Mixed-wet Percolation

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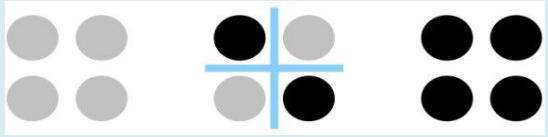
Motivation

Percolation is typically studied in the context of fluid flow in porous media. In this work, we introduce a new percolation model inspired by the flow of immiscible fluids through a mixed-wet porous medium namely mixed-wet percolation.



(a) (b) (c)

Fig 1: In (a), all grains are A-type and in (c), all the grains are B-type which corresponds to no flow, and no links are occupied. In (b), two A-type and two B-type grains are placed diagonally opposite such that they are always adjacently different, and fluid can flow through all the links between them.

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Model

Sites are occupied in primal lattice with probability (p). Bonds are occupied on the dual lattice between every occupied and unoccupied sites. These bonds form perimeter clusters (closed loops) are connected to other such perimeter clusters via knots.

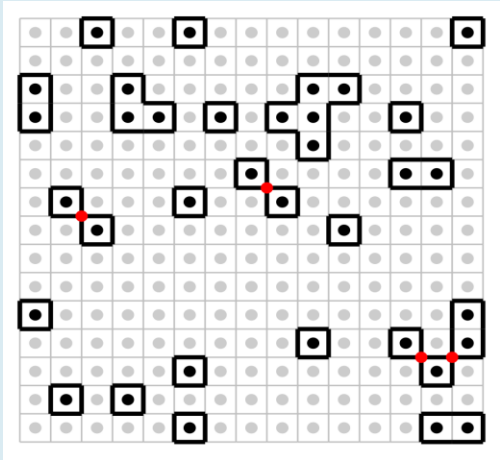


Fig 2: A 16×16 primal lattice at site occupation probability p = 0.15 showing occupied (black) and unoccupied (grey) sites, with perimeter bond clusters forming on the dual lattice. Red circles represents the knots.

Results

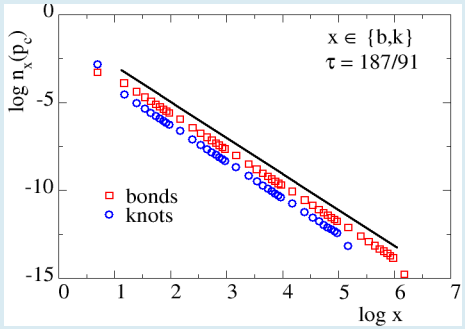
Cluster Size Distribution :

The cluster number density $n_x(p)$ is defined as

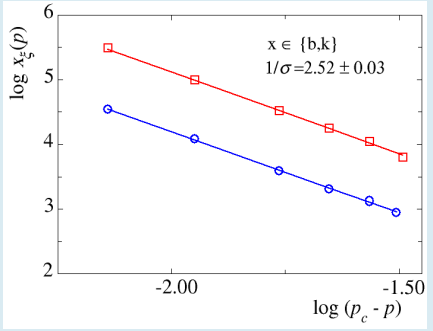
$$n_b(p) = \frac{N_b(p)}{2L^2}$$

So, the perimeter bond cluster size distribution function can be written as

$$n_x(p) = x^{-\tau} N[(p - p_c)x^{\sigma}]$$



(a)



(b)

Fig 3 : (a) Determination of τ and (b) determination of σ for the bond cluster and knot clusters.

Fractal Dimension :

We present here an independent measurement of the fractal dimension of the spanning perimeter bond clusters.

$$M_x(p_c, L) \sim L^{df}$$

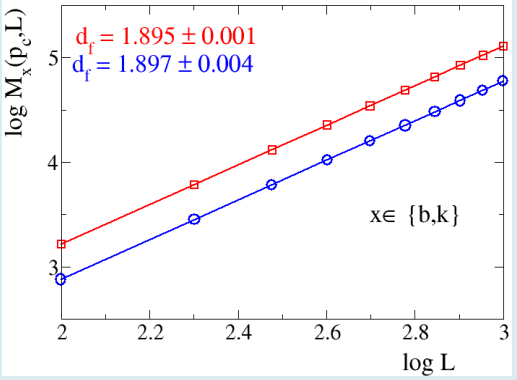


Fig 4: Plot of the mass of the spanning clusters $M_x(p_c, L)$ against lattice size L in a double logarithmic scale.

[1] J. R. Das, S. Sinha, A. Hansen, and S. B. Santra, "Mixed-wet percolation on a dual square lattice," *Physica A: Statistical Mechanics and its Applications*, vol. 679, p. 130957, 2025. doi: 10.1016/j.physa.2025.130957