10539 - 757 (8) Bayesian Physics (1.5L, 1.5P)

2020

Course summary:

Brief review of Bayesian probability basics. Conditional probability, product rule, Bayes' Theorem. Important discrete and continuous distributions. Parameter estimation and model comparison, application to data analysis. Symmetries, entropy and information gain. Varying additional topics depending on time available.

Method of assesment: Flexible assessment

Module relevance in programme:

This module provides insight both on the foundational and practical aspects of data and models in physics and elsewhere. On the one hand, it provides fundamental insight into the basis of the ideas and calculations used in the statistical physics modules, where the observer-based probability definition considerably widens the scope of scientific enquiry. At the other extreme, the module is relevant in practical advanced data analysis procedures and algorithms useful almost everywhere in science, complementing both laboratory work and machine learning.

Outcomes of course:

Unified view of the basic role played by logic-based Bayesian probability in different fields. Interdisciplinary approach to physics, statistics and mathematics.

Lecturer:

Prof H.C. Eggers
Telephone number: (021) 808-3523
E-mail address: eggers@.sun.ac.za
Office: Room 1045 in the Merensky Building.

Mentor:

The Department of Physics has appointed a staff member as mentor for each year of its physics programme to be available to students for consultation. Students should feel free to discuss general issues related to the physics programme or specific modules in the programme with the relevant mentor, in addition to usual consultations with their individual lecturers of modules.

The mentor for the Honours programme and its modules is Dr CM Steenkamp cmsteen@sun.ac.za.

Course content:

Overview: The course introduces a view of physics and science based on a quantitative framework for the acquisition of knowledge. As such, it is more fundamental than even the laws of physics and correspondingly generally applicable. At the same time, the methods introduced are applicable to practical data analysis. A brief review of probability as extended logic leads to Bayes Theorem and its application to knowledge in the form of parameter inference and model comparison. Hartley and Shannon information

and more elaborate versions enter the picture as special limits. Equilibrium statistical mechanics is shown to be an application of the generally applicable principle of minimum information gain.

Core content: Introduction to the Bayesian world view. Conditional probability, product rule, Bayes Theorem. Important discrete and continuous distributions and their roles. Parameter estimation and model comparison using inference. Information and entropy as a limiting case of inference. Hartley, Shannon entropy; information gain. Principle of Maximum Entropy and Minimum Information Gain. Numerical and analytical application to data in physics and elsewhere.

Not covered: Coding theory and image compression.

Tutorials:

Joint problem solving and discussion are critical for success and complement homework problems.

Study material:

Course-specific notes, recommended references.

Assessment:

Methods of Assessment
Continuous Assessment

Venue and time of assessment opportunities
Throughout the course.

Availability of marks:
Usually within a week.

Calculation of final mark for the module:
Homework problems 25-50%; Tests 50-75%;