Title: Research on High Pressure Combustion in Microgravity
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Summary: This proposal outlines a plan for developing a comprehensive ground-based research program to investigate, both experimentally and computationally, the droplet combustion dynamics of liquid fuels at elevated pressures in a microgravity environment that promotes spherical symmetry. The broad objective of this work is to (1) perform high pressure combustion experiments for liquid fuels, including decane (representative of a straight-chain hydrocarbon), butanol (representative of an alcohol and a biofuel), and their mixtures, using a spherically symmetric droplet flame configuration; (2) establish a computational framework to simulate our combustion experiments at elevated pressures; (3) produce butanol from the fermentation broth for combustion experiments through an optimized fermentation process; and (4) construct a unique drop tower facility and high pressure combustion apparatus at Prairie View A&M University (PVAMU) for enhancing institutional research capacity as a Historically Black College and University. The spherical droplet flame adopted in this study is broadly envisioned as providing important combustion properties for our further understanding of physics related to high pressure combustion.

The relevance of the project is that petroleum-based liquid fuels are currently used to power combustion engines such as diesel engines and gas turbines. In these systems, droplets in the spray often evaporate and burn in an ambient at pressures and temperatures well above the critical state of the fuel. However, there is very little fundamental information available to understand the combustion of liquid fuels at elevated pressures. The microgravity environment achieved in a drop tower facility provides the opportunity to reveal the fundamental information about liquid fuel combustion at high pressures that is not currently available. High pressure combustion research at low gravity has tremendous potential to be applied to a wide range of terrestrial applications as more fundamental combustion physics can be revealed when the added complication of gravity is eliminated. The outcome of the project will be new insights on how liquid fuels combust in environments similar to practical engines and providing quantitative results for guiding advanced engine designs. Experimental results obtained in this proposed work will be a valuable database for the research community for developing, validating, and optimizing numerical models. This work is aligned with NASA's research interests of Physical Science Research in Combustion Science area. It is also consistent with recent research proprieties of high-pressure combustion in Glenn Research Center.

The educational objective of this proposal is to develop a new Master of Science (MS) in Mechanical Engineering degree program at PVAMU. With dynamic growth in the past ten years resulting in current enrollment of about 500 undergraduate and graduate students, Mechanical Engineering is one of the largest programs at PVAMU. The proposed project will greatly increase the inventory of research in the department and provide a strong foundation for support of graduate students at the MS level.

The broader impacts of this work include that influence of high-pressure environments on liquid fuel combustion developed has the potential to lead to advanced engine designs with increased engine efficiency and reduced carbon emissions. Broader impacts from an educational perspective for this work include activities to provide graduate students with opportunities to discover new knowledge and explore practical applications, and opportunities for undergraduate students to conduct independent research at an early stage of their careers. Moreover, the research program established will provide various K-12 outreach opportunities. These activities will help to attract more students to pursue a science and engineering career and thus build a more diverse STEM workforce for NASA and the nation.