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Application of a new diagnostic method to observe pre-ignition phenomena of self igniting fuel droplets

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ABSTRACT

A powerful diagnostic method based on chemiluminescence of formaldehyde to observe staged ignition phenomena in the field of droplet combustion was developed and successfully applied. Chemically excited formaldehyde (HCHO*) was used as a excellent natural tracer for low temperature reactions. The faint blue luminescence was utilized to observe pre-ignition phenomena of self igniting fuel droplets. Interaction effects of neighbored selfigniting n-decane fuel spheres were studied in microgravity conditions and compared to single droplet results. Real weak signals became detectable with a sufficient quantum of efficiency by the developed intensified camera (ICCD) concept. The system consist of a proximity focused intensifier with one MCP of second generation with 25 mm diameter and a bi-alkali photocathode on quartz glass. The photocathode is combined with the phosphor screen type P43 and coupled by fiber optics to the CCD with a 256x256 resolution, max. frame rate of 200 f/s and 8-bit resolution. Wavelengths from 200 to 550nm are detectable with a sufficient quantum of efficiency.

For systems evaluation data derived from chemiluminescence monitoring were compared with those from planar laser induced fluorescence (LIF) of formaldehyde excited at 352,2nm by means of an XeF-Excimer Laser. The results derived in normal gravity are discussed. Beyond that all combustion experiments observed by chemiluminescence were done in microgravity conditions at the 4,7s Drop Tower Bremen and were performed with a fixed droplet size of 1,5mm, varying mid spacings and ambient temperatures and pressures. Low temperature reaction zones were observed and regions with an individual cool flame behavior and also common enveloping cool flame zones were found. The dynamic of oscillating coolflames well known from gaseous flames became visible. It was found that droplet spacings exist, that either promote or inhibit hot ignition. An excerption of these findings are displayed to confirm the performance of this new diagnostic method.

This project was done to support the development of numerical models for fuel spray auto-ignition experiments. The experimental database could be improved and the work demonstrate that numerical models for ignition of spray systems have to consider the complex interaction behavior of self igniting fuel droplets.

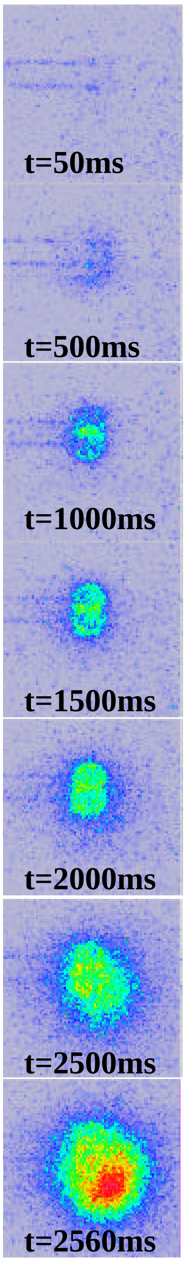

Figure 1:

Cool flame chemiluminescence of two interacting droplets up to hot ignition [microgravity, n-decane, 1,5mm droplet size, 3,5mm droplet spacing, T=750K, p=1bar, max. MCP amplification, 10ms exposure time, triple image average]