguyen, T.M., **Popov, P.P.**, and Sirignano, W.A., *Longitudinal Combustion Instability in a Rocket Engine with a Single Coaxial Injector*, Journal of Propulsion and Power, 2017, https://doi.org/10.2514/1.B36516

3/ Popov, P.P., Sideris, A., and Sirignano, W.A., *Low-probability Events Leading to Rocket Engine Combustion Instability*, AIAA Journal, **55,** (3), pp. 919-929, 2017

4/ Jarrahbashi, D., Sirignano, W.A., **Popov, P.P.,** and Hussain, F., *Numerical Simulation of Liquid Round Jet Atomization*, Physical Review Fluids, **2,** 090504, 2017

5/ Popov, P.P., and Sirignano, W.A., *Transverse Combustion Instability in a Rectangular Rocket Motor*, Journal of Propulsion and Power, **32**, (1), 2016, pp. 620-627

6/ Jarrahbashi, D., Sirignano, W.A., **Popov, P.P.,** and Hussain, F., *Early Spray Development at High Gas Density: Hole, Ligament and Bridge Formations*, Journal of Fluid Mechanics, **792**, 2016, pp. 186-231

7/ Popov, P.P., Sideris, A, and Sirignano, W.A., *Triggering and Restabilization of Combustion Instability with Rocket Motor Acceleration*, AIAA Journal, **54**, (4), 2016, pp. 1652-1659

8/ Popov, P.P., Sirignano, W.A., and Sideris, A., *Propellant Injector Influence on Liquid-Propellant Rocket Engine Instability*, Journal of Propulsion and Power, **31,** 2015, pp. 320-331

9/ Popov, P.P., Sideris, A., and Sirignano, W.A., *Stochastic Modelling of Transverse Wave Instability in a Liquid-Propellant Rocket Engine*, Journal of Fluid Mechanics, **745**, 2014, pp. 62-91

10/ Popov, P.P., and Pope, S.B., *Large Eddy Simulation/Probability Density Function Simulations of Bluff-Body Stabilized Flames*, Combustion and Flame, **161**, 2014, pp. 3100-3133

11/ Popov, P.P., and Pope, S.B., *Implicit and Explicit Schemes for Mass Consistency Preservation in Hybrid Particle/Finite-Volume Algorithms for Turbulent Reactive Flows*, Journal of Computational Physics, **257**, 2014, pp. 352-373

12/ Sirignano, W.A., and **Popov, P.P.,** *Two-Dimensional Model for Liquid-Rocket Transverse Combustion Instability,* AIAA Journal, **51**, 2013, pp. 2919-2934

13/ Popov, P.P., and Pope, S.B., *The Direct Richardson p-th Order (DRP) Schemes: A New Class of Time Integration Schemes for Stochastic Differential Equations*, SIAM Journal on Scientific Computing, **34**, 2012, pp. A137-A160

14/ Popov, P.P., Wang, H., and Pope, *S.B., Specific Volume Coupling and Convergence Properties in Hybrid Particle/Finite Volume Algorithms for Turbulent Reactive Flows*, Journal of Computational Physics, **294**, 2015, pp.110-126

15/ Wang, H., **Popov, P.P.**, and Pope, S.B., *Weak Second Order Splitting Schemes for Lagrangian Monte Carlo Particle Methods for the Composition PDF/FDF Transport Equations*, Journal of Computational Physics, **229**, 2010, pp. 1852-1878

16/ Popov, P.P., McDermott, R., and Pope, S.B., *An Accurate Time Advancement Algorithm for Particle Tracking*, Journal of Computational Physics, **227**, 2008, pp. 8792-8806

Conference Presentations

19/ Popov, P.P., Du, H., and Freund, J.B., *Machine Learning Methods for Early Prediction of Sustained Ignition*, **71st APS/DFD Meeting,** Atlanta, GA, Nov. 2018

20/ Buchta, D., **Popov, P.P.,** Movahed, P., and Freund, J.B., *Transient Laser-Induced Ignition Kernels in Supersonic Flow*, **71st APS/DFD Meeting,** Atlanta, GA, Nov. 2018

21/ Popov, P.P., Buchta, D.A., Anderson, M.J., Tang, K., and Freund, J.B., *Ignition Prediction in a Hydrogen Jet in Turbulent Crossflow by a Laser-Induced Breakdown*, **70th APS/DFD Meeting,** Denver, CO, Nov. 2017

22/ Popov, P.P., Sideris, A., and Sirignano, W.A., *Low-Probability Events Leading to Rocket Engine Combustion Instability*, **54th AIAA Aerospace Sciences Meeting,** San Diego, CA, Jan. 2016

23/ Jarrahbashi, D., Sirignano, W.A., **Popov, P.P.,** and Hussain, F., *Computational Simulation of Liquid Round Jet Atomization*, **69th APS/DFD Meeting,** Portland, OR, Nov. 2016

24/ Popov, P.P., and Sirignano, W.A., *Simulation of High-Pressure Methane Hydrate Combustion*, **68th APS/DFD Meeting,** Boston, MA, Nov 2015

25/ Popov, P.P., and Sirignano, W.A., *Simulation of Small-Scale Liquid Film Combustors*, **68th APS/DFD Meeting,** Boston, MA, Nov 2015

26/ Popov, P.P., Sideris, A, and Sirignano, W.A., *Uncertainty Quantification of Non-Linear Oscillation Triggering in a Multi-Injector Liquid Propellant Rocket Combustion Chamber*, **67th APS/DFD Meeting,** San Francisco, CA, Nov. 2014

27/ Popov, P.P., Sideris, A., and Sirignano, W.A.,*Propellant Injector Influence on Liquid Propellant Rocket Engine Instability*, **52nd Aerospace Sciences Meeting,** Jan. 2014, National Harbor, Maryland

28/ Popov P.P., Sideris, A., and Sirignano, W.A.,*Stochastic Modeling of Transverse Wave Instability in a Liquid Propellant Rocket Engine*, **49th Joint Propulsion Conference**, July 2013, San Jose, California

29/ Popov P.P., Viswanathan, S., Wang, H., and Pope, S.B., *Coupling in Hybrid Particle/Finite Volume Algorithms for Turbulent Reactive Flows*, **7th US National Combustion Meeting**, Mar.2011, Atlanta, Georgia

30/ Popov, P.P., Wang, H., and Pope, S.B., *Stability and Accuracy of Coupling Strategies in Hybrid LES/PDF Algorithms for Turbulent Reactive Flows*, **63rd Annual Meeting of the APS Division of Fluid Dynamics,** Nov. 2010, Long Beach, California

31/ Popov, P.P. and Pope, S.B. *Stochastic Particle Advection for Hybrid Large Eddy Simulation / Filtered Density Function Methods*, **61st Annual Meeting of the APS Division of Fluid Dynamics,** Nov. 2008, San Antonio, Texas

32/ Popov, P.P., and Pope, S.B., *An Accurate Time Advancement Algorithm for Particle Tracking*, **60th APS/DFD Meeting**, Nov. 2007, Salt Lake City, Utah

PROFESSIONAL SOCIETIES

American Physical Society (APS)

American Society of Mechanical Engineers (ASME)

American Institute of Aeronautics and Astronautics (AIAA)

The Combustion Institute