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Simulating solid rocket motor composite propellants at the mesoscale

Solid composite propellants (SCP) are ubiquitous in rocket propulsion due to their simplicity, reliability, and stability during long-time storage. They have been used in applications ranging from the Space Shuttle to hobby rockets, but little has been done to predictively model or optimize their composition for peak performance. In this work develop a model for predicting burn behavior of Ammonium Perchlorate SCPs with binders including hydroxyl-terminated polybutadiene (HTPB) and polybutadiene acrylonitrile (PBAN). The model is designed to handle the solid and gas phases together, while fully resolving the nuances involved in both. We begin by proposing a phase field (PF) type model that is capable of capturing heterogeneous SCPs and resolving the full complexity of the burn front. We demonstrate that the model provides accurate results for a variety of composite geometries including sandwich and packed spheres. We then extend the model to examine the thermoelastic and failure response of SCPs during deflagration. In the last part of the talk, we introduce a novel approach to solid-fluid interaction (SFI) for mass-flux boundary conditions, and provide an overview of the theoretical underpinnings of a diffuse-boundary formulation for resolving a solid-fluid mass flux interface.

Short Bio

Brandon Runnels is an assistant professor of mechanical and aerospace engineering at the University of Colorado Colorado Springs. He obtained his BS in Mechanical Engineering from New Mexico Tech in 2011 and his MS from Caltech in 2012. He completed his PhD work at Caltech in June 2015. He has been a faculty member at UCCS since August of 2015. His research interests include: differential geometry applied to continuum mechanics, multiscale modeling of plasticity, phase transformation and grain boundaries; and high performance methods for computational mechanics.