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Multiphysics and Multiscale Challenges in Liquid-fueled Detonation Engines

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Rotating detonation engines (RDEs) are emerging as an attractive option for realizing compact and highly efficient propulsion and energy conversion. RDEs contain moving detonation waves in confined geometries, sustained by continuous injection of non-premixed reactants into the combustion chamber. When using liquid fuels, several design challenges arise due to the need to rapidly transfer fuel mass to the gas phase and time-constrained mixing and chemical reaction processes. Due to the extreme range of pressure and temperature and the highly compressible and high-speed flows within such systems, new physics regimes and modeling needs also emerge. The focus of this talk is to lay out the complexity of such systems in the context of next-generation computing machinery. Recent progress in the simulation of liquid-fueled RDEs and paths for research will be presented. The role of exascale architecture, the promise of artificial intelligence, and the need for radical changes to modeling and algorithms will be discussed.