10539-757(8) Entropy and Information (1½l, 1½p)

2018

Course summary:

(Presentation subject to staff availability and student numbers.)

Introduction to the Bayesian world view. Conditional probability, product rule, Bayes' Theorem. Multivariate Bernoulli and multinomial distributions. Parameter estimation and model comparison using Bayesian inference. Information and entropy as a limiting case of inference. Hartley, Shannon, conditional and mutual information; Information Gain. Principle of Maximum Entropy under the influence of information. Applications, varying additional topics.

Module relevance in programme:

This module provides crucial insight at the two extremes of the knowledge hierarchy. On the one hand, it provides fundamental insight into the basis of the ideas and calculations used in the statistical physics modules (Physics 314, 721). The observer-based probability definition considerably widens the scope of scientific enquiry. At the other extreme, the module results in practical advanced data analysis procedures and algorithms useful almost everywhere in science, building on the practical module Physics 384 and postgraduate laboratory work. Computational Physics modules 214, 244 and especially Physics 344 provide useful precursors to understand and apply the methods developed in this module.

Outcomes of course:

Unified view of the basic role played by Bayesian entropy and information in different fields. Interdisciplinary approach to physics, statistics and mathematics.

Lecturer:

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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 Prof KK Müller-Nedebock kkmn@physics.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 maximum entropy.

Core content: Introduction to the Bayesian world view. Conditional probability, product rule, Bayes Theorem. Multivariate Bernoulli, multinomial, Poisson and Gauss distributions. 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 with and without constraints; applications.

Time permitting: Improvements on the chi-squared method of data fitting; information-theoretic basis for continuous distributions; transformations as basis for priors..

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%;