LadHyX Seminar – December 4th, 10:45

Ellen Luckins
(Mathematics Institute, University of Warwick, UK)

Modelling evaporation in capillary porous media

The evaporation of a liquid from within a porous material is a multi-scale fluid-structure interaction process involving coupled vapour diffusion, phase-change, and liquid flows. Different drying behaviours are seen in different parameter regimes, and at different stages in the drying process. When capillary forces dominate, liquid is initially drawn to the surface by capillary forces, where it evaporates at a near constant rate; thereafter, a drying front recedes into the material, with a slower net evaporation rate. Modelling drying porous media accurately is challenging due to the multitude of relevant spatial and temporal scales, and the large number of constitutive laws required for model closure. I will derive simplified mathematical models for both stages of this drying process by systematically reducing an averaged continuum multi-phase flow model, using the method of matched asymptotic expansions, in the physically relevant limit of slow vapour diffusion relative to the local evaporation rate. The analysis gives insight into the subtle mechanisms that determine the overall drying rates and explains sudden changes that are observed in the evaporation dynamics. The resulting reduced models may be used to predict both the net evaporation rates and flow dynamics, and have applications in industrial drying processes, soil science, and understanding the salt-weathering of rock.