UNIVERSITAT DE BARCELONA

Fluid imbibition in porous and fractured media: a comparative study

Thesis proposal
Starting: January 2018
Laboratory: Nonlinear Physics – Facultat de Física, Universitat de Barcelona (http://www.ecm.ub.edu/nonlinphys/english/index.html).
Thesis advisors: Jordi Ortín (Fac. de Física, Univ. de Barcelona) and Stéphane Santucci (Labo. de Physique, ENS-Lyon).

Understanding fluid displacements in disordered media is very important in several geophysical and industrial problems, and also in the context of statistical physics of disordered systems.

The Thesis proposed here has two purposes. (1) To study experimentally the dynamics of fluid displacements in model porous media, and compare them with otherwise equivalent displacements in model open fractures. And (2) to advance in the theoretical understanding of their differences.

We will focus on constant flow-rate, stable imbibition displacements, in which a viscous wetting fluid invades the medium and displaces the air initially present. The porous medium will be modeled by a Hele-Shaw cell with randomly placed obstacles of the same height than the cell gap thickness. High resolution recordings of the front as a function of time will provide accurate values of local front velocities. We will study the statistical distributions of front velocities, their spatiotemporal correlations, and other relevant quantities.

We know that the probability distribution of the spatially-averaged velocity of the imbibition front that invades a fractured medium evolves from a generalized-Gumbel distribution at small scales to a Gaussian distribution at large scales. We want to know how these statistical properties are modified in a porous medium.

Preliminary experiments in a Hele-Shaw cell packed with glass beads show that local burst-like motions of the front are limited in extension by the characteristic pore size, but local velocities are much more widely distributed, with power-law tails that resemble the velocity distributions measured in other problems of front dynamics –notably in fracture.

This research is aimed ultimately at better understanding the physical origin of power-law, generalized-Gumbel, and other extreme statistical distributions that are found recurrently in the statistical characterization of several extended nonequilibrium physical systems.

Profile: the potential candidate must be strongly motivated to carry on experimental research and extensive sophisticated data analysis. Knowledge of basic concepts of nonequilibrium statistical physics will be highly valued.