Time: M,W 3:30-4:50, Place: LOW 115

Textbook: Handbook of Stochastic Methods for Physics, Chemistry and Natural Sciences by C.W. Gardiner

Course Website: http://www.amath.washington.edu/courses/572-spring-2008/

Syllabus

1. **Review on probability and random variables:**

   The first two weeks, we shall review the materials on the theory of probability, and also have a brief histroical account. **Required reading**: Ch. 1, Ch. 2; optional reading: a paper by Montroll (on the course web). I shall give lectures on related material, but not follow the book exactly.

   New science, even social sciences, needs new mathematics;

   Beyond the Newtonian mathematics, it is not an alternative, it is a generalization;

   Statistical physics as an example: kinetic of gases and fluid dynamics;

   Probability review. *Joint and conditional probabilities, Mean values and probability density, Characteristic function and correlation functions, Binomial, Poisson and Gaussiani distributions, Central limit theorem.*

2. **Markov Processes:**

   What is a stochastic process? Markov process and the Chapman-Kolmogorov equation, discrete spaces;

   Continuous Markov processes;

   Diffusion processes — Fokker-Planck equation;

   Deterministic processes — Liouville's equattion;

   Kolmogorov forward and backward equations.

4. **Stationary Processes and Correlation Function:**

   Stationary and homogeneous markov processes;

   Autocorrelation function for Markov processes;

   Reversibility and entropy production;

   Time reversibility, symmetry, detailed balance, and potential;

   Relative entropy and entropy production.

5. **Fokker-Planck Equation**

   FPE in 1D, FPE in 2D;

   Reversibility and circulation;

   FPE in several dimentions;

   First passage time problem.

6. **Master Equations and Jump Processes:**

   Random walk and birth-death processes;

   Approximation of Master equations by FPEs;

   Mean first passage times;

   Birth-death systems with many variables and the chemical master equation;

   Poisson representation.

7. **Brownian Motion, Diffusion Processes, and Stochastic Differential Equations**

   Einstein's Brownian motion theory;

   Diffusion equation;

   Langevin equation;

   Stochastic integration and stochastic differential equations.

8. **Approximation Methods for Diffusion Processes**

   Small noise perturbation;

   Elimination of fast variables;

   White noise process as a limit of nonwhite noise process;

   Kramers' proble and barrier crossing.

9. **June 2 and June 4, No Class**