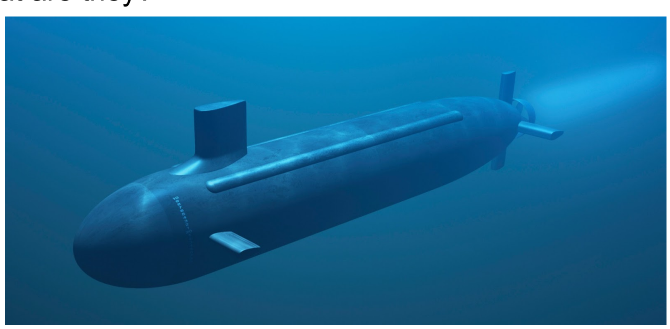
Running droplets on a front windshield

It's an everyday experience: Raindrops on a car's windscreen exhibit different behavior depending on the driving velocity. For low velocities, droplets are moving downwards, beyond a certain threshold velocity they are moving upwards. Physically, we are dealing with phenomena of two-phase flow with water and air being the two fluidic phases. In this project, we are interested in mathematical descriptions for such phenomena which allow predicting specifics of the movement of the drop, for instance, droplet velocities, the coalescence of droplets or contact angle at the so-called triple-line where air, water, and glass meet.

Keywords: Two-phase flow, Navier–Stokes equations.

Optimization of submarine body

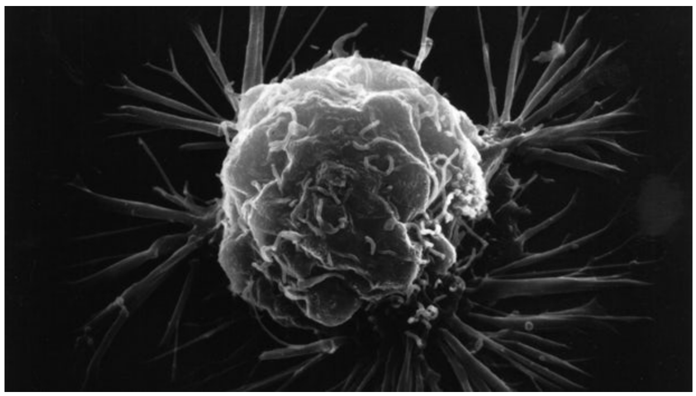
An important aspect of a submarine is its fuel efficiency. This mainly depends on its body shape, which has to be as streamlined as possible. Find a PDE model, including physically meaningful boundary conditions, that describes laminar water flow around a submarine body. Under the constraint that the submarine has to have a given fixed volume and the assumption of radial symmetry, what is the optimal body of a submarine? Are there families of body shapes that are superior, and if so, what are they?



Keywords: low Reynolds numbers, optimization.

Tumor growth

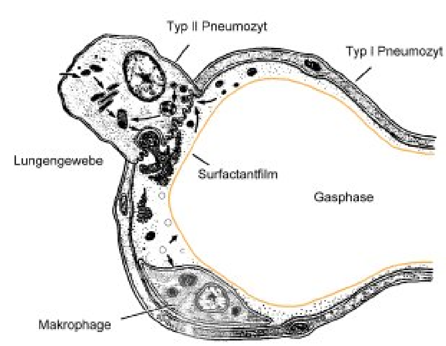
This project deals with the identification of the basic mechanisms of cancer growth by means of mathematical modeling. The progression of cancer in the human body is characterized by the unregulated growth of tissue, which competes with healthy tissue for nutrients and volume. It is governed by (vastly still unknown) processes on multiple spatial and temporal scales. In this project, we are interested in the mathematical modeling of the macroscopic dynamics of morphological changes in the tumor. PDE models shall be studied which—for simplicity—couple evolution equations for the tumor cells, host cells, and nutrient supply.



Keywords: Tumour growth models, phase-field models, reaction–diffusion equations.

Liquid films influenced by SURFace ACTive AgeNTS (surfactants)

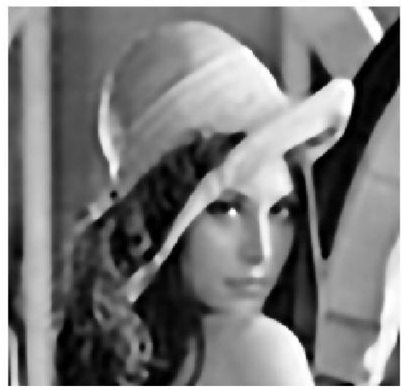
In this project, we are interested in the evolution of thin fluidic films. We focus on experimental settings where the evolution is driven by surface tension at the liquid–gas interface. Surfactants are chemical substances which—located at the liquid–gas interface—change the surface tension and therefore influence the evolution of the films. This is an effect that is not only used in industrial coating and drying processes ("de-icing") but also in the medical treatment of premature infants ("decrease of surface tension in alveolar to facilitate breathing").



Keywords: thin films, surfactants.

Image inpainting

Image inpainting is the task of filling in missing parts of damaged images based on the information obtained from surrounding areas. In this project, PDE models are considered for non-texture inpainting, i.e., for filling of originally approximately uniformly-colored damaged parts of an image. In recent years, approaches based on fourth-order PDE became popular, as they allow to incorporate boundary information both on the grayscale value and its gradient at the edge of the damaged area.



Keywords: Image inpainting, phase-field models, gray-value images.

Traffic jam prevention

Traffic jams are caused by perturbations of the traffic stream, for instance, by construction sides or by spontaneous events such as overtaking cars or accidents. The denser and faster the stream is, the more severe is the caused jam. Hence, some people argue that a general speed limit reduces the occurrences of traffic jams. However, this simple solution comes with a price: beyond traffic peak hours, the traffic stream is reduced as well. Can the probability of traffic jams occurrences be reduced by an *adaptive* (in time and space) speed limit, i.e., as a function of the current local traffic?

Keywords: optimization, randomness.