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THE PERWAVES COMBUSTION EXPERIMENT ON THE ESA MAXUS-9 AND TEXUS-56 SOUNDING ROCKETS

Abstract

The propagation of reaction-diffusion waves in disordered media can be used to describe a wide range of problems in physical sciences. The progression of the front through activated reacting sites separated by an inert medium often involves fundamental features such as percolation, fractal-like shape, and a growth of the front roughness, which are most prominent close to the characteristic low-concentration limit of propagation. The resulting complex structure can best be studied on visually accessible representative systems, such as flames in suspensions of reactive metallic particles in gases. The creation of mixtures of uniformly distributed particles can only be realized in high-quality microgravity environments achieved on sub-orbital and orbital platforms. An example is offered by the PERWAVES project, presented here, which involved testing aboard two European Space Agency sounding rockets – the MAXUS-9 in 2017 and the TEXUS-56 in 2019. The experiments were designed to observe laminar flame propagation in quiescent iron suspensions of oxygen-xenon gas mixtures, which were undisturbed by gravitational effects, such as particle settling and natural convection of hot gases. For this purpose, a fully automated experimental module was designed and built by Airbus Defence and Space. Combustion events occur in transparent glass tubes, which provide direct visual access to various diagnostics. The use of multiple tubes, arranged in rotating carousels and operated by a pre-set algorithm allowed the autonomous operation of the module over the 12 and 6 minutes of microgravity provided by the two sounding rockets, respectively. During the flights, a live comm-link also allowed direct monitoring and manual intervention by the operators on the ground. Images obtained during both campaigns allowed the observation of increased roughness of the front, indicative of percolation behavior, as the flame reached its propagation limit. The derived fundamental characteristics of frontal evolution may be used in the study of reaction-diffusion waves in heterogeneous mixtures involving more complex physics. The experimental results also offer fundamental insights to the combustion of metal powders, used either as zero-carbon energy carriers in power production on Earth, or as potential fuels for In-situ resource utilisation (ISRU) production on the Moon or on Mars.