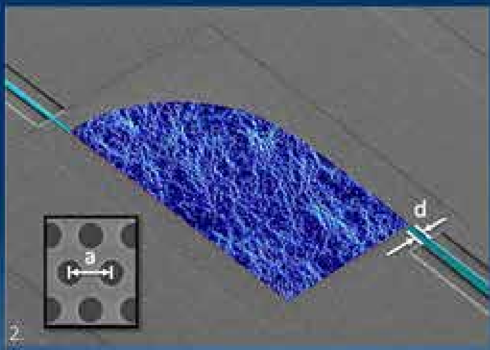
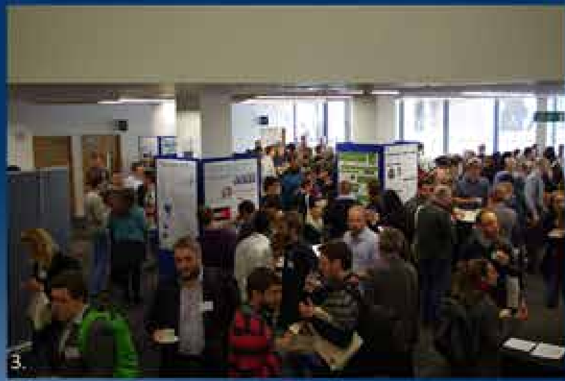
Graduate School Catalogue of Courses and Student Handbook 2016/2017

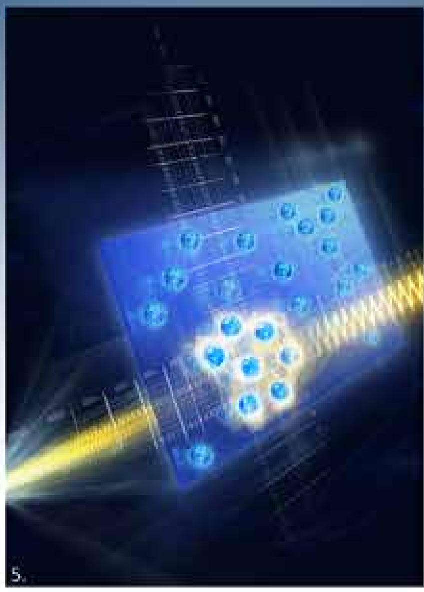
SUPA

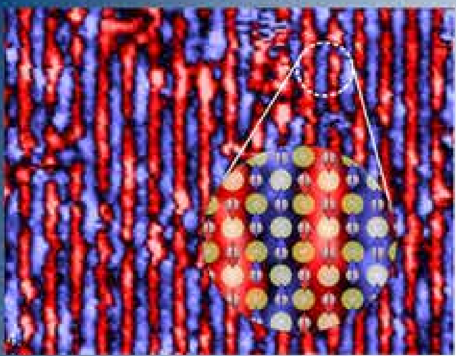
Scottish Universities Physics Alliance

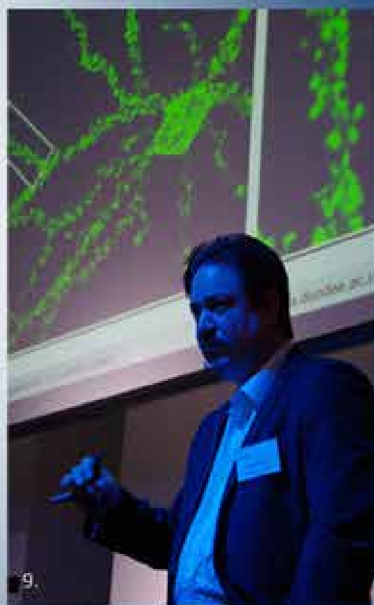
University of Aberdeen · University of Dundee · The University of Edinburgh · University of Glasgow · Heriot Watt University · University of St Andrews · University of Strathclyde · University of the West of Scotland UWS

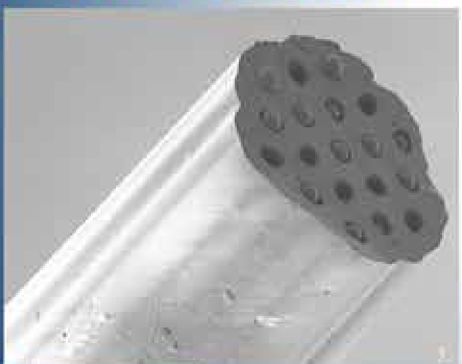


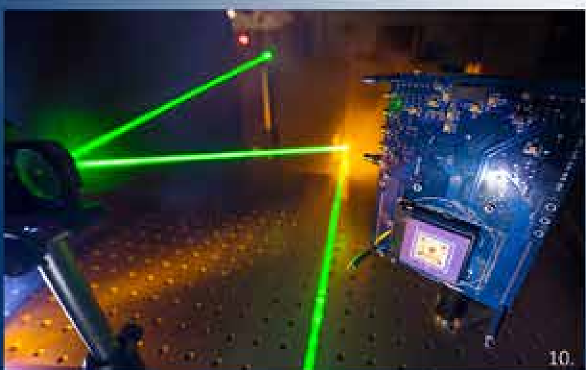


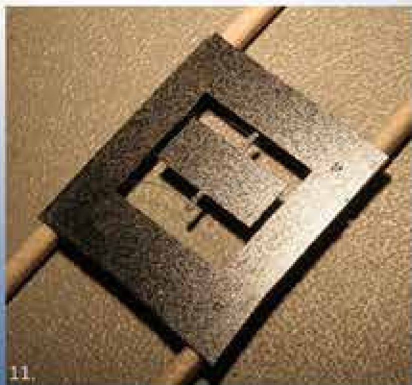












1. Greig Cowan at the SUPA Annual Gathering 2016. ©Valerie Evans
2. 'Rogue Waves'. Image courtesy Andrea di Falco SUPA Newsletter, Feb 2016 edition
3. Guests at the SUPA Annual Gathering 2016. © Valerie Evans
4.'Real Space Imaging' Image courtesy Peter Wahl SUPA Newsletter March 2016 edition.
5. 'Multipartite Entanglement' Image courtesy Luca Tagliacozzo SUPA Newsletter April 2016 edition
6. Alan Miller at the SUPA Annual Gathering 2016. © Valerie Evans
7.Etched Multicore Optical Fibre © Dr Mike Tanner. SUPA Newsletter April 2016 edition
8. The audience at the SUPA Annual Gathering 2016. © Valerie Evans
9. Tomas Cizmar at the SUPA Annual Gathering 2016. © Valerie Evans
10. 'Looking Round Corners' Image Courtesy Danielle Faccio. SUPA Newsletter Jan 2016 edition
11.MEMS Gravimeter Image Courtesy Richard Middlemiss SUPA Newsletter April 2016 edition
12. Low Vibration Lab, University of St Andrews SUPA Newsletter March 2016 edition.

Welcome to the SUPA Graduate School 2016/17

Dear Researchers

Welcome to the SUPA Graduate School 2016/17.

SUPA is a pan-Scotland strategic alliance for research and graduate training in Physics. Eight major universities work in partnership to create the SUPA Graduate School which offers postgraduate research students world class research opportunities, expert supervision, links to national and international facilities, advanced specialist courses, generic skills training, networks, industry engagement, outreach, exchanges and placements, careers and other events, which all draw upon on the knowledge and experience of the whole physics community across Scotland and beyond. This collaborative approach ensures that the SUPA Graduate School can offer the best possible opportunities for research students to acquire all of the skills needed to launch a successful career whether that be in academia, industry, enterprise or public and other sectors.

In the most recent UK wide research assessment exercise, REF2014, the 'research power' of SUPA combining quality and scale of activity was judged to have significantly exceeded that of Cambridge, Oxford, Imperial and UCL; U. Strathclyde was given the top 'grade point average' of any physics school and the joint PHYESTA submission from U. Edinburgh and U. St Andrews came 3rd equal in the UK. The 'impact' of Scottish physics research is extremely high.

Physics studies within SUPA are grouped by theme (Astronomy & Space, Condensed Matter & Material Physics, Energy, Nuclear & Plasma, Particle Physics, Photonics, and Physics & Life Sciences), and courses are given by video-conferenced lectures through the My.SUPA e-learning portal and include tutorials / hands-on-sessions / labs and via residential sessions.

We ask that all PhD students undertake a minimum of 40 hours of physics studies and 20 hours of core skills training during the first two years of their studies. Please note that this is a minimum requirement and some themes and universities will require their students to do more. Additional information about these requirements can be found in this handbook or from your local Graduate School.

Please take maximum advantage of the training offered. The SUPA Graduate School always strives to provide education and training at the highest international level in physics as well as the broader skills needed to establish you in a successful career. I am delighted that you have chosen to pursue your post-graduate studies in Scotland and I wish you every success.

Alan Miller

SUPA CEO

The enrolment dates for 2016/17 are:
Semester I – 1st September 2016 – 10th October 2016
Semester II – 7th November 2016 – 9th January 2017

Disclaimer
Every effort has been made to ensure that the information contained within this brochure is correct at the time of publication. SUPA Graduate School courses are subject to on-going development which could necessitate cancellation of, or alteration to, the advertised courses. The SUPA Graduate School reserves the right to make changes at any time without prior notice.

Please note that the term 'credits' is only used in this handbook to refer to 'SUPA Hours Equivalent Credits' (the number of face to face hours per course that students are credited with towards their minimum coursework requirements). This term does not refer to ECTS or any other crediting system.

This Handbook is also available on the SUPA website at www.supa.ac.uk and My.SUPA. Please check the online version for current information. Should you notice any errors or inaccuracies, please let us know by emailing admin@supa.ac.uk.

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SUPA Contacts

SUPA

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Centres for Doctoral Training

Condensed Matter Doctoral Training Centre

CM-DTC Central Office

School of Physics and Astronomy
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SUPA Videoconference Rooms

Aberdeen

Meston Building
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Contact: Michael Chung
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Dundee

Ewing Building
Basement
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SUPA Room and VC Booking

Email: rooms@supa.ac.uk
Web: www.supa.ac.uk/room_booking

Course Requirements for SUPA Students

SUPA has set course requirements for both Technical Courses (which are focused on specialised training in Physics or related scientific areas) and Core Skills Training (which is focused on developing transferable skills for professional development).

Technical Course Requirements

Every PhD student within SUPA is required to take a minimum of 40 hours of physics related studies during the first two years of their PhD. Within some themes, such as Particle Physics, there is a higher recommended number of hours of technical coursework. Please refer to the theme-specific sections of this catalogue for course listings and more information on coursework requirements and recommendations. Technical Courses include:

- SUPA Graduate School Lectures
- SUPA Distance Learning Courses
- SUPA Residential Courses
- Summer Schools as recommended by the themes
- Non-SUPA courses where appropriate.

(Please refer to 'Non-SUPA Courses' section for more information.)

Core Skills Requirements

Every PhD student within SUPA is required to take a minimum of 20 hours of transferrable or generic skills development during the first two years of their PhD. Please refer to the Core Skills Training section of this handbook for more information about courses available. Core Skills Training includes:

- SUPA Core Skills Training Courses
- Departmental, university or research council programmes as appropriate

(Please refer to 'Non-SUPA Courses' section for more information.)

Earning and Tracking Credit

In order to earn credit to satisfy the SUPA Course Requirement, students must enrol for a course on My.SUPA and, for Technical Courses, pass the assessment. No credit can be given if a student has not met these criteria.

The credit for each SUPA course is listed in this catalogue. Students can track the amount of credit they have earned over the course of their PhD by checking their profiles on My.SUPA. (More information about how to do this can be found in the 'Getting Started with My.SUPA' section of this handbook.)

Course Selection

Guidance on course selection for Technical Courses can be found in the theme-specific sections of this handbook. Students generally take Technical Courses within their main theme, but all students, especially those working on interdisciplinary projects, are welcome to take Technical Courses from across the SUPA Graduate School. All students are strongly advised to discuss their plan of study and specific course selections for both the Technical Course Requirements and Core Skills Training with their supervisors.

Students who are unsure of their 'theme' (this is common for those with interdisciplinary projects) are advised to consult with their supervisors to determine the most appropriate course of study.

SUPA Assessment Policy

Assessment for all SUPA Technical Courses is mandatory unless the student decides to attend the course as a non-assessed student (in this case the student will receive no credit towards their 40-hour requirement). Courses are assessed by various methods as appropriate to the subject area. Examples of assessment include: written examinations, continuous assessment, dissertations, and oral examinations. Information about assessments for specific courses can be found in the course listing in this catalogue. Students are advised to check the course assessment with the lecturer at the start of each course.

If a student does not take the assessment for a course, no credit will be allocated. Students taking non-SUPA Technical courses must agree an assessment with their lecturer(s) and get this approved by their supervisor before the start of the course. Please refer to the 'Non-SUPA Courses' section of this handbook for more information.

Lecturers are required to notify students of the assessment details by the start of the course and to report students' marks by the marking deadline. All marks will be on a 0-100 point scale, with a pass mark of 50. (Where SUPA postgraduate courses are part of the final year undergraduate curriculum, the pass mark may be 40).

There is no assessment requirement for Core Skills Training.

Enrolling for SUPA Courses

To enrol for SUPA courses, log on to the My.SUPA portal (http://my.supa.ac.uk) and follow the enrolment instructions posted on the front page. Before you enrol for the first time, you will be informed about SUPA's videoconference recording policy and asked for your consent. (For more information about this policy, please email admin@supa.ac.uk)

When using My.SUPA to select courses, please note that during the enrolment period, most course areas are available with read-only access to some materials. All course materials will be made available to enrolled students once registration is closed. For more information about using My.SUPA, please refer to the 'My.SUPA and Videoconferencing' section of this handbook. Students must enrol for courses in order to be eligible to earn credit for them.

The deadlines for enrolment are on Page 2. If you miss the enrolment deadlines, late enrolment may be possible but cannot be guaranteed, as the videoconference rooms may have been booked for other events. Please contact the SUPA Administration team at admin@supa.ac.uk in this instance.

If you would like to withdraw from a SUPA course while enrolment is open, you can do so by going to the relevant course page and clicking on the 'Unenrol me from SUPA[XXX]' link.

Please note that if you decide not to complete a course, it is very important that you unenrol on My.SUPA. If you do not unenrol, your SUPA transcript will still contain a record of this course and your mark will be listed as 0. After unenrolling, you can also sign up for the course as a non assessed student (see below for more information) in order to be able to continue to attend the lectures.

Once enrolment has closed, it will not be possible to unenrol on My.SUPA and you will need to make a request to admin@supa.ac.uk. You will normally be expected to show that you have permission from the course co-ordinator.

Please note that if you have not signed up through My.SUPA you may not attend the lectures.

Non-Assessed SUPA Courses

In cases where a student would like to attend a course but would not like to complete the coursework, it is possible to register as a non-assessed student (audit). It is important to note that you will NOT receive credit for courses which you audit. Instructions for registering as a non-assessed student are posted on the My.SUPA portal (http://my.supa.ac.uk). Before you register for auditing the first time, you will be informed about SUPA's videoconference recording policy and asked for your consent. (For more information about this policy, please email admin@supa.ac.uk)

During the enrolment period, which is detailed on Page 2, it is possible for students to switch from a non-assessed student to a fully enrolled student on a course. This is particularly important for students who would like to try out a course before fully committing as an enrolled student. To switch from being a non-assessed student to an enrolled student, go to the relevant course page and click on the 'Unenrol me from SUPA[XXX]' link. Then, re-register as an enrolled student.

Attending SUPA Courses

Videoconferenced Lectures

Most SUPA courses are taught via videoconferencing. To attend, simply go to your local institution's SUPA videoconference room. (See the 'Contacts' page for the location of all SUPA videoconference facilities.) For more information on using the videoconference facilities, please refer to the 'Getting Started with Videoconferencing' section of this handbook. Generally, videoconference lectures start five minutes past the hour and last approximately fifty-five minutes.

Distance Learning Courses

Courses listed as 'Distance Learning' in this handbook have no live videoconferenced lectures. Enrolment on these courses will give you online access to recordings, notes, problem sheets and discussion forums. You will be expected to work through the materials and activities, meet deadlines set by the course lecturer and participate in relevant activities. Opportunities will be provided for you to upload your exercises and receive feedback.

Tutorials/Hands-on sessions/Labs

Some courses may require you to attend tutorials and lab sessions in person. Please check the online timetable and My.SUPA course pages for information about where the tutorials take place and if you are required to travel to attend, SUPA will reimburse travel expenses. Please check with your local department's finance office for procedures for claiming expenses and ensure you complete the departmental travel claim form clearly stating the name of the SUPA course.

Residential Courses

Courses listed as 'Residential' are face-to-face sessions for which you may have to travel and stay overnight. SUPA organises accommodation and meals, and reimburses student travel expenses for such courses. Please check with your local department's finance office for procedures for claiming expenses and ensure you complete the departmental travel claim form clearly stating the name of the SUPA course.

Frequently Asked Questions

What is SUPA?

SUPA is the Scottish Universities Physics Alliance, a grouping of eight Physics departments across Scotland. The SUPA Graduate School facilitates shared learning across these institutions. After enrolling for post-graduate studies in a SUPA-member institution, you are automatically enrolled in the SUPA Graduate School and are subject to its academic policies.

Is there a timetable for the SUPA courses?

The SUPA timetable can be found on the My.SUPA website.

How do I use the videoconferencing equipment?

Training is made available to all students and staff at the start of each semester. You will be informed about these sessions by email. More information can also be found in the 'My.SUPA and Videoconferencing' section of this handbook. If you have a specific issue, please contact your local Graduate School Committee representative or a member of local support. Their contact information can be found in the 'SUPA Contacts' section of this handbook.

How do I obtain a My.SUPA password and username?

To obtain a My.SUPA login, please go to the My.SUPA portal (http://my.supa.ac.uk) and click on the 'Request a My.SUPA login' link. Your new login and password will soon be emailed to you with instructions.

How do I reset my My.SUPA password or username?

You can reset them either by following the 'Lost Password?' link in the login box on the My.SUPA portal or by emailing admin@supa.ac.uk.

Who do I contact if I am having difficulty using My.SUPA to enrol (or unenrol) for courses?

If you encounter any difficulties while enrolling or unenrolling for courses on My.SUPA, please contact the SUPA Office at admin@supa.ac.uk.

How can I contact my lecturer?

The easiest way to do this is through My.SUPA. You can find your lecturer's details in the 'People and Locations' or 'Course Description' area in the front page of the course area.

What if I am unable to attend a SUPA lecture?

If you enrol on a SUPA course, you are expected to attend the lectures. If you are ill or find you have a conflicting obligation, please inform your lecturer and contact the SUPA Office at admin@supa.ac.uk.

How can I obtain a copy of my SUPA transcript?

An electronic copy of your transcript is available on My.SUPA on the 'Grades' tab of your student profile. To obtain an official copy of your transcript certified by the SUPA Graduate School Co-ordinator, please write to the SUPA Office at: admin@supa.ac.uk.

Who can I contact if I have a general question about the SUPA Graduate School?

All general enquiries about the SUPA Graduate School should be addressed to the SUPA Office at admin@supa.ac.uk.

Who is my local SUPA representative?

On the contacts page of this handbook, you can find the names of all SUPA GSC representatives. Do not hesitate to contact them if you have any queries or issues regarding SUPA Graduate School.

Where can I find out about SUPA Events?

All SUPA-sponsored events, such as distinguished visitor lectures, are posted in the SUPA calendar (http://my.supa.ac.uk/calendar/) and the SUPA Events Forum (http://my.supa.ac.uk/mod/forum/). You may receive announcements to the Events Forum via email as well.

I am organising an event, can SUPA help me promote it?

Yes. As long as you are a SUPA member and your event is relevant to those working in Physics in Scotland, SUPA is happy to help with promotion. Please email admin@supa.ac.uk with a succinct description of your event and electronic copies of any promotional materials (such as fliers or posters) that you may have, and SUPA will work with you to promote your event.

Can SUPA help me fund my participation in an event or course not organised by SUPA?

Unfortunately, SUPA only provides funding for SUPA-sponsored and -organised events. If you are attending an event such as a summer school or conference not organised by SUPA, no funding is available.

Can I claim travel expenses from SUPA?

For SUPA events and courses to which PhD students must travel in order to attend (such as a residential course), SUPA will cover reasonable costs, defined as: public transport or mileage on shared rides equivalent to public transport costs, meals or accommodation.

How do I claim back my expenses from a SUPA event?

To claim back expenses for a SUPA event, please submit a claim form to your local department's finance office, clearly stating the name of the SUPA event or course. SUPA Central does not process these claims, unless otherwise stated.

Can SUPA help me fund my PhD studies?

For students who have not yet begun their PhD studies, the SUPA Prize Studentship Competition awards a limited number of fully-funded PhD places within the SUPA participating universities. For more information about this and other funding options, please refer to the 'Student Funding' section of the handbook.

Unfortunately, for students who have already begun their PhD studies, no further funding sources exist within SUPA.

Course List

Below is a list of all the SUPA Courses. Please note that courses marked with a * are biennial and will not run in 2016/17, however, they will run in 2017/18.

Theme	SUPA Code	Course Name	Page
Astronomy	ACO	Advanced Cosmology	10
Astronomy	AAA	Advanced Data Analysis - Astronomy	9
Astronomy	APL	Astrophysical Plasmas*	11
Astronomy	GWD	Gravitational Wave Detection	9
Astronomy	MSP	Magnetofluids and Space Plasmas	10
Astronomy	OBS[1]	SUPA Observing Course	11
Astronomy	TSA	The Sun's Atmosphere	11
Astronomy/ PaLS	ASL	Astrobiology and the Search for Life	11/ 25
CMMP	ASP	Advanced Statistical Physics	12
CMMP	CLP	Chaikin and Lubensky's Principles of Condensed Matter	13
CMMP	CCH	Computational Chemistry	12
CMMP	MAT	Computational Materials Physics*	13
CMMP	ENP	Experimental Nanophysics	14
CMMP	EPS	Interacting Electron Problems in Solids	12
CMMP	MPS	Matrix product state and tensor networks approaches to many body systems	14
CMMP	TOP	Modern Topics in Condensed Matter Physics	13
CMMP	NSM	Non-Equilibrium Statistical Mechanics	14
CMMP	OQS	Open Quantum Systems	12
CMMP	QFT	Quantum Field Theory (MBQT1)	13
CMMP	FTL	Quantum Field Theory (Light) (MBQT1a)	12
CMMP	QMPT	Quantum Magnetism and Quantum Phase Transitions (MBQT3)*	14
CMMP	QST	Quantum Scattering Theory at Low Energies*	15
CMMP	RFN	Response Functions	15
CMMP	SUP	Superconductivity	13
CMMP	TNP	Theoretical Nanophysics	15
Energy	SPR	Solar Power	16
Energy/NPP	NFL	The Nuclear Fuel Cycle	16/ 18
Energy/NPP	LDP	Laser Driven Plasma Acceleration	16/ 18
NPP/ PaLS	BAL	Biomedical Applications of Lasers, Beams and Radiation	17/ 24
NPP	NIN	Nuclear Instrumentation	18
NPP	NRT	Nuclear Reaction Theory and Nuclear Forces	18
NPP	PPH	Plasma Physics	17
NPP/PP	QHS	Quarks and Hadron Spectroscopy	17/ 22
NPP/PP	ACC	Accelerators	17/ 19
PP	COP	Collider Physics	21
PP	DET[1]	Detectors	19
PP	DCL	Discussion Classes	21
PP	FLA[1]	Flavour Physics	21
PP	GTH	Group Theory	20
PP	LAT	Lattice QCD	22
PP	MQF[1]	Modern Quantum Field Theory	20
PP	RQF[1]	Relativistic Quantum Field Theory	20
PP	STR	String Theory	20
PP	SMO[1]	Gauge Theory in Particle Physics	22
Photo	PTC	Photonic Crystals and Plasmonics*	23
Photo	PLC	Polymers and Liquid-Crystals*	23
Photo	STA*	Semiclassical Theory of Atom Light Interactions	23
Photo	UPH	Ultrafast Photonics	23
PaLS	BPS	Biological Physics	25
PaLS	BIP	Biophotonics	24
PaLS	CDB	Collective Dynamics in Biophysical Systems*	24
PaLS	IBP	Introducing Biology to Physicists	25
PaLS	IBS[1]	Introductory Biology School	26
PaLS	MMD	Mathematical Modelling	26
PaLS	PBE	Physics of Biological Evolution*	25
PaLS	SRP	Physics and Life Sciences Short Research Project	26
Core Skills	ADA[1]	Advanced Data Analysis	29
Core Skills	COO[1]	C+ +/ Object Orientated Programming	27
Core Skills	HOW[1]	Hands on Writing	29
Core Skills	HRP[1]	Hanging Your Research Out in Public	29
Core Skills	PYT[1]	Introduction to Python	29
Core Skills	IDA	Introductory Data Analysis	27
Core Skills	PRI	Maths Primer	28
Core Skills	PSS[1]	Problem Solving Skills for Physicists	28
Core Skills	ENT[1]	Research Ventures	29
Core Skills	ROO[1]	ROOT	28
Core Skills	SWC[1]	Software Carpentry	28
Core Skills	VAC	Vacuum Technology	28

Key

- Astronomy
- CMMP - Condensed Matter and Materials Physics
- Energy
- NPP - Nuclear and Plasma Physics
- PP - Particle Physics
- Photo - Photonics
- PaLS - Physics and Life Science
- Core Skills

[1]Eligible for travel costs

The Astronomy and Space Physics courses cover a broad range of topics aimed at widening students' knowledge of the field. They range from advanced extensions of subjects covered at undergraduate level to the introduction of new interdisciplinary sciences. We recommend that students take a mixture of core material, advanced courses (usually 16-20 hours equivalent credit) and more general topics, including computing and data reduction modules, to gain a broad grounding in astronomical methods and modern research areas.

Each course is self-contained, although background reading or another SUPA course may be recommended to bring students from various backgrounds up to speed. Students from other theme areas are very welcome to take Astronomy and Space Physics courses, with particular modules likely to be of interest for Life Sciences and Plasma Physics students, but they should remember that a basic understanding of astronomy and astronomical terms will be assumed by course lecturers.

A typical programme, building to the core requirement of 40 hours of Technical Courses might include:

- A SUPA technical Astronomy course (these generally constitute 16-20 hours)
- A technical SUPA course in another field or a second Astronomy course
- Non-SUPA courses as appropriate (e.g. for students changing specialities)
- Summer Schools in Astronomy and Space Physics

Astronomy students should note that certain Astronomy courses are only run biennially. Each student must consult their PhD supervisor to construct a suitable programme before registering, and students are encouraged not to over-register. The 40 hour course requirement is taken over the first and second years, although students from all years can take extra subjects for interest.

Semester 1

Advanced Data Analysis - Astronomy (SUPAAAA)

Lecturer: Andrew Cameron
Institution: St Andrews
Hours Equivalent Credit: 20
Assessment: Continuous Assessment
This is a final year undergraduate course organised by the University of St Andrews
Course Description
This module develops an understanding of basic concepts and offers practical experience with the techniques of quantitative data analysis. Beginning with fundamental concepts of probability theory and random variables, practical techniques are developed for using quantitative observational data to answer questions and test hypotheses about models of the physical world. The methods are illustrated by applications to the analysis of timeseries, imaging, spectroscopy, and tomography data sets. Students develop their computer programming skills, acquire a data analysis toolkit, and gain practical experience by analysing real data sets.

Gravitational Wave Detection (SUPAGWD)

Lecturer: Mat Pitkin
Institution: Glasgow
Hours Equivalent Credit: 15
Assessment: Essay and Viva
Course Description
This course is for students interested in the physics of gravitational wave detection. Starting from the fundamentals of Einstein's General Theory of Relativity, the wave nature of weak field spacetime curvature perturbations will be derived in the transverse traceless gauge. Interactions of gravitational radiation with matter will be explored, leading to the basic principles of gravitational wave detectors. Astrophysical sources of gravitational waves will be discussed, including expectations for source strengths from coalescing compact binary systems, pulsars, etc. A full description of currently operating detectors will include instrumental noise sources, such as thermal, seismic, optical, and the standard quantum limit. Current topics discussed will include squeezing, and other non-classical light techniques for reducing optical noise in interferometric systems. Plans for detectors on the ground and in space will be presented, ending with a discussion of data analysis techniques.
Assessment Method: A dissertation (or design study), of approximately 2000 words, on a current topic in gravitational wave research, to be submitted at the end of the course. Example topics include: thermal noise reduction, applications of non-classical light techniques, applications of optimal filtering techniques, applications of Bayesian inference in data analysis, astrophysical applications of gravitational wave sources. A twenty minute oral exam is also required for each student at the end of the course. Equal weighting will be given to the two assessment areas.

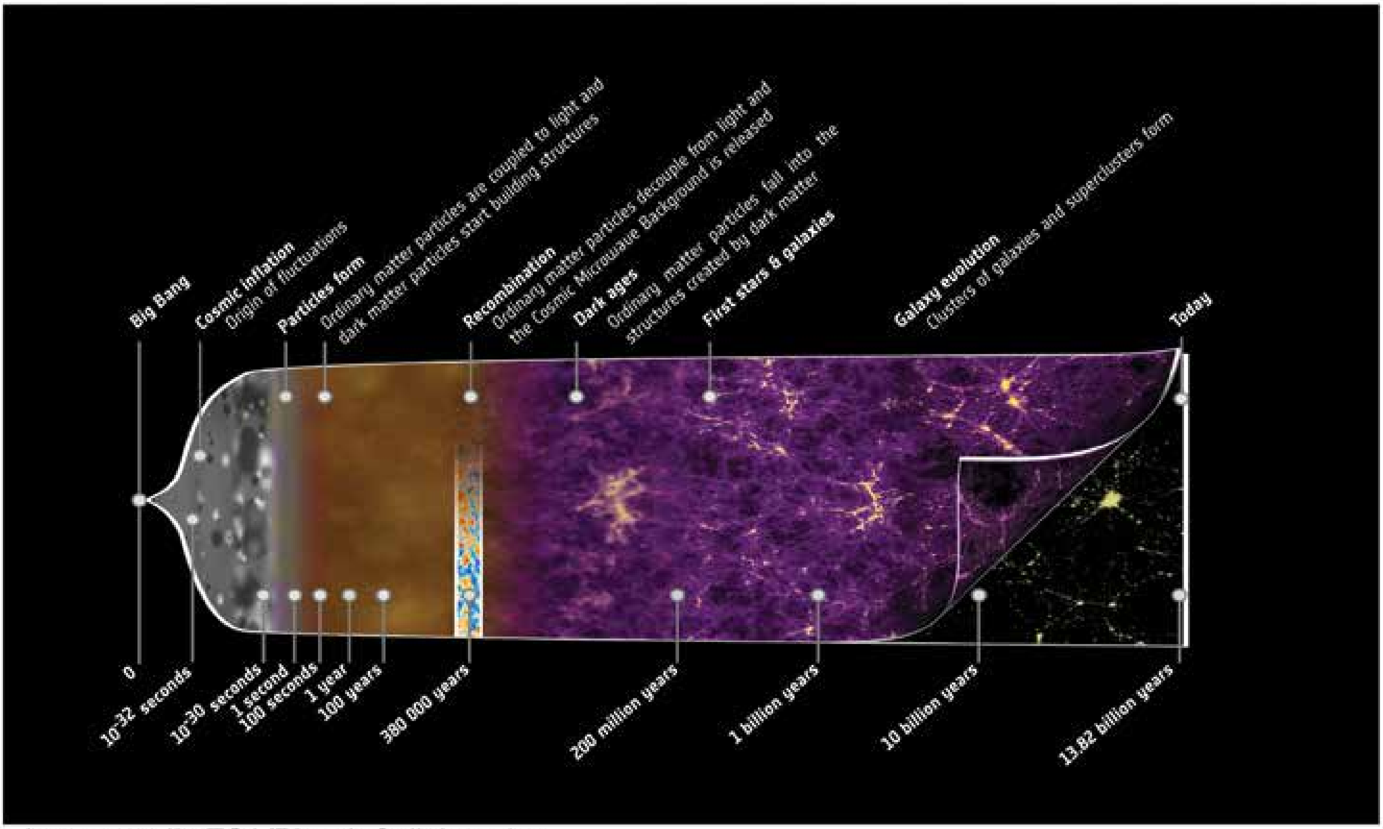


Image credit: ESA/Planck Collaboration

Magnetofluids and Space Plasmas (SUPAMSP)
Lecturer: Moira Jardine
Institution: St Andrews
Hours Equivalent Credit: 27
Assessment: Exam
This is a final year undergraduate course organised by University of St Andrews
Course Description
The interaction of a magnetic field with a partially or fully ionised gas (or plasma) is fundamental to many problems in astrophysics.
Star formation in particular is heavily influenced by the magnetic fields of molecular clouds, and once stars and discs form they can generate their own magnetic fields by dynamo activity. This is a final year undergraduate course run by University of St Andrews. The behaviour of this magnetic field is at the heart of many of the most interesting observations of young stars and their accretion disks. This module covers the basics of magnetohydrodynamics (MHD) with applications to star formation, accretion discs and stellar magnetospheres. Topics include reconnection, coronal heating, dynamo theory, angular momentum transport, stellar winds and magnetic braking.

Advanced Cosmology (SUPAACO)
Lecturer: Andrew Liddle
Institution: Edinburgh
Hours Equivalent Credit: 20
Assessment: Continuous Assessment
This is a final year undergraduate course organised by the University of Edinburgh.
This course will be delivered concurrently with SUPAQFT. Students may not take both courses in the same year. Students enrolling from University of St Andrews will be given instructions on joining the lecture broadcasts.
Course Description
The course will begin by reviewing basic tools and equations. In-depth studies will follow of the hot big bang, including cosmic thermodynamics and particle abundances; cosmological inflation, addressing initial conditions, mathematical solutions, and the variety of possible models; and the formation of structure. Statistical cosmology will be introduced via tools such as the power spectrum and correlation functions, leading into the study of fluctuations by various methods, including both scalar and tensor modes. Anisotropy of the cosmic microwave background and its implications will be considered in depth. Recent developments in gravitational lensing and the nature of dark energy will be described, and the course will end with some new views on anthropics and the multiverse.

Semester 2

Astrophysical Plasmas (SUPAAPL)

Lecturer: Lyndsay Fletcher, Eduard Kontar and Moira Jardine
Institution: Glasgow
Hours Equivalent Credit: 12
Assessment: Multiple Choice Exam, written questions and short Essay
For information only. This is a biennial course which will not run in 2016/17 but will run again in 2017/18.
Course Description
The course will give an overview of the physics of plasmas, and introduce applications in astrophysics. Beginning with basic definitions and ideas such as plasma waves and kinetic theory, the course will develop fundamental concepts in astrophysical plasma diagnostics, including cyclotron and synchrotron radiation, bremsstrahlung and recombination emission, wave-particle interactions and plasma emission (coherent and maser). Magnetohydrodynamics will be studied as a tool for understanding dynamos, solar and solar-terrestrial environments, and magnetospheres. The course will conclude with topical lectures on plasmas in different astrophysical environments. Students are strongly advised to take the Semester 1 course on Plasma Physics in the Nuclear and Plasma Theme first.

Astrobiology and the Search for Life (SUPAASL)

Lecturer: Charles Cockell, et al
Institution: various
Hours Equivalent Credit: 20
Assessment: Online multiple choice test
This course is cross-listed with the Physics and Life Sciences Theme.
Course Description
This course looks into the origin, evolution and distribution of life in the Universe, broadly considered as 'astrobiology'. The objective of the course is to provide a perspective in geology, biology and chemistry at an introductory level. The course will include lectures on the limits and conditions for life on Earth through time and how these may apply elsewhere in the universe. The course looks at the current scientific approaches used to address the hypothesis of life elsewhere in the Universe. The subjects discussed include: the formation of planetary systems and the conditions required for habitability, detection methods for extrasolar planets, the diversity of known exoplanet systems, the origin of life, evidence for earliest life on Earth, the geological and biological history of the Earth, conditions past and present on Mars and the icy moons of the giant planets, and finally the Search for Extra-Terrestrial Intelligence (SETI).

SUPA Observing Course (SUPAOBS)

Lecturer: Aleks Scholz
Institution: St Andrews
Hours Equivalent Credit: 15
Assessment: Continuous Assessment
Course Description
This course will enable PhD students to carry out astronomical observations with large telescopes. The course includes 5 lectures on the basics of professional observations, given by observatory director Dr. Aleks Scholz, covering a virtual tour of the largest telescopes in the world, planning observations, calibration, feasibility, operating large telescopes, observing principles, and on-the-fly data reduction. This core will be complemented by 5 lectures on specialised observing techniques, given by staff members in St Andrews, e.g. multi-object spectroscopy, robotic telescopes, integral field units, infrared satellites. The course will include observing training with the James Gregory Telescope in small groups (maximum 4 students), using the new teaching/control room at the JGT. Each group will be assigned a week of the semester for nighttime observations under the supervision of Dr. Aleks Scholz. For students outside St Andrews the practical training has to be organised as residential course in 1-2 weeks of the semester.

The Sun's Atmosphere (SUPATSA)

Lecturer: Nicolas Labrosse
Institution: Glasgow
Hours Equivalent Credit: 15
Assessment: Viva and computer based exercises
Course Description
•Solar atmosphere: structure and dynamics; Magnetic fields, active regions, magnetic energy; observations of the solar atmosphere from ground and from space
•Solar radiation and plasma diagnostics: Gamma, X-ray, UV, optical, infra-red, radio
•Plasma physics and particle interactions; Particle acceleration & transport
•Solar activity; flares, CMEs; escaping particles, and impact on Earth & space weather
A range of concepts will be covered in order to
1) develop the students' knowledge of emission processes of electromagnetic radiation; plasma physics; instrumentation; data analysis; theory and modelling – all in the context of the solar atmosphere
2) offer initial training in solar physics research which will be useful for students interested in pursuing a career in astrophysics.

Condensed Matter and Materials Physics (CMMP) is a diverse subject covering many different specialities and attracts PhD students arriving from a wide range of backgrounds with different balances of theoretical and practical training. The program of study is therefore tailored individually for each student, in consultation with his or her PhD supervisor. The overall range and level of courses offered aim to introduce students to subject areas outside the immediate confine of their thesis research, as well as providing more specialist knowledge directly relevant to each dissertation. It is envisaged that during the first two years of study every student will complete a minimum of two physics-content courses, at least one summer school, plus at least one module covering transferable skills. A typical program will comprise the following elements:

CMMP courses organised by SUPA: These are either graduate specific or advanced masters courses made available to all centres over the SUPA videoconferencing network. Courses offered are listed below and form the backbone of the CMMP graduate school programme.

Core courses organised by SUPA: Those of particular interest to CMMP students include Advanced Data Analysis and courses in different programming languages such as C++ and Python.

Non-SUPA courses as appropriate (e.g. for students changing specialities)

Summer Schools: Examples of appropriate summer schools include 'Physics by the Lake' for those with an interest in theory and HERCULES (Grenoble, France) for those doing research involving neutron and X-ray scattering at central facilities.

Transferable skills modules

Courses offered by other themes

Semester 1

Advanced Statistical Physics (SUPAASP)

Lecturer: Luigi Del Debbio
Institution: Edinburgh
Hours Equivalent Credit: 22
Assessment: Hand-in exercises
This is a final year undergraduate course organised by the University of Edinburgh

Course Description

In this course we will discuss equilibrium phase transition, of the first and second order, by using the Ising and the Gaussian models as examples. We will first review some basic concepts in statistical physics, then study critical phenomena. Phase transitions will be analysed first via mean field theory, then via the renormalisation group (RG), in real space. We will conclude with some discussion of the dynamics of the approach to equilibrium.

Computational Chemistry (SUPACCH)

Lecturer: Herbert Fruchtl
Institution: St Andrews
Hours Equivalent Credit: 9
Assessment: Continuous Assessment

Course Description

The course will provide an introduction to practical computational chemistry techniques. The focus is on an introduction to the current state-of-the-art computational chemistry codes together with the theory behind the methods. Ab initio, DFT and classical methods, as well as cheminformatics, will be introduced along with how they are used in practice by researchers in Scotland.

Interacting Electron Problems in Solids (SUPAEPS)

Lecturer: Chris Hooley
Institution: St Andrews
Hours Equivalent Credit: 22
Assessment: Continuous Assessment
This is a final year undergraduate course organised by the University of St Andrews.

Course Description

The aim of this course is to give an overview of developments in modern condensed matter physics. The difficulties of a full quantum mechanical treatment of electrons with strong interactions will be discussed. Common existing approaches such as the Hubbard and t-J models and Fermi liquid theory will be compared. It will be shown that, although microscopic models can explain aspects of magnetism, they have little chance of capturing many other features of the fascinating low energy physics of these systems. Instead, we introduce the principle of emergence, and show how it suggests radically new approaches to the problem of complexity in condensed matter physics and beyond.

Open Quantum Systems (SUPAOQS)

Lecturer: Michael Hartmann
Institution: Heriot Watt
Hours Equivalent Credit: 14
Assessment: Continuous Assessment
This is a biennial course and will run in 2016/17 but will not run in 2017/18.

Course Description

The course focuses on the dynamics of quantum systems interacting with their surroundings. Due to the inevitable interaction between a quantum system and its environment peculiar quantum features such as the existence of quantum superpositions and entangled states are quickly destroyed. Starting from a microscopic model, we will derive an equation of motion, the so called master equation, describing the dynamics of a quantum system in the presence of an environment. We will then examine the properties of the dynamics of an open quantum system as described by the master equation and explore two aspects of both fundamental and applicative importance in physics: First we will consider the fragility of quantum superpositions (e.g. Schrödinger cats) and entanglement under the influence of a quantum environment since controlling or suppressing environmental perturbations is essential for future quantum technologies. Then we will discuss how the fact that every quantum system is inevitably connected to an environment can be invoked to (at least partly) explain the quantum-classical border. Assessment will be based on tutorials.

Quantum Field Theory Light (MBQT 1a) (SUPAFTL)

Lecturer: Jonathan Keeling
Institution: St Andrews
Hours Equivalent Credit: 22 (including 5 whole class tutorials)
Assessment: Problem Sheets
This course comprises a subset of lectures from the complete SUPAQFT course and is a core course for DTC students undertaking an experimental research (rather than theoretical research) PhD.

Course Description

The topics covered will include: quantisation of field theories by analogy to quantisation of harmonic oscillators, chains of harmonic oscillators and the continuum limit. Feynman path integrals for propagators and thermal averages. Many body field theory and second quantisation, 2nd quantised operators and bookkeeping. Harmonic theories and Unitary/Bogoliubov transformations – theory of superconductors and Bose Einstein Condensates. Interacting spins and quantum magnetism, bosonic (spin-wave) representations of spins.

Please note that this course is a prerequisite for SUPASUP, SUPARFN (Many-body Quantum Theory 2), SUPAQPT (Many-body Quantum Theory 3). This course is an antirequisite of SUPAQFT

Quantum Field Theory (MBQT1) (SUPAQFT)
Lecturer: Jonathan Keeling
Institution: St Andrews
Hours Equivalent Credit: 27
Assessment: Continuous Assessment
This is a final year undergraduate course organised by the University of St Andrews.
This course will be delivered concurrently with SUPAACO. Students may not take both courses in the same year. Students enrolling from University of Edinburgh will be given instructions on joining the lecture broadcasts.
Course Description
Quantum field theory combines classical field theory with quantum mechanics and provides analytical tools to understand many-particle and relativistic quantum systems. This course aims to introduce the ideas and techniques of quantum field theory starting from many-body quantum mechanics and second quantization and progressing to Feynman and coherent state path integrals. Examples will be drawn largely from condensed matter physics. About one third of the lectures will be given over to working through problem sets. By the end of the course, the student will be able to carry out simple calculations using quantum field theory. Theoretical students will have a strong grounding to attempt more complicated calculations and experimental students an understanding of the essential physics revealed by research papers using these techniques. Please note that this course and SUPAEPS are advised as prerequisites for SUPAQPT (Many-body Quantum Theory 3). This course is an antirequisite of Quantum Field Theory Light.

Modern Topics in Condensed Matter Physics (SUPATOP)
Lecturer: Phil King and Peter Wahl
Institution: St Andrews
Hours Equivalent Credit: 35
Assessment: Problem Sheets, Presentations, Essay
This is a final year undergraduate course organised by the University of St Andrews.
Course Description
The aim of this module is to give an introduction to a variety of modern topics of condensed matter physics that can be realised at the surfaces of materials and in low-dimensional solids. As well as surface properties and probes, we will cover the introductory concepts of topologically non-trivial materials – states of matter that are not characterised by spontaneous symmetry breaking but rather by a distinct topological order of the underlying electronic system. This has recently come to prominence in condensed matter physics with the realisation that seemingly conventional band insulators come in topologically trivial and non-trivial classes, the latter being known as topological insulators. This course will cover the underlying principles and introductory theory of these exotic states of matter, will introduce the probes necessary to investigate them and their application in the study of other quantum materials, and will provide a survey of the current state of experimental results in this new and rapidly evolving field. Topics covered include:
- Properties and Description of Single Crystal Surfaces - Electronic states in low dimensions, Surface States, Spin-Orbit Coupling and the Rashba effect - Time-reversal and inversion symmetry - Ultra High Vacuum, Sample Preparation, Determination of Surface Structure - Photoemission Spectroscopy - Scanning Tunnling Microscopy and Spectroscopy
- Optical Spectroscopy and Related Techniques - Topological numbers in the Quantum Hall Effect - The Quantum Spin-Hall Effect
- 3D topological insulators - Experimental probes of topological insulators
- Properties of real materials - Topological Protection and Topological Phase Transitions.

Superconductivity (SUPASUP)
Lecturer: Andrew Huxley
Institution: Edinburgh
Hours Equivalent Credit: 20
Assessment: Problem Sheets
Course Description
The course will introduce the theory of superconductivity and superfluidity, assuming prior knowledge of undergraduate noninteracting-electron condensed matter physics, thermodynamics and electromagnetism.
Learning outcomes: Appreciation of the physical origin of the Gross-Pitaevskii equation for Bose-Einstein condensation (BEC) and how the excitation spectrum of an interacting BEC gives superfluidity. Understanding London's equations, vortices, Ginzburg-Landau theory and the main properties of superconductors. Ability to use Landau- Ginzburg and London theories to calculate properties such as critical currents. Appreciation of boundary conditions, Josephson junctions and the Anderson-Higgs mechanism. An understanding of BCS theory and ability to apply it to calculate physical quantities. Appreciation of the extensions required to describe non-conventional superconductors. Awareness of issues relevant to current research.

Semester 2

Chaikin and Lubensky's Principles of Condensed Matter (SUPACLP)
Lecturer: Alexander Morozov
Institution: Edinburgh
Hours Equivalent Credit: 25 (18 lectures & 7 tutorials)
Assessment: Continuous Assessment
This is a biennial course and will run in 2016/17 but will not run in 2017/18.
Course Description
This course will primarily involve a combination of directed reading and presentations by the participants on topics chosen from Chapters 1-6 of the graduate text 'Principles of Condensed Matter Physics' by P. Chaikin and T. Lubensky (Cambridge University Press). The course will also entail group work and individual work on problems with hand-ins and/or teleconferenced presentation of solutions by the participants. Assessment will be based on performance in both the student presentations and selected problems.

Computational Materials Physics (SUPAMAT)
Lecturer: Andreas Hermann
Institution: Edinburgh
Hours Equivalent Credit: 10
Assessment: Problem Sheets
For information only. This is a biennial course which will not run in 2016/17, but will run again in 2017/18.
Course Description
Computational Materials Physics is introduced in recognition of the ever-increasing role of large-scale simulation in modern day condensed matter physics. The topics covered will include: Classical force fields, molecular modelling of liquids and interfaces. Electronic structure methods in periodic systems: wave function based approaches, density functional theory, basis sets, and the pseudopotential method. Calculations of structural and electronic properties, lattice dynamics, thermodynamic quantities, BCS superconductivity, vibrational and optical spectra. Nuclear quantum effects (path integral molecular dynamics) and relativistic effects in solids (spin-orbit coupling). Hands-on computer exercises will introduce commonly used software packages in the high-performance computing environment, and students will do calculations using the various methods.

Experimental Nanophysics (SUPAENP)
Lecturer: Brian Gerardot
Institution: Heriot-Watt
Hours Equivalent Credit: 20
Assessment: Continuous Assessment
This is a final year undergraduate course organised by Heriot-Watt University.
Course Description
This course will focus on the emerging techniques and ideas of nanophysics where the small size of systems plays a crucial role in determining their properties and behaviours. The fundamental aim is to provide the students with a working knowledge of contemporary nanophysics. The course explains how such structures can be fabricated, characterized, manipulated and understood. The focus is on the quantum aspects of the behaviour, properties not shared with more conventional condensed matter systems. The course will cover quantisation effects, fabrication of nanostructures, optical and electron microscopy, scanning tunnelling and atomic force microscopy, and quantum dots. On completion of this course, the learner will be able to: achieve a critical knowledge and understanding of nano-scale devices, their fabrication and characterization; demonstrate a detailed knowledge and understanding of advanced concepts and applications in the nano-scale regime; integrate previous knowledge from physics courses with the topics discussed in the module; analyse advanced problems in nanophysics.

Matrix product state and tensor networks approaches to many body systems (SUPAMPS)
Lecturer: Luca Tagliacozzo
Institution: Strathclyde
Hours Equivalent Credit: 12
Assessment: Continuous Assessment
Course Description
The course will provide an overview of the field of matrix product and tensor network approaches to many body systems.
Many-body systems are hindered by an exponential complexity in the number of their constituents and thus are hard to solve. Large many body systems however present exotic emerging behaviour (such as spin liquid, superconducting and super-fluid phases) that we want to understand from first principles. Tensor networks provide a novel theoretical and computational framework to analyse collective emergence in many body systems. We will use Tensor Networks to study classical and quantum many body systems at and out-of equilibrium. The syllabus includes an introduction to the tensor network formalism and graphical notation, the recipe for describing the partition function of a classical model as the norm of a matrix product state (1D),or tensor product state (higher D).
The characterization of the properties of these states like expectation values, correlation functions, and entropies. The renormalization group in the language of tensor networks. The correspondence between statistical mechanics and quantum mechanics and some aspects of out-of-equilibrium dynamics in 1 and higher dimensions. We will describe powerful numerical algorithms based on tensor networks like DMRG in 1D and its generalizations in higher D. Students are expected to have a solid background in quantum mechanics and statistical mechanics .

Non-Equilibrium Statistical Mechanics (SUPANSM)
Lecturer: Martin Evans
Institution: Edinburgh
Hours Equivalent Credit: 12
Assessment: Project
This is a biennial course and will run in 2016/17 but will not run in 2017/18.
Course Description
This course provides an overview of theoretical concepts and tools used in contemporary research into the dynamics of interacting many-body systems. These will primarily be treated with reference to condensed matter systems driven out of equilibrium, but the relevance of the analytical techniques beyond physics (e.g. to population dynamics) will also be discussed. Upon successful completion of this course, it is intended that a student will be able to: explain the origins of stochastic dynamics and entropy production in physical systems, construct a stochastic mathematical model, such as a Boltzmann, Fokker-Planck or Langevin equation, appropriate for a given nonequilibrium system and explain how different formulations are related, write a computational algorithm to solve simple stochastic equations, such as a Fokker-Planck or Langevin equation, show how mesoscopic and macroscopic equations of motion emerge from more fundamental descriptions, analyse stochastic equations of motion to obtain predictions for emergent phenomena in nonequilibrium systems, such as fluctuationdissipation relations, phase transitions and aging, evaluate the appropriateness of stochastic modelling approaches with reference to current research in physics and other disciplines.

Quantum Magnetism and Quantum Phase Transitions (SUPAQMPT)
Lecturer: Bernd Braunecker, Jonathan Keeling
Institution: St Andrews
Hours Equivalent Credit: 18
Assessment: Continuous Assessment
For information only. This is a biennial course which will not run in 2016/17 but will run again in 2017/18.
Course Description
This course provides an introduction to magnetism in condensed matter systems, covering both the magnetic response of paramagnets and various models of spontaneous magnetic ordering. It then goes on to present the phenomenology and theory of quantum phase transitions, in both the insulating and metallic cases. The syllabus is as follows:
Models of magnetic response. Curie and Pauli paramagnetism. Spontaneous magnetic ordering in metals; the Stoner model; the Hubbard model. Spontaneous magnetic ordering in insulators; the Heisenberg model and spin waves; antiferromagnets and frustration; the XY and Ising models. Quantum phase transitions; cold atoms in optical lattices and the Bose-Hubbard model; the XY, XXZ, and Ising models in a transverse field. Quantum critical regions; dynamical exponents; phenomenology and finite-temperature signatures. Quantum criticality with fermions.
For CM-CDT students, QFT light (for which QFT may of course be substituted) is a prerequisite for this course. Non-CM-CDT students should note that knowledge of second quantised notation will be assumed: they should either familiarise themselves with this via the QFT light or QFT courses, or learn it elsewhere, prior to taking Quantum Magnetism and Quantum Phase Transitions

Quantum Scattering Theory at Low Energies (SUPAQST)
Lecturer: Manuel Valiente Cifuentes
Institution: Heriot-Watt
Hours Equivalent Credit: 6
Assessment: Exercises
For information only. This is a biennial course which will not run in 2016/17, but will run again in 2017/18.
Course Description
This course is an introduction to low-energy effective scattering in non-relativistic Quantum Mechanics. After introducing the basic formalism of general scattering theory, the basics of perturbative renormalization will be introduced in a model-independent fashion. These two preliminary chapters provide the necessary skills to tackle the core part of the course, and are important by themselves. The main part of the course introduces effective partial wave scattering at low energies. This is done within the pseudopotential approach of Huang and Yang
as well as in the language of renormalization. Also, the novel method of Tan's distributions – which is very useful when tackling Fermi gases – will be introduced for the first time in lecture format.

Response Functions (MBQT 2) (SUPARFN)
Lecturer: Brendon Lovett
Institution: St Andrews
Hours Equivalent Credit: 13
Assessment: Continuous Assessment
This is a biennial course which will run in 2016/17, but will not run in 2017/18.
Course Description
Response functions and Green's functions provide a powerful mathematical language in which to describe the physics of many-body quantum systems. This course is a short introduction to them. The first few lectures define the various Green's functions of interest, and calculate them explicitly for a few very simple systems at zero temperature. The remaining lectures give brief introductions to several more advanced topics, including Green's functions at non-zero temperature and Green's functions out of equilibrium. The lectures are supplemented by several problem sheets, in which the emphasis is on a strong grasp of the basics. The course is designed to be accessible to any graduate student (theoretical or experimental) who has a decent undergraduate education in quantum mechanics. Some - though not much - knowledge of the formalism of second quantisation (creation and annihilation operators) is required.

Theoretical Nanophysics (SUPATNP)
Lecturer: Ian Galbraith
Institution: Heriot-Watt
Hours Equivalent Credit: 20
Assessment: Continuous Assessment
This is a final year undergraduate course organised by Heriot-Watt University.
Course Description
This course will focus on the theoretical description of nanophysics and nanodevices where the small size plays a crucial role in determining their properties and behaviours. The fundamental aim is to provide the students with a working knowledge of contemporary theoretical nanophysics. The course explains how nanophysical phenomena can be modelled and predictions for behaviour made. The course will begin with a review of solid state basics. The following topics will be covered: correlations & coulomb effects in nanostructures; coulomb blockade; coherent transport and Landauer-Büttiker formalism; carbon-based nanostructures; nanothermodynamics density functional theory for nanostructures. On completion of this module, the learner will be able to: demonstrate a detailed knowledge and understanding of semiconductor quantum devices; integrate previous knowledge from physics courses with the topics discussed in the module; analyse advanced problems in nanophysics; apply the theories of nano-scale devices to problems or situations not previously encountered.

Energy is a new theme, on a very important, and yet diverse topic. Our courses relate to two major aspects of the theme's activities: solar and nuclear power. They are designed to be accessible to all Energy Theme students – so that nuclear students could take the solar power course and vice versa. In addition to these courses, students are encouraged to select courses relevant to their interests and projects from other themes (particularly Condensed Matter and Materials Physics, Photonics and Nuclear and Plasma Physics).

Semester 1

Solar Power (SUPASPR)
Lecturer: Ifor Samuel et al
Institution: St Andrews
Hours Equivalent Credit: 14
Assessment: Problem Sheets and reports on laboratory experiments.
This is a final year undergraduate course organised by the University of St Andrews.
This is a biennial course and will run in 2016/17 but will not run in 2017/18.
Course Description
This course will provide an introduction to solar photovoltaics (PV). Lectures will introduce the problem of energy supply, and the amount of solar power potentially available. The general principles of PV will be covered, followed by lectures on a range of current and future PV technologies: crystalline, polycrystalline and amorphous silicon, thin film inorganic semiconductors, and organic semiconductor PV. Three lab sessions will enable students to explore key ideas in the lectures.
This is an intensive two-day course, using a range of invited lecturers from SUPA institutions.

Semester 2

Laser Driven Plasma Acceleration (SUPALDP)
Lecturer: Dino Jaroszynski & Paul McKenna
Institution: Strathclyde
Hours Equivalent Credit: 16
Assessment: Continuous Assessment
This is a final year undergraduate course organised by the University of Strathclyde. This course is cross-listed with the Nuclear and Plasma Physics Theme.
Course Description
This course will address the topical research in laser plasma interactions, laser-plasma acceleration and plasma based radiation sources.
It will be divided into four connected parts starting with a thorough but brief introduction to the main theoretical concepts of laser-plasma interactions. The second and third parts will address the interaction of intense laser pulses with under-dense and over-dense plasma, respectively, with particular emphasis on laser-plasma acceleration, absorption, propagation, electron transport, plasma waves, shock waves, radiation mechanisms, non-linear optics of plasma etc. The fourth part will introduce students to the main concepts of free-electron lasers, which are important tools for scientists investigating the structure of matter. Students will proceed quickly from basic concepts to advanced and current applications such as compact radiation and particle sources, inertial fusion energy, fast ignition etc. They will gain a good introduction to laser-plasma interactions, which will provide a good basis for postgraduate research in this area.

The Nuclear Fuel Cycle (SUPANFL)
Lecturer: David O'Donnell
Institution: Glasgow
Hours Equivalent Credit: 5
Assessment: Continuous Assessment
This course is cross-listed with the Nuclear and Plasma Physics Theme
Course Description
With policymakers around the world considering a nuclear renaissance as one of the possible solutions to society's low-carbon energy needs in the medium-term, this course will provide an introduction to the nuclear fuel cycle. Covering the technical aspects of nuclear power production at an introductory level, the course will cover radiation interactions, reactor and fuel cycle technology and core physics. In addition, as any discussion of the nuclear fuel cycle is incomplete without some consideration of the economic, industrial and policy dimensions, the course will cover some of the most important non-technical aspects associated with nuclear energy. The course is intended for students with an interest in nuclear technology, whether as a possible future career path or simply for general interest. Specialist knowledge in nuclear or particle physics is not required for this course.

Nuclear and Plasma Physics

The Nuclear and Plasma Physics (NPP) theme covers a wide range of subject areas, including a number of different specialities. Depending on their individual backgrounds and areas of research, Ph.D. students will be required to attend a different set of SUPA courses. The decision on which courses to include should be made in consultation with the student's PhD supervisor. Typically, a two year course program will include:

- Specific NPP lectures taken from the course list
- Core skills classes, such as C++ Programming and Data Analysis, where appropriate
- Transferable skills courses such as an Entrepreneurship course
  Where the number of courses taken exceeds the minimum requirement, students and their supervisors should agree on which courses should contribute towards the overall assessment. There are several Doctoral Training Centres that are part of NPP. PhDs in these Centres are usually four years in duration, where the whole of the first year is dedicated to formal courses and mini-projects. In these cases the student will normally decide on their PhD topic at the end of the first year. Students should contact the Doctoral Training Centre administrators to establish the course requirements.

Semester 1

Accelerators (SUPAACC)

Lecturer: Dino Jaroszynski, Mark Wiggins, Bernhard Ersfeld, Gregory Vieux
Institution: Strathclyde
Hours Equivalent Credit: 9
Assessment: Continuous Assessment
This course is cross-listed with the Particle Physics Theme
Course Description
The course will cover the following topics:
(i) overview and history of the accelerators and outlook for future advances including the development of laser-driven accelerators, (ii) accelerator applications including medical imaging, isotope production and oncology, (iii) RF accelerating cavities including waveguide propagation, superconducting cavities and power delivery, (iv) beam line diagnostics for characterising beam parameters such as charge, transverse profile, energy spread and emittance, (v) transverse and longitudinal beam dynamics outlining beam parameters and transport and the effect of beam quality on transport and focusing, (vi) non-linear beam dynamics including resonances, betatron motion and beam instabilities, (vii) electromagnetic radiation emitted by relativistic charged particles due to their acceleration: synchrotron and betatron, (viii) radiation damping and application of such radiation.

Plasma Physics (SUPAPPH)

Lecturer: Adrian Cross, Kevin Ronald, Bengt Eliasson, Declan Diver
Institution: Strathclyde
Hours Equivalent Credit: 12
Assessment: Multiple Choice Exam and Continuous Assessment
Course Description
This course will address fundamental concepts in plasmas, from plasma creation from a neutral gas through to full ionization. Basic plasma timescales and length scales will be derived, such as the plasma, cyclotron and collision frequencies, skin depth, sheath extent and Larmor radius. Waves and instabilities in fully ionized (and magnetized) fluid and kinetic plasmas will also be addressed. The many natural and man-made types of plasma and their applications will be outlined and in particular magnetically confined plasmas will be discussed with examples, including tokamaks.

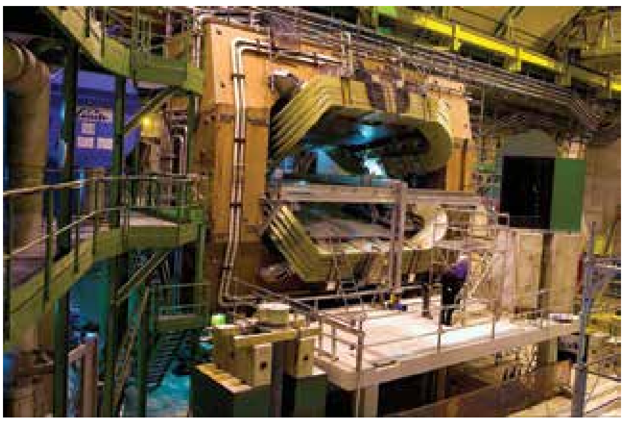
Biomedical Applications of Lasers, Beams and Radiation (SUPABAL)

Lecturer: Bernhard Hidding, Grace Gloria Manahan
Institution: Strathclyde
Hours Equivalent Credit: 12
Assessment: Continuous Assessment
This course is cross-listed with the Physics and Life Sciences theme.
Course Description
Lasers, particle beams and radiation such as x-rays are essential instruments for imaging, drug research and treatment in life sciences. The course would address both established and cutting edge radiation generation methods for a variety of biomedical applications, as well as occurrence of radiation in nature and their effects. Then, the mechanisms of interaction of the different types of radiation on the nuclear, atomic, molecular, cell and system level (e.g. the patient) are discussed. Finally, fundamentals and progress in biomedical applications such as x-ray radiography, magnetic resonance tomography (MRT), positron emission tomography (PET), electron microscopy and other radiology imaging techniques, radiation-assisted drug R&D as well as laser surgery, cancer radiotherapy with photons, electrons, protons, neutrons and ions, and other treatment techniques will be covered. Next to providing an overview on the physics behind these techniques, the course will also include practical considerations and is intended to facilitate and support interdisciplinary research projects and collaborative applications.

Semester 2

Quarks and Hadron Spectroscopy (SUPAQHS)

Lecturer: Bryan McKinnon, Derek Glazier
Institution: Glasgow
Hours Equivalent Credit: 10
Assessment: Continuous Assessment
This course is cross-listed with the Particle Physics Theme
Course Description
The course will cover the following topics: Introduction to fundamentals of QCD, why are models necessary when you've got QCD, quark model predictions of hadronic states, properties of the nucleon and its resonances, "missing" baryonic resonances, pentaquarks - salutory lesson or crucial discovery, experimental techniques, partial wave analysis, the search for exotic states: hybrid mesons, glueballs.



Laser Driven Plasma Acceleration (SUPALDP)
Lecturer: Dino Jaroszynski & Paul McKenna
Institution: Strathclyde
Hours Equivalent Credit: 16
Assessment: Continuous Assessment
This is a final year undergraduate course organised by the University of Strathclyde
This course is cross-listed with the Energy Theme
Course Description
This course will address the topical research in laser plasma interactions, laser-plasma acceleration and plasma based radiation sources.
It will be divided into four connected parts starting with a thorough but brief introduction to the main theoretical concepts of laser-plasma interactions. The second and third parts will address the interaction of intense laser pulses with under-dense and over-dense plasma, respectively, with particular emphasis on laser-plasma acceleration, absorption, propagation, electron transport, plasma waves, shock waves, radiation mechanisms, non-linear optics of plasma etc.
The fourth part will introduce students to the main concepts of free-electron lasers, which are important tools for scientists investigating the structure of matter. Students will proceed quickly from basic concepts to advanced and current applications such as compact radiation and particle sources, inertial fusion energy, fast ignition etc. They will gain a good introduction to laser-plasma interactions, which will provide a good basis for postgraduate research in this area.

The Nuclear Fuel Cycle (SUPANFL)
Lecturer: David O'Donnell
Institution: Glasgow
Hours Equivalent Credit: 5
Assessment: Continuous Assessment
This course is cross-listed with the Energy Theme
Course Description
With policymakers around the world considering a nuclear renaissance as one of the possible solutions to society's low-carbon energy needs in the medium-term, this course will provide an introduction to the nuclear fuel cycle. Covering the technical aspects of nuclear power production at an introductory level, the course will cover radiation interactions, reactor and fuel cycle technology and core physics. In addition, as any discussion of the nuclear fuel cycle is incomplete without some consideration of the economic, industrial and policy dimensions, the course will cover some of the most important non-technical aspects associated with nuclear energy. The course is intended for students with an interest in nuclear technology, whether as a possible future career path or simply for general interest. Specialist knowledge in nuclear or particle physics is not required for this course.

Nuclear Instrumentation (SUPANIN)
Lecturer: Tom Davinson
Institution: Edinburgh
Hours Equivalent Credit: 6
Assessment: Continuous Assessment
Course Description
The objective of this short course of lectures is to provide students with an insight into state of the art of nuclear instrumentation technology and techniques - particular emphasis will be given to topics either not found, or not well-covered, in the standard textbooks. Topics will include: noise, interference, grounding and other black arts, the origins of detector energy and time resolution, ASICS, data acquisition and analysis, and digital signal processing.

Nuclear Reaction Theory and Nuclear Forces (SUPANRT)
Lecturer: Mikhail Bashkanov
Institution: Edinburgh
Hours Equivalent Credit: 6
Assessment: Continuous Assessment
This is a biennial course which will run in 2016/17 but will not run in 2017/18.
Course Description
This course will assume an undergraduate level knowledge of nuclear physics and quantum mechanics and will describe various theoretical descriptions of nuclei and nuclear reactions at a level relevant to a postgraduate experimental physicist. The course will introduce students to the theoretical formalisms commonly encountered in the field of nuclear and hadron physics.
The students will understand basic models of nuclear structure (liquid drop model and Fermi gas model), be able to explain the origin of nuclear shapes and excitation modes, be able to outline the theoretical description of the Nucleon-Nucleon potential from boson field theory,
be able to understand the terms used to parameterise phenomenological NN potentials, show understanding of the role of three-nucleon forces in the nucleus, outline the theoretical formalism for describing elastic and inelastic scattering reactions, understand the classification of reactions as compound, direct or pre-equilibrium, show understanding of the process of partial wave analysis and phase shifts in reaction theory, understand the reaction theories describing fission and fusion and their application in nuclear energy generation.

The SUPA Graduate School runs an extensive programme of Particle Physics courses to provide new graduate students with the necessary skills required to carry out research. The Particle Physics courses are divided into categories corresponding to whether the student is undertaking theoretical or experimental research, core lectures are compulsory for first year students in both areas.

Theory Students are strongly recommended to attend all the 'Common Core' and 'Theory Core' courses. Experimentalists are strongly recommended to attend all the 'Common Core' and 'Experiment Core' courses. Theory students are also welcome to attend courses in the experiment core and vice versa. Students should discuss with their supervisor which optional courses they should attend.

Semester 1

Accelerators (SUPAACC)

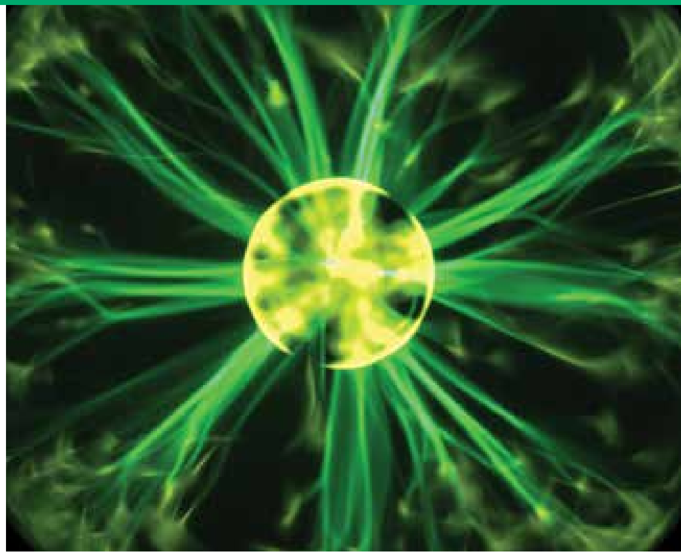
Lecturer: Dino Jaroszynski & Mark Wiggins
Institution: Strathclyde
Hours Equivalent Credit: 9
Assessment: Continuous Assessment
This course is crossed linked with the Nuclear and Plasma Physics Theme
Experimental Core
Course Description
The course will cover the following topics:
(i) overview and history of the accelerators and outlook for future advances including the development of laser-driven accelerators, (ii) accelerator applications including medical imaging, isotope production and oncology, (iii) RF accelerating cavities including waveguide propagation, superconducting cavities and power delivery, (iv) beam line diagnostics for characterising beam parameters such as charge, transverse profile, energy spread and emittance, (v) transverse and longitudinal beam dynamics outlining beam parameters and transport and the effect of beam quality on transport and focusing, (vi) non-linear beam dynamics including resonances, betatron motion and beam instabilities, (vii) electromagnetic radiation emitted by relativistic charged particles due to their acceleration: synchrotron and betatron, (viii) radiation damping and application of such radiation.

Detectors (SUPADET)

Lecturer: Stephan Eisenhardt, Richard Bates & Andrew Blue
Institution: Glasgow & Edinburgh
Hours Equivalent Credit: 16 (11 lectures, 1x2hr lab & 1x3hr Lab)
Assessment: Continuous assessment using problem sheets
Experimental Core
Course Description
The course will give a comprehensive view on the many techniques and technologies utilised in the building of particle physics detectors. The series of 11 hours of lectures is complemented by 5 hours of practical sessions. In the first series of lectures, taught by Stephan Eisenhardt, the students learn about classical detector technologies and concepts that form the basis of the modern developments. The principles of the interaction of radiation with matter are discussed. From principles to state-of-the-art applications, the following technologies are reviewed: gaseous tracking detectors, photon detectors and calorimeters. The methods utilised for particle identification as well as concepts to trigger on rare events are presented. Finally, the students are introduced to how all these building blocks are combined into modern layouts of particle physics detectors. The second series of lectures, taught by Richard Bates, focuses entirely on the physics and applications of Solid State Detectors. Their ever-increasing use in particle physics detectors is motivated; their application in the past, in the present and in the near future is reviewed. The fundamental configurations and properties of semiconductors are introduced and the process of signal formation in semiconductor detectors is discussed. The properties of the microstrip detector are examined in detail as an example of a detector type commonly used today. Radiation damage is the most limiting effect to semiconductor detectors; its effects and cures are presented. In the concluding lecture, Andrew Blue teaches about the fabrication of semiconductors. The main production techniques and their limitations are presented including lithography, additive and subtractive processes, etching, SiO_2 layers and doping. Finally, the semiconductor processing facilities at the Glasgow Electrical Engineering Department are outlined. A two-hour session taking place in a laboratory at Edinburgh will demonstrate a state-of-the-art application of novel photon detectors on the test bench. One focus will be on the integration of control, data acquisition and logging into an integrated test system using Labview. In addition the basics of signal transmission, interfacing kit of hardware and safety when working with high voltages and radioactive sources will be covered. The second laboratory session held in Glasgow will last 3 hours. The session will initially explore the electrical behaviour of silicon detectors. After this the response of the detector to an IR light pulse as a function of detector bias voltage will be examined. Two different detector designs will be used to allow the student to measure the different characteristics of these devices. The laboratory will give the student the opportunity to measure the type of silicon detectors that are discussed in detail in the second part of the lecture course. The course is self-contained and requires no prior knowledge of the field. Students will be assessed using problem sheets.

Group Theory (SUPAGTH)
Lecturer: Saverio D'Auria
Institution: Glasgow
Hours Equivalent Credit: 10 (8 lectures and 2 tutorials)
Assessment: Continuous Assessment
Common Core
Course Description
This course will cover the fundamentals of group theory from a particle physics perspective.
We will begin with the definition of a group and some simple examples including SO(N) and SU(N) which are important in particle physics.
We will then discuss representation theory and irreducible representations. The irreducible representations of SU(2) will be described in detail along with tensor product representations and their decompositions into irreducibles. The concept of isospin will then be discussed in the context of SU(2) representation theory. Next we will discuss the irreducible representations of SU(3) flavour symmetry and how these are used in the quark model to explain the meson and baryon multiplets. Noether's theorem will be revisited in terms of group invariance; the role of groups invariance in gauge theories will be sketched. The Lorentz and Poincaré groups and their representations in particle physics will be described.
If time permits, we will cover the cubic group and its representations in the context of lattice QCD. At the end of this course students should:
understand the difference between Abelian and non-Abelian groups as well as the difference between reducible and irreducible representations of a group; be able to specify the set of the generators of the SU(2), SO(3), SU(3), Lorentz and Poincaré groups and the elements of the corresponding Lie groups; be able to construct the simplest representations of the SU(2), SO(3), SU(3) groups; be familiar with the isospin symmetry;
understand the meaning of Clebsch-Gordan coefficients and be able to use them for the calculation of the matrix elements of different physical processes; understand the role of the Casimir operators.
Understand the classification of fundamental and composite particles in the standard model in terms of irreducible representations of the Lorentz group.

Modern Quantum Field Theory (SUPAMQF)
Lecturer: Einan Gardi
Institution: Edinburgh
Hours Equivalent Credit: 22
Assessment: Take-home exam OR project and presentation
Theory Core Joint Master's and PhD course delivered at the University of Edinburgh.
Course Description
The course introduces path integral methods in quantum field theory. This modern approach (as opposed to canonical quantisation) allows the relatively simple quantisation of gauge theories and forms an essential tool for the understanding and development of the 'standard model' of particle physics. Topics include: Path integral formalism, Feynman rules, LSZ formalism, loop diagrams and divergencies, regularisation and renormalisation.
- Path Integrals for quantum mechanics and quantum field theory, Green's functions and generating functionals for free scalar fields
- Interacting scalar fields, Feynman rules/diagrams, connected and one-particle-irreducible Green's functions
- Spectral functions, in/out states, reduction formulae (LSZ formalism), S-matrix
- One loop Feynman diagrams for scalar theories, divergencies, dimensional regularisation, renormalisation, renormalisation group, beta- and gamma-functions, Landau poles, infra red and ultra-violet fixed points
- Path integrals for fermions, Grassmann variables, Yukawa interactions



Relativistic Quantum Field Theory (SUPARQF)
Lecturer: Richard Ball (lectures and tutorials in Edinburgh) & David Miller and Christine Davies (lectures and tutorials in Glasgow)
Institution: Edinburgh & Glasgow
Hours Equivalent Credit: 32 (22 lectures & 10 tutorials)
Assessment: Take-home exam (Glasgow). Closed-book exam (Edinburgh).
Common Core Joint Master's & PhD course, delivered at the University of Edinburgh and University of Glasgow.
Notes: Edinburgh students should attend the Edinburgh lectures and tutorials given by Richard Ball and Glasgow students should attend the Glasgow lectures and tutorials given by David Miller and Christine Davies.
Course Description
The course will cover the following topics: classical Lagrangian field theory, Lorentz covariance of relativistic field equations, quantisation of the Klein- Gordon, Dirac and electromagnetic fields, interacting fields, Feynman diagrams, S-matrix expansion and calculating all lowest order scattering amplitudes and cross sections in Quantum Electrodynamics (QED).

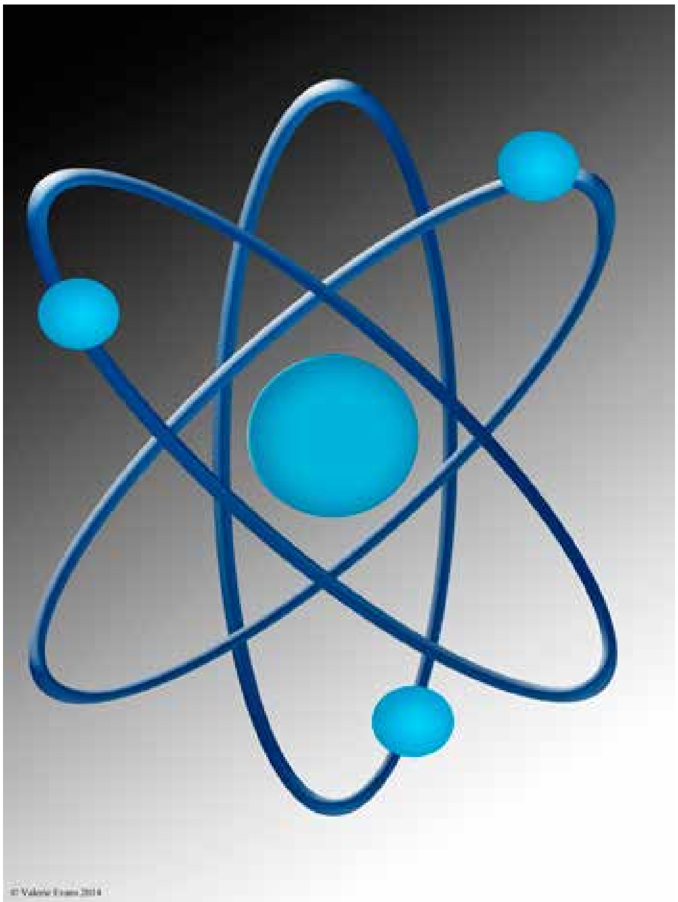
String Theory (SUPASTR)
Lecturer: N/A
Institution: Edinburgh
Hours Equivalent Credit: N/A
Assessment: This course is available for background reading only. No credit available.
Course Description
String theory is currently the most successful theory of quantum gravity and is one of the most researched areas of theoretical physics today. The aim of this course is to give a flavour of the basics of the subject to students with a working knowledge of general relativity and some exposure to quantum field theory. The course is as self-contained as is possible and mainly concentrates attention on the bosonic string theory mentioning along the way the results for superstrings.
The following is an outline:
Why we need String Theory.
Quantising the relativistic point particle.
Quantisation of the relativistic string.
Open strings and D-branes
Compactification and T-duality

Semester 2

Collider Physics (SUPACOP)
Lecturer: Christos Leonidopoulos
Institution: Edinburgh
Hours Equivalent Credit: 18 (16 lectures & 2 tutorials)
Assessment: Essay and Problem Sets
Common Core
Course Description
The SUPACOP lectures provide the common core for all particle physics students in semester 2. The course covers three main subject areas: Electroweak Physics (including Higgs), QCD and Beyond the Standard Model (including Supersymmetry). The objective of the course is to provide a general overview of theoretical, phenomenological and experimental aspects of electroweak theory, QCD and beyond the Standard Model (BSM) physics, concentrating on the most influential and/or recent measurements from colliders
The course will include:
• An introduction to lepton and hadron collider basics: kinematics, PDFs, Monte Carlo methods, jets, triggering and reconstruction, experimental techniques
• Results from LEP and Tevatron and on W, Z, top and Higgs searches
• LHC physics: Standard Model and QCD results; BSM searches; the Higgs discovery
• The BSM part of the course will introduce the concept of naturalness in the context of supersymmetry, supersymmetry breaking, and compositeness.
At the end of the course, we expect students to be familiar with basics of collider physics and the theoretical and experimental aspects of QCD, Electroweak, MSSM and Higgs physics.

Discussion Classes (SUPADCL)
Lecturer: Aidan Robson & Matthew Needham
Institution: Glasgow
Hours Equivalent Credit: 8
Assessment: Presentation
Common Core
Course Description
The aim of this course is to provide students with an opportunity to investigate current topics of interest relating to Particle Physics and to present them. Intended outcomes are to research a specific topic using published literature and preprints, to expand in some detail work that is relevant to one's thesis topic, to convey details to an audience of non-experts, to be able to field questions on a newly researched topic competently, and to improve one's presentation skills.

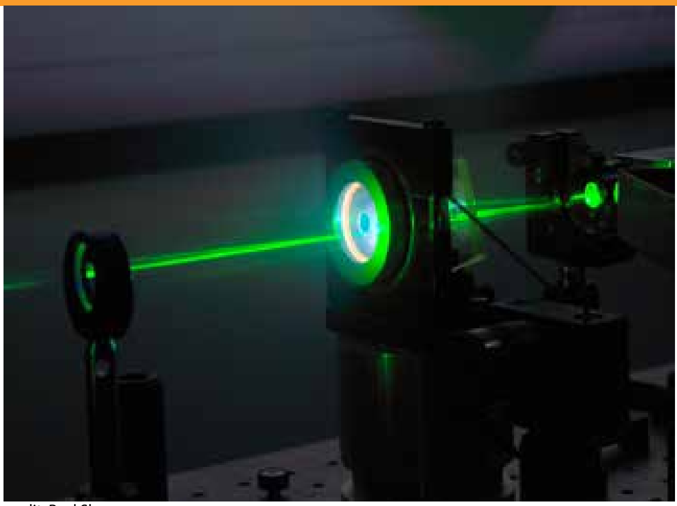
Flavour Physics (SUPAFLA)
Lecturer: Matthew Needham
Institution: Glasgow
Hours Equivalent Credit: 14 (12 lecture & 2 practical)
Assessment: Continuous Assessment
Common Core: This course includes two lab sessions based in Glasgow which students will be required to attend in person.
Course Description
Flavour Physics attempts to answer some of the most profound open questions in modern physics, such as how do we understand the pattern of masses in the Standard Model and what is the origin of CP violation. This introduction to Flavour Physics consists of two parts, dealing separately with Flavour Physics of the quark and lepton sectors.The Heavy Flavour Physics and CP Violation part of the course will cover the rather broad topic of CP violation in the quark sector, focussing on the main historic achievements and discoveries, and on recent issues related to the search for signatures of New Physics. We will begin by discussing introductory concepts such as the C, P and T symmetries, and the CPT Theorem. We will then examine the phenomenology of CP violation in the Standard Model, and in particular, the phenomenology and experiments relevant to the K, B and D systems, current CKMTriangle constraints and prospects, and rare B decays. The main objective of the Neutrino Physics part of the course is to try to understand some of the properties of the neutrino, one of the most fascinating particles in the Standard Model. We will cover some of the historical aspects of neutrino physics, look at different models of neutrino mass, review the theory of neutrino interactions, review experiments to determine neutrino mass and finally look at the theory and experimental evidence for neutrino oscillations and the future outlook of neutrino physics, including the search for leptonic CP violations. After taking this course, students should: understand the basic concepts of C, P and T symmetries, the CPT Theorem and the phenomenology of CP violate on; understand the historic importance of these concepts in the building of the Standard Model; be able to describe CP violation experiments dealing with K, B and D mesons and their different challenges; grasp the differences in the CP violation phenomenology of K, B and D mesons;
understand the current constraints on, and prospects for, the CKMTriangle; have a general understanding of the role of Flavour Physics and CP violation in the search for New Physics beyond the Standard Model; be able to describe historical aspects of neutrino physics, including beta decay, the discovery of each of the neutrino flavours and early theories for weak interactions (Fermi theory, V-A theory); understand the physics of Standard Model neutrino interactions (neutrino-electron scattering, neutrino-nucleon quasi-elastic and resonance scattering, neutrinonucleon deep inelastic scattering); understand the origin of neutrino mass (Dirac and Majorana mass) and the see-saw mechanism; be able to describe experiments that measure directly the mass of the neutrino; be able to describe double beta decay experiments and their importance in determining the Majorana nature of the neutrino; understand the phenomenology of neutrino oscillations, including oscillations in matter (MSW effect); be able to describe neutrino oscillation experiments (solar neutrinos, atmospheric neutrinos, accelerator and reactor based oscillation experiments); be able to understand the role of future experiments in determining leptonic CP violation.



Lattice QCD (SUPALAT)
Lecturer: Christine Davies
Institution: Glasgow
Hours Equivalent Credit: 6
Assessment: Project
Theory Core
Course Description
The course will provide an introduction into the methods of lattice QCD. In particular, we will discuss gluon actions, algorithms, quarks on the lattice, algorithms for that, how to do a lattice calculation, systematic errors and recent results.

Quarks and Hadron Spectroscopy (SUPAQHS)
Lecturer: Bryan McKinnon and Derek Glazier
Institution: Glasgow
Hours Equivalent Credit: 10
Assessment: Continuous Assessment
Experimental Core This course is cross-listed with the Nuclear and Plasma Physics Theme
Course Description
The course will cover the following topics: why are models necessary when you've got QCD, quark model predictions of hadronic states, properties of the nucleon and its resonances, "missing" baryonic resonances, pentaquarks - salutory lesson or crucial discovery, partial wave analysis, the search for exotic states: hybrid mesons, glueballs.

Gauge Theory in Particle Physics (SUPAGAT)
Lecturer: Brian Pendleton
Institution: Edinburgh
Hours Equivalent Credit: 40
Assessment: Take home exam
Common Core Joint Master's and PhD course delivered at the University of Edinburgh
This is a face to face course which is available to University of Edinburgh students only in 2016/17. We may be able to offer this course to all SUPA students again in 2017/18.
Course Description
This course provides a comprehensive treatment of the field theoretical approach to the Standard Model of particle physics; it is taught in two parallel threads.
The QED and QCD thread begins with path integral quantisation and renormalisation of Quantum Electrodynamics (QED). It then moves on to a detailed study of Quantum Chromodynamics (QCD), beginning with quantisation, Feynman rules and renormalisation, and then applying a wide range of topics in modern perturbative QCD to collider physics, including deep inelastic scattering and Higgs production.
The electroweak physics and lattice field theory thread focuses on the field theoretical construction and application of the standard model of particle physics, including the Goldstone theorem and the Higgs mechanism, weak decays and flavour physics. Further focus is on detailed calculations in perturbation theory and comparison with experiment. The final part of the course provides an introduction to non-perturbative methods via lattice field theory.
Each thread will have two hours of lectures and two hours of tutorial workshops every week, giving a total of 40 lecture hours and 40 tutorial hours. Students are expected to engage with the material presented in lectures by working through and discussing weekly formative problem sheets in the tutorial sessions. There will be a total of 4 summative hand-ins, which will be marked and individual written will be feedback provided on each. Individual feedback will also be administered verbally during tutorial sessions.


credit: Paul Shaw

The programme offered within the Photonics Theme involves a selection of lecture courses which we hope will be of interest to you. Additionally there are opportunities to take part in some distance learning courses. It may also be useful for you to look at courses offered through other themes, especially Condensed Matter and Material Physics and the Core courses. Students are also encouraged to attend Photonics related seminars hosted across Scotland.

Semester 1

Photonic Crystals and Plasmonics (SUPAPTC)

Lecturer: Liam O'Faolain, Andrea di Falco
Institution: St Andrews
Hours Equivalent Credit: 16
Assessment: Exam, Presentation and Assessed Tutorials
This is an MSc course organised by the University of St Andrews
For information only. This course will not run in 2016/17, but may run again in 2017/18.

Course Description

Nanostructured materials such as photonic crystals or plasmonic metamaterials are very hot topics in contemporary photonics. The fascination arises from the fact that the properties of these materials can be designed to a significant extent via their structure. While photonic crystals are made of dielectric materials, plasmonic structures are typically made of metals. Many of the properties of these nanostructured materials can be understood from their dispersion diagram or optical bandstructure, which is a core tool that will be explored in the course. Familiar concepts such as multilayer mirrors and interference effects will be used to explain the more complex features such as slow light propagation, high Q cavities in photonic crystal waveguides and supercontinuum generation in photonic crystal fibres. Similarly, the concepts of propagating and localized plasmons and their properties will be explained and expanded to include the novel effects of superlensing and optical cloaking in metamaterials.

Polymers and Liquid Crystals (SUPAPLC)

Lecturer: Graham Turnbull
Institution: St Andrews
Hours Equivalent Credit: 13
Assessment: Exam and Tutorial Sheet
For information only. This is a biennial course which will not run in 2016/17 but will run again in 2017/18.

Course Description

This Module describes the materials science and device physics that underpins modern display technologies. The module is delivered in a Distance Learning format. The syllabus includes an overview of types of displays and characterisations on display properties. The module then focuses on two contemporary display technologies: liquid crystal and organic semiconductors. Topics include: Displays - Types of displays, characterisation of display properties. Semiconducting polymers - Chemical structure; energy states; photoluminescence and electroluminescence. Factors determining OLED efficiency; light-emitting diodes and field effect transistors. Dendrimer OLEDs. Liquid Crystals - Nematic, smectic and cholosteric phases; director and order- parameter; splay, twist and bend distortions; anisotropy and birefringence; operation of twisted nematic display.

Semiclassical Theory of Atom Light Interactions (SUPASTA)

Lecturer: Gian-Luca Oppo
Institution: Strathclyde
Hours Equivalent Credit: 24
Assessment: Essay & Continuous Assessment (70%) & Oral Presentation (30%)
For information only. This course will not run in 2016/17 but may run again in 2017/18.

Course Description

The course is beneficial to students interested in the interaction of laser light with materials. It provides useful theoretical and numerical skills that have become basics in many research fields in quantum optics, photonics, quantum information processes, light-matter interaction and their applications. Topics covered include: second quantization, raising and lowering operators, density matrix approach, the Lindblad form of decay rates, two and three level atoms, Rabi oscillations, electromagnetically induced transparency, coherent population trapping, enhanced refractive indices, slow light, sub-natural line widths, self-focusing, spatial solitons during propagation, light-matter interaction in optical cavities, Maxwell-Bloch equations, optical bistability, cavity solitons, parametric down-conversion and optical parametric oscillators.

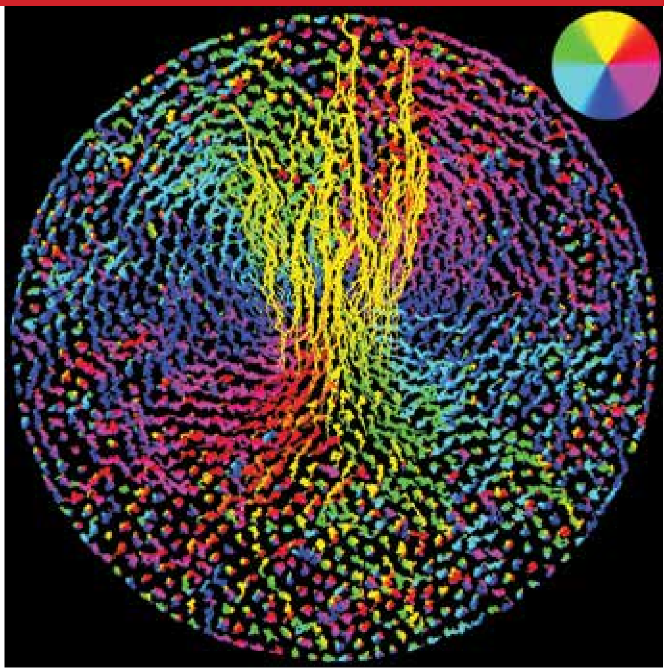
Semester 2

Ultrafast Photonics (SUPAUPH)

Lecturer: Derryck Reid
Institution: Heriot-Watt
Hours Equivalent Credit: 10
Assessment: Online Assessment
This is a Distance Learning Course.

Course Description

Pico/femtosecond techniques. Standing wave and travelling wave resonators. Active and passive modelocking schemes. Saturable gain and loss. Nonlinear optical effects for enhanced modelocking. Application examples and measurement techniques associated with ultrashort laser pulses.



The Theme of Physics and Life Sciences (PaLS) covers a large breadth of both physical and life sciences. As students come from a wide range of backgrounds and experiences, and are pursuing diverse PhD projects, the exact courses to be taken should be discussed with the student's individual supervisor. Students are also invited to select relevant courses from any of the themes and or to take appropriate and relevant non-SUPA courses within their home institution, but it is essential that the appropriate assessment (in the form of examination, written assignment or oral assignment) be discussed and agreed with the PaLS Theme Leader (Gail McConnell) in advance.

Semester 1

Biophotonics (SUPABIP)

Lecturer: Kishan Dholakia, Carlos Penedo-Esteiro, Malte Gather
Institution: St Andrews
Hours Equivalent Credit: 33
Assessment: Attendance, news and views article.
This is a final year undergraduate course organised by University of St Andrews.

Course Description

The module will expose students to the exciting opportunities offered by applying photonics methods and technology to biomedical sensing and detection. A rudimentary biological background will be provided where needed. Topics include fluorescence microscopy and assays including time-resolved applications, super-resolution imaging, optical tweezers for cell sorting and DNA manipulation, single molecule studies, photodynamic therapy, lab-on-a-chip concepts and bio-MEMS. Two thirds of the module will be taught as lectures, including guest lectures by specialists, with the remaining third consisting of problem-solving exercises, such as writing a specific news piece on a research paper, assessed tutorial sheets and a presentation. A visit to a biomedical research laboratory at St Andrews using various photonics methods will also be arranged.

Biomedical Applications of Lasers, Beams and Radiation (SUPABAL)

Lecturer: Bernhard Hidding, Grace Gloria Manahan
Institution: Strathclyde
Hours Equivalent Credit: 12
Assessment: Continuous Assessment

Course Description

Lasers, particle beams and radiation such as x-rays are essential instruments for imaging, drug research and treatment in life sciences. The course would address both established and cutting edge radiation generation methods for a variety of biomedical applications, as well as occurrence of radiation in nature and their effects. Then, the mechanisms of interaction of the different types of radiation on the nuclear, atomic, molecular, cell and system level (e.g. the patient) are discussed. Finally, fundamentals and progress in biomedical applications such as x-ray radiography, magnetic resonance tomography (MRT), positron emission tomography (PET), electron microscopy and other radiology imaging techniques, radiation-assisted drug R&D as well as laser surgery, cancer radiotherapy with photons, electrons, protons, neutrons and ions, and other treatment techniques will be covered. Next to providing an overview on the physics behind these techniques, the course will also include practical considerations and is intended to facilitate and support interdisciplinary research projects and collaborative applications.

Collective Dynamics in Biophysical Systems (SUPACDB)

Lecturer: Antonio Politi and Francesco Ginelli
Institution: Aberdeen
Hours Equivalent Credit: 16
Assessment: Oral Presentation
For information only. This is a biennial course and will not run in 2016/17, but will run again in 2017/18.

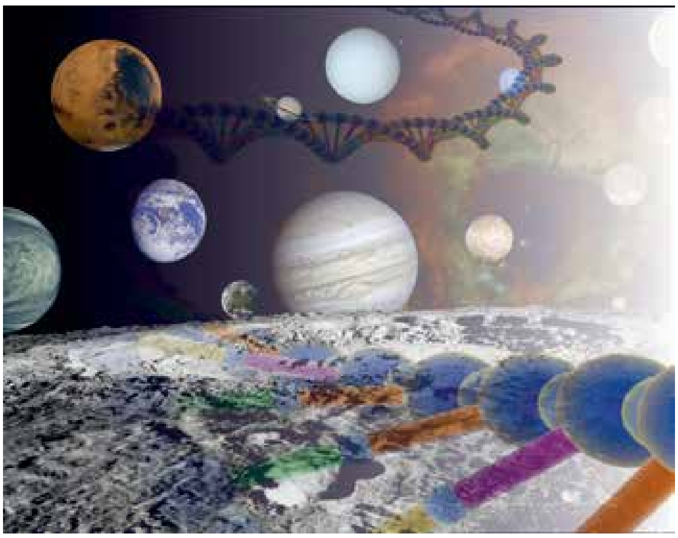
Course Description

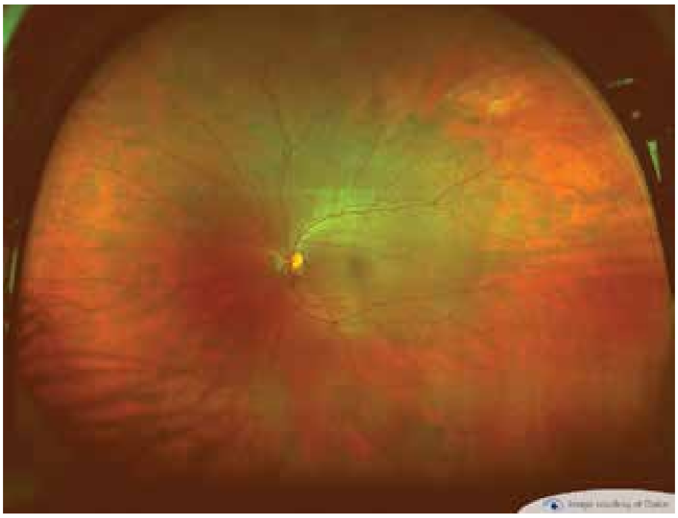
The spontaneous emergence of collective behaviour is a universal property of biological systems that requires a proper theoretical and modelling framework to be fully understood. Our approach aims at showing that minimal models may capture many properties of collective biological phenomena. Minimal model are based on the essential features of the system at hand, such as conservation laws and symmetries, and allow for a deeper understanding of the universal mechanisms lying behind many biological problems. We plan to introduce the basic concepts and tools – both analytical and numerical -- of this approach by analysing two different classes of systems exhibiting non-trivial collective dynamics, both at the forefront of current research: Neural networks – Brain can be described as a network of mathematical models of single neurons, suitably coupled through various kinds of synaptic connections. Various issues must be considered: single neuron dynamics (above/below threshold, number of local variables); synaptic connections (excitatory vs. inhibitory, synaptic own dynamics); network structures (random, scale free, sparse coupling, etc.). The various classes of collective dynamics are discussed.

(ii) Active matter -- Active matter is composed of particles able to self propel themselves in a systematic way by extracting and dissipating energy from their surroundings. Systems of interacting active particles describe the collective motion observed in systems as diverse as animal groups (bird flocks, fish school, etc.), bacteria, molecular motors, as well as driven granular matter.

Introducing Biology to Physicists (SUPAIBP)
Lecturer: Ulrich Zachariae
Institution: Dundee
Hours Equivalent Credit: 22
This is an undergraduate course run by the University of Dundee.
Course Description
An overview of fundamental areas of biology for students with little biology background, emphasizing evolution, connections between length and time scales in biology, and the potential role of physics to inform biology at all of these different scales. Introduction: what is life?, Darwin's theory of evolution, Mendelian genetics, tree of life, basics of prokaryotic cells, basics of eukaryotic cells. Biochemistry and molecular biology: structure and functions of proteins, structure of DNA, DNA replication, transcription, translation, protein folding. Cell biology: membrane structure, membrane transport, metabolism and mitochondria, cytoskeleton, cell cycle. Multicellular organisms: germ cells, fertilisation, development. Populations: introduction to ecology, population genetics and evolution.

Physics of Biological Evolution (SUPAPBE)
Lecturer: Bartek Waclaw
Institution: Edinburgh
Hours Equivalent Credit: 10
Assessment: Problem Sheets
For information only. This is a biennial course which will not run in 2016/17 but will run again in 2017/18.
The course will discuss the basics of biological evolution and examples of physicists' contributions to it. The emphasis will be on problems that can either be solved by the methods of statistical/quantum physics, or those investigated by researchers who considered themselves to be physicists. Topics will include: E. Schroedinger's "aperiodic crystal" for genetic inheritance and the size of the smallest inheritance element, Luria and Delbrueck's proof that mutations occur spontaneously, introduction to population genetics (Moran and Wright-Fisher models), Eigen and Schuester quasispecies model, gene surfing and genetic drift in expanding populations, the role of physical interactions between microbial cells in biological evolution, models of cancer progression, and the evolution of resistance to antimicrobial/anticancer drugs.





Semester 2

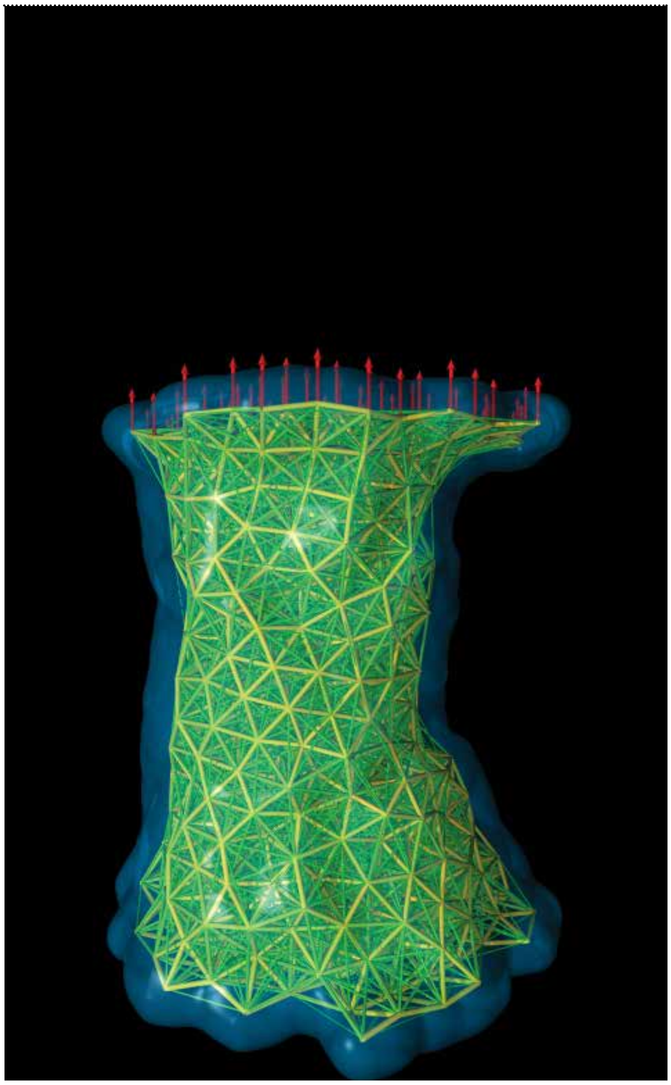
Astrobiology and the Search for Life (SUPAASL)
Lecturer: Charles Cockell, et al
Institution: various
Hours Equivalent Credit: 20
Assessment: Online multiple choice test
This course is cross-listed with the Astronomy and Space Physics Theme.
Course Description
This course looks into the origin, evolution and distribution of life in the Universe, broadly considered as 'astrobiology'. The objective of the course is provide a perspective in geology, biology and chemistry at an introductory level. The course will include lectures on the limits and conditions for life on Earth through time and how these may apply elsewhere in the universe. The course looks at the current scientific approaches used to address the hypothesis of life elsewhere in the Universe. Amongst the subjects discussed include: The formation of planetary systems and the conditions required for habitability, detection methods for extrasolar planets, the diversity of known exoplanet systems, the origin of life, evidence for earliest life on Earth, the geological and biological history of the Earth, conditiions past and present on Mars and the icy moons of the giant planets, and finally the Search for Extra-Terrestrial Intelligence (SETI.)

Biological Physics (SUPABPS)
Lecturer: Simon Titmuss
Institution: Edinburgh
Hours Equivalent Credit: 20
Assessment: Written Assessment
This is a level 11 undergraduate course organised by the University of Edinburgh. It would provide a physics based introduction to Biological Physics for students who have not taken such a course as undergraduates. This course will be taught to SUPA students as a Distance Learning course.
Course Description
There is an increased research effort devoted to problems at the interface between biology and physics. Increasingly it is recognized that physics can provide real insight into the behaviour of complex biological systems and that a physical approach to biological problems can provide a better way of looking at the world. This course will introduce students to the basics of biological systems and provide examples of how familiar physical principles (thermodynamics, statistical mechanics) can be used to explain complex biological phenomena.

Introductory Biology School (SUPAIBS)
Lecturer: Maciej Antkowiak
Institution: St Andrews
Hours Equivalent Credit: 15
Assessment: Continuous Assessment
This is a Residential course running annually in January 2017 and will be restricted to 20 places.
Course Description
Students entering the PALS theme come from a variety of backgrounds, and your needs as graduate students are enormously varied. Some of you will be handling biological materials, some will be carrying out molecular experimental projects, and some will be involved almost entirely with theory or simulation. In order to be productive PhD students, however, all students need a basic grounding in Biology and the challenges of biological research. This short course is designed to give you a taster, an exposure to the language of biology, taught by biologists with extensive experience of working at the interface with the physical sciences. The Summer School will consist of three half-days of lectures from members of the School of Medicine and the School of Biology at St Andrews that will cover the very basics (the structure of a cell, cellular contents, and how they can be manipulated). The rest of the course will consist of two half-day practical sessions, covering the basics of handling and manipulating biological cells, performing useful microscopy, and taking quantitative measurements. Many of you coming into the PALS theme are likely to need to handle some biological materials (e.g. for microscopy or related applications), and we aim to teach you how to keep cells alive, or if tissues or samples are fixed, what to look for to ensure samples are of good quality. For those students undertaking non-experimental programmes, we hope that this exposure will demonstrate the "messy" nature of biological experiment and its associated inherent uncertainty.

Mathematical Modelling (SUPAMMD)
Lecturer: Marco Thiel
Institution: Aberdeen
Hours Equivalent Credit: 32
Assessment: Continuous Assessment
This is a final year undergraduate course organised by the University of Aberdeen.
Course Description
Physical Sciences intend to describe natural phenomena in mathematical terms. This course bridges the gap between standard courses in physical sciences, where successful mathematical models are described, and scientific research, where new mathematical models have to be developed. Students will learn the art of mathematical modelling, which will enable them to develop new mathematical models for the description of natural systems. Examples from a wide range of phenomena will be discussed, e.g. from biology, ecology, engineering, physics, physiology and psychology. A focus will be the critical interpretation of the mathematical models and their predictions. The applicability of the models will be assessed and their use for the respective branch of the natural sciences will be discussed. Many difference modelling techniques (ODEs, PDEs, cellular automata, stochastic models (stochastic DE, TASEP and ARMA), network based models, etc) will be taught and actively applied to different areas in physical and life sciences. The topic of the modelling project will be agreed upon jointly by the student and the lecturer; it might well be related to the postgraduate work of the student.

Physics and Life Sciences Short Research Project (SUPASRP)
Lecturer: Cait MacPhee
Institution: Various SUPA institutions
Hours Equivalent Credit: 40+
Assessment: Short thesis to be submitted within one month of completing the project.
This course is to be carried out over 3 months during Year 1 or 2.
Course Description
Students in the PALS theme should aim to be working closely with collaborators from the Life Sciences. The purpose of this project is to allow students to immerse themselves in a Life Science laboratory for three months, learning the techniques and language of biological research, and networking with their peers. The research undertaken should be relevant to the proposed area of PhD study since the duration of PhD funding cannot be extended. Projects will be offered by appropriate research laboratories in Life Science disciplines, often but not always to align with existing programmes and collaborations. The existence of an existing collaboration between research groups is not a requirement. Students will undertake a self-contained well-defined research project, and write a short thesis describing the background, methods, and outcome of their work, appropriate for an interdisciplinary audience. Individual project descriptions will be posted on the SUPA website. Projects MUST be approved by the Theme Leader in advance, but project proposals may be put forward at any time.



Core Skills Courses

All SUPA students are required to complete 20 hours of Core Skills Training during the first two years of their PhD studies. SUPA Core Skills Training Courses are listed on the following pages. However, students may also participate in Generic Skills Training run by their local departments and universities or run by Vitae (a UK-wide organisation sponsoring Generic Skills Training) or their Research Councils.

Please note that enrolment for Core Skills Training is often run separately from enrolment procedures for Technical Courses. Information about enrolment procedures for each course will be posted on My.SUPA course areas and announced to all students via email. If you have any questions about enrolment for SUPA Core Skills Training Courses, please email admin@supa.ac.uk.

Information about Generic Skills courses run by Vitae and individual universities can be found at the following websites:

Vitae:
http://www.vitae.ac.uk/events
University of Aberdeen:
http://www.abdn.ac.uk/cops/graduate/generic-transferable-skills-242.php
University of Dundee:
http://www.dundee.ac.uk/opd
University of Edinburgh:
http://www.ed.ac.uk/schools-departments/institute-academic-development
University of Glasgow:
http://www.gla.ac.uk/researcherdevelopment/
Heriot Watt University:
http://www.hw.ac.uk/research/ald/develop/research-futures-student-workshops.htm
University of St Andrews:
http://www.st-andrews.ac.uk/capod/students/pgresearch/gradskills/
University of Strathclyde:
http://www.strath.ac.uk/careers/pgr/
University of the West of Scotland:
http://www.uws.ac.uk/research/

Semester 1

C++/Object Oriented Programming (SUPACOO)
Lecturer: Sarah Boutle
Institution: Glasgow
Hours Equivalent Credit: 12 (4 x 1hour lectures and 4x2hr tutorials)
Assessment: Continuous Assessment
This course includes four lab sessions based in Glasgow which students will need to attend in person. This course has priority booking for Particle Physics students. Please refer to the timetable and visit the My.SUPA course area for more information.

Course Description

Programming is used more and more in scientific research to analyse data and simulate nature. Just as in lab research, results when running a software must be reproducible. Instead of writing the same code twice for different applications, only one code should be written and used by both applications. Software should also be easily extended to allow the research to answer new questions that the scientist did not have when the study began. C++ is the programming language that proved most useful for the scientific world, as it satisfies these features, is versatile and is very fast. Furthermore, the same code can be used on different operating systems, once it is compiled again there. To illustrate how useful C++ is, two thirds of the software that powers a smart phone is written in C++!
This course introduces C++ via four pairs of lecture and computer lab. The computer lab gives you access to a Linux environment with C++ compiler and an Emacs or Vim text editors. As it sometimes slows when many people connect at the same time, you are encouraged to bring your own laptop with Linux or Mac OS to work directly in your day to day work environment, if available.
The topics covered are the basic C++ that needs to get you going in your research. However, object-oriented notions, such as classes and inheritance, will not be covered in this introductory C++. The topics covered include: basic C++ syntax; standard C++ data types (bool, float, char, etc); standard C++ streams (cout, cin, error, etc); standard C++ operators (==, &&, %, etc); conditionals and loops (if, for, while, switch, case, etc); standard templated library types (string, vector, map, list, stringstream, etc); pointers and references; functions; overloading functions; passing argument to a function by reference; templated functions; how to compile your code as an executable or a shared library to be used by another piece of code; how to convert on data type to another data type; how to compute the time it takes to run your code; how to pass arguments at the command line.

Introductory Data Analysis (SUPAIDA)
Lecturer: Katherine Kirk
Institution: UWS
Hours Equivalent Credit: 6
Assessment: Continuous Assessment

Course Description

This course provides an introduction to uncertainty in measurement. Topics will include: random error and relation to statistics; probability distributions and their properties; calculation and estimation of uncertainty; least squares model; applications of data analysis.

Maths Primer (SUPAPRI)
Lecturer: Patrik Öhberg
Institution: Heriot Watt
Hours Equivalent Credit: 6
Assessment: Continuous Assessment
Course Description
The course will be in the form of a maths primer intended for beginning PhD students in condensed matter, solid state and photonics.
The topics which will be covered include: Matrix diagonalisation, functional derivatives, complex integration and residues, Fourier transforms, and a discussion on different notations which the students will encounter during their studies.

Problem Solving Skills for Physicists (SUPAPSS)
Lecturer: Peter Sneddon
Institution: Glasgow/ Edinburgh
Hours Equivalent Credit: 2 full days
Assessment: Continually assessed by portfolio
Course Description
This course is based around the teaching of skills, rather than new theoretical knowledge. It will use examples from a wide range of physics disciplines to highlight key skills that physicists need, whatever their speciality and intended destination after graduation. The course will use case studies from across the subjects of astronomy and physics, but is designed in such a way as to be suitable for all SUPA students, no matter their speciality. It will feature a range of techniques and approaches that are useful when facing unfamiliar problems, such as: when to use approximations and when not to; back of the envelope and order of magnitude calculations; dimensional analysis; use of multiple representations; error estimation and calculation; problem type identification. The course will be delivered in two face-to-face day workshops to facilitate group working and cooperation, supported by online resources and materials. Assessment will be by the construction of a brief portfolio of teaching resources which illustrate the principles behind or examples of the use of some of the featured techniques: this will also give practice (and provide useful resources) for graduate teaching assistant activities.

Software Carpentry (SUPASWC)
Lecturer: Norman Gray
Institution: Glasgow
Hours Equivalent Credit: 2 full days
Assessment:
Course Description
Many researchers need to write (computer) code of some type or other, though typically as an auxiliary activity – researchers should not turn into 'programmers'. It is useful for researchers to do that part of their work effectively, now and in the (transferrable) future.
Quite often, the habits they end up with are those they acquire from their supervisors and peers; right now, those are often rather poor software habits.

The Software Carpentry course (SWC, which is based on material from <http://software-carpentry.org/>) is focused on exactly this group – coding scientists. The goal of the SWC course is to instil pragmatic good practice in scientists who are more interested in doing science than in programming. The course covers effective use of the Unix shell and configuration management tools, code testing, and software revision control tools.

This is not a programming course, as such, and there are no prior requirements, but a very basic familiarity with Python would probably be useful for some parts of the course.

ROOT (SUPAROO)
Lecturer: Sarah Boutle
Institution: Glasgow
Hours Equivalent Credit: 9 (3 x 3 hour Labs)
Assessment: Continuous Assessment
Course Description
In experimental particle physics there are very many particle collisions produced by particle accelerators and colliders. Each collision produces a very complex "photograph" captured by a 3D digital camera called particle detector. For scientific research about these fundamental ingredients of the Universe, these particles need to be 1) recorded, 2) analysed statistically and 3) the results be represented in graphical form to be made public in journal papers. Wouldn't it be nice to have one program to satisfy all these needs?

The CERN laboratory has produced such a program and offers open access to it. It is now used in all particle physics experiments and starts to be used in nuclear physics and astroparticle physics as well. The software is called ROOT and is based on C++. In other words, it is a collection of C++ libraries that address all the three main goals. ROOT is possible thanks to the object-oriented features C++ of classes and inheritance. The data is stored in a very compact format, allowing for big data storage, both in a format for every collision (called tree), or on counts for the entire sample (histograms). All major types of statistical analyses are implemented. Finally, plots are saved to .pdf, .eps, .gif files. There is also an option to use ROOT from within Python, which simplifies the syntax of the commands. This is called PyROOT and is also used more and more.

This class is an introduction to ROOT to get you started in your research. The prerequisites are the knowledge from the SUPACOO class, but classes and inheritance will be discussed in this class. We will read a data tree in a visual mode and in code, will fill histograms from the tree, will fit a histogram to a function, will overlay different histograms to compare them (the standard in physics when the experiment is done in two different conditions and the results are compared) and save the results in graphical form. Depending on the time, we will go further into ROOT. We will also introduce PyROOT, and mention more advanced ROOT tutorials where you can study more.

Vacuum Technology (SUPAVAC)
Lecturer: Richard Moug
Institution: Heriot Watt
Hours Equivalent Credit: 10
Assessment: Continuous Assessment
Course Description
This course will concentrate on the practical aspects of vacuum technology, and will be primarily of interest to students who are confronted with a vacuum system for the first time or are faced with using, maintaining or developing a system. Topics which will be covered include:

1. Introduction to vacuum technology. The basic classification of vacuum grades and system types. Important gas properties relevant to vacuum systems. Sources of Information.
2. Measurement of pressure in vacuum systems.
3. Pumping: Classes of pumps and examples of different pumping machines.
4. Gas flow in through a system, gas throughput and conductance, sources and pumping speed. Leaks, virtual leaks and outgassing.
5. System design, construction and troubleshooting. High Vacuum and ultra high vacuum components.
6. Mass spectrometers and leak detection. Residual gas composition in different pressure regimes.
7. Real system examples. Here, students will be encouraged to discuss their own systems and any problems they may have encountered.

Semester 2

Advanced Data Analysis (SUPAADA)
Lecturer: Martin Hendry
Institution: Glasgow
Hours Equivalent Credit: 14
Assessment: Continuous Assessment via series of multiple choice questions. Optional mock data challenge also available, although not compulsory.
Course Description
This course is taught via a series of lectures and tutorials delivered face-to-face over two days at the University of Glasgow. Provisional course dates for 2016-17 are Thursday January 5th and Friday January 6th 2017. The course will also include a curry night at a local restaurant with all participating students, on the evening of January 5th.
The course will cover the following topics: theoretical foundations and the nature of probability; the essentials of line and curve fitting; an introduction to Bayesian inference; hypothesis testing and goodness of fit; an advanced toolbox for Bayesian inference; covariance and the Fisher information matrix; Bayesian evidence and model selection; assigning prior probabilities; analysis of very large datasets; data compression and principal component analysis; efficient techniques for generating random numbers; Markov chain Monte Carlo methods. Learning outcomes:
to acquire a working knowledge of advanced data analysis methods - i.e. to a level sufficient to permit their successful application to real data analysis problems, as might be encountered in students' own research projects; to gain familiarity with the key differences between a frequentist and Bayesian approach to data analysis; the assumptions upon which each approach is founded and the circumstances in which each is applicable. To develop awareness of the current literature on advanced data analysis for the physical sciences, and the software available to support its application to real problems.

Hands on Writing: How to Master Scientific Academic Writing (SUPAHOW)
Lecturer: Marialuisa Aliotta
Institution: Edinburgh
Hours Equivalent Credit: 15
Attendance on this course will be restricted to 25 places.
Course Description
The course is specifically tailored to PhD students in scientific disciplines. It will provide practical tools and strategies to help students understand key elements of good scientific writing. The course will cover the 5 steps of the writing process, from pre-writing to proofreading, and will focus on the structure and style of good academic writing. The course runs as a three-day residential workshop and will provide plenty of opportunities for students to develop and hone effective writing skills. Topics covered will include: purpose and structure of different sections (Introduction, Methodology, Data analysis and Results, Discussion and Conclusions, Abstract); use of language and grammar (parallel sentences, appropriate tenses, sentence coordination); supporting materials (figures and tables, bibliography, appendices).

Hanging Your Research Out in Public (SUPAHRP)
Lecturer: Kenneth Skeldon and Lucy Leiper
Institution: Aberdeen
Hours Equivalent Credit: 8
Course Description
In this highly interactive workshop you will gain awareness and develop core skills important for engaging a range of stakeholders with your research. This is becoming very important for research councils and funders and is a key element of a strong CV. Practical sessions will form the bulk of the course and follow-through opportunities will be presented, relevant to geographical regions across the SUPA University set.
This 1 day course will be split over 2 days with participants taking part in a live public event in the evening of day 1.

Introduction to Python (SUPAPYT)
Lecturer: Michael Alexander
Institution: Glasgow
Hours Equivalent Credit: 8 (4 lectures & 2x2hour tutorials)
Assessment: Assignment Problem
Course Description
This course serves as a first introduction to the powerful, object-oriented scripting language Python, which combines ease of use with extensive functionality and simple extensibility. The basic setup and working environment of Python will be covered, as well as some common tools for writing scripts. The main body of the course will cover the syntax of the language, the main data types, functions, looping techniques, modules, classes, input and output through the console and files, and exception handling. After completion, it's intended that users will be familiar with the concepts and philosophy of Python, be able to use it to solve a wide range of everyday problems, and be able to extend its functionality with user defined classes and modules for more specialised problems.

Research Ventures (SUPAENT)
Lecturer: Various
Hours Equivalent Credit: 2 days (21 hours)
Schedule: June 2017
This course will be organised by the Researcher Development Department at the University of Glasgow.
Course Description
This two day course is aimed at researchers with an interest in:
•Knowledge exchange, research impact and winning funding for academic career progression
•Exploring the commercial possibilities of a research idea and how your research might attract industrial funding or be used in setting up a spin-out company
•Future employment in industry
•Collaboration with researchers from other disciplines
The course is a mixture of practical activities and case studies. It includes talks from experts and entrepreneurs with inspiring stories and first hand experience of bringing exciting ideas to life. Our speakers will share their knowledge of:
•Creative thinking and what being enterprising means to them
•Business planning and different models of research commercialisation (including spin-outs and licensing)
•Protecting your ideas and intellectual property
•Compelling and convincing communication, that helps you to bring others on board and win funding
•How to inspire and motivate others, whether you see yourself as working in business or building a research group
•Sources of support, advice and funding and how to deal with set-backs
•How to develop a network

Credit for Non-SUPA Courses

To achieve the minimum SUPA requirements of 40 hours Technical Skills (physics related studies) and 20 hours Core Skills (generic or transferrable skills), it is possible to gain credit for non-SUPA courses as follows:

Technical Skills (40 hours)

All final honours and master's level courses are accepted as SUPA-approved courses in order to make up the mandatory 40 hour requirement.

Process – At the start of academic years 1 and 2 of a PhD, a student discusses and gets agreement locally. In order for the result to be logged on My.SUPA, the GSC representative (or nominee) at the end of each academic year informs SUPA Central of the course name, number of hours, the pass mark and the student mark.

Summer schools will only be accepted by approval of GSC where the school has been assessed either at the summer school or by local assessment following the summer school. Broadly, the taught content and assessment should be comparable to a Graduate School Technical Skills course of equivalent SUPA credits to those being requested for the Summer School.

Process – A student discusses and gets agreement locally. The GSC representative requests GSC approval by circulation via the SUPA Graduate School Secretary. In order for the result to be logged on My.SUPA, the GSC representative (or nominee) at the end of each academic year informs SUPA Central of the Summer School name, number of hours, and the student mark. The pass mark will be assumed to be 50%.

All other courses including bachelor's level modules will only be accepted by approval of GSC where the course has been assessed.

Process – A student discusses and gets agreement locally. The GSC representative requests GSC approval by circulation via the SUPA Graduate School Secretary. In order for the result to be logged on My.SUPA, the GSC representative (or nominee) at the end of each academic year informs SUPA Central of the course name, number of hours, the pass mark and the student mark.

SUPA Central cannot organise assessment for non-SUPA courses. There is an agreed 30 hours credit cap on a single non-SUPA technical course.

Core Skills (20 hours)

All generic or transferrable skills courses run by universities and/or the research councils, VITAE or other 'approved' bodies are accepted as SUPA-approved courses in order to make up the 20 hour requirement.

Process – The student informs SUPA Central of the course name and number of hours when the course has been completed so that it can be logged on My.SUPA to make up the mandatory 20 hours. Attendance and/or completion will not be checked by SUPA – student information provided will be assumed as correct.

Record Keeping

SUPA Central will record on My.SUPA up to 40 hours Technical Skills and 20 hours Core Skills (in order for the GSC to check that students have completed their minimum SUPA requirement). SUPA Central will flag up any concerns in advance of an annual check. Normally SUPA Central will not log non-SUPA courses beyond the 40/20 minimum but further hours may be logged on request.

Student Funding

This page details the possibilities for funding available to the students within SUPA and its affiliated departments and organisations. Further information about funding options for students is available from the funding council, research councils and from the funding offices of individual institutions.

Funding and Research Councils

Science & Technology Facilities Council (STFC):
http://www.stfc.ac.uk/
Scottish Funding Council (SFC):
www.sfc.ac.uk
Engineering & Physical Sciences Research Council (EPSRC):
www.epsrc.ac.uk
Biotechnology and Biological Sciences (BBSRC):
www.bbsrc.ac.uk

Institutional Funding Offices

University of Aberdeen:
http://www.abdn.ac.uk/study/postgraduate/finance.php
University of Dundee:
http://www.dundee.ac.uk/postgraduate/fees_funding/
University of Edinburgh:
http://www.ed.ac.uk/studying/postgraduate/fees-finance/scholarships
University of Glasgow:
http://www.gla.ac.uk/postgraduate/feesandfunding/fundingyourstudies/
Heriot Watt University:
https://www.hw.ac.uk/postgraduate/index.htm
University of Strathclyde:
http://www.strath.ac.uk/search/scholarships/index.jsp
University of St Andrews:
http://www.st-andrews.ac.uk/physics/prosp_pg/phd/phd_funding
University of the West of Scotland:
http://www.uws.ac.uk/study-at-uws/postgraduate/fees-and-funding/

SUPA Prize Studentships

Background

The SUPA Prize Studentships are prestigious and competitive awards intended to attract outstanding physics students from around the world, irrespective of nationality, to study for a PhD in Scotland. Every year, SUPA offers a limited number of fully funded Prize Studentships. These provide tuition fees, an annual maintenance grant and a Research Training Support Grant (RTSG), normally for a three-and-a-half year period. Studentships in certain research areas also cover expenses for Essential Travel.

Application process

Applications should be made using the online application form at apply.supa.ac.uk.

The next competition will open on Monday 3rd October 2016, and close on Tuesday 31th January 2017.

Condensed Matter Doctoral Training Centre Studentships

Background

The Scottish Doctoral Training Centre in Condensed Matter Physics is a tri-institutional collaboration between the Universities of St Andrews, Edinburgh and Heriot-Watt, providing international-level doctoral training in the core discipline of condensed matter physics. It offers more than ten 4-year PhD fully funded studentships per annum. For more information, please visit http://cm-dtc.supa.ac.uk/.

Application Process

Doctoral Training Centre places will be allocated to outstanding students on a rolling basis. Applications should be made using the online application form at apply.supa.ac.uk. To ensure fair consideration, students are strongly advised to apply early. Late applications may be considered if places are unfilled. Informal enquiries are welcome and should be sent to the Manager, Julie Massey at cm-dtc@supa.ac.uk. (Contact information can be found in the 'Contacts' section of this handbook).

Other Student Funding

Background

Individual Physics departments within SUPA (Aberdeen, Dundee, Edinburgh, Glasgow, Heriot-Watt, St Andrews, Strathclyde & UWS) also have various departmental funding sources available to students. PhD studentships generally provide tuition fees, an annual maintenance grant and RTSG, normally for a three-and-a-half year period. Most of these are for eligible UK and EU applicants, but some universities also have dedicated studentships to support overseas students.

Application Process

Qualified candidates who meet the funding eligibility criteria should contact the physics department of the university they wish to attend directly. Applicants are advised to check their eligibility for certain types of funding by consulting the websites of the relevant funding council and the participating universities.

My.SUPA (http://my.supa.ac.uk) is an online space for managing all your SUPA-related activities. We strongly encourage you to check My.SUPA regularly as this is our main tool for contacting you with important information such as requirements for your lectures, changes to the course timetable and event announcements.

Obtaining a Username and Password

To obtain a My.SUPA login, please go to the My.SUPA portal (http://my.supa.ac.uk) and click on the 'Request a My.SUPA login' link. You should always use your university email address when completing your request. Your new login and password will soon be emailed to you with instructions. If you forget your My.SUPA username or password, you can reset them either by following the 'Lost Password?' link in the login box on the My.SUPA portal or by emailing admin@supa.ac.uk.

For incoming first-year PhD students, SUPA should automatically create an account for you and contact you via email with your account details in early September. However, occasionally we do not receive complete details for incoming students and so cannot create accounts for them. If you have not received an email with your username and password by the time you are registering for SUPA courses, please email admin@supa.ac.uk.

Courses and My.SUPA

In order to register for SUPA courses, either as an enrolled or non-assessed student, you will need to use My.SUPA. Go to the My.SUPA portal (http://my.supa.ac.uk) and follow the enrolment instructions posted on the front page. Before you register for the first time, you will be informed about SUPA's videoconference recording policy and asked for your consent. (For more information about this policy, please email admin@supa.ac.uk)

When selecting courses on My.SUPA, please note that most courses are only available with read-only access to some materials during the registration period. All course materials will be made available to enrolled and non-assessed students once registration is closed. You will be expected to participate fully in the courses for which you have enrolled, whereas non-assessed students will simply be required to attend the courses. Please consult your supervisor and refer to the 'SUPA Graduate School Basics' and theme-specific sections of this handbook for more guidance on selecting appropriate courses.

The end dates of the SUPA registration periods are listed on Page 2. If you miss the deadlines, late registration may be possible but cannot be guaranteed. Please contact the SUPA Courses Office at admin@supa.ac.uk in this instance. Once you have registered for a course (either as non-assessed or enrolled), you will be able to check the course area on My.SUPA for information such as lecture notes and changes to the course schedule. You will also be able to communicate with your classmates and lecturer(s) individually (through the 'People and Locations' tab) and as a group (by using the News Forum). Messages posted on the course area News Forum will be automatically sent to the email address you have provided to SUPA.

If you would like to unenrol from a SUPA course, either as a nonassessed student or as a fully enrolled student, you can do so by going to the relevant course page and clicking on the 'Unenrol me from SUPA[XXX]' link. If you would like to change between being a nonassessed student and full enrolment, please unenrol for the course and then re-register in the alternate role. This will only be possible during enrolment, at all other times should you wish to unenrol, please contact admin@supa.ac.uk. For fully enrolled students, it is crucial that you unenrol if you decide not to complete the course, or else your transcript will retain a record of the course.

Once enrolment has closed, it will not be possible to unenrol on My.SUPA and you will need to make a request to admin@supa.ac.uk. You will normally be expected to show that you have permission from the course co-ordinator.

Transcripts and My.SUPA

As noted in the 'Graduate School Basics' section of this handbook, all SUPA students are required to complete 40 hours of Technical Courses and 20 hours of Core Skills Training in the first two years of their PhD. You can track the number of course hours you have completed by viewing your online transcript in My.SUPA. To do so, after logging in to My.SUPA, click on your name in the upper right hand corner of the screen. (The link should say: You are logged in as [NAME]). This will take you to your user profile. Click on the 'Grades' tab to view your transcript. To obtain an official copy of your transcript certified by the Graduate School Director, please email admin@supa.ac.uk.

Timetable, Calendar and Events Forum

The latest version of the Graduate School Timetable, the SUPA Events Forum and the SUPA Calendar can be found on the My.SUPA homepage. If you would like to advertise an event through the Events Forum, please email admin@supa.ac.uk.

Further Training and Support

If you experience any difficulties while using My.SUPA, please email the SUPA Administration Office at admin@supa.ac.uk. To report errors on the site or to request technical help, please contact webmaster@supa.ac.uk.

Getting Started with Videoconferencing

This page gives an introduction to using the videoconference facilities across the SUPA institutions. Videoconferences are primarily used in SUPA to deliver courses, however, they are also used for a variety of other purposes such as research meetings, seminars, interviews and distinguished visitor lectures. More information on using SUPA videoconference facilities, including video tutorials, can be found in Getting Started with Video-Conferencing at: http://my.supa.ac.uk/

Making a Booking

SUPA videoconferences must be booked in advance by SUPA. If you are attending a scheduled SUPA course or event, the booking has already been made for you. If you are organising a meeting or event and would like to use the SUPA videoconference facilities, please visit the SUPA website and use the booking form to make a booking (http://www.supa.ac.uk/room_booking).

Setting Up

SUPA videoconferences usually begin at five minutes past the hour. As the bookings are made in advance, the videoconference call will be made automatically, so there is no need to dial in.

There are slight differences in the videoconference system and the layout of the videoconference rooms at each institution. (The system at UWS is totally different to another SUPA sites.)

When you arrive in the room:

• If the projectors/screens are not turned on, use the remote control or control switch to turn them on.
• You will see the main page of the SUPA rooms list on the ceiling monitor. Wait here for the incoming call. When the call starts, you'll be automatically taken to the Participants Screen.

Shutting Down

• SUPA lecture calls end at the hour.

• To end a call prematurely press  on the Vidyo remote control.
• If no lecture follows yours, please switch off the screens / projectors by the remote control and the room's light and lock the door. To check whether there is a conference following yours, please refer to the SUPA timetable (online at http://my.supa.ac.uk/course/supa_timetable.php).

Further Training and Support

Further training in the use of the videoconference facilities and assistance during videoconferences is available from Local technical support at each site . Contact details can be found on page 4 of this Handbook. The Getting Started with Video Conferencing My.SUPA page can be found at http://my.supa.ac.uk/course/view.php?id=91.

The Researcher Development Framework

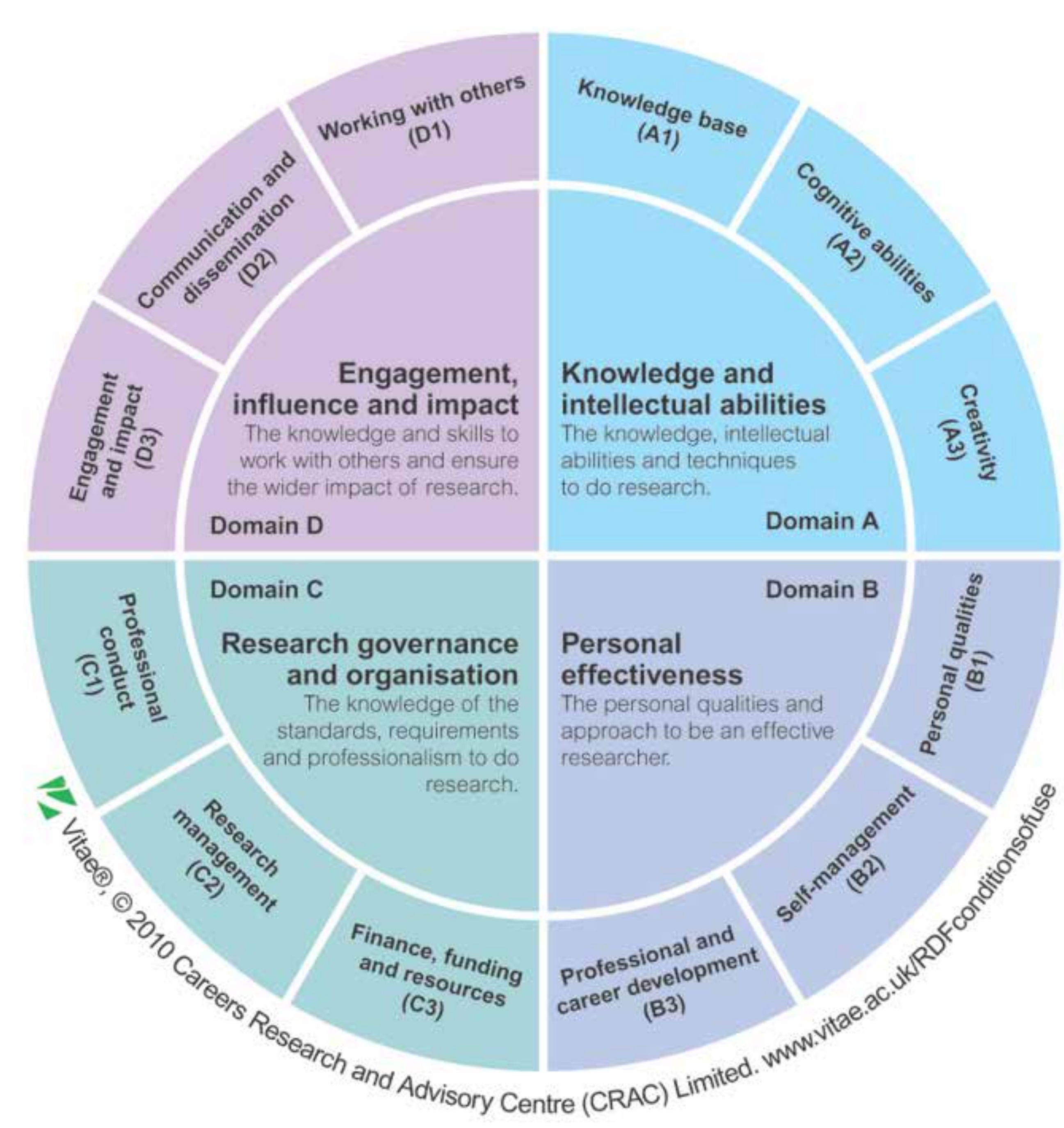
The Researcher Development Framework describes the knowledge, behaviours and attributes of researchers and encourages them to aspire to excellence through achieving higher levels of development. It will be invaluable for planning, promoting and supporting the personal, professional and career development of researchers in higher education.

The Researcher Development Statement

The Researcher Development Statement sets out the knowledge, behaviours and attributes of effective and highly skilled researchers appropriate for a wide range of careers. Further information can be found online at: www.vitae.ac.uk/rdf

RDF Personal Development Planner

The Researcher Development Framework (RDF) has been incorporated into the Professional Development Planner to allow researchers to identify the areas in the framework they want to develop further, create an action plan and record evidence of their progress. For further information, visit: https://www.vitae.ac.uk/researchers-professional-development/about-the-vitae-researcher-development-framework



Notes