Preliminary shock-tunnel experiments on liquid fragmentation and atomization in hypersonic flows

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Abstract

The present work describes the objectives, the set-up and the preliminary results of an experimental study on the fundamental mechanisms of fragmentation and atomization of a bulk of liquid in hypersonic gas flows. Additionally, we introduce a former series of experiments and calculations also carried out at ISL.

The current experiments are conducted by means of a horizontal shock tube which is operated as hypersonic wind tunnel (shock tunnel, see Fig. 1). The experimental set-up used is capable of reproducing conditions of real atmospheric flights from Mach 3 at ground-level conditions up to Mach 14 at a flight altitude of 70 km.

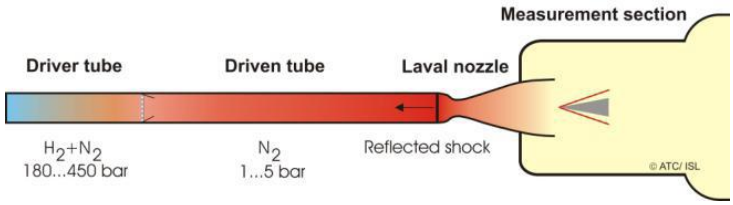

Figure 1. Principle sketch of the shock tunnel with a contoured nozzle

This work focuses on shock tunnel experiments on the fragmentation and atomization of a bulk of liquid suddenly exposed to hypersonic atmospheric flow. The liquid substance to be studied is filled into a latex balloon which is placed in front of the shock tunnel nozzle. A needle driven by a magnetic mechanism pierces the balloon shortly before the nozzle flow sets-in, so that the bulk of liquid is introduced into the flow in an almost non-intrusive way (see Fig. 2).

A first series of experiments at Mach 4.5 has been conducted with the help of a high-speed camera to observe the fragmentation of a bulk of 5 ml of water, ethanol and hexane at flight altitudes of 10, 20, 30 and 40 km (see Fig. 3). The analysis of the atomization and the evolution of the drop sizes require more sophisticated optical measurement techniques. Therefore, in a series of experiments already started a special Particle Image Velocimetry (PIV) technique is used to determine the velocity of the drops. A first result is presented in this paper. Beside this, a LIF-technique is being developed and adapted to observe the evolution of drop size and liquid evaporation.

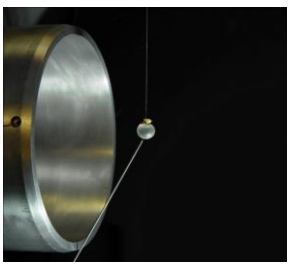

Figure 2. Piercing mechanism

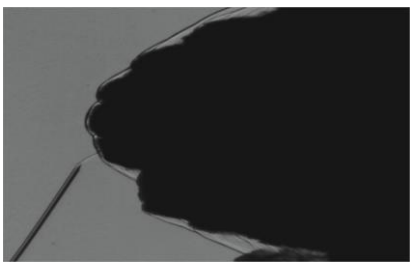

Figure 3. High-speed camera shadowgram

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