Evaporating droplets tracking by holographic high speed video in turbulent flow

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Keywords: Holography, Inverse Problem, Droplet Evaporation, Turbulent flow

HIGHLIGHTS

• Lagrangian Tracking of droplets evaporating in turbulent flow is performed using In Line Digital Holography.
• An inverse problem approach is adopted to achieve highly accurate diameter and position measurements.
• Vapor wake information is obtained by using a Standard Phase retrieval algorithm on IPA residual images.
• Results from a sample of trajectory show that turbulence may influence significantly evaporation processes.

ABSTRACT

In many practical situations droplets vaporize in turbulent flow. It is then of primary importance to know whether or not turbulence influences evaporation. The most physically relevant approach to investigate this question is to adopt a Lagrangian point of view and measure the phase change of the droplet by following its diameter evolution along its trajectory. Diethyl Ether droplets was released in a homogeneous isotropic and strong turbulence produced by synthetic jets. The Lagrangian tracking is performed using in-line digital holography associated with an Inverse Problem Approach (IPA) providing the highly accurate measurement of droplet size and position required for both droplet tracking and evaporation rate measurement at a relatively large distance. The In-line Digital Holography set-up consists of a diverging laser beam and a high speed camera running at 3kHz. Hologram sequences are processed by using the IPA method to track the droplets and measure their diameter evolutions. The vapor wake resulting from evaporation and clearly visible on holograms is also study by applying a standard back light propagation algorithm on IPA residual images (see a single image processing example in fig 1). Experimental results are compared to a simple model of evaporation/condensation previously validated in free falling conditions. The wake orientation is aligned with the 2D projection of relative velocity deduced from IPA measurement and the droplet equation of motion with a relaxation time in the order of 0.5 ms. For some trajectories, the measured evaporation rate deviates from the the standard d² law, showing that turbulence may affect droplet evaporation even if the involving mechanisms have not been clearly identified yet.

Fig. 1 hologram example (a), IPA residual (b) after best fit model subtraction and phase retrieved image of the vapor wake.

Acknowledgements. This work was partially funded by the French National Research Agency (ANR) under grants AMO-COPS (ANR-13-BS09-0008-02) and TEC2 (ANR-12-BS09-0011).