Melting, erosion, and dissolution dynamics

Chair: Physics of Fluids group

Description

Melting, dissolving, and eroding are similar processes that are frequently found in nature and industrial processes, which in both situations can result in some very interesting geometries. Formation of ice scallops (dimpled surface), stone forests, and river sedimentation and shaping are some examples that can be found. In the figures below several examples of occurring phenomena can be found. Our aim is to study these effects in a controlled lab environment such that we can increase our understanding of these phenomena and their relevance (e.g. how to model the effect of morphology in the melting rate of ice, relevant to effects of global warming).

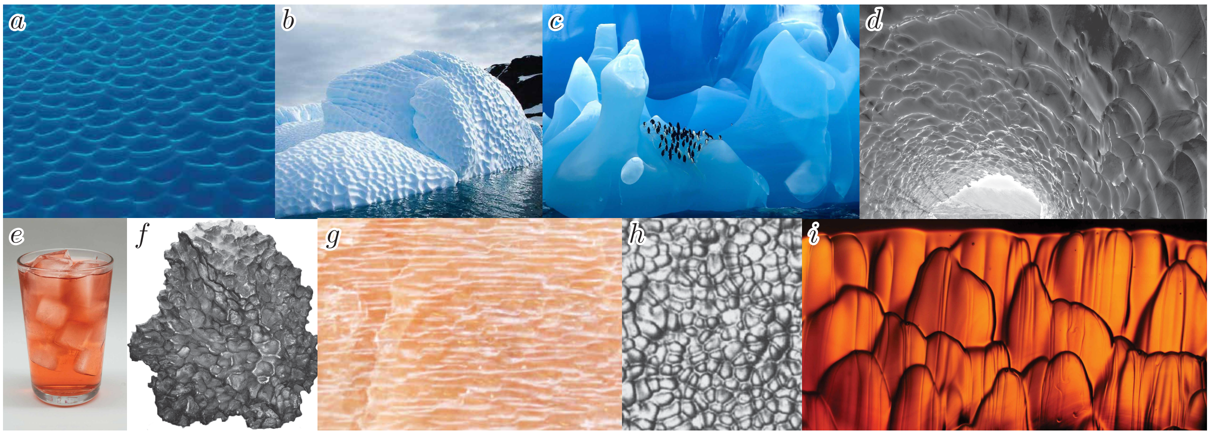

Figure 1: Patterns in melting, dissolving, and ablation: *a*: Submerged side of a freely-floating iceberg (size of a scallop (dimple) ≈ 10 cm) [1]. *b*: Overturned iceberg revealing scalloped surface [2]. *c*: Blue ice of Antarctica (penguins for scale) [3]. *d*: Ice tunnel with ≈ 1 m features [4]. *e*: 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 (≈ 50 cm view) [6]. *h*: Surface morphology of salt surface exposed to water (≈ 1 cm features) [7]. *i*: Caramel block dissolving into water (5 mm features) [8].

Assignments

We have a variety of different projects available to choose from. Some of the assignments are suitable for either BSc. or MSc. assignments, where the MSc. version will be more elaborate and detailed than the BSc. version. The Physics of Fluids turbulence labs contain several setups that can be utilised for the assignments. Some are just regular water tanks/aquaria, but we also have facilities that are more turbulent, see figure 2. What we are interested in is the melting(dissolving, eroding) dynamics of objects either in quiescent or turbulent surroundings, either fixed in place, moving Lagrangianly, or freely-floating. We are also interested in the patterns that are created during these processes, and how these affects the melting rate again (i.e. how is the morphology of the object created, sustained, evolving etc and how does it affect the flow around it and vice versa).

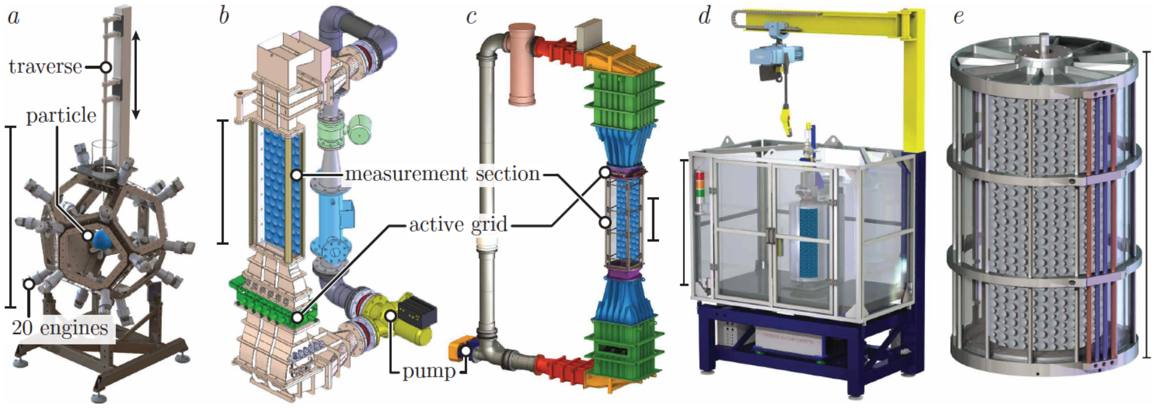

Figure 2: All setups that are possible to use for assignments. a: Homogeneous isotropic turbulence facility with 20 engines. b; c: Twente Water Tunnels [9, 10] with large test sections and active grids to enhance and control the turbulence. d; e: Turbulent Taylor–Couette facilities [11, 12], the flow between concentric, coaxial rotating cylinders. Ice (alternatively sugar) particle/surfaces are drawn in Fig. a-d, Fig. e has a replica surface. Each facility is brine proof and has a scale bar of 1 m.

BSc.

The following topics are available for BSc. Assignments:

- Melting of a sphere in the dodecahedron with turbulence
- Erosion of a blunt object in a bubble column
- Melting of a cylinder/spike in varying angles of inclination
- Dissolution of a cylinder in varying angles of inclination

During the assignment you will learn to prepare and perform experiments, under supervision of a PhD student or a postdoc. Most experiments will use high-speed imaging techniques to record data. You will learn how to use the (high-speed) cameras that we choose to use for the experiment. You will learn image analysis techniques to extract information from the images that are taking during the experiments.

MSc.

The following topics are available for MSc. Assignments:

- Dissolution of a cylinder/block in varying angles of inclination
- Melting of a submerged (gallium/wax/ice) sphere/cylinder
- Towed erosion or dissolution
- Melting, erosion, or dissolution in bubble induced turbulence
- Extension of any of the previous subjects by adding initial patterning on the objects

As mentioned before, it is also possible to pick one of the BSc. assignments and extend these projects where you would not study just the shape and rate of change, but also the surrounding flow that carries away material. It is also possible to extend a project, in scope, by applying a pattern on the initial geometry, possibly influencing the outcome in a specific way. Another important parameter for melting is the ambient temperature and salinity which can have a major impact on the melting process. For some more perspective and some of the open problems please read “Sculpting with flow” [13] and the references therein. What we aim is to find the general melting dynamics in conical systems which can be used by geophysicists to better climate change predictions.

During the assignment you will learn to prepare and perform experiments, first with guidance of one of the researchers, and later individually. Most experiments will use (high-speed) imaging techniques to record data. You will learn how to use the cameras that we choose to use for the experiment. You will learn image analysis techniques to extract information from the images that are taking during the experiments.

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