10702 - 721 (16) Statistical Physics B
(Introduction to Interacting and Non-equilibrium Systems) (3L,3P)

2019

Course summary:

Phase transitions and critical phenomena, phenomenological theories (Landau-Ginsburg, scaling hypothesis), simple model systems, approximation methods (mean field theory, self-consistent approach). Statistical physics of liquid crystals and polymers. Simulation methods. Dynamic correlation and response functions, Langevin theory, stochastic differential equations (Fokker-Planck equations).

Module relevance in programme:

role and connections to the remaining physics programme.

In the undergraduate physics programme one mostly deals with physics systems of a few particles that interact. Statistical physics (314) was introduced in the third year, defining the basic thermodynamic quantities and a way of thinking about the physics of collectives of many particles. These approaches differ markedly from other ones taught in the remainder of undergraduate programme, and statistical physics forms one of the pillars of physics. The current module builds on the theoretical foundations, shining yet again a different light on them, but, crucially, introduces dealing with interactions among particles. This opens the world on phase transitions from a microscopic point of view and their descriptions. We also investigate how systems of large numbers of particles behave when disturbed from equilibrium. The course provides tools and opens doors to the study of matter from the collective point of view.

Outcomes of course:

The student will develop an understanding of both the formal aspects of statistical mechanics and of applying these in order to understand real systems. The concept of scaling in phase transitions will feature strongly. The student will also develop skills in the most important approximation methods in statistical physics. The student will investigate several ideas through a computational approach.

Lecturers:

Prof KK Müller-Nedebock
Telephone number: (021) 808-3386
E-mail address: kkmn@sun.ac.za
Office: Room 1009 in the Merensky Physics Building

Dr L Boonzaaier
E-mail via: leandro.boonzaaier90@gmail.com

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:

Molecular dynamics simulations. Formal aspects of statistical physics are covered, i.e, statistical ensemble theory. The role of interactions is investigated firstly using the Mayer cluster expansion method. The role of interactions is further investigated by the study of phase transitions using mainly the Ising model as a prototype and scaling laws are introduced. Several approximation methods are discussed. Finally, Langevin dynamics, the fluctuation-dissipation theorem and Boltzmann's *H*-theorem are treated as an introduction to nonequilibrium statistical mechanics

Practical (Tutorials):

Weekly tutorials for discussion of homework and any additional problems take place as per honours timetable.

Study material:

Various books are recommended, *but not prescribed*:

- J. Yeomans ***"Statistical Mechanics of Phase transitions"***, Clarendon (Oxford), 1992.
- R.K. Pathria ***"Statistical Mechanics"***, Pergamon (Oxford), 1972.
- J.J. Binney ***"The Theory of critical phenomena"***, Clarendon (Oxford), 1992.
- L. Reichl ***"A modern course in Statistical Physics"***, Wiley, 2009.
- H.E. Stanley ***"Introduction to phase transitions and critical phenomena"***, Oxford Press, 1987.

These references and other literature for consultation during the course will be made available on the reserve section in the Departmental Library.

Learning opportunities:

Lectures, discussions and tutorials as per **honours course schedule.**

Assessment:

Methods of Assessments
Assessment is based on continuous assessment, comprising two written tests, an oral exam, a computational project and presentation, as well various assignments.

Venue and time of assessment opportunities
See timetable

Availability of marks:
Within two weeks following assessment

Calculation of final mark for the module:
Tests 1/2, computational project 1/4, remaining assignments 1/4.