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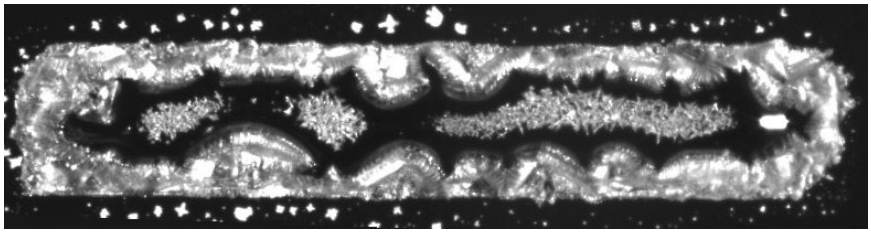
Limits of metastability and nucleation of crystals in supersaturated salt solutions

Water in Nature is rarely pure and the concentration of solutes (e.g., salts) can exceed the maximum solubility in many situations (e.g. drying or temperature changes). Such a supersaturated solution is metastable and the solute can precipitate suddenly into a crystal following a critical fluctuation in the metastable solution. This event plays a key role in various important contexts: crystallization can strongly damage the material if it happens inside a porous medium (e.g. concrete or stones, see picture below), while in the atmosphere it is thought to have an important impact on the formation and evolution of aerosols and clouds. The phenomenon thus has strong implications for historical heritage preservation, civil engineering, and climate models, but is still not well understood.

At ILM we measure the development of metastability and the kinetics of nucleation using well-controlled model systems (glass capillaries, nanoporous media, functionalized surfaces etc.) containing salt solutions subject to evaporation. As the solutions get more concentrated due to evaporation and enter the metastable regime, their properties are measured by optical spectroscopy (Brillouin, Raman). The goal of the internship will be to accurately record optical spectra and calibrate them as a function of the degree of metastabiliy (supersaturation) achieved by evaporation of a NaCl solution in various systems. The results will be compared to statistical theories of thermally induced nucleation in metastable systems including the effect of confinement and surface phenomena. The internship may be extended into PhD study.



Left: erosion damage on a statue from salt crystallization. Right: nucleation and growth of various forms of NaCl crystals nucleated in an elongated droplet at a concentration 60% higher than of equilibrium solubility.

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