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A Chemical Kinetics Shock Tube for Synchrotron Studies

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In recent years many impressive studies have been conducted at synchrotron light sources using X-rays and VUV photons to probe combustion phenomena from chemical mechanisms in low pressure flames and flow reactors to particle formation in flames. Recent developments promise to bring more synchrotron based diagnostics to bear on combustion studies. However, most practical combustion devices operate in temperature and pressure spaces that are not accessible to the reactors that are most frequently used at synchrotrons. In laboratory studies shock tubes have provided much of the high temperature experimental kinetic data and also have been used to probe reactions at pressures up to 1000 bar and as a class encompass the conditions found in most combustors. Consequently, shock tube experiments at synchrotrons have the potential to complement existing synchrotron based kinetic experiments. However, due to their large size and very low firing rates traditional shock tubes are not compatible with synchrotron based diagnostics.
A miniature (0.25”bore, ˜24”long) shock tube has been designed that can be fired at repetition rates up to 4Hz and generate reaction conditions in the range 700-3000 K and P < 100 bar. The shock tube has been designed in a modular manner to facilitate use with a variety of diagnostic devices. The apparatus has been installed at both the Advanced Photon Source (Argonne National Laboratory) and the Advanced Light Source (Lawrence Berkeley National Laboratory). At the APS X-ray densitometry has been used to measure gas properties behind shock waves and at the ALS VUV-photoionization mass spectrometry studies were performed, both of which will be discussed.

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