PIV measurement of an oil droplet colliding with an oil-water interface

Ulrich Miessner, Emil Coyajee, Harmen Slot, Ralph Lindken, Bendiks Jan Boersma, René Delfos and Jerry Westerweel

J.M. Burgerscentrum for fluid mechanics, Delft University of Technology, Laboratory for Aero & Hydrodynamics
Leeghwaterstraat 21, 2628 CA Delft, The Netherlands

A large variety of physical and chemical processes involve two immiscible liquids, e.g. extraction, oil production & transport, emulsification and separation. Understanding of the motion of individual droplets and their mutual interaction is crucial for economically and ecologically optimized design. While the behavior of single droplets is known to a large extent, the interaction of two dispersed droplets (e.g. deformation, break-up, collision and coalescence) is less understood.

We investigated the gravity-driven motion of an oil droplet immersed in a water/corn syrup mixture approaching the liquid/liquid interface (i.e., the oil and water/corn-syrup interface). The oil is in fact a mixture of two oils (Shell Garia and Shell Macron) to match the refractive index (RI) of the water/syrup mixture. This allows us to make simultaneous PIV measurements in the two phases, i.e. both inside and outside the droplet. While both phases are seeded with particles needed for PIV (8 micrometer Sphericel), a fluorescent dye (Hostasol Yellow 3G) is added to the disperse phase, in order to establish the possibility to discriminate the signals originating from the two phases. We use a two camera configuration to measure simultaneously the PIV and LIF signals. Based on the grey value signals obtained, the change of geometry and velocity of the droplet is calculated directly. Additionally a masking technique will be applied to the grey value information[1] and used on the measured velocity fields in order to provide the ability to distinguish the disperse phase from the continuous phase.[2,3] Each imaging sequence contains a time series of a single droplet of reproducible size (equivalent diameter = 11.2 mm) formed by a computer controlled syringe pump.

The experimental results are compared to results from a numerical simulation using a recently developed Mass Conserving Level-Set (MCLS) method, which is a numerically fast method to track a deforming interface taking into account the interfacial tension between fluids of different physical properties.[4]

Validation indicators chosen are: 1) the trajectory of the droplet centroid, i.e. its rising speed; 2) the droplet aspect ratio, and 3) the velocity fields in both fluids.

---

[1] Lindken, R., Merzkirch, W. (2002) 'A novel PIV technique for measurements in multiphase flows and its application to two-phase bubbly flows', Experiments in Fluids 33 (2002) 814-825.

2 Honkanen, M. , Saarenrinne, P., Stoor, T.,Niinimaki, J. (2005) 'Recognition of highly overlapping ellipse-like bubble images', Meas. Sci. Technol. 16 (2005) 1760–1770

[3] Laakkonen, M., Honkanen, M., Saarenrinne, P., Aittamaa, J. (2005) 'Local bubble size distributions, gas–liquid interfacial areas and gas holdups in a stirred vessel with particle image velocimetry', Chemical Engineering Journal 109 (2005) 37–47.

[4] Coyajee, E.R.A., Delfos, R., Slot, H. and Boersma, B.J. (2005) '*Simulation of Droplet Impact on a Liquid-Liquid Interface*', 58th Annual Meeting of the Division of Fluid Dynamics, November 20–22, Chicago (USA).