Liquid fragmentation in Nature and Industry

29 June – 3 July 2015 @Snellius

In this workshop we focused on understanding how a bulk liquid breaks up into small fragments. Until now, knowledge on liquid fragmentation has remained dispersed among the different fields of application, such as fluid physics, environmental sciences, engineering, geophysics, and industry. The central aim of our workshop was therefore to establish a general framework to describe the liquid fragmentation phenomena that arise in many different applications but rely on the same physics, and to identify the key challenges for the field.

Each workshop day was organized around one or two common theme(s). In the mornings there were keynote lectures and contributed talks around these theses, to allow the participants to get an overview of the current status of the field and get to know each other's work. In particular, we let the younger participants speak on the first day, which worked very well to involve them actively in all future discussions. Each afternoon was entirely devoted to discussion sessions, first plenary, and later in subgroups. Given the small group of participants (~25) this worked out very well. From the beginning of the week on the atmosphere was very open and proactive. A new format we tried out was to let each day be moderated by two senior participants. Already before the week, we provided these moderators with a list of goals and guiding questions for their day, and on top of that a list of questions the participants came up with before and during the week. At the end of each day the moderators presented the main conclusions of that day to the group. In our view, this summary was very helpful to conclude on the diverse and lively discussions and emerge a common view.

During the week, we have seen diverse examples of liquid fragmentation in both natural and industrial applications, such as the aerosol production from sea sprays, disease transmission through contaminated droplet sprays, rainfall dynamics, pesticide spray formation, Diesel spray formation in engines, droplet breakup in nanolithography, and drop formation in inkjet printing. It became apparent that in all these applications, researchers are facing similar challenges: on one hand a challenge is how to make a controlled spray, and how to accurately determine the drop size distribution and droplet ejection angle or velocity in a spray. Current numerical methods are not able to simulate accurately the final breakup events, and detailed experimental data is often lacking. On the other hand, people aim to avoid fragmentation and spray formation. A key question is how smart design of e.g. nozzles, or addition surfactant/polymers/particles to the liquids influences or even suppress the fragmentation process.

An important fundamental conclusion of the workshop came with the realization that the spontaneous piercing of thick films is not yet understood and that the traditional nucleation vision for thin films is inappropriate. For thicker films (beyond the nanometric length), an external perturbation is needed to trigger film thinning and rupture; spontaneous collapse of these films is not possible. The challenge for each type of problem is to identify what mechanism is responsible for bringing the film down to the nanometric scale. We laid out several fragmentation pathways through which a fluid could become dispersed into another fluid. All these routes involve the formation of tubular structures (ligaments/necks), since these are the only truly unstable geometry and are hence a fundamental structure in the breakup process.

We identified several open fields that have so far remained almost unexplored. Amongst them are the fragmentation of liquids in phase transition (liquid solidification, boiling, close to the triple point) or liquid bodies that are loosing mass (due to e.g. evaporation, combustion), the effect of interaction of turbulent flows with a liquid interface on its fragmentation, and the fundamental fluid dynamic description of the breakup cascade of a corrugated ligament.

Overall, we feel it has been a very inspiring, useful and productive week. It really was a workshop, not just another conference. The Lorentz Center did a great job in advising us on what workshop format to choose, and taking care of a major part of the organizational work, such that we could focus on the science!

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