University of Leicester

Centre for Interdisciplinary Science

PA3015: Project

Project Topics

2013 - 2014

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Contents

01 | Measuring the effect that sebaceous sweat has on overall fingerprint sweat corrosion of brass

Supervisor

Dr John Bond
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Project Description

Fingerprint sweat corrosion of brass is now well documented. However, it is also well documented that different people will corrode brass by different amounts. Some of this variation has been shown to be due to the different composition of sweat (i.e. some is more saline than others). It has also been documented that when the water content is removed from the sweat, the corrosion process stops (as the mobility of the ions is effectively stopped and the current produced by the electrochemical reaction can no longer flow). This project is to assess what effect the sebaceous (oily) component of sweat has on the rate of corrosion and the final visibility. It is hypothesised that the oily components may inhibit the evaporation of water from the sweat which will enable the electrochemical corrosion to carry on for a longer period (in a similar way that a thin film of oil on the surface of a puddle of water slows down the evaporation of the water). The project will be to compare the rate and final corrosion of different people's a) eccrine, b) sebaceous and c) eccrine and sebaceous sweat on brass. Some statistics may be required to analyse and interpret the data. If time permits (and the equipment is available), it would be useful to examine the Cu/Zn ratio of the corrosion over time for a), b) and c) above using EDX.

02 | Measuring the effect that a mixture of eccrine and sebaceous sweat has on the temporal variation of a fingerprint profile (requires AFM)

Supervisor

Dr John Bond
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Project Description

Some years ago, Thomas and Reynoldson (1975) measured the variation in profile of a fingerprint sweat ridge deposit on glass over time. This was achieved with interference microscopy. It is not clear whether Thomas and Reynoldson used eccrine or sebaceous sweat or a mixture of the two. Using a comparison of a) eccrine, b) sebaceous and c) a mixture of the two, this project will measure the temporal variation in fingerprint sweat ridge profile using Atomic Force Microscopy, a more modern technique than that employed by Thomas and Reynoldson. Results will be compared to Thomas and Reynoldson for sweat deposits on glass slides. If time permits, further variation can be added by storing samples in varying humidity, heating etc.

03 | Effect of digital mapping of fingerprints on everyday objects

Supervisor

Dr John Bond
jwb13@le.ac.uk

Project Description

Previous research by an Interdisciplinary Science student (Peel and Bond 2012) has shown how digital mapping can be used to enhance the visibility of fingerprints on metal objects that have been heated. This work was carried out on metal disks. This project will use the methodology of this technique and apply it to everyday items that might be encountered at a crime scene (drinks can, coffee packet etc.) and which have been subject to elevated temperatures. The project will assess how the visibility of the digitally mapped fingerprint is affected by different temperatures.

04 | Investigate use of UV spectrometer to image fingerprint corrosion

Supervisor

Dr John Bond
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Project Description

It is well known that fingerprint corrosion on metals such as brass can be visualised in natural daylight and various theories for this have been postulated that include constructive interference in a thin film (of oxide corrosion) and the fingerprint ridge lines acting as a diffraction grating. To date, this visualisation has been undertaken using radiation in the visible part of the spectrum. This project is to assess the feasibility of visualising fingerprint corrosion on metal using UV radiation and the UV spectrometer in the Physics Department.

05 | Low Cost Environmental Monitoring

Supervisor

Dr Neil Arnold
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Project Description

On June 11th, 2008, the European Union agreed its latest standard on what constituted an acceptable concentration of air pollutants, such as nitrogen dioxide and ozone [1]. Traditional techniques for measuring air quality have focused on high precision using a small number of sophisticated, but expensive, detection systems [2]. Modelling is then used to estimate concentration variability across a region. However, transport and chemical processes ensure that errors can be significant [3]. An alternative approach is to deploy a larger number of low cost sensors that take advantage of off-the-shelf computing and communications technology.

A microprocessor-controlled unit measuring temperatures, humidity, nitrogen dioxide and carbon monoxide has been developed for monitoring indoor air quality, especially in office and industrial settings [4]. It is proposed that we evaluate whether this unit can be modified for outdoor use by replacing the CO sensor with an ozone sensor and placed within a suitably robust housing [5].

The student should ideally have an interest in environmental science and be prepared to learn a little about programming and how electronic equipment works [6].

References

[1] http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm
The website of the European Union outlining its policy on air quality.

[2] http://www.environment-agency.gov.uk/business/regulation/31845.aspx
The government website outlining the technical specifications of the instrumentation that can be used to monitor air pollution.

[3] Melamed M. L. , R. Basaldud, R. Steinbrecher, S. Emeis, L. G. Ruíz-Suárez, and M. Grutter, Detection of pollution transport events southeast of Mexico City using ground-based visible spectroscopy measurements of nitrogen dioxide, Atmos. Chem. Phys., 9, 4827-4840, 2009 doi:10.5194/acp-9-4827-2009.

[4] http://airqualityegg.com/
The site of the air quality network with a description of the aims and methods of the community for measuring pollution.

[5] http://www.sgxsensortech.com/site/wp-content/datasheets/metal_oxide/mics-2610.pdf
A manufacturer's specification sheet for the ozone sensor explaining how the detector works.

[6] http://arduino.cc/
The website of the Arduino micro-controller community with descriptions, tutorials and a forum for discussions of the latest developments.

06 | Calculating the Flux of Extraterrestrial Material onto the Ancient Earth's Surface by Collecting Micrometeorites

Supervisor

Dr John Bridges (Space Research Centre)
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Project Description

Background
The flux of primitive asteroidal, dust and cometary material across the Solar System and onto the Earth's surface has varied since formation of the planet. Knowledge of the ancient flux can potentially help inform models of asteroid breakup and climate change. By separating micrometeorites from slowly deposited ancient sediments of known age and checking their composition on a scanning electron microscope we can calculate an ancient extraterrestrial flux and compare it to the modern one.

Project Goals
(i) To separate the magnetic fraction from previously identified ancient sediments (260-300 Ma). (ii) Learn the operation of a scanning electron microscope and energy dispersive X-ray spectrometer and use them to identify extraterrestrial material. (iii) Calculate the ancient extraterrestrial flux and compare it to the modern one e.g. the Grün Model.

Nature of the Project:
This project is mainly experimental work.

Background reading:

Grün, E. 2001, Interplanetary dust, 1st edn, Springer, Berlin, pp 295.

Taylor, S., Lever, J. & Harvey, R. 1998, "Accretion rate of cosmic spherules measured at the South Pole", Nature, vol. 392, no. 6679, pp. 899-903.

07 | Tracking tropical biomass burning from space

Supervisor

Dr Michael Barkley
mpb14@le.ac.uk

Project Description

Background
The burning of terrestrial tropical vegetation, from wild and agricultural fires, is an extremely important process in the climate system. Biomass burning releases large amounts of aerosols and other trace gases into the atmosphere that can influence atmospheric chemistry and air quality. We can detect fires from space using satellite instruments such as ATSR or MODIS thereby enabling us to track seasonal burning patterns. Two important gases released from biomass burning are formaldehyde (HCHO) and nitrogen dioxide (NO2), both of which are key indicators of air-quality and can be observed from space by the Ozone Monitoring Instrument (OMI). The objective of this project is to examine spatial and temporal correlations between HCHO, NO2 and fires over Africa and the Amazon, to determine the seasonal variations in burning and their influence on tropospheric composition.

Project goals
1. To learn about the importance of biomass burning in climate
2. To investigate seasonal variations in HCHO and NO2 owing to biomass burning

Nature of Project
data analysis, computational

Skills, Courses & Publications
Some knowledge of remote-sensing, IDL programming

Any particular requirements
none

08 | El Niño years: modification of precipitation patterns in the tropical region

Supervisor

Dr Alessandro Battaglia
ab474@le.ac.uk

Project Description

Background
The TRMM Precipitation Radar (PR), the first of its kind in space, is an electronically scanning radar, operating at 13.8 GHz that measures the 3-D rainfall distribution over both land and ocean, and defines the layer depth of precipitating systems (http://trmm.gsfc.nasa.gov/). It has been flying for more than one decade and can provide unique information about precipitation pattern variability. Spatial coverage is between 38 degrees north and 38 degrees south, thus providing extensive coverage in the tropics.

The student will analyse 2A25 product specifically targeting the anomalies in precipitation partner during El Niño years. El Niño/La Niña-Southern Oscillation (ENSO) is a quasi-periodic climate pattern that occurs across the tropical Pacific Ocean roughly every five years. It is characterized by variations in the temperature of the surface of the tropical eastern Pacific Ocean and air surface pressure in the tropical western Pacific. ENSO causes strong modification of the weather and precipitation patterns in many regions of the world and particularly in those bordering the Pacific Ocean. This project will give students an opportunity to directly work with EO datasets, to get acquainted with and to interpret radar echoes and to get a deeper understanding of climate change.

Project Goals
1) To generate precipitation maps and anomalies during El Niño years derived from TRMM-PR
2) To study the vertical structure of precipitating systems.

Nature of Project
data analysis, computational

Skills, Courses & Publications
Some knowledge of remote-sensing, IDL or Matlab programming (useful but not mandatory)

Any particular requirements
none

09 | Tracking precipitation with the 3-mm space-borne CloudSat radar

Supervisor

Dr Alessandro Battaglia
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Project Description

Background
Clouds and precipitation represent an important yet not fully understood component of the Earth water cycle, with crucial effects in the energy balance and with a main role played in a changing climate. The launch of the CloudSat NASA mission has paved the way to the exploitation of millimetre radars in space-borne cloud and precipitation observation. In this project, the 94 GHz CloudSat radar datasets in presence of precipitation will be examined. A statistical analysis (e.g. with Contour Frequency Altitude Displays) will be conducted in order to characterize the vertical structure of precipitating systems in different climatic regions over sea (e.g. North Atlantic, North Sea, West Pacific, East Pacific). This project will give students an opportunity to directly work with EO datasets, to get acquainted with and to interpret radar echoes.

Project goals
1) To generate global precipitation maps derived from CloudSat
2) To study the vertical structure of precipitating systems

Nature of Project
data analysis, computational

Skills, Courses & Publications
Some knowledge of remote-sensing, IDL or Matlab programming (useful but not mandatory)

Any particular requirements
none

10 | Combining infrared galaxy searches: IRAS & WISE

Supervisor

Professor Andrew Blain
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Project Description

Background
Less than a year ago, an infrared survey was made of the whole sky using the WISE satellite. The previous all-sky survey was made 25 years ago by the IRAS satellite (and a deeper, but still relatively shallow one about a decade ago by the Japanese Akari satellite).

Project goals
The project will involve understanding the populations of galaxies found in the IRAS survey, and firming up the properties of identified subsets of these objects using the WISE data.

Skills, Courses & Publications
IDL programming (or other suitable programming language).

Nature of Project
data analysis, computation

Any particular requirements
None

11 | Red quasars with WISE, and the 2dF and SLOAN redshift surveys

Supervisor

Professor Andrew Blain
ab520@le.ac.uk

Project Description

Background
Surveys taking optical spectra have acquired samples of thousands of active galaxies, many of which recently have infrared data available from the WISE satellite.

Project goals
The project will start with an investigation of the catalogues from the optical surveys, and the fraction of these galaxies that are likely to be rendered tough to detect based on these central objects being reduced in intensity by absorption in dust in the host galaxies. A comparison with the infrared properties found by WISE will be used to test these ideas.

Skills, Courses & Publications
IDL programming (or other suitable programming language).

Nature of Project
data analysis, computation

Any particular requirements
None

12 | Investigating the link between Fluorescence and Formaldehyde formation

Supervisor

Dr Hartmut Boesch
hb100@le.ac.uk

Project Description

Background
Formaldehyde (CH_2O) is an important atmospheric trace gas found throughout the troposphere, produced from the oxidation of volatile organic compounds. Enhancements CH_2O enhancements often occur near localised VOC sources with isoprene being the dominant biogenic VOC emitted from terrestrial vegetation.

Isoprene emissions are difficult to model and the factors controlling isoprene emissions include a number of biological, physical and chemical variables.

One uncertain parameter is the photosynthetic photon flux density that interacts with leaves which is usually calculated with models. The absorbed photosynthetically-active radiation can also be determined from new space-based observations of signals from plant fluorescence.

In this project, we will analyse a 5 year dataset of Formaldehyde from the GOME-2 satellite and investigate correlations with fluorescence signals for several key regions of intensive VOC emissions considering also additional parameter such as soil moisture or air temperature.

Project goals
Investigate correlations between space-based observations of Formaldehyde with newly available fluorescence data.

Nature of Project
data analysis, computational

Skills, Courses & Publications
Knowledge of remote-sensing and IDL programming (or other suitable programming language)

Any particular requirements
none

13 | Evolution of volcanic sulphur plumes

Supervisor

Dr Hartmut Boesch
hb100@le.ac.uk

Project Description

Background
Volcanic eruptions generate a large amount of sulphur that will enter the atmosphere together with ash particles and other gases. The sulphur dioxide that enters the atmosphere have a large impact on impact on atmospheric chemistry and it leads to particle formation and thus impacts the radiation budget and hence on the climate. Furthermore, the acidic pollution can be transported by wind over many hundreds of kilometres, and is deposited as acid rain.

There are now a number of satellites that measure SO_2 (sulphur dioxide) either using UV/visible or infrared light and the data is available operationally to monitor volcanic plumes globally. These dataset allow monitoring and tracking of such volcanic SO_2 plumes and to gain insights into the dispersion and transport pathways and the lifetime of these plumes.

In this project, we will investigate the Sarychev eruption in June 2009. We will use observations from the IASI and GOME-2 sensors in the IR and UV, respectively, to develop a picture of the evolution of the SO_2 plume and we will use air mass trajectories to compare the observed evolution to the prevailing winds.

Project Goals
Develop a time series of the SO_2 plumes using IR and UV satellite sensors and analyse the evolution of the plume. Interpret the plume evolutions using air mass trajectories

Nature of Project
data analysis, computational

Skills, Courses & Publications
Knowledge of remote-sensing and IDL programming (or other suitable programming language)

Any particular requirements
none

14 | Field-aligned currents in Saturn's magnetosphere

Supervisor

Professor Emma Bunce
ejb10@ion.le.ac.uk

Project Description

Background
Large-scale electric currents flow between the ionosphere and magnetosphere in Saturn's environment, producing easily-recognisable signatures in magnetic field data acquired by the Cassini spacecraft. In this project the properties of these currents will be investigated via their magnetic signatures and comparison made with the boundary between open and closed magnetic field lines from particle data, in particular how these vary at a particular position as the planet (and magnetosphere) spins.

Project goals
The main goal of the project is to study the basic properties and variations of the field-aligned currents and open-closed field line boundary as a function of hemisphere, local time, "magnetosphere oscillation phase" (related to the unknown planetary period!).

Skills, Courses & Publications
Courses: Space plasmas. Relevant research papers will be provided.

Nature of Project
data analysis, computation

Any particular requirements
The project centres on data analysis using IDL, and is suitable for those with starting skills in this area, or those wishing to develop such skills

15 | Fluorescence spectroscopy and electron mobility measurements in dense gases

Supervisor

Dr Klaus von Haeften
kvh6@ion.le.ac.uk

Project Description

Background
In this project pressurised gases will be electronically excited using a corona discharge. The spectrally dispersed fluorescence will be measured and the mobility of the electrons emitted during this process will be derived through the measured current-voltage dependency. Impurity gases and nanoparticles will be added.

Project goals
The main target of this project is to measure transport properties and energy localisation of nanoscale systems. This project runs with relatively little experimental effort but requires nevertheless enthusiasm and good time-management. Interested students are invited to meet with the supervisor of this project, Dr Klaus von Haeften, to discuss further project details before making their choice.

Skills, Courses & Publications
Courses: no specific courses required; relevant papers or books: to be discussed.

Nature of Project
experimental

Any particular requirements
None

16 | Complex Systems – Agent-Based Modelling with NetLogo

Supervisor

Professor Derek Raine
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Project Description

NetLogo is a computer programme (and programming language) that is used to model interacting 'agents', that is objects that can receive and process information and act on it independently. An interesting application in physics is to magnetic systems (the agents are the spins on a lattice), but these methods have been extended to other sciences (including social sciences). The project will investigate the use of NetLogo in the context of various complex systems, depending on the interests of the students.

Examples

- 'SugarScape' – Investigating artificial societies
- Magnetic systems
- Evolution of Altruism in artificial societies
- Technological innovation and wealth distribution in artificial societies

17 | Land surface temperature changes and climate

Supervisor

Professor John Remedios
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Project Description

Background
The temperature of the land surface is a fundamental parameter which is important in both climate and weather, and clearly of relevance to humans. Changes in land surface temperature (LST) over years inform us of the overall impact of changes in the climate cycle whilst the spatial pattern of land surface temperature is controlled by local environmental factors. In both cases the change in temperature is determined by the laws of physics, and is also best observed by physics-based techniques.

The latest infra-red instruments offer a big advance in land surface temperature measurements because of their improved calibration, their increasing ability to remove cloud-affected data, and an improving understanding of the physical state of the land surface. Data from the Advanced Along Track Scanning Radiometer or AATSR should be particularly useful in this regard but have only just been produced to cover a large range of years.

In this project, the students will have the opportunity to be amongst the first scientists to explore such data sets and characterize long-term behaviour. The students will select key regions for investigating time series of land surface temperature, comparing and contrasting results as a function of time and physical state (e.g. amount of vegetation). Results will be compared against expectations of global climate and regional changes in temperature.

The results of this project will provide an excellent opportunity for the student to learn about practical applications of Physics to fundamental climate problems, and to contribute to major new developments in remote sensing of temperature.
http://www.leos.le.ac.uk/aatsr/

Project goals
To use land surface temperature data from AATSR to examine changes over time in selected regions
To investigate the selected time series of land surface temperature data to understand the significance of the results and assess uncertainties.

Skills, Courses & Publications
Course 3653 is useful but not mandatory. Knowledge of IDL is very useful but not mandatory.

Nature of Project
computational, data analysis

Any particular requirements
None

18 | Jupiter's nightside aurora

Supervisor

Dr Tom Stallard
tss8@le.ac.uk

Project Description

Background
Observations of Jupiter's upper atmosphere have always be made from the Earth looking outwards, resulting in a good understanding of the planetary aurora on the side facing the sun. Relatively little is known about what happens to the aurora when it turns away onto the night-side of the planet. Using unique data from the NASA-Cassini mission, you will investigate this night-side infrared aurora for the first time.

Project goals
Analyse Cassini-VIMS instrument data of the aurora of Jupiter, in particular to look for mid-to-low latitude emission - this is controversial emission seen on the dayside, but disputed. If it were seen on the night side, this would be proof of its auroral origin for the first time.

Skills, Courses & Publications
Suitable for those with good computing skills or those wishing to improve such skills. Relevant courses include: plasma physics, solar-terrestrial relations, ionospheric physics. Stallard et al., Complex structure within Saturn's infrared aurora. Nature, Volume 456, Issue 7219, pp. 214-217 (2008); Stallard et al., On the Dynamics of the Jovian Ionosphere and Thermosphere. II. The Measurement of H3+ Vibrational Temperature, Column Density, and Total Emission. Icarus, Volume 156, Issue 2, pp. 498-514 (2002)

Nature of Project
Data analysis, literature review

Any particular requirements
None

19 | Comparing Jupiter's infrared and ultraviolet auroral images

Supervisor

Dr Tom Stallard
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Project Description

Background
Images of ultraviolet aurora on Jupiter have allowed us a great deal of understanding about the conditions in the planets surrounding space environment. However, far less is known about the infrared aurora - in particular how the infrared aurora differs from the ultraviolet. We now, for the first time, have images of both the infrared and ultraviolet aurorae taken simultaneously. In comparing these, we can gain significant insight into the processes that control both.

Project goals
Using observations of H3+ ion from NASA's InfraRed Telescope Facility and images from the Hubble Space Telescope, this project will directly compare the two aurora. As these two sources of data differ, the data will need to be converted so that a direct comparison can be made, including some modelling of the effects of differing conditions in the atmosphere at Jupiter and the effects of the Earth's atmosphere (since Hubble lies in orbit, while infrared observations are taken from the ground). Once this is done, direct comparisons between the two data can be made.

Skills, Courses & Publications
The project centres on data analysis (principally using IDL) and interpretation, and is suitable for those with good computing skills or those wishing to improve such skills. The project will use computing equipment and software provided by the Radio & Space Plasma Physics Group. Relevant courses include: plasma physics, solar- terrestrial relations, ionospheric physics.

Nature of Project
data analysis, literature review

Any particular requirements
none

20 | Probing Jupiter's ionosphere: Altitude profile

Supervisor

Dr Tom Stallard
tss8@le.ac.uk

Project Description

Background
While our understanding of the upper atmospheres of the Gas Giants has greatly improved over the past decade, one significant gap remains largely unanswered: how does the upper atmosphere change with altitude? This is a difficult question to answer, since, in the past, ground-based telescopes do not have the resolution to observe the atmosphere itself and so we have had to rely on previous observations from spacecraft. However, such observations are also notoriously difficult. This difficult impasse has recently been dramatically reversed following an observation, made by the VLT in Chile, that took spectral observations of Jupiter's upper atmosphere using Adaptive Optics, the first time such observations have ever been made. This project will investigate this new data for the first time, looking at two spectra that examine the light near and above Jupiter's limb, one in the equatorial region and one within the aurora.

Project goals
The main aims of this project are to produce an altitude measurement for emission from the H^{3+} molecule, a principle component in the upper atmosphere of Jupiter. This will allow us to compare and contrast the physical conditions within the auroral and equatorial regions for the first time.

Skills, Courses & Publications
The project centres on data analysis (principally using IDL) and interpretation, and is suitable for those with good computing skills or those wishing to improve such skills. The project will use computing equipment and software provided by the Radio & Space Plasma Physics Group. References: Jystrup et al., The Astrophysical Journal 677, 790-797, (2008)

Nature of Project
data analysis, literature review

Any particular requirements
none

21 | The gamma-ray burst population as seen by different satellite missions

Supervisor

Dr Rhaana Starling
rlcs1@le.ac.uk

Project Description

Background
A number of gamma-ray-burst-detecting satellites are in operation, each with its own unique set of detection parameters including energy range, count rate thresholds and sky coverage. This project will compare and contrast the gamma-ray burst samples detected by each mission, to determine whether these are drawn from the same parent population or rather comprise different classes of gamma-ray burst.

Project goals
To analyse current observational data, gain an understanding of the transient detection techniques employed by different missions, collate additional information from the literature and compare a number of samples.

Skills, Courses & Publications
Data analysis, literature search, basic computational analysis
Scientific Inference 1 (PA2250)

Nature of Project
Analysis and interpretation of satellite data

Any particular requirements
none

22 | The Variability Spectrum of the Climate on Geological Timescales

Supervisor

Dr Simon Vaughan
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Project description

Background
Data extracted from various sources - including cores of sedimentary material obtained from the ocean floor, ice cores obtained from Greenland and Antarctica, and stalactites - reveal information about the climate of the distant past. Different records provide different climate proxies, and cover different time spans. By piecing several of these together we may be able to obtain detailed quantitative information about how the most basic climate parameters (e.g. average ocean temperature) vary on different timescales.

Project goals
The primary goal is to obtain several (reliable) paleoclimate records from public databases, apply time series analysis tools to estimate a power spectrum for each, and combine these to produce a power spectrum covering timescales ranging from thousands to millions of years. (A power spectrum quantifies the amplitude of variability as a function of frequency of variability.) This will reveal on which timescales the climate shows strongest variations and provide some clues about physical processes that might operate of different timescales.

Skills required: This project is mainly computational (using IDL and/or R) and is suitable for students who already have or wish to develop a reasonable grasp of computational data analysis.

Nature of project:
computational, data analysis

Relevant Papers
- "Brief introduction the history of climate" by R. Muller available at: http://muller.lbl.gov/pages/iceagebook/history_of_climate.html
- Winograd et al. 1992, Science, v258, p255 "Continuous 500,000-Year Climate Record from Vein Calcite in Devils Hole, Nevada"
- "Paleoclimatology: reconstructing climates of the Quaternary" by R. S. Bradley (1999)
- Zachos et al. 2001, Science, v292, p686 "Trends, Rhythms, and Aberrations in Global Climate 65 Ma to Present"

Any particular requirements
none

23 | Exploring the cosmic X-ray source population

Supervisor

Professor Mike Watson
mgw@star.le.ac.uk

Project Description

Background
Studies of the sky at X-ray wavelengths over the last 40 years have allowed us to determine what kind of astrophysical objects dominate the population of X-ray sources detected. The main components of the Galactic X-ray source population turn out to be the active stars, black holes neutron stars or white dwarfs in interacting (accreting) binary systems and supernova remnants. In contrast the extragalactic source population is dominated by active galactic nuclei and clusters of galaxies.

This project will explore specific parts of the X-ray source population by focusing on a sample of objects drawn from the recently completed "2XMM" catalogue of X-ray sources, the largest such catalogue ever compiled, using simple selections on the catalogue to extract objects with specific X-ray properties (e.g. X-ray spectral parameters) or cross-matching with other astronomical catalogues to select objects of particular types etc. Several different projects can be pursued this way, for example:

- samples of objects with very "soft" X-ray spectra
- samples of objects with unusual infra-red or radio properties

Once assembled, further analysis of these samples will be carried out to investigate which different types of astrophysical object are selected and the correlations between object properties at X-ray and other wavelengths.

Project goals
Project will provide experience of research-style investigation and in particular:
- handling of astronomical survey data and online databases
- astronomical data analysis techniques
- developing techniques for fitting and simulating data
- how to deal with measurement errors and other measurement issues
- some astrophysics relating to various types of X-ray sources
  and the fundamental mechanisms that power these objects

Skills, Courses & Publications
Project requires some programming in IDL (preferred) or alternatively in C, Fortran or Java.

Nature of Project
computational, data analysis

Any particular requirements
none

24 | The Inter Galactic Medium - is there anything out there?

Supervisor

Professor Richard Willingale
rw@star.le.ac.uk

Project Description

Background
Very little is known about the space between galaxies. Is it empty or is there some Inter Galactic Medium? Observations of the X-ray afterglows of Gamma Ray Bursts may give us a clue as to what may be lurking in the IGM. We now have swift data for a large number of GRBs with redshifts which we can use to address this problem in a new way. This project aims to do just that. It involves understanding how X-rays interact with matter, how we calculate the absorption of X-rays which are coming from very distant objects in the Universe and how we apply these ideas in data analysis.

Project goals
This project aims to do just that. It involves understanding how X-rays interact with matter, how we calculate the absorption of X-rays which are coming from very distant objects in the Universe and how we apply these ideas in data analysis.

Skills, Courses & Publications
Computer modelling, data analysis, programming using R, IDL or C

Nature of Project
X-ray physics, cosmology and data manipulation

Any particular requirements
none

25 | Investigating waves in the upper atmosphere using shortwave broadcasts

Supervisor

Dr Darren Wright
Dmw7@ion.le.ac.uk

Project Description

Background
The project requires testing/calibrating a PCB representing the detector stage of a sensitive shortwave receiver. Once that is done this will be connected to a receiver and data recorded from broadcast stations which will act to monitor waves in the ionosphere. The waves could be atmospheric or magnetospheric in origin. The data will be logged and a signal/time series analysis will be carried out.

Project goals
To be discussed with supervisor

Skills, Courses & Publications
Experimental skills.

Nature of Project
experimental, computational

Any particular requirements
Can be run with more than one pair of students (discuss directly with supervisor)

26 | River Restoration

Supervisor

Professor David Harper
dmh@le.ac.uk

Project Description

Over 95% of the rivers in lowland Britain have been modified by humans for drainage, flood prevention or agricultural improvement. In the words of modern ecology, their 'ecosystem services' to the wider community have been sacrificed for limited benefits to a few sectors of the community.

Things are now changing thanks in no small part to the EU, which 10 years ago enacted the Water Framework Directive. This requires that the watercourse of all Member states must be in "Good Ecological Status" by 2027, with an interim appraisal by 2015.

Considerable work, up and down the country is being funded by the UK Government to try to restore rivers back to a semblance of their original ecological state, because it is recognised that about 80% currently fail to achieve GES.

The university, in partnership with the Welland Rivers Trust, has received support for a project to restore about 2km of urban river Welland running through Market Harborough. Opportunities exist for dissertations to be carried out on the ecological, hydrological, geomorphological or social aspects of this restoration, which is in its early stages of design and presentation to the community of Harborough and their District Council.

Interested students are invited to discuss potential projects with David Harper, email dmh@le.ac.uk

27 | Sustainable Tropical Ecosystems

Supervisor

Professor David Harper
dmh@le.ac.uk

Project Description

Students who have taken the 2nd/3rd year field course *Sustainable Livelihoods in Kenya* camped beside an alkaline-saline lake characterised by hundreds of thousands of flamingos. Although that course worked among the village communities around the lake and not the ecology of the lake itself, saline lakes are fascinating ecosystems with an instability that is not really understood.

Flamingos depend upon about a dozen lakes up and down the Rift Valley, whose instability makes the continued existence of lesser flamingos in particular, precarious, made worse by human activities which threaten the integrity of entire lakes. Several projects can be developed about the ecology of one or more of these lakes, depending up the individual student's interest, which would be based upon the analysis in Leicester of data from a short period of fieldwork (it is not necessary to have done the *Sustainable Livelihoods* field course, although students that have will be familiar with the environment).

Interested students are invited to discuss potential projects with David Harper, email dmh@le.ac.uk

28 | The molecular basis for photoperiodic seasonal timing

Supervisor

Dr E Tauber, Room 131, Adrian (Genetics)
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Project Description

Background
We are trying to understand the molecular basis for day-length measurement (photoperiodism), which is a mechanism used by many organisms for seasonal timing. The parasitic wasp *Nasonia* is a powerful emerging model that shows a strong photoperiodic response; the response is maternally transmitted to the progeny. The molecular basis for this response is yet unknown. You will be testing the expression of various genes and their effect on the photoperiodic response. The recently developed method to knockdown genes by double-strand RNA (dsRNAi) will also be used.

Methodology
Lab-based methodologies, including behavioural analysis, carrying wasp crosses. Molecular biology methods including DNA extraction, PCR and gel electrophoresis. dsRNAi injection. Statistical analysis of results.

Useful Links and Papers
Werren, JH and Loehlin DW, (2009). The Parasitoid Wasp Nasonia: An Emerging Model System With Haploid Male Genetics. Cold Spring Harb Protoc. doi:10.1101/pdb.emo134.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2916733/

29 | Effective Science Communication

Supervisor

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Project Description

Background

In recent years there has been a significant trend to move from Public Understanding of Science to Public Engagement with Science. Government, Research Councils and the science community as a whole recognise the need to engage the general public with science rather than just telling them about it. Science Communication and Public Engagement are high on the agenda of many Research Councils and are therefore becoming increasingly important into today's competitive funding market. Science Communication should not just be fun; it should also be effective to serve a purpose!

Project Aims

GENIE, the Centre for Excellence in Teaching and Learning (CETL) in Genetics at the University of Leicester (www.le.ac.uk/genie), has a well-established and varied outreach programme. This project will look for development and evaluation of outreach activities for school and colleges and the general public. Working closely with GENIE staff the student undertaking this project will explore a range of Science Communication methods and their effectiveness in reaching target audiences.

30 | Latent fingerprint enhancement on copper-based materials

Supervisor

Professor Rob Hillman
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Project Description

Electroless deposition of silver has been shown to reveal latent fingerprints on copper-containing metals, from elemental copper to alloys such as brass and bronze. Simplistically, the process works via a redox reaction in which Ag(I) oxidizes Cu(0): the copper goes into solution as Cu(I) and silver deposits on the surface as Ag(0). For small objects, dipping the item in a suitable solution is a simple means of accomplishing this. Such an approach would work well in, for example, processing evidence from a shooting in which brass bullet casings were recovered. However, in the much more common situation of metal theft, where substantial amounts of large and/or irregularly shaped objects are involved, this approach is impractical and uneconomic. To solve this, an alternative means of delivery of the reagent is required. In principle, spraying the silver-containing solution onto the objects would be simple, amenable to any size/shape of object, good at placing reagent comprehensively over the surface and economical in terms of use of reagent. The challenge is that the optimum formulations for this process are highly viscous ionic liquids that are not readily sprayed. The project would involve inception and testing of reagent formulations that permitted efficient spraying and retained the excellent forensic efficacy of the process.

31 | Investigate the effectiveness of different types of swab at recovering DNA from the crime scene

Supervisor

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Project Description

DNA is routinely recovered from objects by swabbing. However, where there is no visible stain (such as for contact DNA) results are variable and different types of swab have been produced to improve recovery rates. Working in conjunction with the Department of Genetics and Leicestershire Constabulary, this project is to test the effectiveness of various swab types at recovering DNA from different substrates. This project is not only multi-disciplinary (Chemistry & Genetics) but also would enable the student to spend time in the Crime Lab at Leicestershire Constabulary.

32 | Culturing trypanosomes in *Drosophila*

Supervisor

Dr Eamonn Mallon
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Project Description

Trypanosomes vectored by insects cause some of the most important diseases in tropical climes. The long term aim of this project is to establish a natural fruit fly/trypanosome model both to study transmission and specificity of the insect immune system. This undergraduate project is a first step. It will optimise in vitro culturing of *Drosophila* trypanosomes. Techniques used will include microscopy and culturing, with potentially PCR for interested students.

33 | Engineering cell signalling proteins

Supervisor

Professor Nick Brindle
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Project Description

Signal transduction pathways play essential roles in regulating cell function, and defects in signalling underly a wide range of diseases. This project will contribute to studies using protein engineering and structural approaches to better understand molecular mechanisms of cell signalling and to create new molecules with therapeutic and other applications. The project will use a variety of techniques including manipulation of cDNA, protein expression, protein interaction analysis and cellular studies.

34 | Novel genic transposon insertions and human transcriptomic diversity

Supervisor

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Project Description

Background

Human specific transposable element (TE) insertions are often dimorphic in human populations. Recently bioinformatic mining of sanger sequencing trace archives and high throughput genome sequencing (HTS) datasets has revealed a cohort of previously uncharacterised, polymorphic TE insertions within many human genes. A recent analysis of HTS transcriptomic data has revealed transcriptional termination as a common feature of genic TE insertions. This project will initially focus on in silico analysis of such insertions to identify a subset in genes known to cause human disease when mutated. PCR based genotyping assays will be developed to validate the existence of these polymorphisms. Candidate insertions, predicted to have significant transcriptional termination properties, will be genotyped in a population panel to determine their allele frequency and distribution.

Methodology

Bioinformatic analysis of trace archive sequences, Programmatic analysis of TE polymorphisms in human genes. Data mining of publically available datasets. PCR primer design, PCR optimisation, PCR genotyping by agarose gel electrophoresis. Analysis of population genotyping data.

Useful Links and Papers

- Cell type-specific termination of transcription by transposable element sequences. Conley AB, Jordan IK. Mob DNA. 2012 Sep 30;3(1):15. [Epub ahead of print] PMID:23020800
- LINE dancing in the human genome: transposable elements and disease. Belancio VP, Deininger PL, Roy-Engel AM. Genome Med. 2009 Oct 27;1(10):97.PMID: 19863772 LINE-1 retrotransposition activity in human genomes.Beck CR, Collier P, Macfarlane C, Malig M, Kidd JM, Eichler EE, Badge RM, Moran JV. Cell. 2010 Jun 25;141(7):1159-70.PMID: 20602998
- Gene-breaking: a new paradigm for human retrotransposon-mediated gene evolution. Wheelan SJ, Aizawa Y, Han JS, Boeke JD. Genome Res. 2005 Aug;15(8):1073-8. Epub 2005 Jul 15.PMID: 16024818

35 | Educational Research: Concept Tests in a Natural Sciences Programme

Supervisor

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Project Description

Background

The use of standardised concept tests is an increasingly popular way of determining student learning gains. A number of these concepts test exist for Physics and Chemistry that have been validated, most commonly at US institutions. They differ from examination type tests in attempting to explore the depth of conceptual understanding, rather than taught material per se, and are often used, by delivering the same tests pre- and post- teaching, to evaluate the effect of specific learning and teaching interventions.

Method

The project will look at concept testing in the context of a Natural Sciences (Interdisciplinary Science) programme using examples from existing concept inventories. The project will involve acquiring ethical clearance, administration of the test and data analysis using standard statistical packages. (These will be part of the project for students without the necessary background). The project will provide an introduction to educational research.

References

- D. Hestenes, M. Wells and G. Swackhamer: *Force Concept Inventor,* The Physics Teacher, 30, 141-158 (1992).
- Conceptual Understanding in Physics web site http://www.physics.le.ac.uk/physicsconcepts/index.shtml

36 | Preparation of Multimedia Learning Resources

Supervisor

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Project Description

In many cases students struggle to do problems, not knowing where to start, yet when they are shown the solution they think that it was relatively easy. In face to face workshops students can ask questions and staff can give hints on how to proceed at a particular stage however this requires a timetabled activity. It would be advantageous if this type of help were available "on student demand" rather than on "staff availability". This project will involve the development and evaluation of short, structured multimedia resources designed to illustrate the process of solving chemistry problems to be used as online tutorials and revision aids.

Students participating in this project will be asked to research part of the level 1 or 2 curriculum. Students will then develop a series of short, focused video tutorials that will demonstrate how to solve problems of this type. Students will learn about theories of learning styles and will assess the impact of the new resources using approaches adopted by educational researchers.

Project Aims

By the end of this project students will be able to:

- Demonstrate their understanding of theories of the learning and teaching process
- Demonstrate an ability to research selected concepts from the level 1 and 2 curriculum.
- Plan and record a series of short video tutorials based on material from the level 1 and 2 curriculum
- Evaluate the impact of resources developed as part of a project through analysis of appropriately selected data.
- Communicate project findings in both written and oral forms