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Energy dissipated through Haines jumps in disordered media

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We study energy dissipation in quasistatic two-fluid displacements in disordered media, analytically, numerically and experimentally. We establish the energy balance for a recent model that successfully reproduces collective capillary instabilities (Haines jumps), hysteresis and memory of pressure-saturation trajectories [1]. Strikingly, we discover that energy dissipation can emerge from cooperative behavior mediated by lateral correlations between individually reversible capillary displacements. This contrasts the widely-used compartment (Everett) model which rely on the existence of a basic noninteracting hysteretic unit.

We find that the energy dissipated in individual Haines jumps between two consecutive equilibrium configurations (i) needs not to be proportional to the corresponding increase in saturation (avalanche size), (ii) spans many orders of magnitude, and (iii) can greatly exceed the work invested in driving the system between these two configurations. We study parametrically how the dissipation depends on system properties such as the microstructural heterogeneity and gravity (Bond number). Finally, we expose the connection between dissipation and large-scale imbibition-drainage hysteresis. We show that the accumulated dissipation along a cyclic pressure-saturation trajectory coincides with the area enclosed by the cycle.

[1] Holtzman, R. et al., Nature Communications Physics, 3:222 (2020).

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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