Diffusion processes in the brain

Fredrik E. Pettersen

April 25, 2014

Contents

Brief introduction to the brain

Cells in the brain

Neurons:

- Signal processing

Neuroglia:

- Janitorial tasks

Basic diffusion

The basic diffusion equation reads

$$\frac{\partial C}{\partial t} = D\nabla^2 C \tag{1}$$

Einstein relations

$$D = \frac{k_B T}{6\pi\eta r} \tag{2}$$

$$\langle r^2 \rangle = 2dDt \tag{3}$$

Molecular dynamics

- Study of systems of atoms and their time-development
- Most research towards fracture mechanics and flow in tight rocks
- Much of the geometry is similar, but the length scale is a bit to small
- Dissipative fluid dynamics

My experiment - motivation

- Results from 2003 article by Hrabětová and Nicholson
- Max value of tortuosity $\lambda \leq 1.225$
- Diffusion modeling on regular geometries

My experiment - results

- Making spheres of stationary atoms
- Measuring self diffusion constant of liquid using Einstein relation
- Comparing to self diffusion constant of bulk fluid
- Found $\lambda \approx 1.41$
- Limitations

Random walks

- Percolation theory
- Random walks and diffusion
- Spanning cluster
- Results from by Hrabětová and Nicholson
- Limitations

Firing in auditory nervous system

- Unanswered questions
  - limitation of tortuosity
  - tortuosity constant for increasing α
- Other modeling methods
- Multi scale models; the best from both worlds?

Thank you!

Output from DTI

Output from DTI