PH5024 – Modern Topics in Condensed Matter Physics

Credits: 15.0  Semester: 1  Number of Lectures:  
Lecturer: Dr Philip King and Dr Peter Wahl  Academic Year: 2017-18

Overview
This module focuses on current topics in modern solid state physics, concentrating on the rich structural and electronic phases that can be stabilized at surfaces of materials. The first part will provide an overview of the distinct environment which surfaces provide, as well as detailing the experimental probes that can be used to investigate them. The second part of the module will introduce the concepts of topology in the context of electronic states in condensed matter systems. It will concentrate on topologically non-trivial states of matter, phases that are not characterised by spontaneous symmetry breaking but rather by a distinct topology of the underlying bulk electronic system, with a particular focus on the implications for stabilizing exotic states at surfaces and their experimental probes.

Aims & Objectives
The primary aim of this module is for students to gain an introduction to some of the most exciting developments of recent years in the area of hard condensed matter physics, in particular novel electronic and structural phenomena that can be stabilised at surfaces, together with a thorough grounding in the probes and principles necessary to study these experimentally. The module aims to bridge the gap between the general introduction to solid state physics given in the 4000 level module PH4039 and the knowledge of more specialist topics in condensed matter that are appropriate to starting graduate-level study in this area.

Learning Outcomes
As well as lectures introducing the relevant underlying concepts in surfaces, symmetry, and topological phenomena in condensed matter systems, a significant focus will be devoted to developing skills in selecting, reading, and presenting scientific research papers on relevant topics as well as in performing simple numerical calculations. Through dedicated assignments and journal club style presentations, it will provide a route for students to develop research, analysis and communication skills. Students will gain experience in using bibliographic search tools, critical reading of the scientific literature, developing presentations, participating in scientific discussions and numerical techniques at an advanced level.

Synopsis
Topics covered include:
- Properties and description of Single Crystal Surfaces
- Electronic states in low dimensions, spin-orbit coupling and the Rashba effect
- Ultra high vacuum, sample preparation
- Probes of surface properties including photoemission spectroscopy, scanning tunnelling microscopy and spectroscopy, structural probes and optical spectroscopy
- Graphene
- Landau levels and the quantum Hall effect
- 2D and 3D topological insulators
- Experimental probes of topological insulators and recent developments

Pre-requisites
PH3061, PH3062, (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3080, (PH4037 or PH4041), PH4039, PH4044

Anti-requisites
None

Assessment
Coursework = 100% (Four take-home tutorial sheets/problem sets with analytical and computational problems [2 for assessment], 40%; Group literature research project, 10% for presentation and its content, 10% oral assessment following the presentation; Individual journal club style presentation on
research papers, 10% for presentation and its content, 10% for meaningful participation in discussions; Review Essay (4 pg. report on the journal-club style presentation and discussion), 20%
No Re-assessment available - assignment based

Additional information on continuous assessment etc
Please note that the definitive comments on continuous assessment will be communicated within the module. This section is intended to give an indication of the likely breakdown and timing of the continuous assessment.

- Literature research project presentation: week 5
- Problem set 1: week 7
- Journal club: week 10/11
- Problem set 2: week 10/11
- Review essay: end week 11

This is a 15 credit module, so is expected to take 150 hours of study for the average student at this level. The module’s work is finished by revision week, so students can expect to commit about 14 hours a week to the module in weeks 1 to 11, including the hours scheduled in lectures and in discussions. MPhys students are reminded that if they choose multiple “no-exam” modules then they will inevitably have a higher workload per week during weeks 1 to 11 than if they chose modules where some of the 150 hours was spent in the revision and exam weeks.

Recommended Books
Please view University online record:
http://resourcelists.st-andrews.ac.uk/modules/ph5024.html

General Information
Please also read the general information in the School's honours handbook.