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A Multiphysics Approach to Solid Fuels and Propellants

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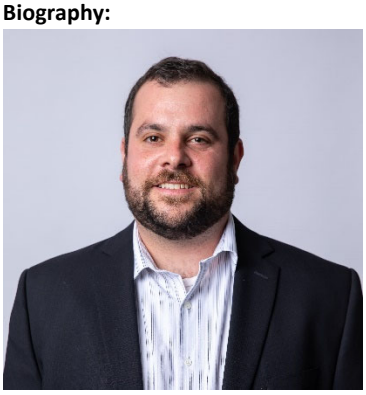
Abstract:
Solid propulsion systems are used in many space exploration and national defense applications. Fuels and propellants for the next generation of solid fuel ramjets (SFRJ) and solid rocket motors (SRM) require understanding the fundamental physics and chemistry of manufacturing, aging, and combustion. In this talk, experimental and computational results are presented exploring each of these areas. Sessile droplet and droplet impact experiments are shown to quantify the wettability of ammonium perchlorate (AP, a common oxidizer) with changes to the polymeric binder structure and AP surface for manufacturing applications. Partially decomposed AP particle studies demonstrate the role of strain within the crystal lattice on low temperature decomposition for aging and storage issues. Several aspects related to SFRJ and SRM combustion are also reported. To study SFRJ combustion, computational studies of high enthalpy air diffusion flames determines the role of hydrogen abstraction reactions play to increase the extinction limits. Additionally, recent advances with boron-based materials for ramjet applications are shown to alter ignition and combustion rates through the inclusion of combustion aids. Finally, challenges with measuring aluminum agglomerations at rocket motoring pressures are investigated. Uncertainty of agglomerate size measurements at high pressures are quantified through ray tracing calculations in simulated propellant flames. The changing flame structure as pressure and AP particle size increase refracts light more leading to additional measurement error. A synchrotron-based x-ray technique to study Al agglomerates at 1000 psi is used to mitigate the influence of refraction. The first of its kind, these measurements provide a quantitative measure of agglomerate size with unprecedented fidelity. Additional details of the agglomeration process never before observed by an *in situ* technique are presented. The future direction based on these results is also discussed.

Biography:



Dr. Joseph Kalman is currently an assistant professor of mechanical and aerospace engineering at California State University, Long Beach where he has been since 2018. He received his bachelor and master's degrees from Rutgers University in 2008 and 2010, respectively. His Ph.D. was awarded from the University of Illinois at Urbana-Champaign in 2014. All three degrees are in mechanical engineering. Following graduate school, Dr. Kalman was previously the lead researcher in the Combustion Sciences Lab within the Combustion Science and Propulsion Research Branch at the Naval Air Warfare Center Weapons Division-China Lake. His research is primarily motivated by solid propulsion applications and focuses on aspects of multiphase combustion and energetic materials with an emphasis on applying non-intrusive diagnostics to these challenging systems and environments. Dr. Kalman has secured over $1.5 million in federal grants since joining CSULB. He was awarded the CSULB 2020-2021 Early Academic Career Excellence Award due to his contributions to research, teaching, and service for the university.

Department of Mechanical Engineering, Edward E. Whitacre Jr. College of Engineering
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2:00 – 3:00 PM
MES 205 and Online
Online: https://texastech.zoom.us/j/94591486607?pwd=MHhsSnJyM2RJQjl1ZmdsWkZuVExrQT09
Meeting ID: 945 9148 6607
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