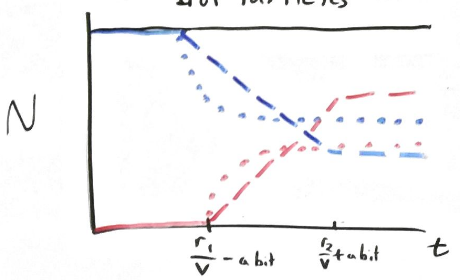
① System + Expected Behavior

\# of Particles

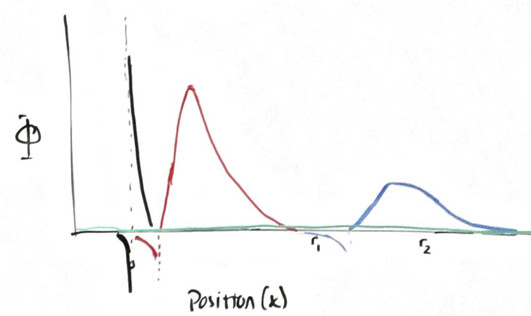


N = # of particles

N_t = # of traveling particles

N_B = # of bound particles

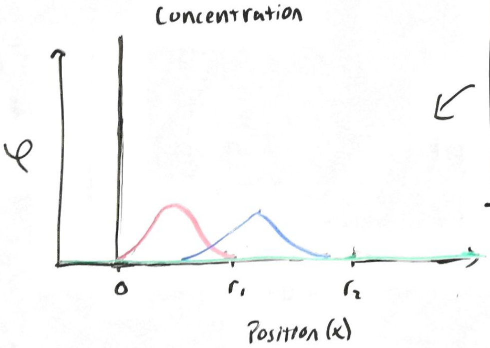
Flux



Note → Dashed lines represent linear binding model

Dotted lines represent space-limited decaying binding model

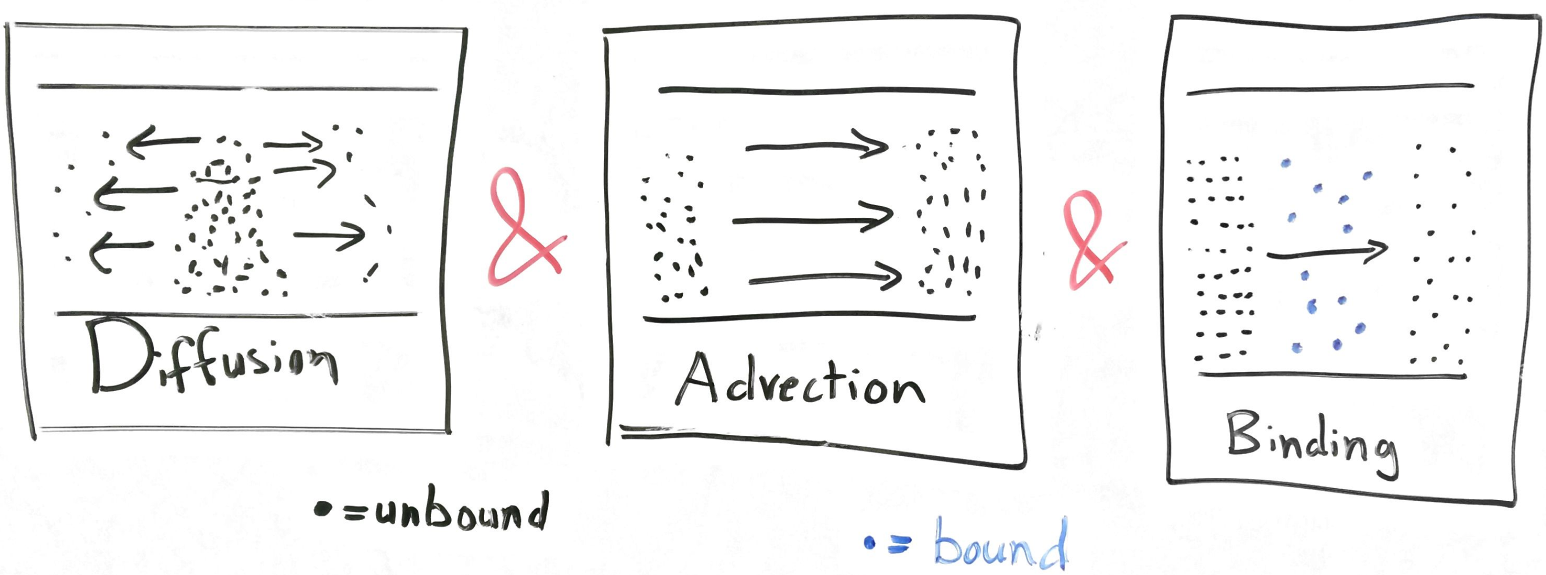
Concentration



LEGEND

- ■ $t = 0$ + a teensy weensy bit of time
- ■ t = a little later, $t < \frac{r_1}{v}$
- ■ t = even a little more time, $\frac{r_1}{v} < t < \frac{r_2}{v}$
- ■ t = past filter, $t = \infty$

② APPROACH



③ Notation + Units

N = total # of particles in system

N_T = # of unbound particles in system

N_B = # of bound particles in system

β = Binding constant of porous material
units = particles/time

φ = Concentration of particles
units = particles/Area

D = diffusion constant
units = $\frac{1}{cm \cdot s}$

t = time
units = seconds

x = position
units = cm

V = velocity of water
units = cm/s

t_e = time such that $\varphi(r_1, t) > 0$
units = seconds

t_x = time such that $\varphi(r_2, t) = 0$ AND $\varphi(r_2 + dx, t) > 0$
units = seconds

4 THE EQUATIONS

$$\underbrace{N_B}_{\text{\# of bound particles}} = \underbrace{N}_{\text{total \# particles}} - \underbrace{\int_0^{\infty}\int_0^{t_e}\left(\underbrace{D\frac{\partial^2\varphi}{\partial x^2}}_{\text{Diffusive term}} - \underbrace{\frac{\partial^2\varphi}{\partial x\,\partial t}}_{\text{Advective term}}\right)dt\,dx}_{\text{Before particles enter reaction zone}} - \underbrace{\int_0^{\infty}\int_{t_e}^{t_x}\left(\underbrace{D\frac{\partial^2\varphi}{\partial x^2}}_{\text{Diffusive term}} - \underbrace{\frac{\partial^2\varphi}{\partial x\,\partial t}}_{\text{Advective term}} - \underbrace{\frac{\beta}{A}}_{\text{Binding loss}}\right)dt\,dx}_{\text{After particles enter reaction zone}}$$

BOUNDARY CONDITIONS

No position-based boundary conditions; assume infinitely long tube

Time-based $\rightarrow$ $t=0$, $\varphi(0,0) = N/A$