Percolation induced Phase Transition in the Effective Conductivity of Highly Heterogeneous Composite Media.

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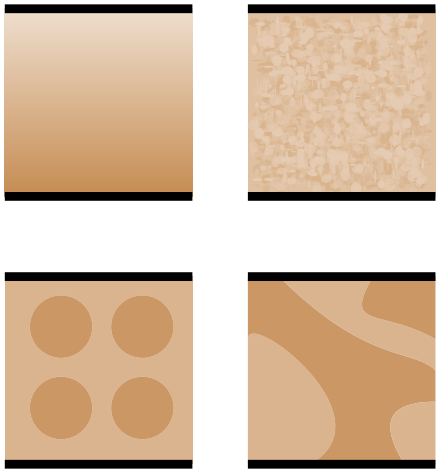
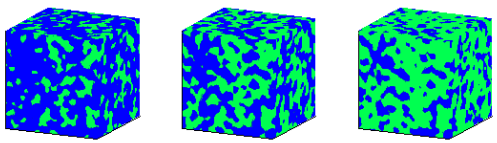
Colin Clark: Effective Conductivity in Composite Media





Consider a highly heterogeneous, irregular, composite medium with conductivity field $K(x)$ and the flow equation with appropriate boundary conditions for incompressible fluids in porous media.

$$\nabla \cdot \Big(K(x) \nabla H \Big) = 0$$

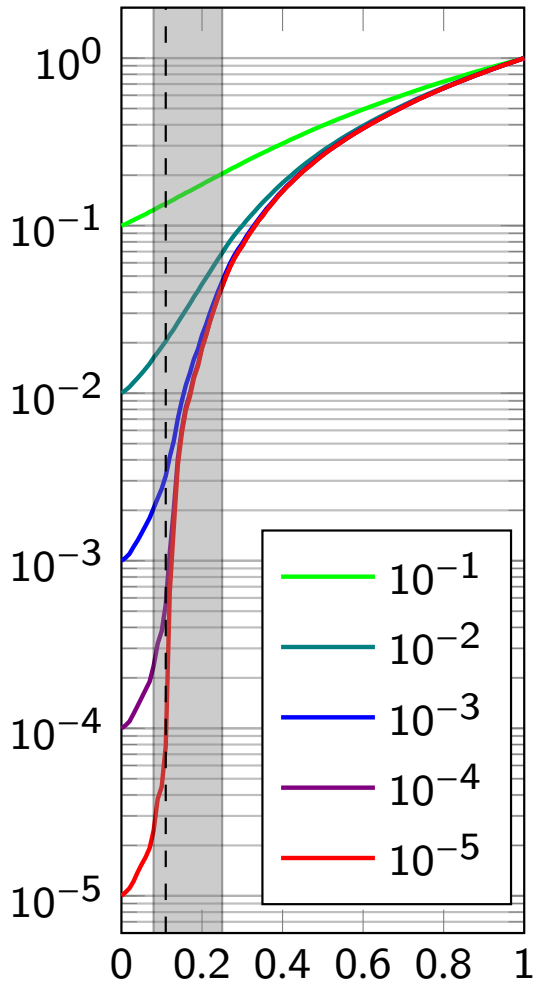
The equivalent conductivity is a constant K_e that induces the same volumetric flux, Q, under the same boundary conditions.

We propose the model:

$$\frac{\partial}{\partial v} K_e(v; K_2) = \Big(1 - \mathscr{C}(v)\Big) f_-(v) + \mathscr{C}(v) f_+(v)$$

$$\mathscr{C}(v) = \left(\frac{1}{1 + \exp(-(v - v_0)/\omega)} \right)^{\rho}$$

$\log_{10}\left(K_e(v)\right)$ **for select** K_2



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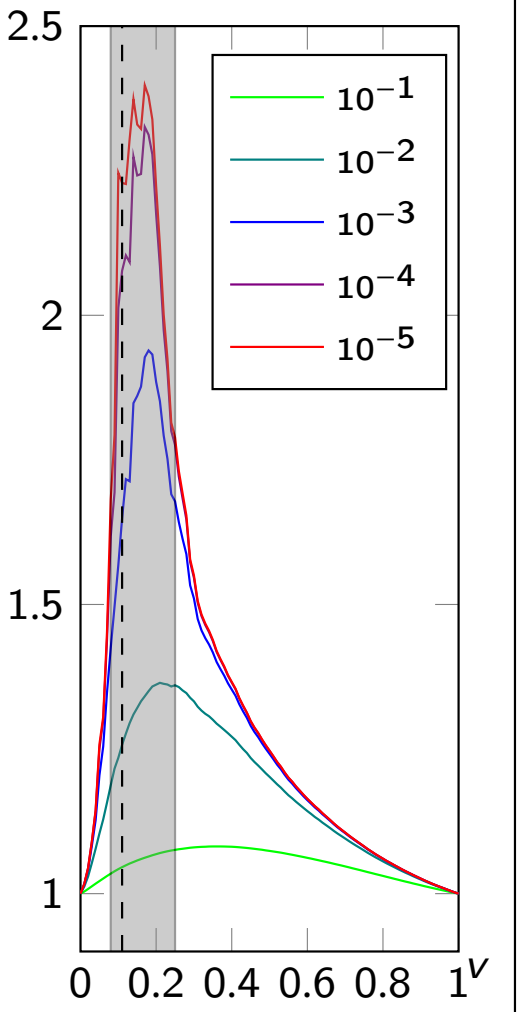
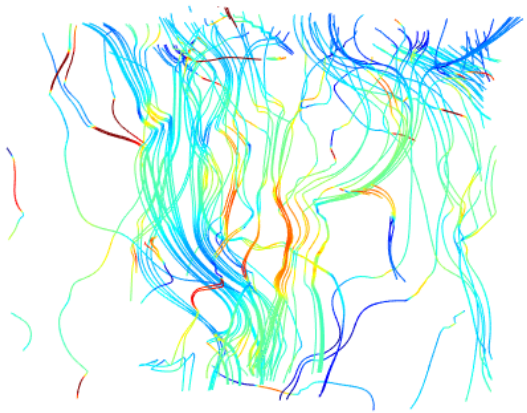


For $v \approx v_c$ and for $K_2 \ll K_1$, fluid flow is dominated by:

1. the high resistance associated with even very brief passages through low conductivity regions,
2. the potentially very long detours around such regions.



Streamlines by velocity:
Red: fast, Blue: Slow.