Transport under advective trapping

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- Motivation:
  - Advective trapping occurs when solute enters low velocity zones in heterogeneous porous media.
  - Classical approaches combine slow advection and diffusion into a dispersion coefficient or a single memory function.
- Objective
  - We investigate advective trapping in homogeneous media with low permeability circular inclusions.
  - We build an upscaled model in the continuous time random walk framework.

- Mean velocity in the matrix is proportional to the area occupied by the inclusions χ.
- Velocity in the inclusions is not constant. The mean velocity in the inclusions $\overline{v}_i$ is log-normally distributed and proportional to χ.

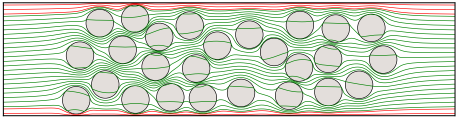

FIGURE 1: Streamlines in a medium with randomly placed inclusions.

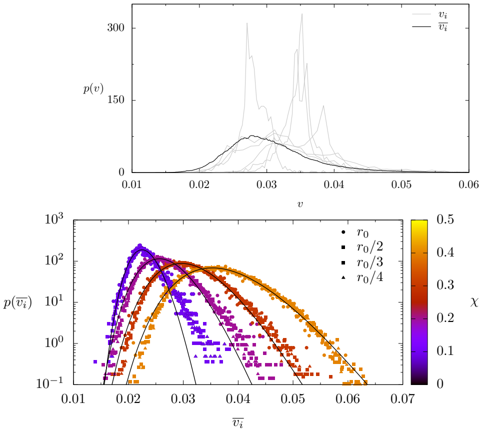

FIGURE 2: Velocity distribution inside the inclusions (top) and mean velocity distribution (bottom).

- The breakthrough curves reflect the trapping of particles in the low permeability inclusions.
- The trapping rate follows a Poisson distribution.

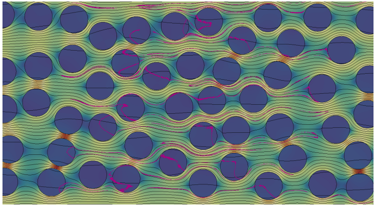

FIGURE 3: Transport through a medium with randomly placed inclusions.

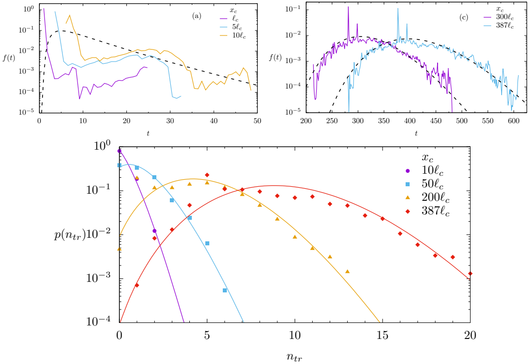

FIGURE 4: Breakthrough curves at increasing distance from the inlet and advection - dispersion equation solution fit (top). The number of trapping events follows a Poisson distribution (bottom).

UPSCALED CONTINUOUS RANDOM TIME WALK MODEL I

- We consider advective-dispersive particle transitions in the mobile matrix

$$dx(s) = v_{\text{matrix}} ds + \sqrt{2D_m ds}\,\xi(s),$$

with s the mobile time spend outside the inclusions, D_m is diffusion (from Eames & Bush, 1999) and $\xi(s)$ a Gaussian white noise.

- During the mobile time s particles encounter n_s inclusions. The clock time $t(s)$ after the mobile time s has passed is given by

$$t(s) = s + \sum_{i=1}^{n_s} \tau_i$$

where n_s is Poisson distributed and the trapping times τ_i depend on the distance (random uniform) and the velocity at the visited inclusion (random log-normal)

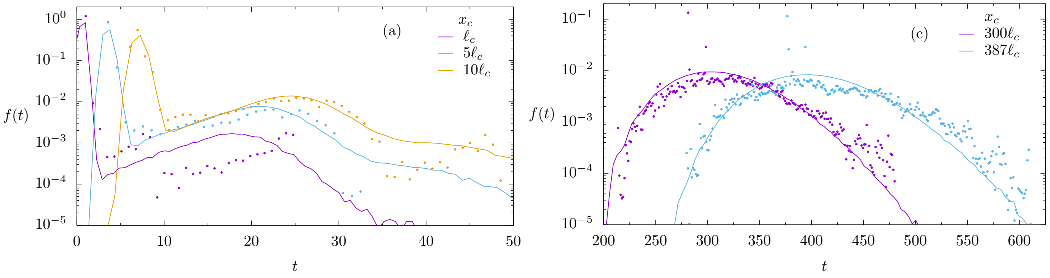

FIGURE 5: Breakthrough curves at increasing distance from the inlet (dots) and upscaled CTRW model results 8solid line).

Summary & Conclusions

- Purely advective transport was here considered as a limiting case for advective-diffusive transport.
- The shape of breakthrough the curves cannot be predicted with a macrodispersion coefficient.
- We developed a CTRW model developed parameterized by measurable medium properties: the trapping rate (Poisson distributed), the velocity in the matrix (a function of χ) and the mean velocity distribution inside the inclusions (log-normal).

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