SCHOOL OF PHYSICS AND ASTRONOMY
UNDERGRADAUTE PROJECTS ABSTRACTS
3rd year MSci SPA6913 Physics Review Project

This booklet contains a series of abstracts designed to help students pick their supervisor for the Physics Review Project component of the MSci programme.

Once you have read through these abstracts and decided on which 8 supervisors you wish to list in the online form please go to the online selection area make your choices about which supervisor you prefer. If you do not pick 8 different supervisors you will be randomly allocated supervisors to fill the remaining slots (i.e. if you only pick one person we will add in the remaining 7 choices for you!).

Project selections must be submitted by 13h June 2014. You will be notified by email of your supervisor in early July.

When choosing a supervisor you must make sure that their abstracts correlate with your degree programme. Therefore students on the Astrophysics programme must do a project related to Astrophysics. Students on the Theoretical Physics programme must undertake a theory project (although this could be theoretical astrophysics and theoretical condensed matter as well as projects supervised by CRST staff). Students on Physics with Particle Physics must likewise select a project related to their degree programme.

The abstracts in this booklet are listed by research group and then alphabetically by staff member within that group.

CONTENTS

ASTRONOMY UNIT

Craig Agnor

Origin and Evolution of Planetary Systems

With the expanding inventory of extrasolar planets, multiple robotic missions roaming the solar system, and the continued discovery of additional primitive bodies (e.g., near Earth asteroids, planetary satellites, Kuiper Belt objects and comets) planetary astrophysics is the fastest growing area in astronomy. The formation and evolution of planetary systems involves a wide range physical process (e.g., stellar evolution, collisions, tidal interactions, gravitational dynamics, atmospheric evolution, geodynamics, giant collisions, mass accretion, orbital migration, ...etc.). In this project, the student will study a particular planet or satellite system of interest (e.g. the giant planets of the solar system, systems of satellites, Earth's Moon, planetary rings, the asteroid or Kuiper belts, or an extrasolar planetary system) conduct a critical review of the fundamental processes that affect the system and those that best account for its observed properties.

Guilem Anglada-Escude

Searching small exoplanets in publicly available data

Several missions and programs have accumulated many years of high-precision observations. This includes space-based photometry (e.g., Kepler) and ground based spectroscopic measurements (e.g. HARPS spectrograph). Many of these datasets need to be carefully re-analysed to detect small signals that might be missed by automatic search algorithms. When a signal is spotted, several tests muct be applied to verify its statistical significance and likelihood. We will go through the complete process of exo-planet detection on selected targets and fully characterize new planetary systems if found.

Prerequisites : interest in programming and data analysis (some training will be provided).

David Burgess

The outer boundary of the heliosphere

The solar wind is an example of an astrophysical plasma. As the solar wind expands away from the sun it eventually interacts with the local interstellar medium. A number of important boundaries form as the solar wind decelerates including the termination shock and heliopause. This project will investigate what is known from observations by the Voyager and IBEX missions about the outer limits of the heliosphere. The project will require study of some basic plasma physics including particle motion in electromagnetic fields and plasma waves. Some analysis of spacecraft data may be possible. Prerequisites: A high level of understanding of basic electromagnetism, and a good level of mathematical ability especially in vector calculus.

Bernard Carr

Multiverse proposal and cosmological fine-tuning

This project will examine the possible evidence for fine-tuning in the universe, involving both the constants of particle physics and various cosmological parameters. The weight of evidence for these tunings and their possible interpretation will be critically assessed. In particular, the possible relationship to the multiverse proposal, in which our universe is just one of a huge ensemble of universes, will be considered. There are many different multiverse scenarios, so students may choose to focus on some of these in more detail. This project also offers the possibility of a slightly more philosophically-oriented topic.

James Cho

Climate

What was the temperature structures of Earth's Pliocene (about 5.3 to 2.6 M years ago) like? What is its link to the general circulation pattern? what are its implication, if any, for present-day global climate change? In this project, the student will review climate dynamics theory and current ideas about Earth's climate in the recent past. The project will involve performing a critical analysis of several recent papers and developing tests for simple general circulation model simulations.

Richard Donnison

Multiple extrasolar planet systems

Currently 1105 planetary systems have been discovered by various means of detection having 1782 planets. 459 of these systems are multiple planet systems with a variety of planetary masses and separations. In this project particular systems with many planets will be examined and compared, particularly with our own solar system. Possible formation scenarios for the systems will be considered. This is essentially a review but there is obvious scope for originality.

James Lidsey

Inflationary Cosmology

Inflation is the cornerstone of modern, Early Universe cosmology. This project will explain the problems of the standard Big Bang model, the cosmic dynamics of scalar fields that drove inflation, and explain qualitatively how quantum fluctuations generate the initial conditions that led to the generation of anisotropies in the microwave background.

Karim Malik

Inflationary Cosmology

In this project the student will review the "standard model" of modern cosmology, including the period of accelerated expansion in the early universe called inflation.

Late universe project

In this project the student will review some basic general relativity and the "standard model" of modern cosmology. The late time acceleration of the universe and observational evidence for this acceleration will be discussed, with a brief introduction to dark energy and modified gravity.

Carl Murray

The structure of planetary ring systems

The planets Jupiter, Saturn, Uranus and Neptune all possess ring systems of differing sizes and complexity. The aim of the project is to make use of the latest space- and ground-based observations to review current knowledge of the dynamical structure of each planetary ring system as well as the theories that have been proposed to account for them. The student would be expected to summarise the key features of each system, identifying the basic properties and the physical processes involved in determining ring structure at each planet. Any examples of the same processes operating in different ring systems should be identified.

Richard Nelson

Extrasolar planets and planet formation

Since 1995 more than 1000 confirmed planets have been discovered orbiting stars other than the Sun, with many additional discoveries being announced on a weekly basis. In this project you will review the detection methods used to discover these systems, the range of planetary system architectures that have been discovered, and our current understanding of how planetary systems form.

Alexander Polnarev

Primordial Black Holes (PBHs)

PBHs as a unique probe of the Very Early Universe. The range of masses, different mechanisms of PBH's formation, amplification of their fractional density in radiation dominated expansion, Hawking radiation, observational constraints (nucleosynthesis, gamma-ray background and gamma-ray bursts). The hydrodynamics of PBH's formation and the problem of initial conditions. (Prerequisites: Any courses on Cosmology and General Relativity).

Will Sutherland

Surveys for High Redshift Quasars

Quasars are believed to be powered by supermassive black holes. The high-redshift quasars (redshift $z > 6$) are observed when the universe was less than 1 billion years old. They provide us with a probe of the early universe, and important constraints on the early growth of galaxies. Discovering them is a "needle in a haystack" problem, since there are roughly 1 million foreground stars to each high redshift quasar. This project will review the observational methods used, generally based on multi-colour imaging, to discover high redshift quasars.

David Tsiklauri

Magnetic fields in the solar corona

The project involves critical analysis of the literature on importance of magnetic field reconnection in solar coronal heating.

Dissipation of Alfven waves via phase mixing

The project involves critical analysis of the literature on importance of MHD wave dissipation via phase mixing in solar coronal heating.

Sergei Vorontsov

Interference of the acoustic waves, excited by turbulent convection in lower solar atmosphere, brings standing waves, or global modes of solar acoustic oscillations, known as solar p modes, with measurable oscillation frequencies. Millions of solar p-mode frequencies are now available from dedicated measurements, providing a unique source of accurate diagnostic information about the structure and dynamics of the solar interior. In this review project, you are expected to address the basic diagnostic properties of solar p-mode frequencies, observational techniques which allow their measurements, current achievements in the field of solar seismology, and how similar methods are applied in the seismology of distant stars.

CENTRE FOR CONDENSED MATTER AND MATERIALS PHYSICS

Mark Baxendale

Energy scavenging: are thermoelectric generators the answer?
There are many sources of heat that dissipate energy to the environment, for example computers, car exhausts, humans. A thermoelectric generator is a device that employs semiconductor materials to generate electrical energy from a temperature gradient. These all seem to work a high temperature and none at the modest temperatures that are the sources of what we call 'low-grade heat'. Can you answer this question: Why? Can you also tell us about the latest developments in this field?

Physics and renewable energy
Review the physics of any aspect of renewable energy.

John Dennis

DFT for NMR
Nuclear Magnetic Resonance spectroscopy ("NMR") is the most powerful analytical tool in molecular structure determination. However, in the majority of cases it alone is unable to make a unique identification. Quantum chemical calculations that simulate molecular spectra are hence a useful additional aid in interpretation of NMR spectra. This is because strongly help in discriminating between spectra with same nominal form (i.e., two spectra with the same number of lines with the same distribution of peak intensities will have differing groupings of line/intensity combinations, which the simulated spectra may differentiate). However, the ability of the simulations to aid depends on the method used to perform the calculations (some are better than others). Hybrid Density Functional Theory ("DFT") and Hartree Fock ("HF") methods have proved quite reliable; where he 6- 31G**/B3LYP method is particularly successful. There are however, several other methods which may prove more reliable under certain conditions. Indeed it might be better to choose the simulation method depending on the conditions of the measurements.

During the project, the student will review the literature on quantum-chemical simulations of 13C NMR spectra of fullerenes and fullerene derivatives, together with that on experimental spectra of the same molecules. The student will then compare and contrast the experimental data and the analogous simulated data in order to draw meaningful conclusions on which hybrid HF/DFT methods make the better simulations for each of the different types of fullerene and different types of fullerene derivatives.

Martin Dove

Simulation methods to study capture of carbon dioxide using porous crystalline materials

One critically important environmental problem for modern societies is that of controlling the mount of CO_2 we put into the environment. One solution is to capture CO_2 at the industrial sources. Current methods are expensive, and there is a lot of interest in looking for new materials for this task. One approach is to use porous crystalline materials, with a lot of interest in hybrid metal-organic materials that form crystal structures that contain large pores and channels.

The project is to evaluate computer simulation methods currently being used within the scientific community. There has recently been an explosion of publications reporting on a wide range of simulation methodologies. For example, many methods use simple functions to describe the forces between atoms, which are parameterised either using quantum mechanical methods or by fitting to experimental data. One question to ask is how good are these methods, and are some approaches better than others? And also, it would be useful to evaluate the extent to which computer simulation actually makes a valid contribution. Are we better placed to design materials for CO_2 capture based on simulation studies?

The atomic structure of nanoparticles

Nanoparticles are of great importance and interest for a wide variety of applications, from energy to healthcare. But what do we really know about their atomic structure? There are methods that can provide this information (for example, some diffraction and spectroscopy methods). But how good are these, and do they rely too much on what we know about the crystal structure of the bulk material? This project will review recent literature on this problem to better understand the state of knowledge of the atom structure of nanoparticles.

David Dunstan

Algae for biofuels

Most biofuels compete unacceptably for resources against other needs, such as food. Algae can grow in tanks in deserts or at sea and can be used to make, for example, diesel fuel. What determines and controls the efficiency of this renewable resource?

Lighting gemstones

What are the optical properties of materials that make some highly prized as gemstones? Given these optical properties, how should they be lit in a static environment (e.g. a museum display) to optimise their appearance for viewers?

Theo Kreouzis

Organic Photovoltaics

Photovoltaic action allows the direct conversion of light into electrical energy. Traditional photovoltaic devices are based on inorganic systems such as crystalline and amorphous Silicon and III-V highly crystalline semiconductors. Great advances have been made on the use of organic (carbon based) molecular systems to construct working photovoltaic devices. The review will concentrate on the working principles and characterisation techniques of organic semiconductor based photovoltaics and a comparison between these and their traditional inorganic counterparts.

Alston Misquitta

Topics in intermolecular interactions

This is a big field encompassing all of non-chemical molecular interactions. The intermolecular interactions are responsible for much of the interesting phenomena in the physical world: the existence of gases, liquids and some solids, the self-assembly of complex molecular systems. The Casimir effect is a more general case of the van der Waals (or dispersion) interaction. In this review project you will be able to choose from a number of topics in this field.

** General theory of intermolecular interaction

** Charge-transfer : this is a special interaction seen in hydrogen-bonds

** The van der Waals interaction : In particular, exploring the link between perturbation theory expressions for van der Waals and the continuum approach developed by Lifshitz.

Bayesian methods in fitting

When we fit a function to a set of data we usually minimize the error in a least-squares sense. This is all very well and it works, but for multi-dimensional fits this approach has a problem: how can we be sure that we have enough data in all parts of the multi-dimensional space so as to be confident that the fit is reasonable? Here we enter the realm of Bayesian methods that allow us to quantify our confidence in the fitting function itself. Bayesian methods give us a way of quantifying common sense and quantitatively compare models. In this project you will learn the basics of Bayesian methods and review the literature on using these methods to multidimensional fitting problems.

Anthony Phillips

Why are there (still) so few multiferroics?

Background: Ferromagnetism, the behaviour of familiar magnets, has been known since prehistoric times: in fact, magnetic beads have been discovered in Sumerian tombs built six millenia ago. Since then, other "ferroic" behaviours have been discovered. For instance, just as a ferromagnet can "switch" its magnetisation in response to an external magnetic field, a ferroelectric can switch its polarisation in response to an external electric field. Multiferroic materials combine two or more of these properties, and are of great technological interest: for instance, used in computer disks they might enable data to be written electrically but read magnetically. However, despite widespread scientific interest in this field, progress has been relatively slow, partly since so few materials with this property are known.

This project will involve reading recently published papers to review progress in multiferroics, particularly over the last decade. A paper published in 2000 famously asked "Why Are There so Few Magnetic Ferroelectrics?" (J. Phys. Chem. B 2000, 104, 6694-6709). Is it still true that few materials in this category are known, and what are currently the principal obstacles to progress?

Andrei Sapelkin

Future quantum dot systems

Quantum dots – materials reduced in size down to just a few nanometers possess a range of interesting physical properties due to effect of quantum confinement of the charge carriers (electrons and holes) and a large surface-to-volume ratio. These properties can be used in variety of applications including tagging of living cells and observation of communication in neuron networks. This project aims to review the current trends in quantum dot applications in bio-related areas and identify possible future directions and potential materials.

Kostya Trachenko

Glasses as encapsulation matrices of nuclear waste

The need for a solution of the problem of dealing with nuclear waste is more urgent now than ever before. For highly-radioactive materials it is necessary to encapsulate the radioactive ions within an inert matrix material (waste form) which prevents the ions from diffusing out and becoming a health and environmental hazard. The last few decades have seen increased research in this area, with new proposals and ideas, experimental and modelling results discussed and debated. This project will review these results, with the emphasis on research efforts and its results on glass waste forms. Both policy documents from the UK and EU communities and research papers will be reviewed, and both advantages and disadvantages of several classes of glass waste forms will be discussed.

Crystalline ceramics as encapsulation matrices of nuclear waste: effects of radiation damage

The need for a solution of the problem of dealing with nuclear waste is more urgent now than ever before. For highly-radioactive materials it is necessary to encapsulate the radioactive ions within an inert matrix material (waste form) which prevents the ions from diffusing out and becoming a health and environmental hazard. The last few decades have seen increased research into using crystalline ceramic materials as waste forms. The important issue is the potential degradation of the waste form due to radiation damage. The project will review recent results and proposals related to using crystalline ceramics as waste forms. Recent reports by the UK and USA laboratories as well as research papers will be reviewed and discussed, with particular emphasis on the effect of radiation damage on the performance of waste forms.

CENTRE FOR RESEARCH IN STRING THEORY

David Berman

Topology in Physics
This will review some basics of topology and how these ideas are realised in physics.

(Prerequisites: Strong mathematical ability)

Andi Brandhuber

Geometric phases
A geometric phase -- also known as Berry phase -- is the phase acquired when a physical system undergoes a cyclic adiabatic process, and is a consequence of geometrical properties of the parameter space of a physical system. This phenomenon can occur in classical systems e.g. Foucault pendulum and in quantum mechanical systems e.g. Aharonov-Bohm effect. This project will examine various examples of geometric phases in the classical and quantum world. (Requires PhD, QMA, QMB).

Black hole physics
One of the most fascinating objects predicted by Einstein's theory of General Relativity (GR) are black holes and a complete understanding of the quantum physics of black holes remains a challenge for theoretical physics. This project will introduce the student to the basic concepts of black holes, starting with their classical description in terms of solutions of Einstein's equation, moving on to the quantum description and the thermodynamics of black holes. Depending on time the student will study (some of) the following topics:
1) experimental evidence for the existence of black holes
2) Hawking radiation as a quantum mechanical tunnelling effect
3) thermodynamics of black holes in Anti-de-Sitter (AdS) space.
(Prerequisites: PhD, STG, QMA)

Sanjaye Ramgoolam

Plasma Physics and Nuclear fusion

The project consists of working through equations of fluid dynamics and of charged particle motion in electromagnetic fields, which are relevant to plasma physics. In addition the student will be expected to read reviews of developments in nuclear fusion technology over the last few decades, and to use the theoretical calculations to give a clear exposition of these developments. A good understanding of MT3 is a requirement for this project.

Rodolfo Russo

Supersymmetry, a simple example.

The project focuses on the simple case of two dimensional theories and provides the basic concepts of what supersymmetry is by stressing its theoretical foundations. The 2D theory analysed has an interesting application in the construction of superstring theories in the RNS formalism.

Prerequisites: MT3 and Physical Dynamics

A model for the ammonia molecule
The ammonia molecule is an interesting quantum mechanical system with a range of applications (for instance masers, radioastronomy etc.). In this project the student will develop a simple quantum mechanical model describing the ammonia ground state and show that it captures the basic properties of this system. Prerequisites: QMA and MT3

Prerequisites: MT3 and QMB

Steve Thomas

Topological defects in physics

The concept of topological defects is an important one in physics with applications ranging from a description of defects in certain liquid crystals, through to cosmic strings and domain walls in cosmology and more recently to fundamental aspects of superstring theories. This project will introduce the student to the basic ideas by studying simple physical examples ranging from line defects in fluids, crystal defects and some simple field theory defects described by domain wall and vortex solutions. The emphasis will be on the basic physical properties of the defects that arise as a consequence of their topological nature.

Brian Wecht

Exact and Numerical Solutions for Solitons
Solitons are interesting solutions to nonlinear wave equations which can be found in a variety of fields of physics, including optics, condensed matter, theoretical high energy physics, and more. In this project, we'll examine solitonic solutions from both exact (analytical) and approximate (numerical) standpoints, with an eye towards modeling interacting solitons on the computer.

Population Models in Mathematical Biology
Nonlinear systems can be used to model populations in a variety of interesting biological systems. By starting with Lotka-Volterra predator-prey models, this project will aim to describe various cycles of population growth and decline

throughout the animal kingdom. If time allows, the project can also include oscillatory systems in cells and other biological systems

Electrodynamics in Higher Dimensions
Maxwell's equations describe the electrodynamics of point charges in four dimensional spacetime. In higher dimensions, analogs of electric and magnetic fields can be sourced by extended objects like strings or membranes. This project will examine the generalization of Maxwell's equations to arbitrary dimensions. Mathematical topics to be covered along the way include differential forms and higher dimensional geometry.

Donovan Young

What does Einstein's relativity look like?

When we learn about relativity and length contraction we expect that if we saw a spaceship zooming by near the speed of light we would see its length contracted. Although its length really is contracted it wouldn't look that way to your eyes. In this project you will calculate what relativistic effects actually do to the scene captured by the eye. Depending on time the student will also study the lensing of light produced by black holes.

PARTICLE PHYSICS RESEARCH CENTRE

Adrian Bevan

CP violation and the CKM Matrix

In 1972 Kobayashi and Maskawa proposed a 3x3 quark mixing matrix to account for CP violation observed in the decay of neutral kaons. In 2008 having had their model verified by the B Factory experiments (BaBar and Belle), they shared a Nobel Prize in physics. The amount of CP violation that we know about is a billion times too small to explain the matter-anti matter asymmetry in the universe, and the CKM matrix has only been "precisely" tested with s and b quark flavor transitions. The precision of these tests is of the order of 10%, which leaves a lot of scope for physics beyond the standard model to affect what we measure. The s and b quarks are both down type quarks, and a programme of measurements using c quark transitions to test the CKM matrix has recently been outlined. This review will delve into the known aspects of the CKM matrix and explore possible tests to examine the validity of the model further.

PeV energy scale particle physics

The Large Hadron Collider represents the high energy frontier in particle physics with 14Te collision energy expected in 2015 once the current upgrade period has finished. This collision energy will be enough for physicists to search for new physics up to 10^12 eV. Accelerator technology is not expected to significantly push beyond this limit without some radical new breakthrough. Cosmic rays can provide particles with energy up to 10^21 eV, with low rates. What can we do with those to further our understanding of physics, and how will we do it?

Flavour physics at the LHC

The ATLAS detector triggers on di-muon events, and as a result collects data suitable for rare decay_studies. The study of such decays is complementary to the high energy direct detection approach and_relies on understanding subtle interference patterns between different contributions to the final states. There are two ares of interest for this project: The first pertains to B physics: The family of decays including a b quark transition to a strange quark and di-muon pair is being studied by our at ATLAS. Recent results provide some hint that all may not be well with the Standard Model and we are working on trying to understand if this anomaly is statistical in nature or a hint of something new. I am also expanding my interest in rare top decays, which forms the second possible are for project research. This second area is more challenging as it is less well defined and require students opting for this route to take more initiative in order to understand and define the scope of the project. The former route has the option of allowing students to re-analyse 2011 data from ATLAS in the context of recent theoretical developments.

Marcella Bona

Inputs to the Unitarity Triangle fit.
To completely characterise the Standard Model, we need to extract the values of some parameters from various high energy experiments and theoretical calculation. The UTfit project is a global fit analysis that using the Bayesian statistics extracts SM parameters and SM predictions on various observables using the most updated results from experiments and lattice QCD. Some of the inputs need special statistical treatments and analyses that have to be regularly updated.

C++ programming is necessary.
The analysis is performed within the Root package (root.cern.ch) that should be installed on the used computer.

Invariant Mass Fits For The Search Of Rare B Decays Into Two Muons.
The B mesons can decay into two muons and the probability of this decay is very low but accurately calculated within the Standard Model. ATLAS experiment at LHC is searching for these decays and the crucial part of the analysis is calculating the invariant mass of any pair of two muons in the collision events and then perform a fit to the invariant mass distribution taking into account all the signal and background components.

C++ programming is necessary.
The analysis is performed within the Root package (root.cern.ch) that should be installed on the used computer.

Multivariate analysis methods for rare B decays
As the B mesons decay into two muons with a very low probability, it is fundamental to develop methods to distinguish between the actual signal and the random background component that is dominant in the collision data. There are several methods that can be used to exploit the different topologies and event characteristics and obtaining a single variable that can be used to separate between signal and background. Fisher discriminant, Boosted Decision Tree, Neural Network have to be tested and the optimal method selected for the purpose of the search of rare B decays.

C++ programming is necessary.
The analysis is performed within the Root package (root.cern.ch) that should be installed on the used computer.

Jon Hays

After several decades since it was first proposed, the Higgs boson was discovered at the LHC in the Summer of 2012. Summarise the accelerators, detectors, theory and experiment that lead to this discovery.

Teppei Katori

Lorentz and CPT violation

Lorentz symmetry is a fundamental symmetry of both Quantum Field Theory (QFT) and General Relativity (GR). However, ultra high energy theories, such as String Theory, imply a violation of Lorentz symmetry,
and a tiny violation could be observable in our energy scale. Therefore, test of Lorentz violation offers a rare opportunity to test Planck scale physics directly. In the effective field theory, Lorentz violation is realized by additional coordinate-dependent couplings with vacuum, and the QFT including Lorentz violation, so-called the “Standard Model Extension (SME)” is a general formalism to test Lorentz violation.

In this project, we study the structure of Lorentz violation. We start from the QFT, then Dirac equation with Lorentz violation (modified Dirac equation), and finally we derive the formula to describe Lorentz violation for neutrinos. There are world-wide efforts to find Lorentz violation in various fields. We also review and study experimental searches of Lorentz violation in various field.

Neutrino oscillations

Neutrino oscillations are only known particle physical phenomenon beyond the Standard Model (SM). Therefore, the high energy physics community has a strong interest in this and many experiments are running right now, all over the world. Queen Mary is active member of T2K long baseline neutrino oscillation experiment in Japan, one of the leading experiments investigating oscillations. In this project, we study the basis of the particle physics, then we study neutrinos and neutrino oscillations. Finally we review neutrino oscillation experiments all over the world to understand differences
and their purposes.

Neutrino astrophysics

Neutrinos have special roles to understand the stellar evolution and the cosmology. The type of astrophysical neutrinos detected are limited: from the Sun, from supernova, and perhaps from the nearby galaxies (not confirmed yet). Queen Mary is active member of SNO experiment, a solar neutrino detector located in Canada. In this project, we study the basis of the astrophysics. We also study the particle physics, with a special emphasis on neutrinos. Then we study the role of neutrinos in astrophysics and cosmology. We will also review major neutrino experiments trying to detect astrophysical neutrinos.

Eram Rizvi

Global warming and cosmic rays

The IPCC is the United Nations body that assesses the scientific evidence for, and possible causes of climate change. In its 4th Assesment Report they have published a huge body of evidence from many different areas of science, which taken together indicate a globally warming climate caused by human greenhouse gas emissions. In this project the student will review the latest evidence and will have the opportunity to look in detail at issues regarding estimates of the past climate, namely discrepancies in the proxy temperature series, and the evidence for the global or local nature of the Medieval Warm Period, and the Little Ice Age. Recent debate centres on the role of the sun in the Earth's climate. The Danish scientist Henrik Svensmark has claimed a link between solar activity and cosmic rays which seed cloud formation and therefore affects the albedo of the Earth. This is hotly contested and some of the assumptions are being tested by the CLOUD experiment at CERN.

Matthew Machowski (PLEASE CONTACT DR RIZVI WITH ENQUIRIES)

Politics of Physics: The Iranian Bomb

As we sit on the brink of a potential Western/Israeli-led pre-emptive war with Iran over their alleged nuclear weapons programme, this project investigates the impact of nuclear weapons (technology) acquisition on international politics and security. Iran’s nuclear programme has now spanned over three decades, much in defiance of both international demands and legal constraints. Despite much political rhetoric and decades-long accusations against Iran, both the IAEA and all the Western intelligence agencies struggle to provide irrefutable evidence for either the presence or the extent of Iran’s weaponisation.

This project is predominantly aimed at students considering a career in politics, security, risk management and science policy, but also those willing to investigate the correlation between nuclear physics and current affairs. Although you are encouraged to develop you own niche theme, issues surrounding nuclear weapons technology, nuclear deterrence, legal and political anti- and counter-proliferation efforts, nuclear intelligence gathering and analysis, or support for nuclear terrorism may be of particular interest here.

Bio: Matthew is a Middle Eastern security specialist and a former research analyst for the Middle East and North Africa Programme of the Royal United Services Institute for Defence and Security Studies (RUSI). He has so far consulted the UK Parliament and governments of Japan, Poland and Qatar. He has additional experience in journalism and human rights advocacy. He spent over four years living in the Middle East, where among others he worked for one of the region’s royal families. His commentary was featured in international media, including The Times, NHK World News etc.

Jeanne Wilson

Supernova neutrino detection

When a star undergoes a type II supernova explosion, more than 99% of its gravitational binding energy is released as neutrinos. This results in more neutrinos being produced in the span of a few seconds than are released in the rest of the star's life combined. In 1987 a supernova occurred about 50kpc away from earth in the Large Magellanic Cloud, and neutrinos were detected by the KamiokandeII, IMB and Baksan neutrino detectors (11, 8, and

5 events, respectively in ~13s). In this review project, the student will research the different current and future experiments capable of detecting supernova experiments, review the difference interactions they use and asses the relative sensitivities and capabilities in terms of the information that can be derived about both neutrino properties and supernova physics.

Neutrino-less Double Beta Decay Experimental Status

Neutrino-less double beta decay is considered the golden channel for probing the fundamental nature of the neutrino as this rare decay process can only occur if the neutrino is a majorana-type particle. Furthermore, the process proceeds at a rate proportional to the neutrino mass so could help us understand the absolute neutrino mass scale. This project will review the theory and techniques applied to neutrino-less double beta decay searches and summarise the current status and projected sensitivities of the leading experiments in this field.