10753-754(8) Many-body theory (1½l, 1½p)

2017

Course summary:

Multi-particle wave functions and the symmetrisation postulate; creation and annihilation operators for fermions and bosons (second quantisation); variational principles and the Hartree-Fock approximation; screening and linear response; Boqoliubov transformations; superconductivity and magnetic flux quantisation.

Module relevance in programme:

The module draws upon quantum mechanics (714) in providing tools to deal with quantum systems consisting of many particles. The tools are useful in solid state systems (713), to field theory (755) and nuclear physics (748), but also in statistical physics (721), and should completement what you learn in these subjects.

Outcomes of course:

One aim of the course is to give students a basic working knowledge of the formalism of second quantization (creation and annihilation operators) and its application to many-body systems. This includes the ability to formulate and interpret a many-body problem in the context of second quantization and the ability to use basic approximation methods to solve such problems. At the end of the course students should also be familiar with some basic results regarding interacting many body systems in a condensed matter setting.

Lecturer:

Prof M Kastner
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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:

Formal lectures
This course is usually presented in the second semester and constitutes a first exposure to second quantisation in Quantum Mechanics. Many-body systems of identical particles, symmetries of the many-body wave function and the formalism of occupation number representation are covered in detail. The second quantization format is used to study interacting systems. First some toy-models are considered for which exact results are available. These results are used to justify mean field and other approximations. Linear response theory is covered. The theory is then applied to calculate physical quantities in some condensed matter systems. In the final lectures one of the main triumphs of many-body theory, namely the BCS description of the superconducting state, is studied.

Laboratory work

None

Practical (Tutorials):

Six 2-hour tutorials: These are used for working through examples and discussing homework problems

Study material:

Study material will be provided during the course.

Learning opportunities:

Assessment:

Methods of Assessments
One homework project per week for the duration of the course. Each project will contribute approximately 10% of the total mark. One closed book test at the end of the course weighing 50%.

Venue and time of assessment opportunities
See timetable

Availability of marks:

Calculation of final mark for the module:
Each of five homework projects will contribute approximately 10% of the total mark. One closed book test at the end of the course weighing 50%.