Imperial College London

# Module Specification (Curriculum Review)

## Basic details

| | | | |
|---|---|---|---|
| UID | | Cohorts covered | Earliest cohort: 2024-25; Latest cohort: |
| Long title | Quantum Theory of Matter | | |
| New code | PHYS70018 | New short title | |
| Brief description of module *(approx. 600 chars.)* | This course is an introduction to superfluidity and superconductivity, seen in liquid helium, ultracold atomic gases and electronics materials. The course covers the key concepts behind these two phenomena as well as recent developments in topological states of matter which revealed the existence of Majorana fermions in unconventional superconductors. | | |
| | 353 characters | | |
| Available as a standalone module/ short course? | N | | |

## Statutory details

| | ECTS | CATS | Non-credit | | |
|---|---|---|---|---|---|
| Credit value | 7.5 | 15 | N | HECOS codes | |
| FHEQ level | Level 7 | | | | |

## Allocation of study hours

| | Hours | |
|---|---|---|
| Lectures | 26 | |
| Group teaching | 10 | *Incl. seminars, tutorials, problem classes.* |
| Lab/ practical | 0 | |
| Other scheduled | 11 | *Incl. project supervision, fieldwork, external visits.* |
| Independent study | 140.5 | *Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.* |
| Placement | 0 | *Incl. work-based learning and study that occurs overseas.* |
| Total hours | 187.5 | |
| ECTS ratio | 25.00 | |

## Project/placement activity

| | |
|---|---|
| Is placement activity allowed? | No |

## Module delivery

| | | | |
|---|---|---|---|
| Delivery mode | Taught/ Campus | Other | |
| Delivery term | | Other | Term 2, exam in term 3 |

## Ownership

| | |
|---|---|
| Primary department | Physics |

| | |
|---|---|
| Additional teaching departments | None |
| | |
| | |
| Delivery campus | South Kensington |

## Collaborative delivery

| | |
|---|---|
| Collaborative delivery? | N |
| External institution | N/A |
| External department | N/A |
| External campus | N/A |

## Associated staff

| Role | CID | Given name | Surname |
|---|---|---|---|
| Module Leader | | Derek | Lee |
| Module Leader | | Frank | Schindler |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

# Learning and teaching

## Module description

| | |
|---|---|
| Learning outcomes | At the end of the course, the student should:<br>(1) understand the phenomenology of superfluids and conventional superconductors, including Ginzburg-Landau theory<br>(2) understand the basic formalism of second quantisation<br>(2) understand the microscopic theory of neutral superfluids: Bogoliubov theory<br>(3) understand the BSC theory of superconductors<br>(4) understand the Bogoliubov-de-Gennes formalisms for quasiparticles in superconductors<br>(5) understand examples in topological superconductors, e.g. Majorana fermions in Kitaev chain and p+ip superconductors |
| Module content | 1.Phenomenology of neutral superfluids (liquid helium, ultracold gases): superfluidity, quantised vorticity<br>2.Phenomenology of conventional superconductors: Meissner effect, vortex lattices, dc Josephson effect2.Microscopic theory of superfluids and superconductors<br>a.Second quantisation using sound waves as the canonical example<br>b.Microscopic theory of quantum Bose fluid: Bogoliubov theory<br>c.Microscopic theory of superconductors<br>□BCS theory for conventional (s-wave) superconductors<br>□Bogoliubov-de Gennes theory of BSC quasiparticles<br>3.Topological superconductivity: |
| Learning and Teaching Approach | Lectures complemented by office hours and rapid feedback sessions to assist learning via problem sheets. |

| | |
|---|---|
| Assessment Strategy | Final written exam of 2 hours. |
| Feedback | Rapid feedback session weekly with a demonstrator to assist with the problem sheets as well as lecture content. |
| Reading list | • J Annett, "Superconductivity, superfluidity and condensates" (OUP)<br>• Bernevig & Hughes, “Topological insulators and topological superconductors”. |

## Quality assurance

| | |
|---|---|
| Date of first approval | |
| Date of last revision | |
| Date of this approval | |
| Module leader | Derek Lee |

## Office use only

| | |
|---|---|
| QA Lead | |
| Department staff | |
| Date of collection | |
| Date exported | |
| Date imported | |

| | |
|---|---|
| Notes/ comments | |

Template version 16/06/2017

## Programme structure

### Associated modules

| UID | Legacy code | Module title | Requisite type |
| --- | --- | --- | --- |

## Assessment details

| Grading method | Numeric | Pass mark | 50% |
|---|---|---|---|

## Assessments

| Assessment type | Assessment description | Weighting | Pass mark | Must pass? |
|---|---|---|---|---|
| | | | 50% | |
| Examination | 2 hour written examination. | 100% | 50% | N |