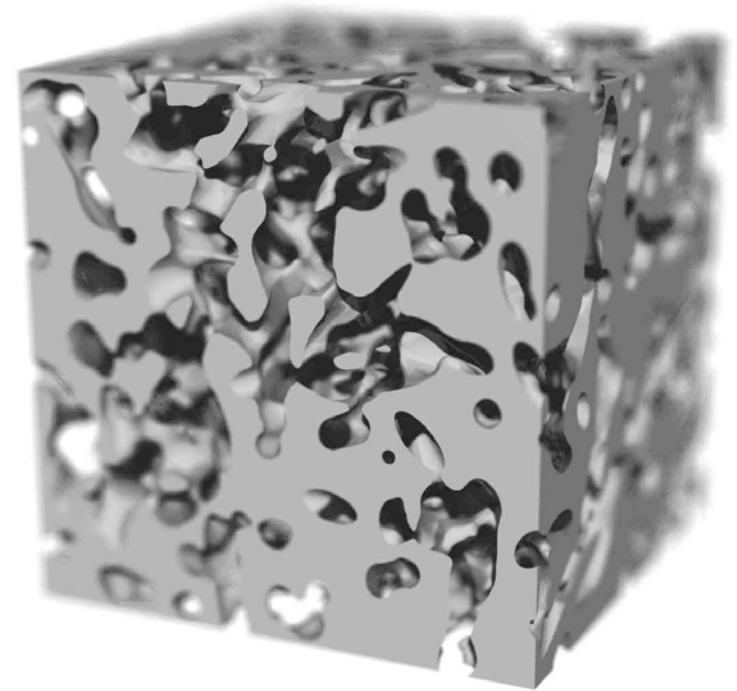


# Porous materials

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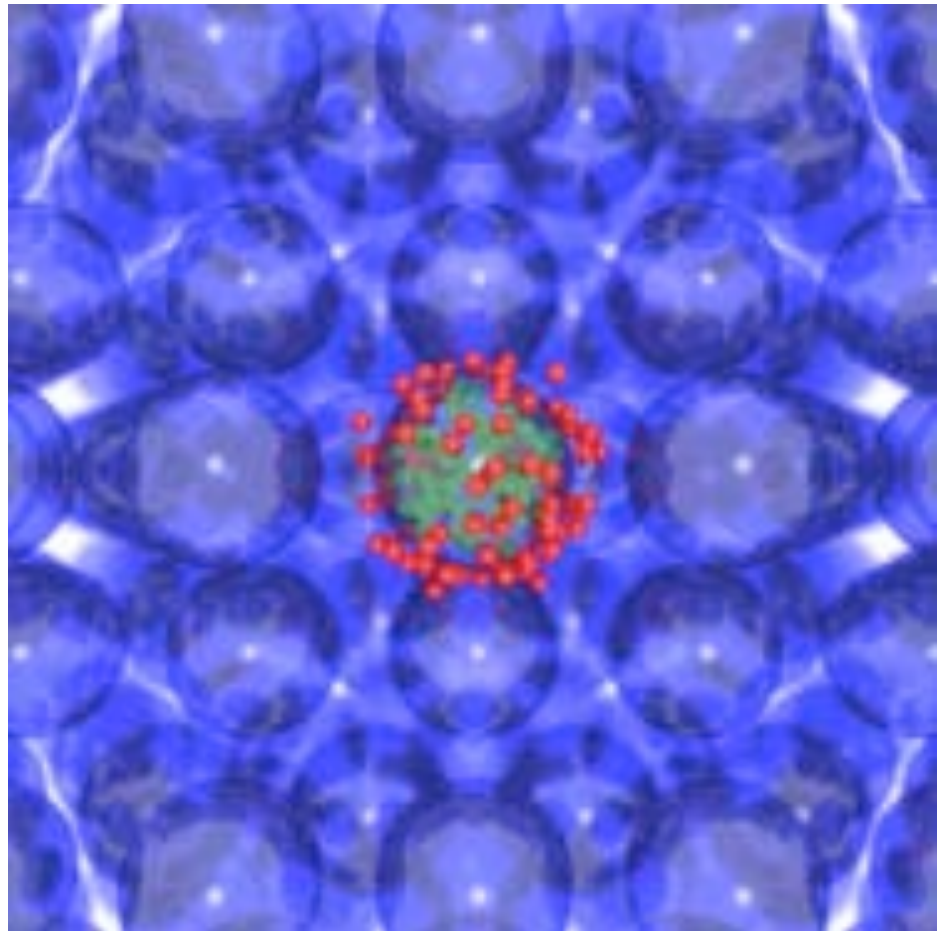
- Rocks, soil, wood, brain tissue ...



# Info from diffusion NMR

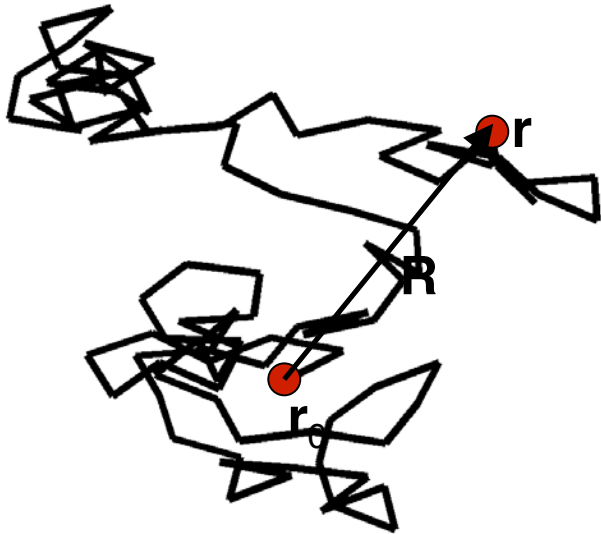
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- Pore size
- Tortuosity
- Anisotropy

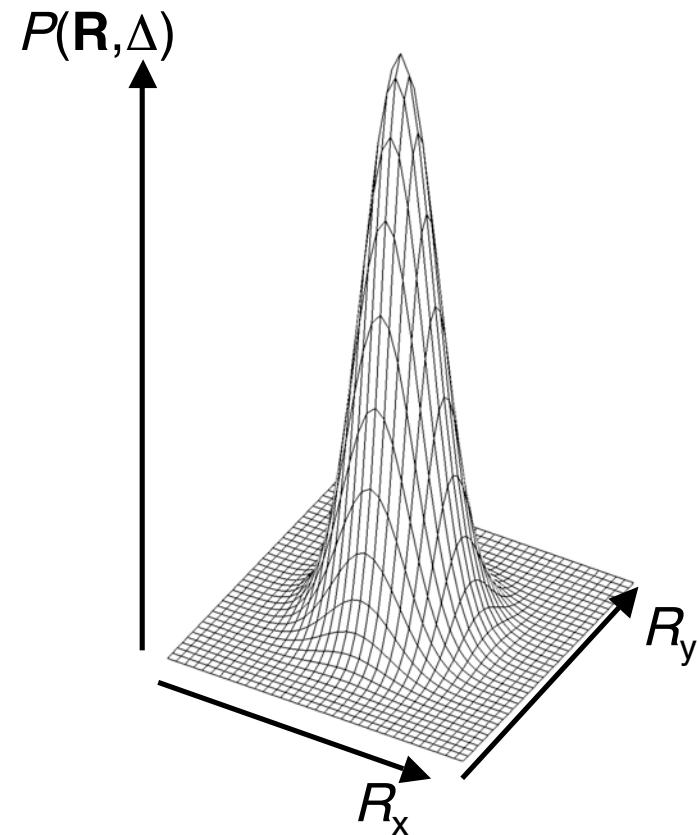


# Diffusion propagator, $P(\mathbf{R}, \Delta)$

- Probability density for a spin having the displacement  $\mathbf{R}$  during the diffusion time  $\Delta$



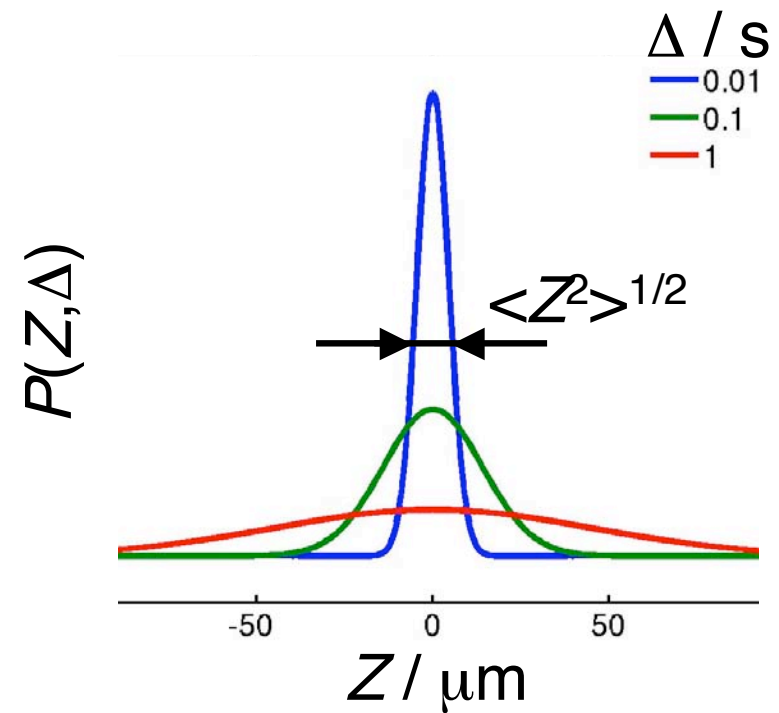
Free diffusion: Gaussian



# Gaussian diffusion

$$\langle Z^2 \rangle = 2D\Delta$$

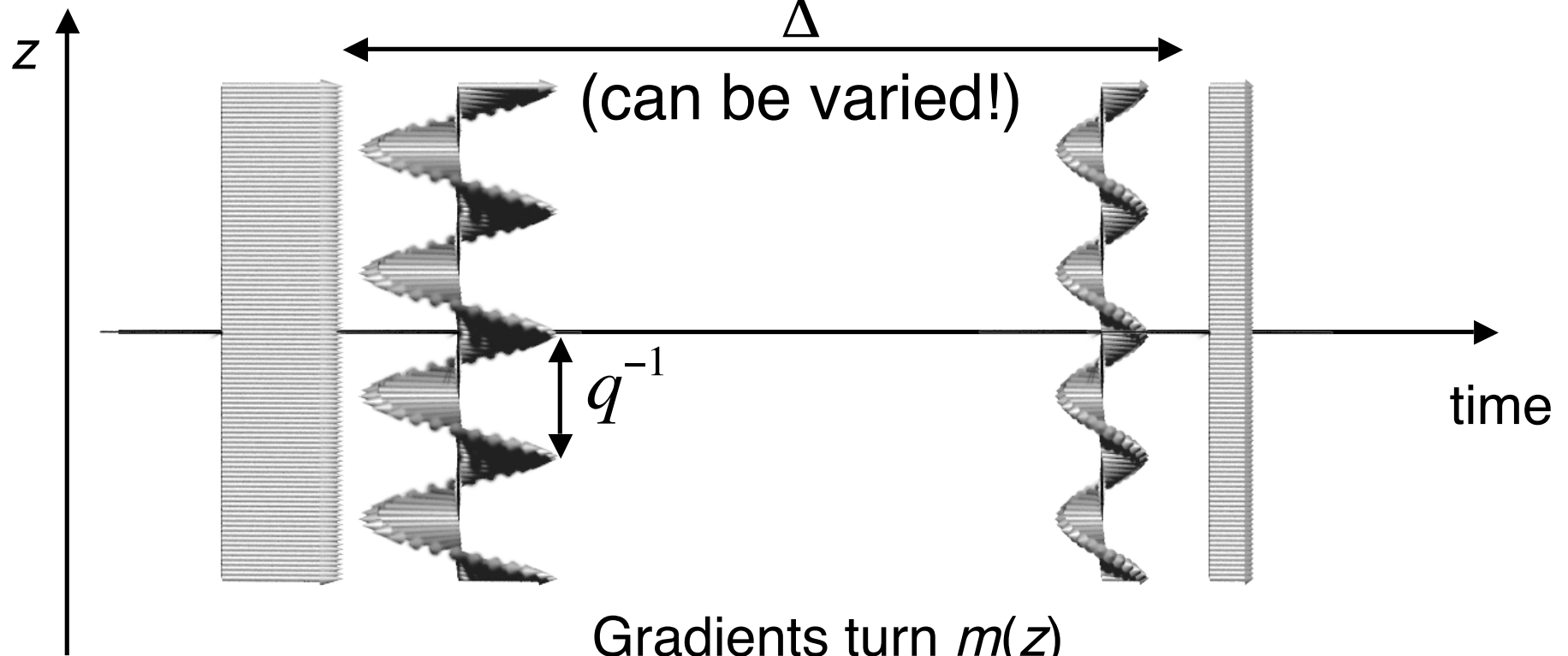
mean-square  
displacement,  $\langle Z^2 \rangle$   
diffusion coeff.,  $D$



# Short gradient pulse approximation

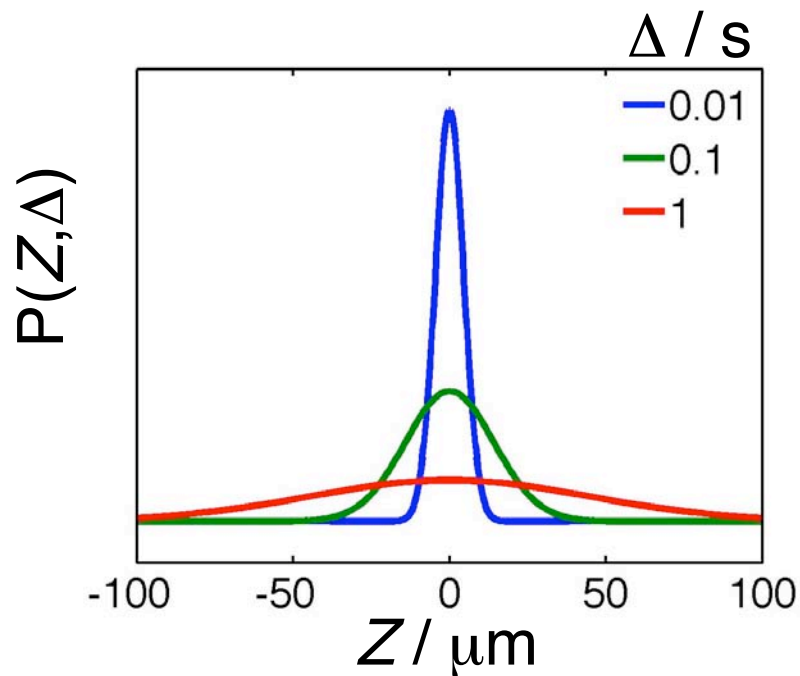
$$E(q, \Delta) = \int_{-\Delta/2}^{\Delta/2} P(Z, \Delta) e^{-i2\pi qZ} dZ$$

$$q = \frac{\gamma G \delta}{2\pi}$$

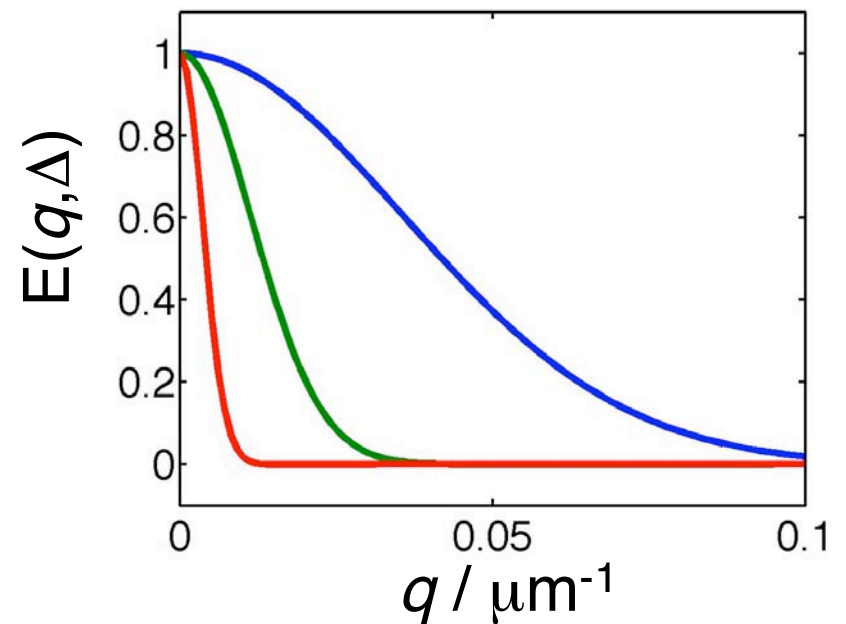


Gradients turn  $m(z)$  instantaneously

# Fourier pair: $P(Z,\Delta)$ - $E(q,\Delta)$

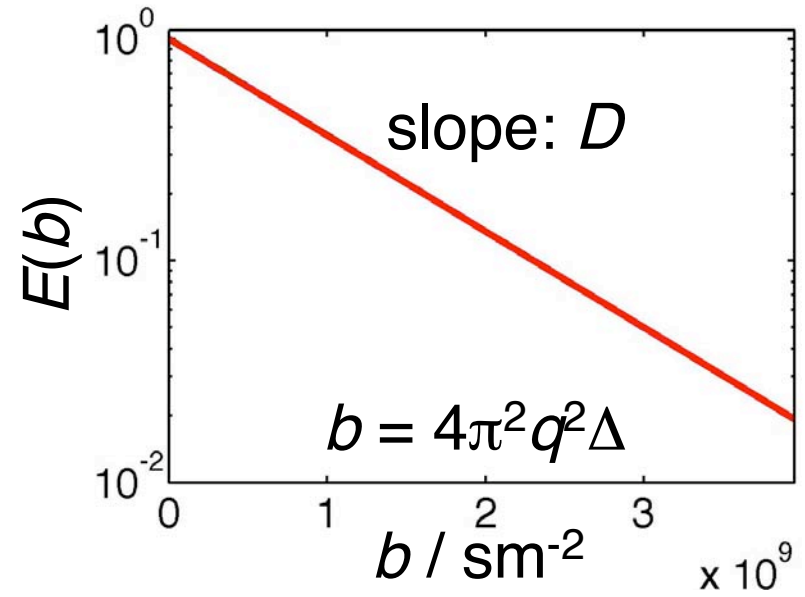
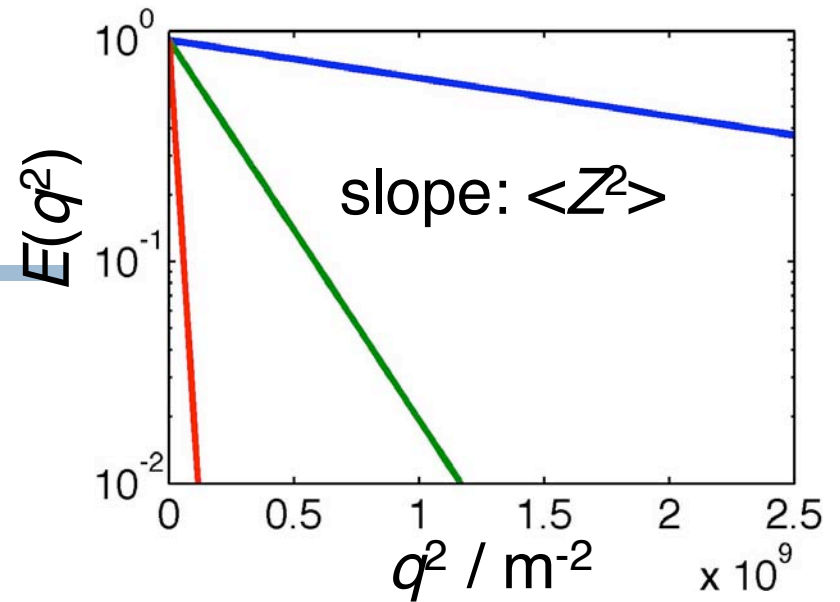
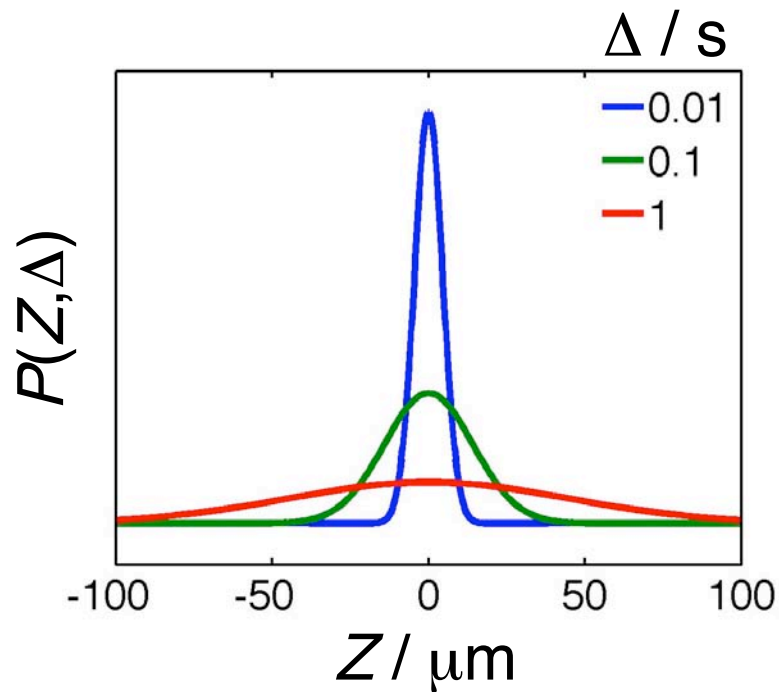


$$E(q) = e^{-2\pi^2 q^2 \langle Z^2 \rangle}$$

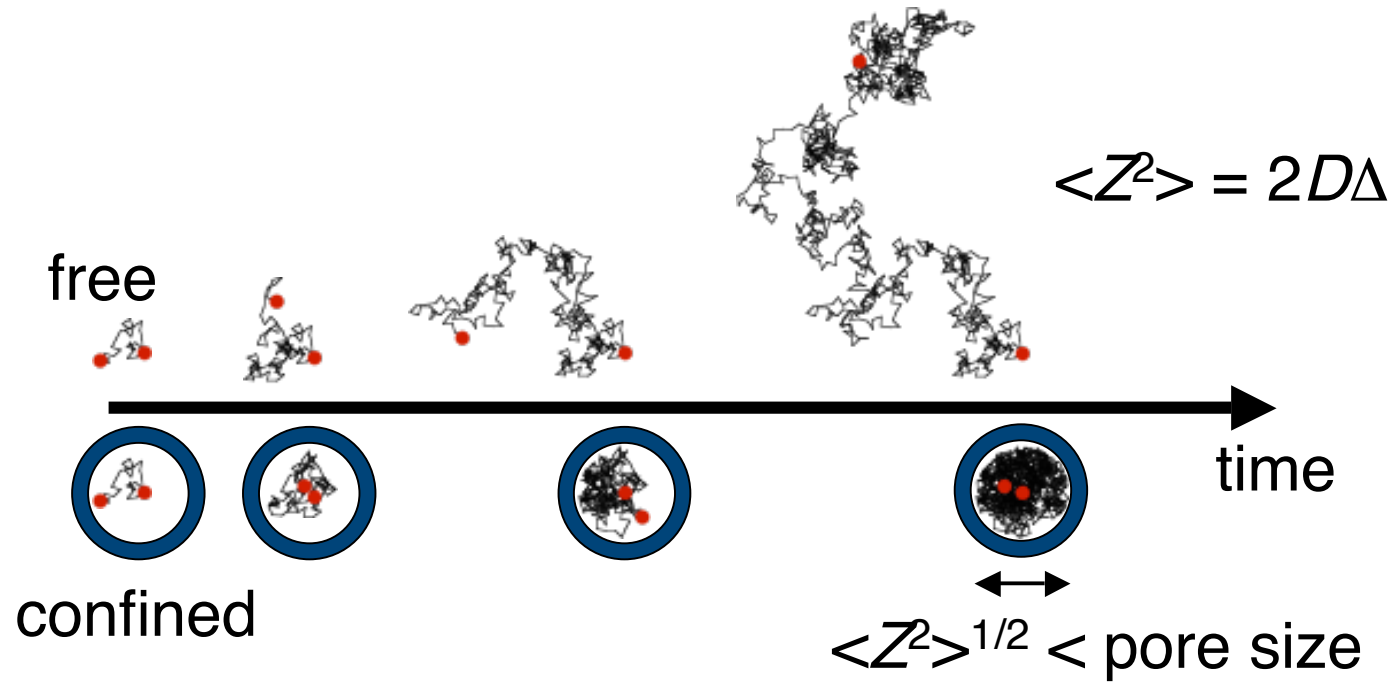


# Gaussian diff.

$$\langle Z^2 \rangle = 2D\Delta$$

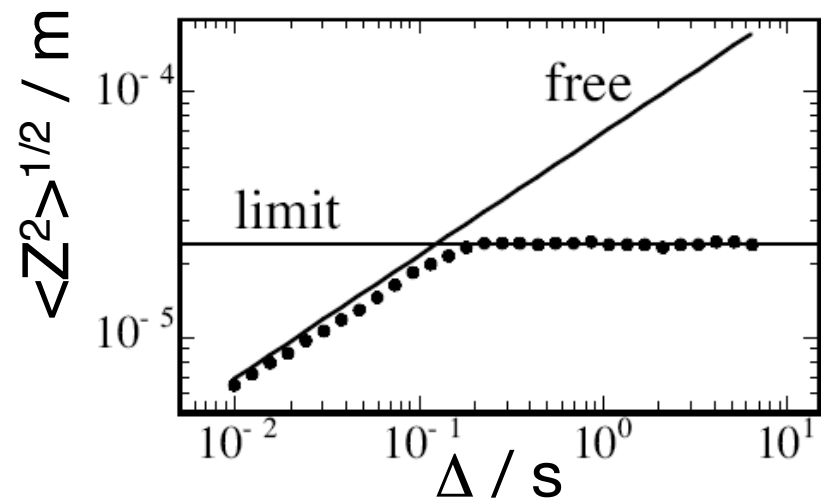
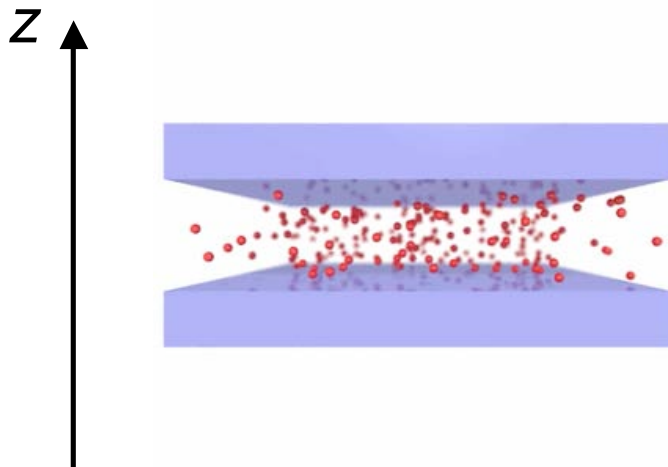


# Confinement

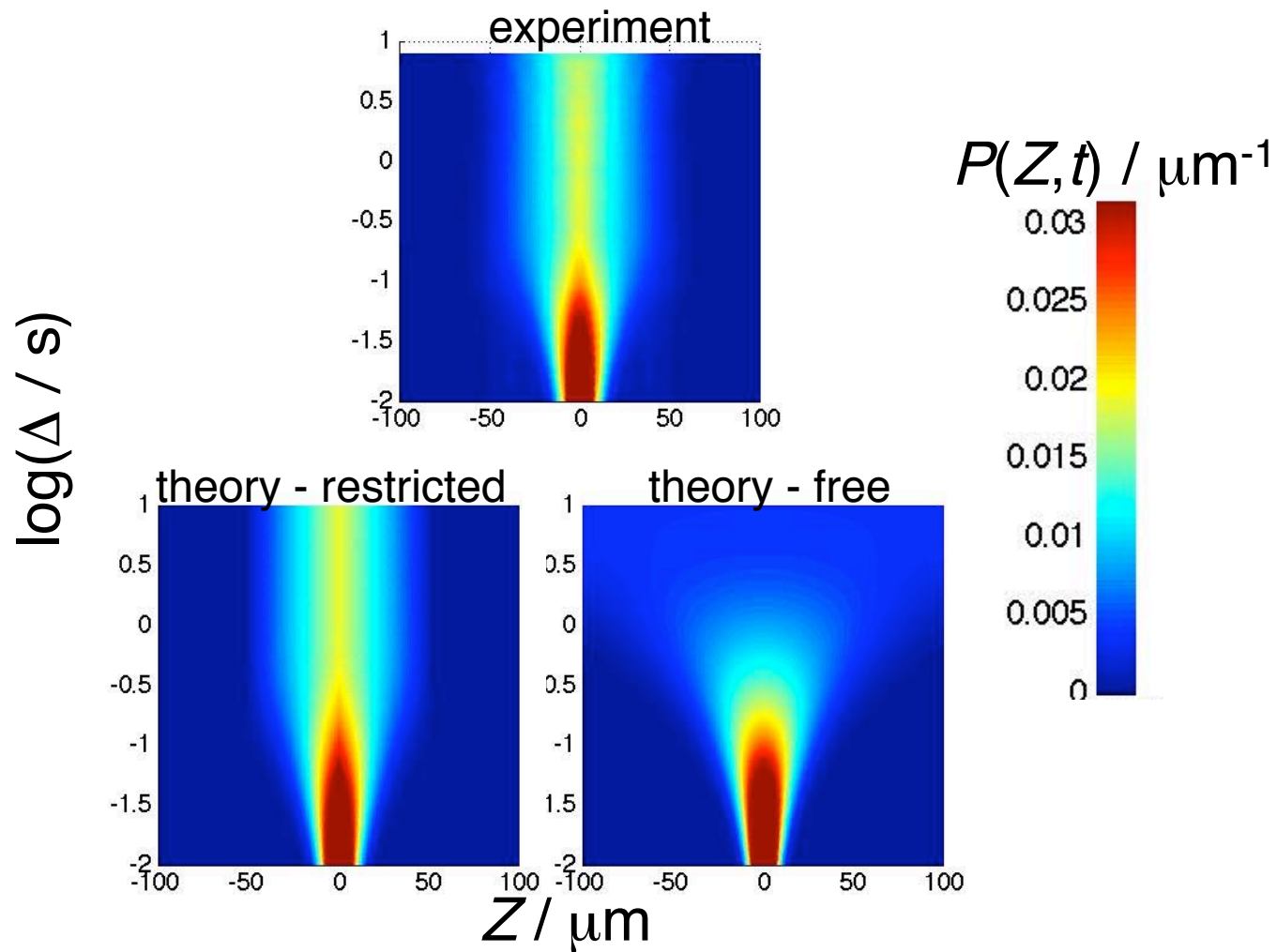




# Single pore

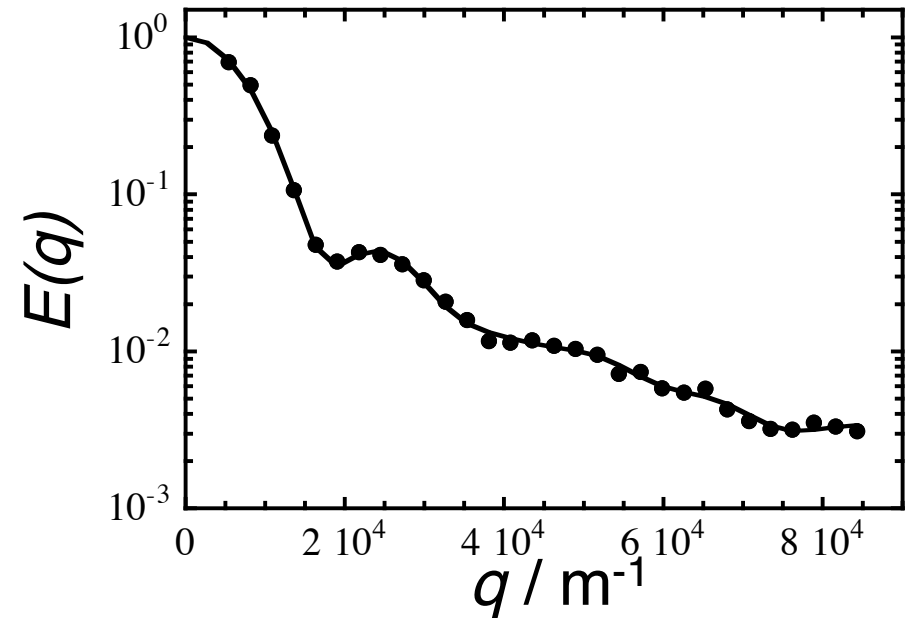
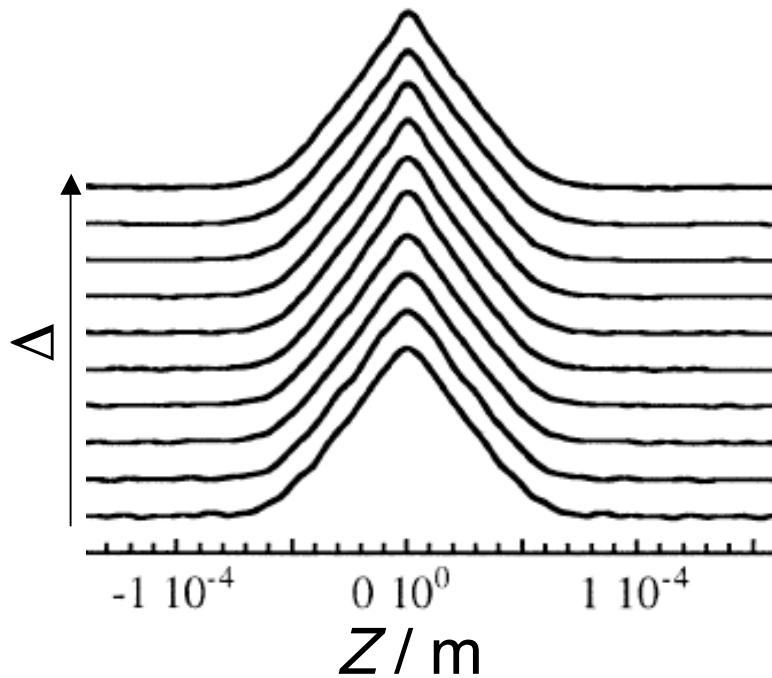


# Propagator for single pore

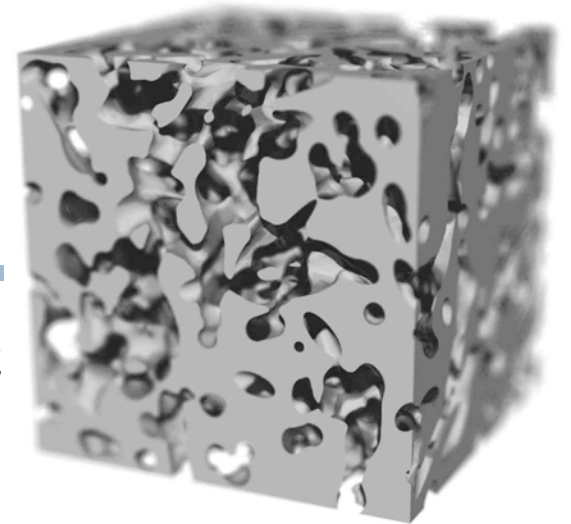


# Diffusion diffraction

## Non-Gaussian propagator

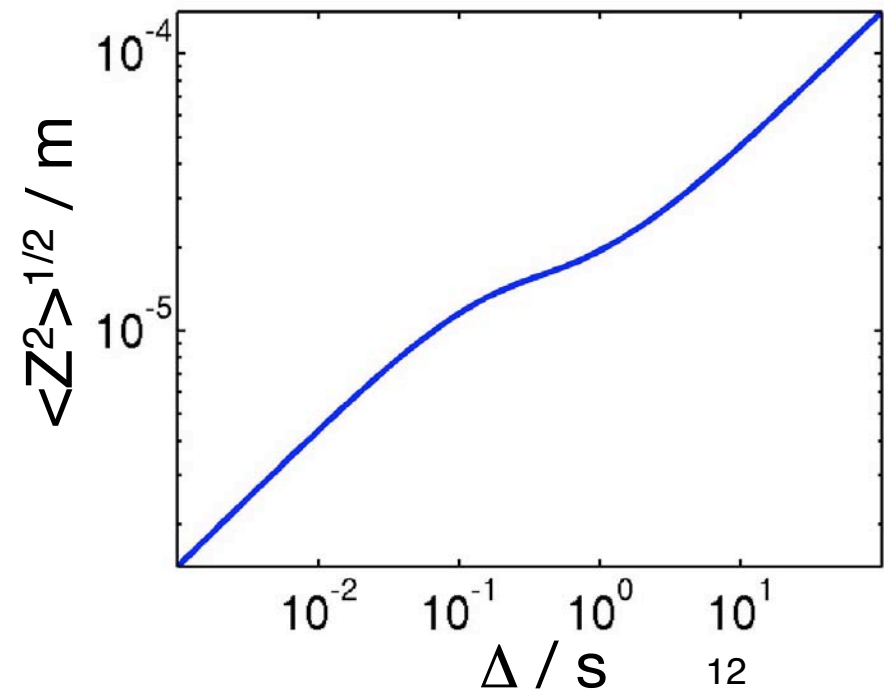
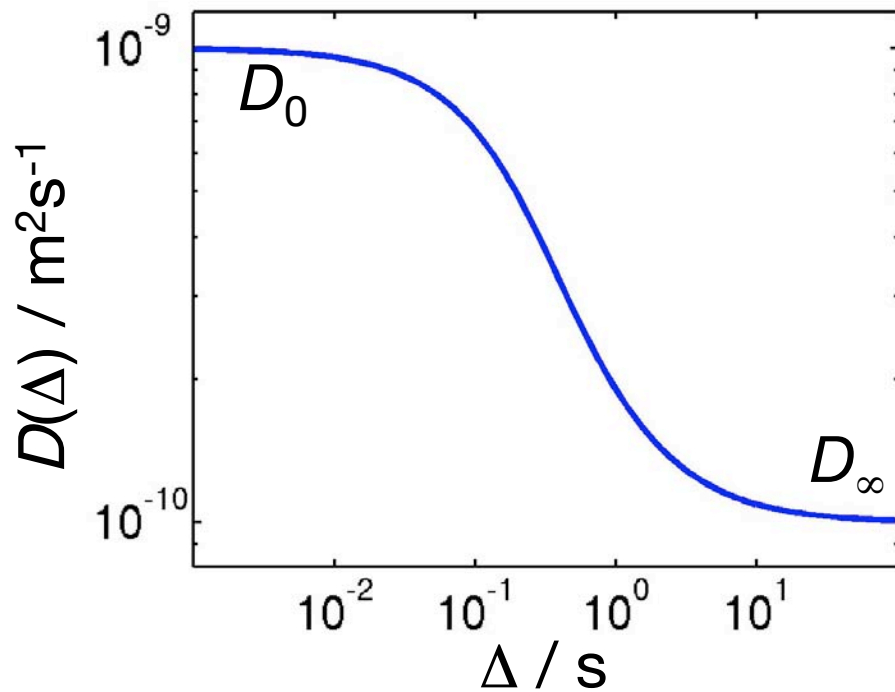


# Connected pores

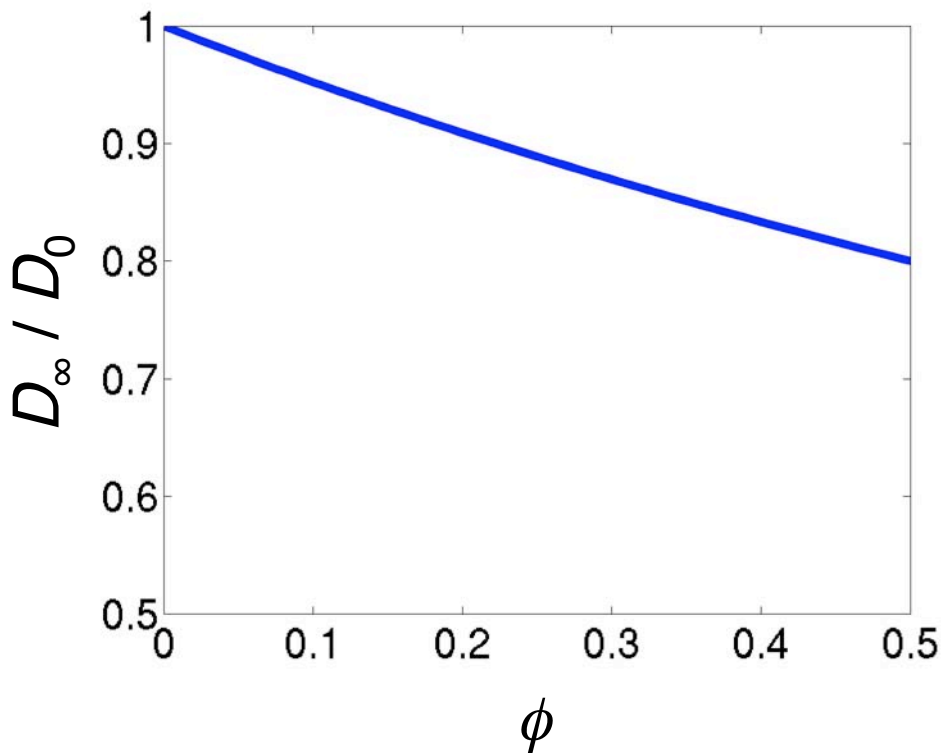


Apparent diffusion coeff., ADC

$$D(\Delta) = \langle Z^2 \rangle / 2\Delta$$

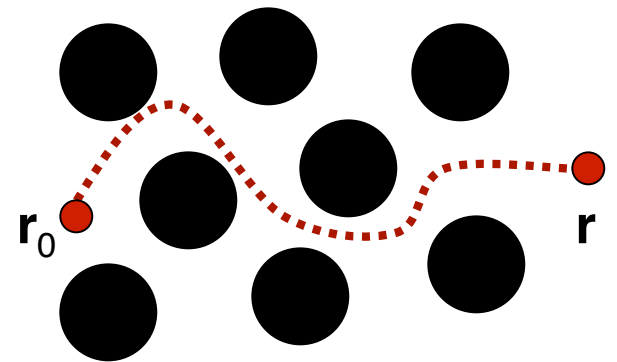


# Obstruction / tortuosity



$$\frac{D_\infty}{D_0} = \frac{1}{1 + \phi/2}$$

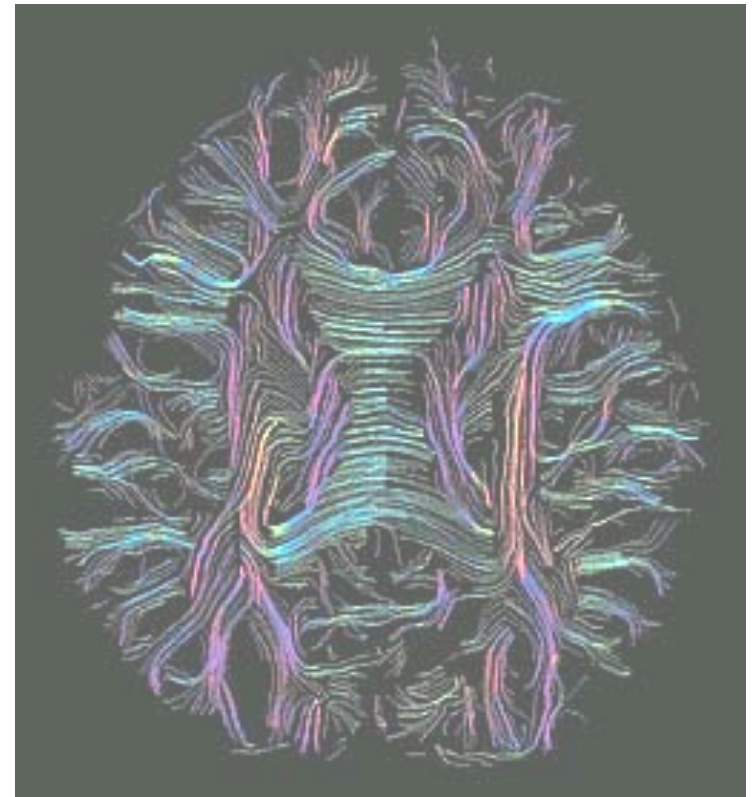
volume fraction  
obstructing particles,  $\phi$



# Diffusion anisotropy

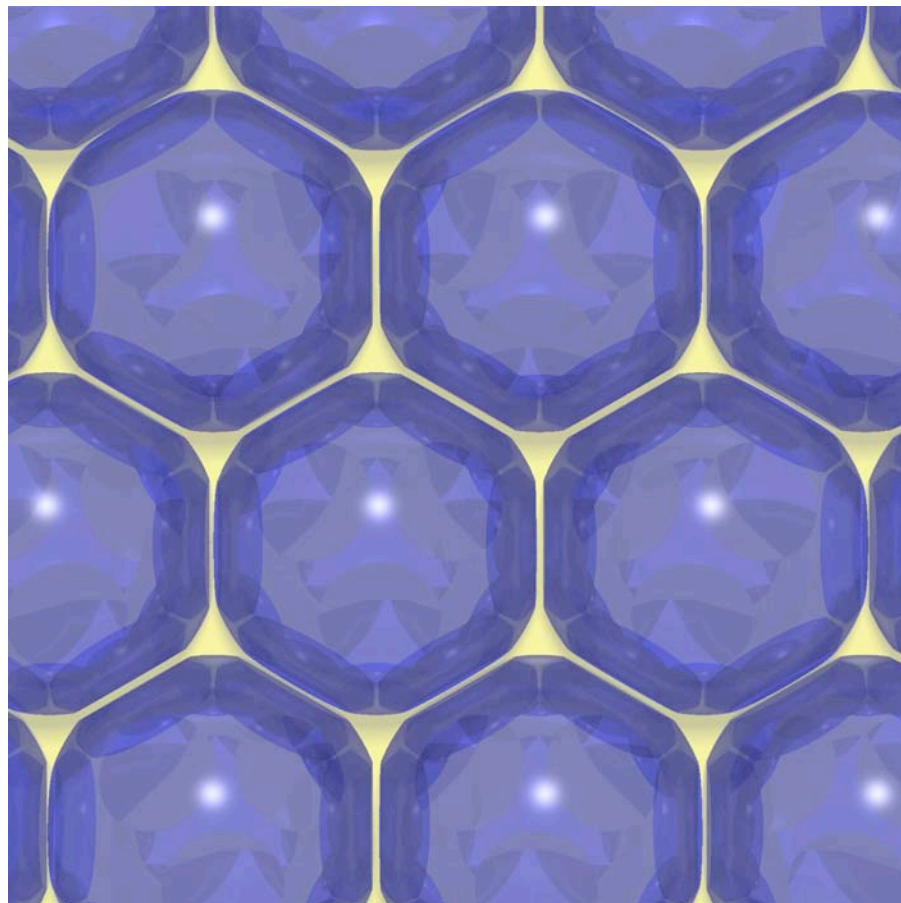
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## Nerve fiber mapping

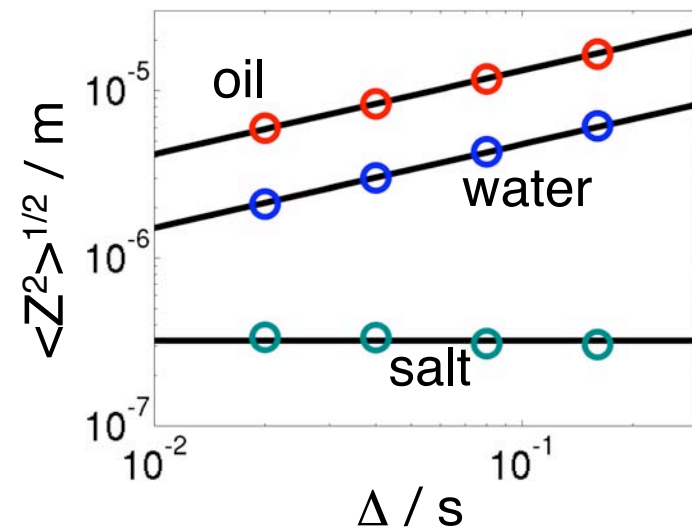


mednews.stanford.edu

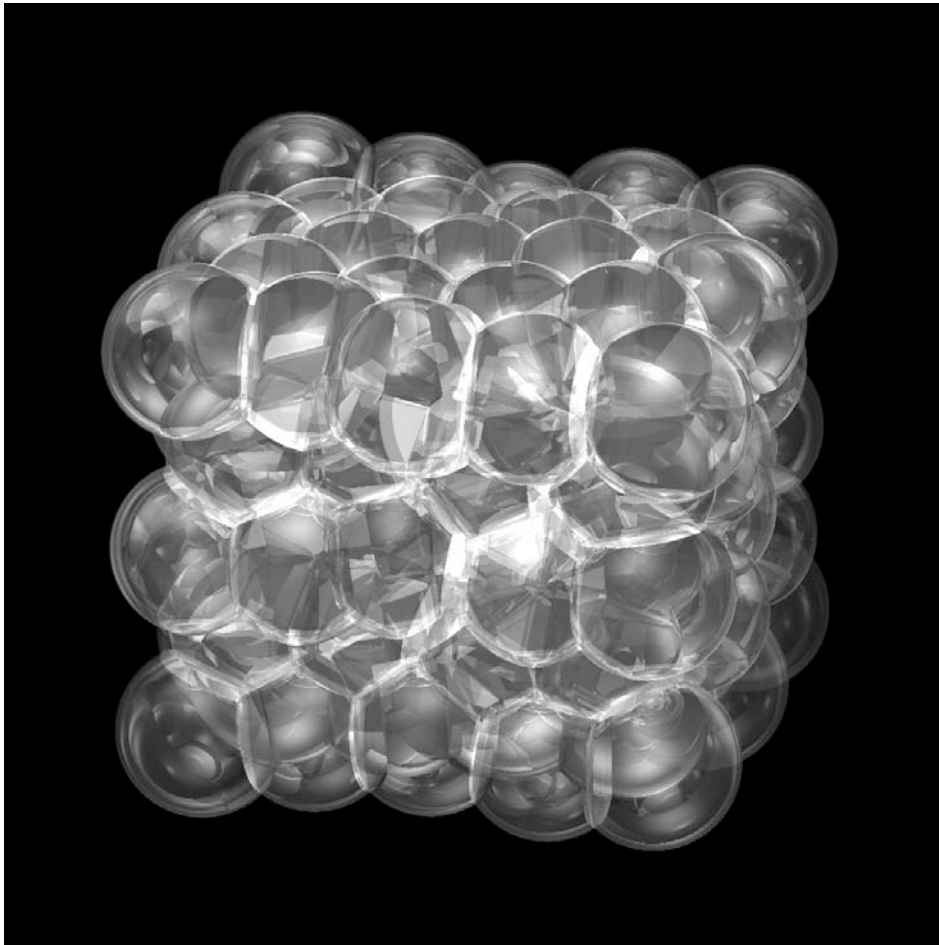
# Multiple components



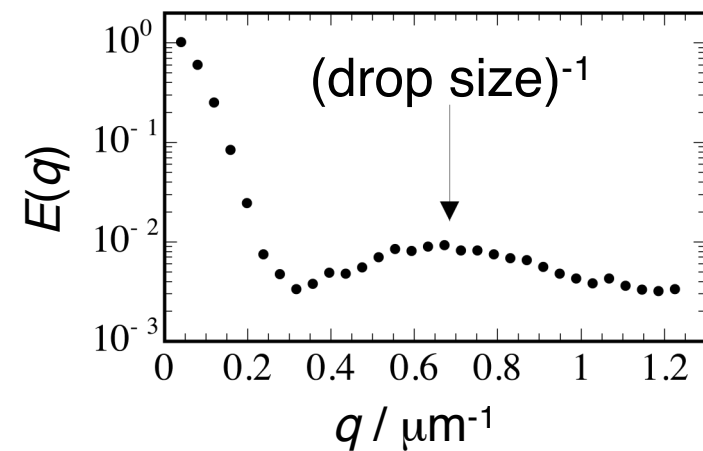
## Concentrated water-in-oil emulsion



# Diffusion diffraction

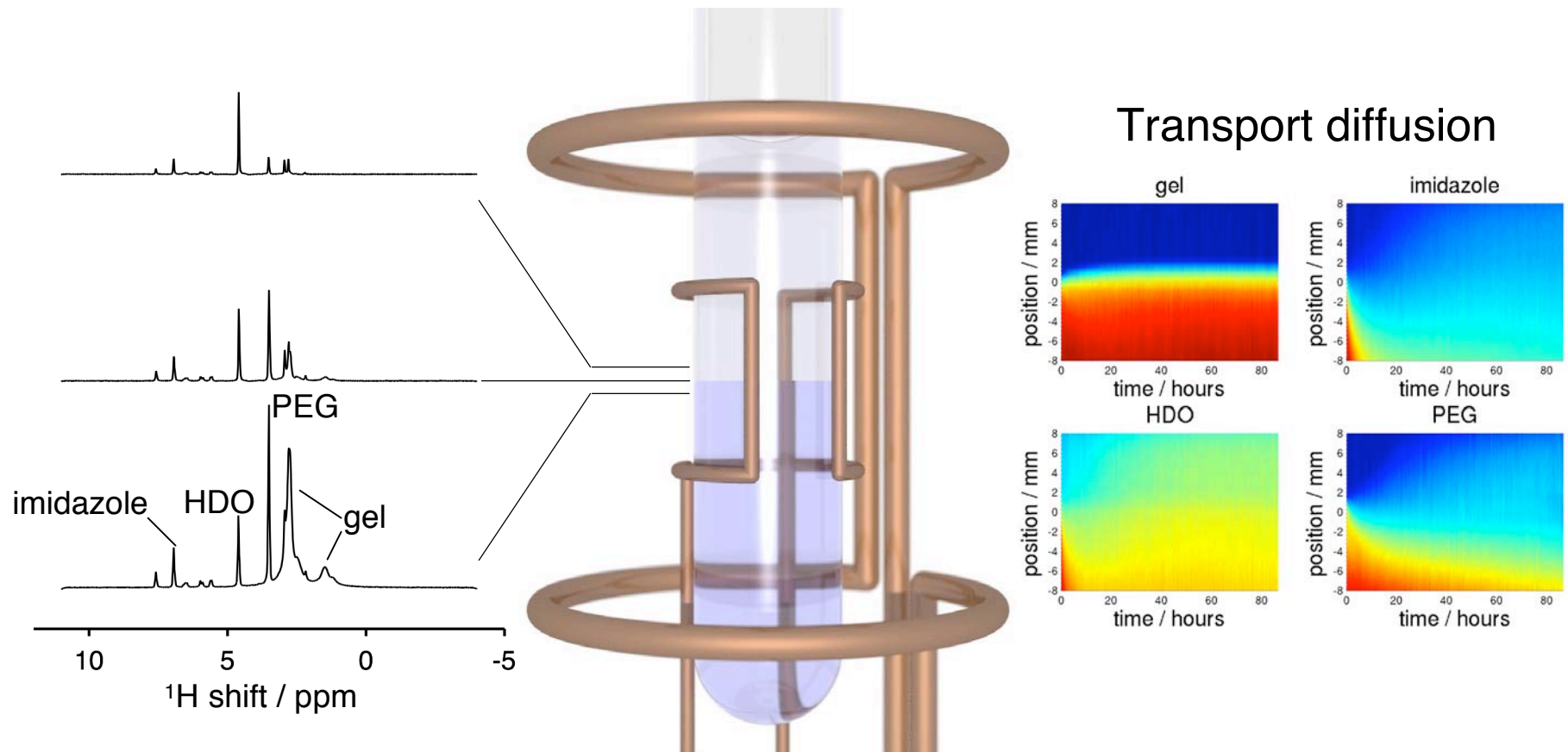


Non-Gaussian propagator with some preferred jump distance



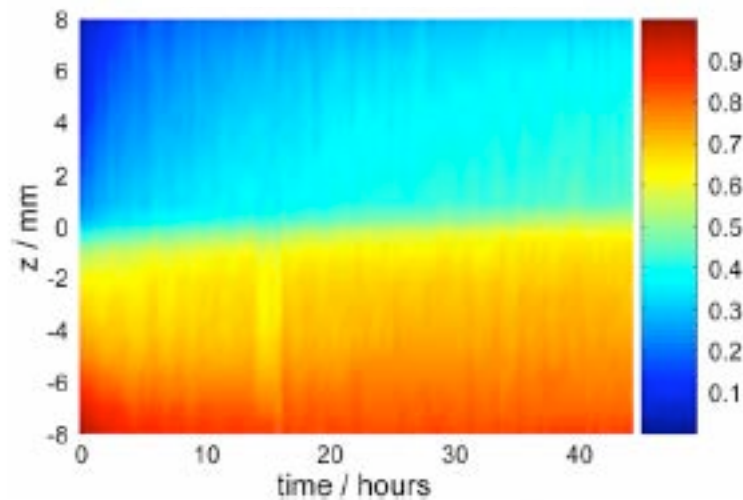


# Chemical shift imaging

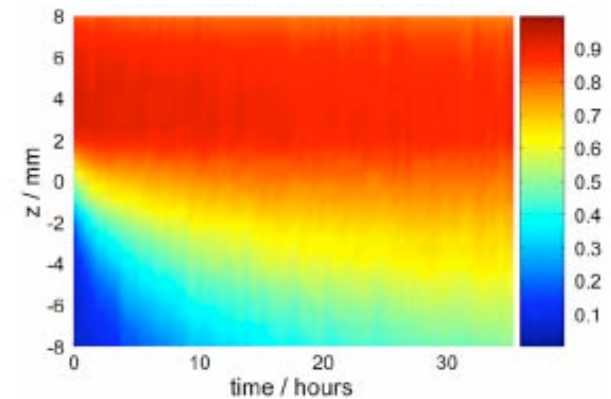


# Triggered release from hydrogel

Control: TMA<sup>+</sup>



Triggering solute: Me-G<sup>2+</sup>



Release: TMA<sup>+</sup>

