Joseph K. Lefkowitz

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Faculty of Aerospace Engineering
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Education

Princeton University Princeton, NJ
Ph.D., Mechanical and Aerospace Engineering January 2016
Concentration: Combustion
Adviser: Prof. Yiguang Ju

Johns Hopkins University Baltimore, MD
B.S., Mechanical Engineering May 2009
Minor: Mathematics

Research Interests

Experimental and numerical energy conversion physics, including combustion and plasma chemical kinetics, flame initiation dynamics, quantitative laser diagnostics, characterization of alternative fuels, and flame stability.

Research Experience

Air Force Research Laboratory Wright Patterson AFB, OH
NRC Research Associate January 2016 – September 2017

Research in the area of hypersonic propulsion focusing on ignition in scramjet engine environments and fundamental studies of plasma-assisted ignition.

1) Experimental study of ignition using nanosecond duration repetitively pulsed spark discharges in a Mach 2-4 flow field similar to scramjet engine conditions, utilizing a range of optical diagnostics to explore the transient phenomena and optimize the ignition characteristics.
2) Study of ignition dynamics in well defined subsonic flow field to explore the optimal plasma discharge parameters for ignition in non-quiescent environments, focusing primarily on the relationship between pulsed discharge frequency and energy with ignition probability and ignition kernel development rate.
3) Investigation of ignition in a well-stirred reactor with residence times in the 10 – 100 ms range, similar to gas turbine engines and scramjet cavities, focusing on the relationship between residence time, turbulence intensity, and fuel reactivity with ignition probability and flame development rate.

Princeton University Mechanical and Aerospace Engineering
Doctoral Research September 2009 – January 2016

Research focused on plasma-assisted combustion experiments and modeling, quantitative laser diagnostics, and flame initiation dynamics.

1) Experimental and numerical investigation of plasma-assisted combustion kinetics.
    - Direct measurement of excited atomic oxygen $O(^1D)$ reaction rates with hydrocarbons in a photolysis reactor using direct absorption spectroscopy and Faraday rotation spectroscopy to measure products including HO_2, H_2O and CH_2O.
    - Quantitative measurement of temperature and product/intermediate species concentrations in a dielectric-barrier discharge using laser absorption spectroscopy and gas chromatography (GC).
    - Development of predictive kinetic models and modeling tools for coupled electron collision reactions, excited and ionized species reactions, and hydrocarbon combustion reactions.

2) Applications of plasma-assisted combustion in engines and engine-like environments.
   - Investigation of dielectric-barrier discharges for extension of MILD combustion operating limits.
   - Investigation of the effects of nanosecond repetitively pulsed discharges on flame development dynamics in flow tubes and pulsed detonation engines (collaborative work with AFRL).
   - Application of microwave-assisted spark discharges to small internal combustion engines.

3) Alternative fuel kinetics and flame stability.
   - Investigation of Dimethyl Ether kinetics in a flow tube via Faraday rotation spectroscopy measurements of HO_2 and OH and GC sampling measurements of other products and species.
   - Optimization of flame sampling procedure in counterflow diffusion flames using a combination of GC sampling, laser-induced fluorescence, and particle image velocimetry.
   - Investigation of *t*-butanol, *iso*-butene, and acetone flame kinetics via product and intermediate species sampling, extinction limit measurements, and kinetic modeling.

Awards and Honors

- Ravitz Foundation Career Advancement Chair, Ravitz Foundation, 2018.
- National Research Council Research Associateship Program, Air Force Research Laboratory, 2015.
- Best Presentation Award, Tokyo Institute for Technology ACEEES Conference, 2014.
- Air Force Summer Faculty Fellowship Program, Air Force Research Laboratory, 2012.
- Martin Summerfield Memorial First Year Fellowship, Princeton University, 2009.
- Pi Tau Sigma Mechanical Engineering Honor Society, Johns Hopkins University, 2007.
- Tau Beta Pi Engineering Honor Society, Johns Hopkins University, 2007.

Teaching Experience

Princeton University Princeton, NJ
Assistant in Instruction Spring 2011 – Fall 2013

Assisted in the instruction of: Integrated Engineering Science (Laboratory); Thermodynamics; Energy Conversion and the Environment: Transportation Applications.

Johns Hopkins University Baltimore, MD
Tutor Fall 2007 – Spring 2009

Undergraduate tutor for mechanical engineering courses, both as a university employee and privately.

Reviewing Activities

AIAA Journal, Combustion and Flame, Combustion Theory and Modeling, IEEE Transactions on Plasma Science, Optics Express, Proceedings of the Combustion Institute

Memberships

American Institute of Aeronautics and Astronautics, Combustion Institute

Journal Publications

14) R.D. Stachler, **J.K. Lefkowitz**, J.S. Heyne, S.D. Stouffer, T.M. Ombrello, J.D. Miller, "An Investigation into the Effect of Residence Time and Equivalence Ratio on Ignition in a Toroidal Jet Stirred Reactor," *Proc. Combust. Inst.* (Submitted).

13) L. Wermer, **J.K. Lefkowitz**, T. Ombrello, S. Im, "Ignition Enhancement by Dual-pulse Laser-induced Spark Ignition in a Lean Premixed Methane-air Flow," *Proc. Combust. Inst.* (Submitted).

12) J.M. Bonebrake, D.L. Blunck, **J.K. Lefkowitz**, T.M. Ombrello, "The Effect of Nanosecond Pulsed High Frequency Discharges on the Temperature Evolution of Ignition Kernels," *Proc. Combust. Inst.* (Submitted).

11) **J.K. Lefkowitz**, T. Ombrello, "Reduction of Flame Development Time in Nanosecond Pulsed High Frequency Discharge Ignition of Flowing Mixtures," *Combust. Flame* (Submitted).

10) L. Wermer, **J.K. Lefkowitz**, T. Ombrello, M.S. Bak, S. Im, "Spatiotemporal Evolution of the Plasma from Dual-pulsed Laser-induced Breakdown in an Atmospheric Air", *Plasma Sources Sci. Technol.* 27 (2018) 015012.

9) **J.K. Lefkowitz**, T. Ombrello, "An Exploration of Inter-pulse Coupling in Nanosecond Pulsed High Frequency Discharge Ignition," *Combust. Flame* 180 (2017) 136-147.

8) A. Rousso, S. Yang, **J.K. Lefkowitz**, W. Sun, Y. Ju, "Low Temperature Oxidation and Pyrolysis of n-Heptane in Nanosecond-pulsed Plasma Discharges," *Proc. Combust. Inst* 36 (2017) 4105-4112.

7) S. Yang, **J.K. Lefkowitz**, S. Nagaraja, X. Gao, V. Yang, Y. Ju, W. Sun, "Numerical and Experimental Investigation of Nanosecond Pulsed Plasma Activated C_2H_4/O2/Ar Mixtures in a Flow Reactor," *J. Propul. Power* 32 (2016) 1240-1252.

6) Y. Ju, **J.K. Lefkowitz**, C.B. Reuter, S.H. Won, X. Yang, S. Yang, W. Sun, Z. Jiang, Q. Chen, "Plasma Assisted Low Temperature Combustion," *Plasma Chemistry and Plasma Processing* 36 (2016) 85-105.

5) **J.K. Lefkowitz**, P. Guo, A. Rousso, Y. Ju, "Species and Temperature Measurements of Methane Oxidation in a Nanosecond Repetitively Pulsed Discharge," *Phil. Trans. R. Soc. A* 373 (2015) 20140333.

4) **J.K. Lefkowitz**, P. Gou, T. Ombrello, S.H. Won, C. Stevens, J. Hoke, F. Schauer, Y. Ju, "Schlieren Imaging and Pulsed Detonation Engine Testing of Ignition by a Nanosecond Repetitively Pulsed Discharge," *Combust. Flame* 162 (2015) 2496-2507.

3) **J.K. Lefkowitz**, M. Uddi, B.C. Windom, G. Lou, Y. Ju, "*In situ* Species Diagnostics and Kinetic Study of Plasma Activated Ethylene Dissociation and Oxidation in a Low Temperature Flow Reactor," *Proc. Combust. Inst.* 35 (2015) 3505-3512.

2) **J.K. Lefkowitz**, S.H. Won, Y. Fenard, Y. Ju, "Uncertainty Assessment of Species Measurements in Acetone Counterflow Diffusion Flames," *Proc. Combust. Inst.* 34 (2013) 813-820.

1) **J.K. Lefkowitz**, J.S. Heyne, S.H. Won, S. Dooley, H.H. Kim, F.M. Haas, S. Jahangirian, F.L. Dryer, Y. Ju, "A Chemical Kinetic Study of *tertiary*-Butanol in a Flow Reactor and a Counterflow Diffusion Flame," *Combust. Flame* 159 (2012) 968-978.

Conference Papers

25) **J.K. Lefkowitz,** R. Brayfield, J. Miles, S. Adams, T. Ombrello, "The Effect of Inter-pulse Coupling on Plasma Temperature in Nanosecond-pulsed High-frequency Discharges," *The 20th Israeli Plasma Science and Applications Conference*, Tel Aviv, Israel (2018).

24) T. Ombrello, **J.K. Lefkowitz**, S.D. Hammack, C. Carter, K. Busby, "Scramjet Cavity Ignition Using Nanosecond-Pulsed High-Frequency Discharges," *10th US National Combustion Meeting*, College Park, MD (2017) 3H07.

23) L. Wermer, **J.K. Lefkowitz**, T. Ombrello, S.-K. Im, "Ignition and Flame Propagation Enhancement by Dual-Pulsed Laser-Induced Breakdown," *10th US National Combustion Meeting*, College Park, MD (2017) 1E09.

22) **J.K. Lefkowitz**, T. Ombrello, "Reduction of Flame Development Time Using Nanosecond-Pulsed High-Frequency Discharges in Flowing Mixtures," *10th US National Combustion Meeting*, College Park, MD (2017) 1E07.

21) R.D. Stachler, **J.K. Lefkowitz**, T.M. Ombrello, S.D. Stouffer, J.S. Heyne, J.D. Miller, "The effect of residence time on the ignitability of ethylene and air mixtures in a toroidal jet-stirred reactor," *10th US National Combustion Meeting*, College Park, MD (2017) 1J02.

20) **J.K. Lefkowitz**, T. Ombrello, "Study of Nanosecond Pulsed High Frequency Discharge Ignition in a Flowing Methane/Air Mixture" *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX (2017) AIAA 2017-1777.

19) A. Rousso, **J.K. Lefkowitz**, S. Yang, W. Sun, Y. Ju, "n-Heptane low temperature oxidation kinetics in nanosecond-pulsed plasma discharges," *2016 Eastern States Section of the Combustion Institute Spring Meeting*, Princeton, NJ (2016) 2A15.

18) A.C. Rousso, **J.K. Lefkowitz**, Y. Ju, "Measurements of low temperature oxidation of n-heptane/O_2/Ar mixtures in nanosecond-pulsed plasma discharges," *54th AIAA Aerospace Sciences Meeting*, San Diego, CA (2016) AIAA 2016-0958.

17) **J.K. Lefkowitz**, "Kinetic study of low temperature methane oxidation in a nanosecond repetitively pulsed dielectric barrier discharge," *22nd International Symposium on Plasma Chemistry*, Antwerp, Belguim (2015) presentation O-4-3.

16) **J.K. Lefkowitz**, A. Rousso, P. Guo, Y. Ju, "A kinetic study of low temperature methane oxidation in a nanosecond repetitively pulsed discharge," *9th U.S. National Combustion Meeting*, Cincinnati, OH (2015) 3B03.

15) X. Yang, **J.K. Lefkowitz**, B.E. Brumfield, Q. Chen, G. Wyscoki, Y. Ju, "Kinetics studies of O_3/O_2/CH_3OH/Ar mixtures in a photolysis flow reactor," *9th U.S. National Combustion Meeting*, Cincinnati, OH (2015) 1A10.

14) S. Yang, S. Nagaraja, W. Sun, V. Yang, **J.K. Lefkowitz**, Y. Ju, "Numerical and experimental study of pulsed nanosecond plasma discharges for C_2H_4/O_2/Ar gas mixtures in a low temperature reactor," *9th U.S. National Combustion Meeting*, Cincinnati, OH (2015) 3B01.

13) **J.K. Lefkowitz**, P. Guo, A. Rousso, Y. Ju, "Low temperature oxidation of methane in a nanosecond pulsed plasma discharge," *53rd AIAA Aerospace Sciences Meeting*, Kissimmee, Florida (2015) AIAA 2015-0665.

12) T. Wada, **J.K. Lefkowitz**, Y. Ju, "Plasma Assisted MILD Combustion," *53rd AIAA Aerospace Sciences Meeting*, Kissimmee, Florida (2015) AIAA 2015-0666.

11) S. Yang, S. Nagaraja, V. Yang, W. Sun, **J.K. Lefkowitz**, Y. Ju, "Numerical and Experimental Investigation of Nanosecond-Pulsed Plasma Activated C_2H_4/O_2/Ar Mixtures in a Low Temperature Flow Reactor," *53rd AIAA Aerospace Sciences Meeting*, Kissimmee, Florida (2015) AIAA 2015-1614.

10) Y. Ju, **J.K. Lefkowitz**, T. Wada, X. Yang, S.H. Won, W. Sun, "Plasma assisted combustion: new combustion technology and kinetic studies," *53rd AIAA Aerospace Sciences Meeting*, Kissimmee, Florida (2015) AIAA 2015-0156.

9) B. Brumfield, N. Kurimoto, X. Yang, T. Wada, P. Diévart, **J. Lefkowitz**, G. Wysocki, Y. Ju, "Kinetic Studies of Low and Intermediate Temperature Oxidation of Dimethyl Ether," *248th ACS National Meeting & Exposition*, San Fransisco, California (2014).

8) B. Brumfield, X. Yang, **J. Lefkowitz**, Y. Ju, G. Wysocki, "Towards Simultaneous Measurement of OH and HO2 in Combustion Using Faraday Rotation Spectroscopy," *CLEO:2014*, San Jose, California (2014) SF21.4.

7) **J.K. Lefkowitz**, B.C. Windom, W. MacDonald, S. Adams, T. Chen, M. Uddi, Y. Ju, "Time Dependent Measurements of Species Formation in Nanosecond-Pulsed Plasma Discharges in C_2H_4/O_2/Ar Mixtures" *52nd AIAA Aerospace Sciences Meeting*, National Harbor, Maryland (2014) AIAA 2014-1179.

6) **J.K. Lefkowitz**, M. Uddi, B.C. Windom, Y. Ju, "*In situ* Mid-infrared Absorption Measurements in a Nanosecond Pulsed Plasma Discharge," *The 2nd International Education Forum on Environment and Energy Science*, Huntington Beach, California (2013).

5) **J.K. Lefkowitz**, Y. Ju, C. Stevens, T. Ombrello, F. Schauer, J. Hoke, "The Effects of Repetitively Pulsed Nanosecond Discharges on Ignition Time in a Pulsed Detonation Engine," *49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit*, San Jose, California (2013) AIAA 2013-3719.

4) M. Uddi, **J.K. Lefkowitz**, B. Windom, Y. Ju, "Species Measurements of Ethylene Oxidation in a Nanosecond-Pulsed Plasma Discharge Using QCL Absorption Spectroscopy Near 7.6μm," *51st AIAA Aerospace Sciences Meeting*, Grapevine, Texas (2013) AIAA 2013-0435.

3) **J.K. Lefkowitz,** Y. Ju, R. Tsuruoka, Y. Ikeda, "A Study of Plasma-Assisted Ignition in a Small Internal Combustion Engine," 50*th AIAA Aerospace Sciences Meeting*, Nashville, Tennessee (2012) AIAA 2012-1133.

2) **J.K. Lefkowitz**, J.S. Heyne, S.H. Won, S. Dooley, H.H. Kim, F.M. Haas, S. Jahangirian, F.L. Dryer, Y. Ju. "A Chemical Kinetic Study of the Alternative Transportation Fuel, *tertiary*-Butanol," *49th AIAA Aerospace Sciences Meeting*, Orlando, Florida (2011) AIAA 2009-698.

1) J. Heyne, **J.K. Lefkowitz**, F.M. Haas, S.H. Won, S. Dooley, H.H. Kim, S. Jahangirian, F.L. Dryer, Y. Ju, "Combustion Kinetics Study of *t*-Butanol," *7th U.S. National Combustion Meeting,* Atlanta, Georgia (2011).