Stochastic Processes in Astrophysics and Cosmology

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Syllabus:

Stochastic processes are ubiquitous in nature. These lectures intend to give graduate students a basic understanding of the foundation of stochastic models and their application to astrophysical phenomena. The lectures will be complemented with practical classes that will help students to familiarize with the theoretic material through the use of numerical simulations.

Day 1

Introduction & Fundamentals:

- Introduction Stochastic Systems (10h00-11h00)
- Random Variables & Probability Distributions (11h00-12h00)
- Moments & Generating Functions (14h00-15h00)
- Binomial, Poisson & Gaussian Distributions (15h00-16h00)

TD: Statistics (16h00-18h00)

Day 2

Elements of Stochastic Models:

- Random Walks & Diffusion Processes (10h0-12h00)
- Langevin & Fokker-Planck Equations (14h00-16h00)

TD: Analytical Solutions of Stochastic Problems (16h00-18h00)

Day 3

Numerical Methods:

TD: Monte Carlo Simulations & Ito Processes – Part I (11h00-12h00)

- First Passage Problems (14h00-15h00)

TD: Monte Carlo Simulations & Ito Processes - Part II (16h00-18h00)

Day 4

Astrophysical Applications (I):

- Dark Matter Halo Abundance: Excursion Set Theory (10h00-12h00)
- Cosmic Ray Diffusion Models (14h00-16h00)

TD: Class Work on Astrophysical Problem Solving (I) (16h00-18h00)

Day 5

Astrophysical Applications (II):

- Star Formation Models: Initial Stellar Mass Function (10h00-11h00)
- Signal Treatment: Time Series Analysis (11h00-12h00)

TD: Class Work on Astrophysical Problem Solving (I) (16h00-18h00)

Pre-requis:

Basic knowledge of computational programming (Python preferred)

Logistique:

Tableau Noire – Video Projecteur – Access to computers for running Python scripts