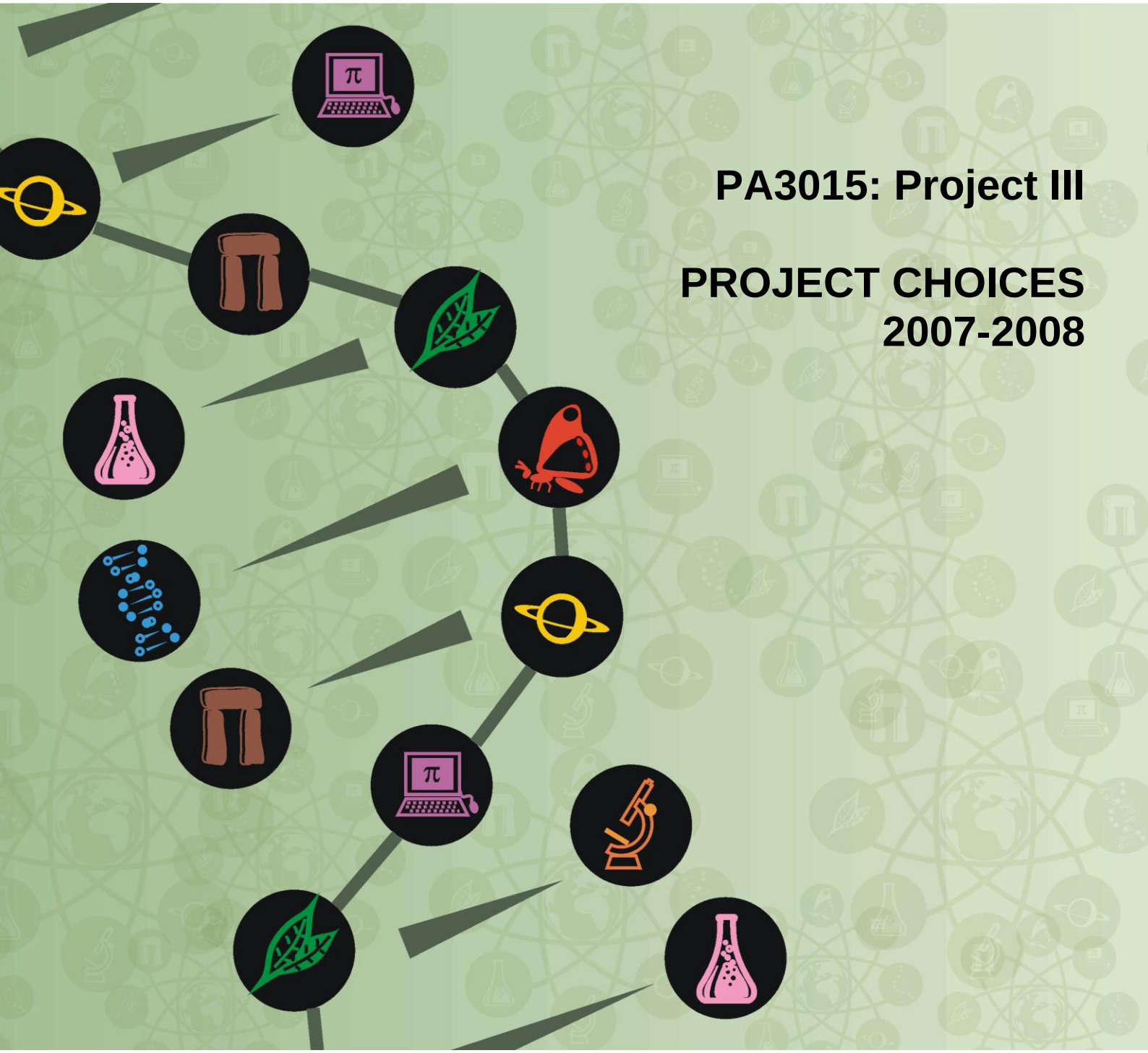
INTERDISCIPLINARY SCIENCE



PA3015: Project III

PROJECT CHOICES 2007-2008

University of Leicester

Contents

Heliacal rise events in historical naked-eye astronomy

Supervisor: Dr S. L. Symons

Introduction

The first sighting of a star after its yearly period of invisibility is called the 'heliacal rising'. The star appears on the eastern horizon briefly before sunrise. Many factors influence whether or not the star is visible, including atmospheric effects, human factors, and attributes of the star. This project will investigate the factors affecting heliacal rise visibility. The project involves three particular areas:

1) atmospheric modelling (including a computing component)
2) positional astronomy and observational factors
3) historical significance (for example in ancient and classical civilisations)

The balance between these elements can be adjusted to suit the interests and skills of the project student.

Project Aims

To understand the issues (general and localised) surrounding near-horizon observation

- To quantify the effects the structure of the atmosphere has on position and visibility of a star
- To discuss the cultural and historical significance of heliacal rise
- To develop a model to predict heliacal rise date

Modelling Autocatalytic Networks

Supervisor: Dr D J Raine

Introduction

Metabolism in biological cells requires a complex system of catalysts (enzymes) which have to be produced in the cell itself. Such a network of reactions is known as an auto-catalytic set. The order implied in this network structure can be represented in terms of the entropy of the network. This entropy therefore characterises a 'thermodynamics' of the living cell. This project will set up and compute the properties of the entropy function.

Project Aims

- To understand the evolution of autocatalytic networks
- To represent network structure in terms of an entropy
- To investigate the relation between an entropy function and thermodynamic properties.
- To look for evidence of a change of phase as a network becomes autocatalytic.

Ecology of Bird Species

Supervisor: Dr David Harper

Introduction

For almost 20 years, data have been collected on bird abundance at Rutland Water, both waterbirds and also songbirds from mist-net samples. The project would analyse selected species records from this data set, look for temporal variation, and interpret the results in terms of meteorological and other external factors both her and at the species' wintering (if summer migrant) or breeding (if winter migrant) locations and in the context of what is known about the species' ecology.

Measuring and modelling photosynthesis and its distribution in the canopy

Supervisor: Dr Jörg Kaduk

Introduction
This projects aims at identifying the patterns of photosynthetic capacity and their dependence on environmental conditions and relationships to nutrient status. For example it is well known that sun leaves have a higher photosynthetic capacity than shade leaves. However, it is not clear how exactly the photosynthetic capacity changes within the canopy for closed and open canopies as well as with orientation to the sun. The project should comprise measuring light saturated photosynthesis and incident light levels in the field in different canopy locations and for different canopy geometries. Leaf nitrogen concentrations should be determined in the lab. The analysis should determine relationships between measured light levels, N concentration, light saturated photosynthesis and leaf position in the canopy.

For safety reasons this project should be conducted together with project 2 with which it also shares the main equipment. The idea would be to obtain the field measurements for both projects in a team of two students.

Project Aims
- use of the IRGA
- ability to develop small models in matlab or maple
- using basic statistics
- field work

Measuring and modelling soil respiration and its spatial and temporal distribution

Supervisor: Dr Jörg Kaduk

Introduction
This projects aims at identifying the patterns of soil respiration (soil CO_2 efflux) and its dependence on environmental conditions and relationships to soil carbon content and fine root biomass. It is well known that soil respiration responds to temperature in an exponential fashion. However, less is known about its spatial distribution and its response to soil moisture. The project should comprise measuring soil moisture at a large number of locations as well as soil temperature and moisture. In the lab fine root biomass and soil carbon content should be determined for a representative number of soil cores. Optionally the soil and root nitrogen concentrations can be determined in addition. The analysis should determine relationships between measured soil respiration, soil temperature and moisture, fine root biomass and soil carbon content as well as examine the question whether there are spatial patterns in soil respiration and possible causes for these patterns.

Project Aims
- use of the IRGA
- ability to develop small models in matlab or maple
- using basic statistics
- field work

Tools for visualising the molecular world

Supervisor: Dr J Woodward

Introduction
This project will be the first i-Science project to commence a collaboration between the department of chemistry and the University's Centre of Excellence in Spatial Literacy in Teaching and Learning (based in the Geography department). The aim of the project is to design and develop computer based tools for improving spatial visualisation of the molecular world.

This project will be suitable for students interested in one or more of the following interdisciplinary areas;

1) Molecular representation and visualisation
2) Structure, bonding, chemistry of materials
3) Software development
4) Innovative teaching methods

Project Aims

- Establishing (through literature research) what are the key problems associated with peoples ability to visualise the molecular world in three dimensions.
- Formulating methodologies to try to overcome one or more of the identified problems.
- Defining the operational parameters of computer based methods for implementing these methodologies.
- Developing actual software tools for visualisation based on standard computer hardware and / or the Virtual Reality cinema.

Investigation of the effect of mobile phone radiation on the rate of a photochemical reaction

Supervisor: Dr J Woodward (Chemistry)

Introduction
This project will be based in the Magnetic Field Laboratory in the Department of Chemistry.

There has been a great deal of interest, particularly in the public arena over the potentially harmful effects of mobile phone radiation. It has been shown that both static and oscillating magnetic fields in isolation and in combination are capable of altering the yield and rate of radical reactions through the radical pair mechanism. Most modern mobile phones transmit radiation in the low microwave frequency range but produce lower frequencies as well due to the modulation schemes employed. It is possible that the combination of a weak magnetic field from the speaker in a mobile phone in combination with the frequencies generated during operation may be capable of generating resonant effects in the reactions of radical pairs. The aim of this project is to make measurements on a magnetically sensitive photochemical reaction of the effect (or absence thereof) of a nearby mobile telephone.

Project Aims
The project will involve many interdisciplinary aspects of science including;

- RF and microwaves
- Photochemistry
- Magnetic fields
- Modulation techniques
- Light sources and optics
- Electron spin dynamics

Recommended background reading
J. R. Woodward, Progress in Reaction Kinetics and Mechanism, 2002, 27, 165-207.

Communicating ethics

Supervisor: Dr C Willmott

Introduction
Recent years have seen unprecedented developments in biomedicine. "Designer babies", transplant organs from animals, personalised medicine, stem cells and cloning are - to varying degrees - stepping from science fiction to science fact. Whilst the technology has made great strides, the ethical discussion has often failed to keep up.

Project Aims
This project will look at the development of resources for teaching about ethics at secondary and/or undergraduate level. In particular, the project will involve producing and evaluating study guides focussed around pre-existing online Reusable Learning Objects such as news footage streamed on the BBC website or YouTube videos.

Environmental monitor for schools

Supervisor: Dr. N.F. Arnold

Introduction
As part of the second/third year group research project, students are designing a system to measure atmospheric nitrogen dioxide and other environmental parameters, such as temperature and wind velocity that ultimately will be made available to schools/colleges. For this venture to be successful, it must meet the curriculum requirements for science/ICT.

Project Aims

- Learn about the basic principles of environmental monitoring.
- Interact with the teams responsible for developing the hardware and software and influence the specifications that are being drawn up.
- Generate documentation and study materials that would support learning and teaching for a range of school ages and abilities.

An ultrasound radar simulator

Supervisor: Dr. T.K. Yeoman

Introduction
Radar systems have a wide variety of uses in industry and commerce, as well as environmental and geo-science and space exploration. Ultrasound has with a frequency of tens of kHz and a wavelength of order one cm, Such a wavelength is similar to those used in a number of radar systems, although the frequency and wave speed are very different. Ultrasound can thus be used to simulate the operation of radar systems in the laboratory. In this project a simple ultrasound radar simulator will be constructed and tested, using both individual transducers and a phased array of transducers to form the transmitted and received beams. The use of continuous wave, pulsed and chirped transmitted signals will be investigated. The performance of the radar in beamforming and steering, and in the location, identification, and tracking of objects will be investigated and optimised.

Project Aims

The design and construction of the basic elements of a radar system using ultrasound. The driving signals will be produced by a flexible signal generator, while an analogue-to-digital conversion system will log the transmitted and received signals on a computer. This digital output will then be used to test, quantify and optimize the performance of the system under a number of configurations. The performance of the system will be compared to the expected performance of radar systems using basic radar theory.