

# Fujia Wu

Postdoctoral Research Associate

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## Education

- Ph.D. 2014**      **Princeton University, Princeton, NJ**  
Mechanical and Aerospace Engineering  
• Advisor: Prof. Chung K. Law  
• Thesis: “Dynamics, Instabilities and Chemistry of Laminar and Turbulent Flames”
- M.A. 2010**      **Princeton University, Princeton, NJ**  
Mechanical and Aerospace Engineering
- M.E. 2008**      **Tsinghua University, Beijing, China**  
Power Engineering and Engineering Thermophysics  
• Thesis: “Using Biodiesel Based Oxygenated Blend Fuels for Reducing Emissions from Diesel Engines”
- B.E. 2006**      **Tsinghua University, Beijing, China**  
Vehicle Engineering

## Honors and Awards

- **Bernard Lewis Fellowship**, The Combustion Institute, 2014 (to encourage high quality research in combustion by young scientists and engineers, awarded to no more than five recipients in the world every two years)
- **Runner-up for the Best Presentation**, “Ignition, Propagation and Acceleration of Expanding Flames”, MAE Annual Research Day Prize, Princeton University, September 13, 2013
- **First Place Award**, “Three Faces of An Expanding Flame”, Technical Merit of the Combustion Art Competition, 8th U.S. National Combustion Meeting, Park City, Utah, May 19-22, 2013
- **Best Presentation Award**, “New Fundamental Understandings of Flame Chemistry and Dynamics from Experimentation on Expanding Flames”, First International Education Forum on Environment and Energy Science, Hawaii, December 14-18, 2012
- **George H. Markstein Best Paper Award**, “Laminar Flame Speeds of Cyclohexane and Mono-alkylated Cyclohexanes at Elevated Pressures”, Technical Meeting of the Eastern States Section of the Combustion Institute, University of Connecticut, Storrs, Connecticut, October 9-12, 2011
- **Cummins Merit Fellowship**, Princeton University, 2008
- **Excellent Undergraduate Award**, Tsinghua University, 2004, 2005

## Publications

### Peer-Reviewed Journal Articles

1. Chung K. Law, **Fujia Wu**, Fokion N. Egolfopoulos, Vyaas Gururajan, and Hai Wang. On the rational interpretation of data on laminar flame speeds and ignition delay times. *Combustion Science and Technology*, 2015; 187: 27-36
2. **Fujia Wu**, Wenkai Liang, Zheng Chen, Yiguang Ju, and Chung K. Law. Uncertainty in stretch extrapolation of laminar flame speed from expanding spherical flames. *Proceedings of the Combustion Institute*, 2015; 35: 663-670
3. **Fujia Wu**, Abhishek Saha, Swetaprovo Chaudhuri, and Chung K. Law. Propagation speeds of expanding turbulent flames of  $C_4$  to  $C_8$  *n*-alkanes at elevated pressures: experimental determination, fuel similarity, and stretch-affected local extinction. *Proceedings of the Combustion Institute*, 2015; 35: 1501-1508
4. Xiaoyu Li, Xiaoqing You, **Fujia Wu**, and Chung K. Law. Uncertainty analysis of the kinetic model prediction for high-pressure  $H_2/CO$  combustion. *Proceedings of the Combustion Institute*, 2015; 35: 617-624
5. **Fujia Wu**, Abhishek Saha, Swetaprovo Chaudhuri, and Chung K. Law. Facilitated ignition in turbulence through differential diffusion. *Physical Review Letters*, 2014; 113: 024503
6. Swetaprovo Chaudhuri, **Fujia Wu**, and Chung K. Law. Turbulent flame speed scaling for expanding flames with Markstein diffusion considerations. *Physical Review E*, 2013; 88: 033005
7. **Fujia Wu** and Chung K. Law. An experimental and mechanistic study on the laminar flame speed, Markstein length and flame chemistry of the butanol isomers. *Combustion and Flame*, 2013; 160: 2744-2756
8. **Fujia Wu**, Grunde Jomaas, and Chung K. Law. An experimental investigation on self-acceleration of cellular spherical flames. *Proceedings of the Combustion Institute*, 2013; 34: 937-945
9. **Fujia Wu**, Andrew P. Kelley, and Chung K. Law. Laminar flame speeds of cyclohexane and mono-alkylated cyclohexanes at elevated pressures. *Combustion and Flame*, 2012; 159: 1417-1425
10. Swetaprovo Chaudhuri, **Fujia Wu**, Delin Zhu, and Chung K. Law. Flame speed and self-similar propagation of expanding turbulent premixed flames. *Physical Review Letters*, 2012; 108: 044503
11. **Fujia Wu**, Andrew P. Kelley, Chenglong Tang, Delin Zhu, and Chung K. Law. Measurement and correlation of laminar flame speeds of CO and  $C_2$  hydrocarbons with hydrogen addition at atmospheric and elevated pressures. *International Journal of Hydrogen Energy* 2011; 36 (20): 13171-13180
12. Jianxin Wang, **Fujia Wu**, Jianhua Xiao, and Shijin Shuai. Oxygenated blend design and its effects on reducing diesel particulate emissions. *Fuel* 2009; 88: 2037-2045
13. **Fujia Wu**, Jianxin Wang, Wenmiao Chen, and Shijin Shuai. A study on emission performance of a diesel engine fueled with five typical methyl ester biodiesels. *Atmospheric Environment* 2009; 43 (7): 1481-1485
14. Xu He, Xiao Ma, **Fujia Wu**, and Jianxin Wang. Visualization investigation of soot characteristics of engine fuelled with biodiesel fuel. *Chinese Internal Combustion Engine Engineering* 2009; 30(2): 1-5
15. Xu He, Xiao Ma, **Fujia Wu**, and Jianxin Wang. Investigation on the soot formation of biodiesel fuel by laser diagnostics. *Chinese Internal Combustion Engine Engineering* 2009; 30(1): 1-5
16. Wenmiao Chen, **Fujia Wu**, Jianxin Wang, and Shijin Shuai. Effect of cetane number on combustion and emission of a Euro-IV diesel engine. *Chinese Internal Combustion Engine Engineering* 2008; 29(6): 1-5

## Conference Publications

1. **Fujia Wu**, Abhishek Saha, Swetaprovo Chaudhuri, and Chung K. Law. An investigation on fuel similarity of turbulent flames for  $C_4$ - $C_8$  *n*-Alkanes. *Technical Meeting of the Eastern States Section of the Combustion Institute*, Clemson University, South Carolina, October 13-16, 2013
2. **Fujia Wu**, Wenkai Liang, Chung K. Law, and Zheng Chen. On the uncertainty of extrapolation of laminar flame speed and Markstein length from expanding spherical flames. *Technical Meeting of the Eastern States Section of the Combustion Institute*, Clemson University, South Carolina, October 13-16, 2013
3. **Fujia Wu** and Chung K. Law. Laminar flame speed, Markstein length and flame chemistry of the butanol isomers from 1 atm to 5 atm. *8th US National Combustion Meeting*, Park City, Utah, May 19-22, 2013
4. **Fujia Wu**, Grunde Jomaas, and Chung K. Law. On self-acceleration of cellular spherical flames. *Technical Meeting of the Eastern States Section of the Combustion Institute*, University of Connecticut, Storrs, Connecticut, October 9-12, 2011
5. **Fujia Wu**, Andrew Kelley, and Chung K. Law. Laminar flame speeds of cyclohexane and mono-alkylated cyclohexanes at elevated pressures. *Technical Meeting of the Eastern States Section of the Combustion Institute*, University of Connecticut, Storrs, Connecticut, October 9-12, 2011 (George H. Markstein Best Paper Award)
6. **Fujia Wu**, John Bechtold, and Chung K. Law. Effects of variable thermodynamic and transport properties on Markstein number and flame front stability. *Technical Meeting of the Eastern States Section of the Combustion Institute*, University of Connecticut, Storrs, Connecticut, October 9-12, 2011
7. Swetaprovo Chaudhuri, **Fujia Wu**, Delin Zhu, and Chung K. Law. Turbulent flame speeds and self similarity of expanding premixed flames. *Technical Meeting of the Eastern States Section of the Combustion Institute*, University of Connecticut, Storrs, Connecticut, October 9-12, 2011
8. **Fujia Wu**, Andrew P. Kelley, Delin Zhu, and Chung K. Law. Further study on effects of hydrogen addition on laminar flame speeds of fuel-air mixtures. *7th US National Combustion Meeting*, Atlanta, Georgia, March 20-23, 2011
9. **Fujia Wu**, Jianxin Wang, Wenmiao Chen, and Shijin Shuai. Effects of different biodiesels and their blends with oxygenated additives on emissions from a diesel engine. SAE Technical Paper 2008-01-1812, *Society of Automotive Engineers Fuels and Lubricants Congress*, Shanghai, China, June 23-26, 2008
10. Xu He, Xiao Ma, **Fujia Wu**, Jianxin Wang, and Shijin Shuai. Investigation of soot formation in laminar diesel diffusion flame by two-color laser induced incandescence. SAE Technical Paper 2008-01-1064, *Society of Automotive Engineers World Congress*, Detroit, USA, April 14-17, 2008
11. Wenmiao Chen, Jianxin Wang, Shijin Shuai, and **Fujia Wu**. Effects of fuel quality on a Euro IV diesel engine with SCR after-treatment. SAE Technical Paper 2008-01-0638, *Society of Automotive Engineers World Congress*, Detroit, USA, April 14-17, 2008
12. Wenmiao Chen, **Fujia Wu**, Jianxin Wang, and Shijin Shuai. Effects of diesel fuel quality on engine emission characteristics. *Chinese Automotive Powertrain Conference*, Tianjin, China, September 6-9, 2007
13. Wenmiao Chen, Jianxin Wang, Shijin Shuai, and **Fujia Wu**. Effect of sulfur in diesel fuel on engine performance. *First Meeting of Oil Product and Clean Fuels Branch of Chinese Society for Internal Combustion Engines*, Beijing, China, May 20-21, 2007

## Conference Abstracts

1. **Fujia Wu**, Abhishek Saha, Swetaprovo Chaudhuri, Sheng Yang, and Chung K. Law. Similarity and

scaling of turbulent flame speeds for expanding premixed flames of C<sub>4</sub>-C<sub>8</sub> *n*-alkanes. *66th Annual Meeting of the APS Division of Fluid Dynamics*, Pittsburgh, Pennsylvania, November 24-26, 2013

2. **Fujia Wu** and Chung K. Law. Three faces of an expanding flame. *Princeton Research Symposium*, Princeton, NJ, October 20, 2013
3. **Fujia Wu** and Chung K. Law. Ignition, Propagation and Acceleration of Expanding Flames, *Princeton University MAE Annual Research Day*, Princeton, New Jersey, September 13, 2013 (Runner-up for the Best Presentation)
4. **Fujia Wu** and Chung K. Law. New fundamental understandings of flame chemistry and dynamics from experimentation on expanding premixed flames. *The First International Education Forum on Environment and Energy Science*, Hawaii, December 14-18, 2012 (Best Presentation Award)
5. Swetaprovo Chaudhuri, **Fujia Wu** and Chung K. Law. Turbulent flame speed scaling for positive Markstein number expanding flames in near isotropic turbulence. *65th Annual Meeting of the APS Division of Fluid Dynamics*, San Diego, California, November 18-20, 2012
6. Swetaprovo Chaudhuri, **Fujia Wu**, Delin Zhu and Chung K. Law. Turbulent flame speed and self similarity of expanding premixed flames. *64th Annual Meeting of the APS Division of Fluid Dynamics*, Baltimore, Maryland, November 20-22, 2011
7. Xu He, Xiao Ma, **Fujia Wu**, and Jianxin Wang. Investigation of soot formation in the oxygenated fuels flame by laser induced fluorescence and incandescence. *7th International Conference on Modeling and Diagnostics for Advanced Engine Systems*, Sapporo, Japan, June 28-31, 2008

## Patents

1. Jianxin Wang, **Fujia Wu**, Jianhua Xiao, and Shijin Shuai. Oxygen-containing blended fuel for reducing small particle emission of diesel car. Publication No. CN 101338227, Published in People's Republic of China on January 7, 2009 (in Chinese)

## Research Experience

### Postdoctoral Research Associate, Princeton University, 10/2014-present

- Led research projects funded by Air Force Office of Scientific Research (AFOSR) and DOE.
- Experimentation and computational multi-scale adaptive modeling of the propagation and structure of turbulent premixed flames subjected to flamefront instabilities at high pressure and high Reynolds number conditions.
- Experimentation, direct numerical simulation (DNS) and reduce-order modeling of point-source initiation of premixed expanding flames with influence of low temperature combustion chemistry.
- Development of computational algorithms for the reduction and analysis of complex reaction networks.

### Graduate Research Assistant, Princeton University, 09/2008-10/2014

- Led research projects funded by Air Force Office of Scientific Research (AFOSR) and DOE.
- Developed a unique dual-chamber, high-pressure, fan-stirred, preheated combustion vessel for studying both laminar and turbulent flames with well-defined initial and boundary conditions.
- Developed time-resolved high-speed Schlieren imaging and particle image velocimetry (PIV) system.
- Computed the propagation and internal chemical structure of laminar premixed flames using direct numerical simulation (DNS) of multi-component Navier-Stokes equations with detailed chemistry.
- Developed a software tool (using Java) for displaying and analyzing informatics of complex chemistry

in flames allowing the discoveries of important scientific insights in combustion chemistry.

- Acquired high-pressure laminar flame speed data for various fuels, including  $H_2$ , carbon monoxide,  $C_1$ - $C_8$  *n*-alkanes,  $C_6$ - $C_8$  cyclo-alkanes, butanols, dimethyl ether (DME), toluene and xylenes, and quantified the experimental uncertainty.
- Acquired turbulent flame speed data at various conditions for various fuels, including hydrogen,  $C_1$ - $C_8$  *n*-alkanes, ethylene, dimethyl ether (DME) at turbulent Reynolds number up to 16,000.
- Explained the fundamental reason why cyclohexane has higher flame speeds than mono-alkylated cyclohexanes, and why the general rule that branching of fuel molecule lowers flame speed for hydrocarbons can also be applied to alcohols.
- Discovered that unstable flames due to hydrodynamic instability always undergo strong acceleration, with propagation speed being non-integer powers of flame radius, suggesting fractal geometry.
- Discovered that for normal conditions turbulent flame speed scales well with a Reynolds number defined based on the properties of the laminar flamelet; however, for lean burning of heavy hydrocarbon fuels, stretch-induced local extinction destroys this scaling.
- Discovered that turbulence can facilitate spark ignition when the thermal diffusivity sufficiently exceeds the mass diffusivity of the deficient species.
- Quantified the systematic uncertainty associated with experimental determination of the laminar premixed flame speeds using direct numerical simulations (DNS) and multivariable regression analysis.
- Theoretically analyzed the diffusion-reaction structure of premixed flames using large activation energy asymptotic analysis based on one-step chemistry.

#### **Graduate Research Assistant, Tsinghua University, 09/2005-07/2008**

- Led research projects funded by automotive industry.
- Developed a method for sampling and separating engine-emitted particulate matter into soot, sulfate and organic fraction.
- Evaluated the engine performance of five typical biodiesels made from different source materials.
- Based on oxygen content and autoignition tendency, designed a novel fuel blend using regular diesel, biodiesel and ethanol (or dimethyl carbonate), which could reduce engine-emitted particulate by 80%.
- Both  $NO_x$  and soot emissions were reduced simultaneously and Euro IV test was passed without any after-treatment device.

## Teaching Experience

### **• Teaching Assistant for “MAE305-MAT301, Mathematics in Engineering”**

Fall 2011, Princeton University

Instructor: Prof. Howard A. Stone

Responsibilities: Gave weekly precept lectures, designed and graded homework and exams.

### **• Teaching Assistant for “MAE322, Mechanical Design”**

Spring 2011, Princeton University

Instructor: Prof. Daniel M. Nosenchuck

Responsibilities: Guided course projects in machine shop, graded project demonstration and reports.

### **• Teaching Assistant for “MAE423, Heat Transfer”**

Fall 2010, Princeton University

Instructor: Prof. Frederick L. Dryer

Responsibilities: Gave weekly precept lectures and classroom lecture on “Numerical Methods”.