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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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RESULTS FROM THE PERWAVES MICROGRAVITY EXPERIMENT ON-BOARD MAXUS-9

Abstract

The PerWaves experiment is an attempt to realize—for the first time—a reactive wave propagating through a three-dimensional (3-D) array of random, discrete media wherein the discreteness dominates the wave propagation. The propagation of reactive waves in 3-D discrete media is of intense attention due to practical applications (e.g., flame propagation in particulate suspensions, calcium waves in cellular signaling, phase transition fronts, etc.) and theoretical interest (i.e., as a means to study experimentally front roughening kinetics in 3-D that have previously been verified in two-dimensions). The need for microgravity to realize an environment for the study of particulate combustion has been long-standing, both for creation of initially well-quantified suspensions of particulates and the elimination of buoyancy-driven disruption of the flame once established. Two decades of experiments examining flame propagation through particulate suspensions onboard parabolic flight aircraft have established the need for high-quality and longer duration microgravity that can only be realized in space-based experiments. This rationale is the motivation for the PerWaves experiment onboard the ESA MAXUS-9 sounding rocket platform. In this experiment, particulate clouds of iron ($\approx$20 μm in size) are dispersed into a flow of oxygen/xenon, filling a glass tube with a uniform suspension. A reactive wave (flame) ignited from one end propagates through the quiescent suspension, with each iron particle burning heterogeneously via surface reaction. The use of xenon as the diluent gas ensures the reactive wave propagates in a regime wherein the interparticle diffusion of heat dominates the front propagation. The initial suspension, flame propagation along the tube, and close-up of the structure of the front are recorded by three separate video cameras. A carousel system rotates a new glass tube into alignment with the dispersion and evacuation system after the completion of every two tests, ensuring a clean tube, for up to 36 possible experiments during the duration of the sounding rocket flight. This presentation will present results from the MAXUS-9 flight (April 2017) and a preliminary analysis and comparison to the results of discrete reactive wave theory. Of particular interest is the predicted independence of reactive wave speed on oxygen concentration and the morphology of the front.