Ben-Gurion University of the Negev
Blaustein Institutes for Desert Research
The Swiss Institute for Dryland Environmental and Energy Research
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Non-equilibrium flows in porous media

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Multiphase and reactive flow in porous media is ubiquitous in a wide range of applications across scales, from fuel cells and microfluidics to carbon geosequestration, storage of hazardous waste, subsurface transport of water, contaminants and nutrients and enhanced production of energy. Common to many of these systems is their out-of-equilibrium behavior, including the emergence of instabilities, preferential pathways and focusing of flow and reactions, and path- and rate-dependency.

I will overview my approach to expose the underlying physics of these systems, combining numerical simulations with controlled experiments and theory. I will exemplify how small-scale heterogeneity and coupled hydro-mechanical-chemical mechanisms control the behavior at larger scales in processes ranging from drying granular materials and gas migration in sediments to karst formation.

I will expand on a fundamental problem which has been intensively studied over the last century by hydrologists, physicists and engineers: Hysteresis, memory and energy dissipation in disordered media. We present an ab initio model of quasistatic fluid-fluid displacements in a Hele–Shaw cell with random gap spacing, akin to the fluctuationless random-field Ising model in ferromagnetism. In contrast with existing phenomenological approaches, all our model parameters have a clear, identifiable physical meaning, making it accessible to rigorous experimental and analytical scrutiny. This provides a quantitative link between the microscopic capillary physics, spatially-extended collective events (Haines jumps), energy dissipation and large-scale drainage–imbibition hysteresis.

Date & Location:

Tuesday, May 25, 2021, 11:00