Melting & dissolution across scales in multicomponent systems

Project name	MultiMelt
Funding agency	European Research Council (ERC)
Project duration	5 years
Type	5 PhD positions
PhD duration	4 years
Start	2023–2024
Location	University of Twente, Enschede, Netherlands
Faculty	Science & Technology
Group	Physics of Fluids
PI	Prof. Dr. Detlef Lohse

The Physics of Fluids group works on a variety of aspects in fluid mechanics. The focus of our work is the fundamental understanding the phenomena of the physics of fluids. Present research areas include turbulence and multiphase flow, and micro- and nanofluidics. Both fundamental science and more applied science—then often in close collaboration with industrial partners—is done in the group and both experimental, theoretical, and numerical methods are used. The group presently has 10 scientific staff members, 5 part-time professors, 4 supporting technicians, and typically 15 postdocs, 50 PhD students, and 10–15 bachelor/master students.

Our research is embedded in the Max Planck Center Twente for Complex Fluid Dynamics and the J.M. Burgers Research Center for Fluid Mechanics (JMBC). The group receives external research funds from ERC, NWO, EU, and several industrial partners.

Melting and dissolution induce temperature and concentration gradients in liquid systems. These gradients induce flows, namely buoyancy driven flows on large scales and phoretic flows on small scales. Such flows locally enhance or delay the melting or dissolution process and thus determine the objects' shape. On large scales, a relevant example for the climate are glaciers and icebergs melting into the ocean, where cold and fresh meltwater experiences buoyant forces against the surrounding ocean water, leading to flow instabilities, thus shaping the ice and determining its melting rate. Another example is the dissolution of liquid CO2 in brine for CO2 sequestration. Next to buoyant forces also phoretic forces along the interfaces come into play. For dissolving drops at the microscale the phoretic forces become dominant. The resulting Marangoni flow not only affects their dissolution rate, but can also lead to their autochemotactic motion, deformation, or even splitting.

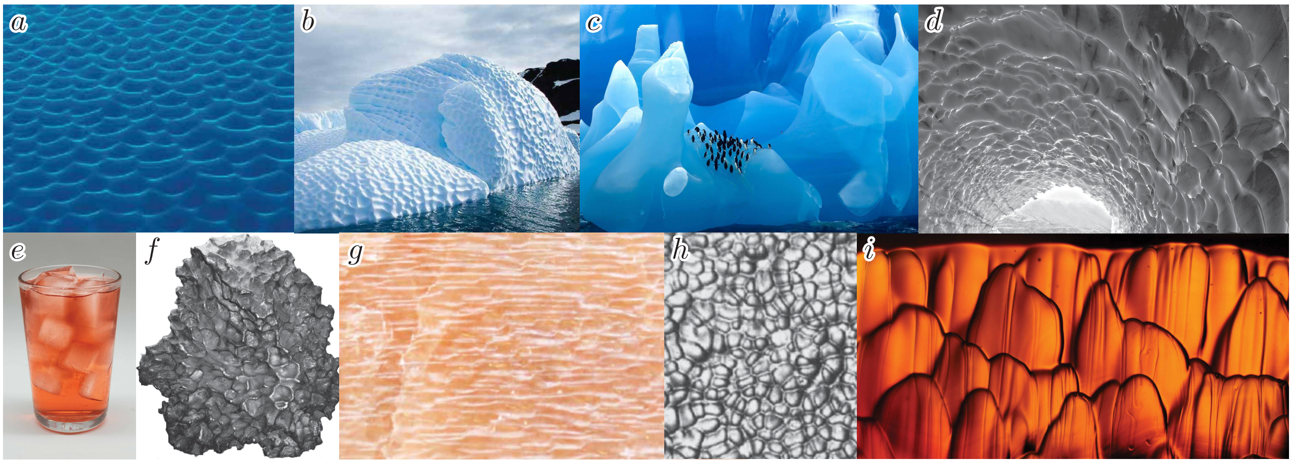

FIG. 1. Patterns in melting, dissolving, and ablation: *a*: Submerged side of a freely-floating iceberg (size of a scallop (dimple) $\approx$ 10 cm) [1]. *b*: Overturned iceberg revealing scalloped surface [2]. *c*: Blue ice of Antarctica (penguins for scale) [3]. *d*: Ice tunnel with $\approx$ 1 m features [4]. *e*: Beverage cooled by melting ice cubes. *f*: Meteorite shows regmaglypts [5]. *g*: Dissolution by free convection of a salt block in water, striped instability visible ($\approx$ 50 cm view) [6]. *h*: Surface morphology of salt surface exposed to water ($\approx$ 1 cm features) [7]. *i*: Caramel block dissolving into water (5 mm features) [8].

In spite of the relevance for these and many other applications, such multicomponent, multiphase systems with melting or dissolution phase transitions are poorly understood, due to their complexity, multiway coupling, feedback mechanisms, memory effects & collective phenomena. The objective of this project is a true scientific breakthrough: We want to come to a quantitative understanding of melting & dissolution processes in multicomponent, multiphase systems, across all scales and on a fundamental level. To achieve this, we perform a number of key controlled experiments & numerical simulations for idealized setups on various length scales, inspired by above sketched problems, but allowing for a one-to-one comparison between experiments and numerics/theory. For the first time, we will perform local measurements of velocity, salt concentration, and temperature and connect them to global transport processes, to arrive at a fundamental understanding of such Stefan problems in multicomponent systems.

Your profile:

– You have a strong background in (applied) physics, aerospace engineering, or mechanical engineering, or in a closely related discipline. You have strong communication skills, including fluency in written and spoken English. You are enthusiastic and highly motivated to do a PhD. For the experimental positions, experimental experience, extended knowledge on fluid mechanics, and experience in image and data analysis are required. For the numerical positions, numerical/coding experience, extended knowledge on fluid mechanics, and experience in data analysis are required.

Our offer:

– We want you to play a key role in an ambitious project in an inspiring and stimulating international work environment.
– We provide excellent mentorship and a stimulating, modern research environment with world-class research facilities.
– You will have an employment contract for the duration of 4 years and can participate in all employee benefits the university offers.
– You will be embedded in a dynamic research group with colleagues working on similar topics.
– Additionally, the University of Twente is a green campus with excellent facilities and resources for professional and personal development, and offers a wide variety of sports facilities.
– You will follow a high-quality personalized educational program.
– The research will result in a PhD thesis at the end of the employment period.
– We strive for diversity and fairness in hiring.

Applicants should be in the possession of a master degree in physics, aerospace engineering, mechanical engineering, or closely related field. **Applications should include:**

1. A motivational letter (1 page max) describing why you want to apply for this precise position including your research interests/experience and how do they connect to this position.
2. A detailed CV.
3. Academic transcripts from your Bachelor's and Master's degrees.
4. To assess a variety of skills we ask you to perform analysis on a data set and submit a 1–2 page (or larger if you want) report, see here: `https://pof.tnw.utwente.nl/vacancies/39` for details.
5. Name and email addresses of at least two visible references who are willing to send a letter of recommendation on your behalf.
6. An interview with a scientific presentation on your previous work will be part of the interview process.

Potential applicants are encouraged to **apply to Prof. Dr. Detlef Lohse and (cc) to Assoc. Prof. Dr. Sander Huisman**. See contact and other details here `https://pof.tnw.utwente.nl/vacancies/39`.

References

[1] B. W. Hobson, A. D. Sherman, and P. R. McGill, Imaging and sampling beneath free-drifting icebergs with a remotely operated vehicle, Deep Sea Research Part II: Topical Studies in Oceanography **58**, 1311 (2011).

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