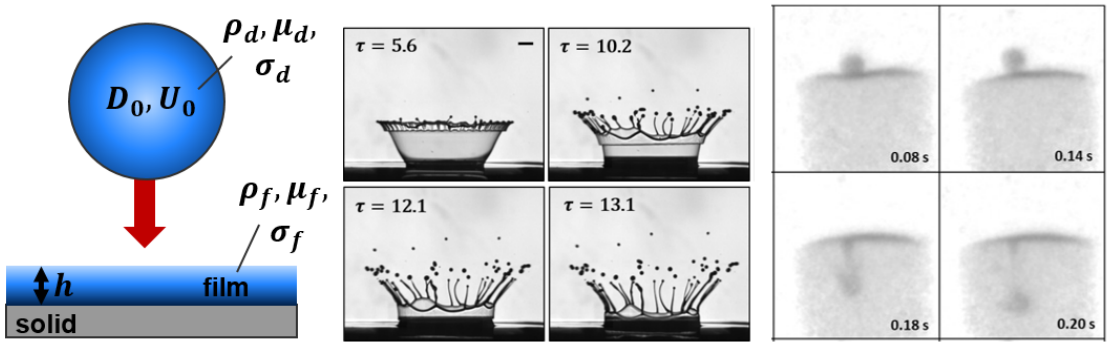
Universität Stuttgart
INSTITUT FÜR THERMODYNAMIK DER LUFT- UND RAUMFAHRT
Direktor: Professor Dr.-Ing. B. Weigand
Pfaffenwaldring 31, 70569 Stuttgart, Germany · http://www.itlr.uni-stuttgart.de

Master's Thesis

"Investigation of mixing during droplet impacts onto liquid films using neutron imaging"

Motivation / Objective:
Impact processes of individual droplets on liquid films (see Fig. 1) are relevant for the resource-efficient use of spray paints or pesticides and refrigerants [1]. While the impact behaviour has been studied extensively, numerous questions remain unanswered, particularly concerning the microscopic fluid dynamics, including the flow and mixing behaviour of the liquid in the crown and crater structures that form, especially for miscible fluids. Trtik et al. [2] conducted a pilot experiment in which they visualized the mixing process of a water droplet falling into a container filled with heavy water using neutron imaging. The contrast difference in neutron imaging of water (H2O) and heavy water (D2O) results from the quantum mechanical properties of the atomic nuclei, which influence the neutron absorbance. Both liquids have very similar macroscopic liquid properties (i.e. density, viscosity, surface tension). Thus, neutron imaging can be used to visualize and analyse the mixing processes of miscible liquids.



(a) Scheme droplet-film interaction

(b) Backlight images of droplet impact process

(c) Images with neutron imaging from [2]

Figure 1: Schematic representation of droplet-wall film interaction (a) and visualization of the impact process (b) on thin films using high-speed backlight imaging and (c) in pools with neutron imaging.

In the scope of this work, droplet impacts on thin wall films will be investigated through neutron imaging for the first time. To do this, H2O drops are dropped onto a thin D2O film. To avoid contamination of the D2O film with water, experiments are conducted in a test chamber which contains an H2O vapor-free environment (nitrogen atmosphere). The aim is to visualize the flow behavior of the droplet and film liquids during impact. A key question is whether the liquids mix during the impact or whether there is a parallel flow of two separate liquids. The main **tasks** to be completed in the scope of this Master's thesis are**:**

- Familiarization with the topic and literature research
- Design support for the test chamber
- Commissioning and validation of the functionality (film and drop generation) of the test chamber
- Possibly: neutron imaging experiments at the Paul Scherrer Institute (PSI)
- Evaluation of the recordings
- Analysis and discussion of the results

The neutron imaging experiments will be conducted as part of an international collaboration with the Paul Scherrer Institute (www.psi.ch/de) in Switzerland. The beam time required has already been approved. The investigation of the impact behavior on thin wall film by means of neutron imaging is a unique pioneering project. As such, a publication of some results in relevant scientific journals is envisioned.

Universität Stuttgart
INSTITUT FÜR THERMODYNAMIK DER LUFT- UND RAUMFAHRT
Direktor: Professor Dr.-Ing. B. Weigand
Pfaffenwaldring 31, 70569 Stuttgart, Germany · http://www.itlr.uni-stuttgart.de

Place and duration of the work:
The master's thesis will be conducted at the Institute of Aerospace Thermodynamics within a 6-month time frame. The two-day neutron imaging campaign will take place at the Paul Scherrer Institute (Villigen, Switzerland).

Start: immediately

If you are interested and for further information, please contact:

Patrick Palmetshofer, M.Sc.
Pfaffenwaldring 31, Room 1.102
Phone: 0711-685-60556
patrick.palmetshofer@itlr.uni-stuttgart.de

Dr. Anne K. Geppert
Pfaffenwaldring 31, Room 1.123
Phone: 0711-685-62413
anne.geppert@itlr.uni-stuttgart.de

References:
[1] G. Liang & I. Mudawar, Review of mass and momentum interactions during drop impact on a liquid film. *Int. J. Heat Mass Transfer* 101, 577-599 (2016).

[2] P. Trtik, M. Morgano, R. Bentz & E. Lehmann, 100 Hz neutron radiography at the BOA beamline using a parabolic focussing guide. *MethodsX* (3), pp. 535-541, (2016).