# Undergraduate Research Projects in U.K. Universities

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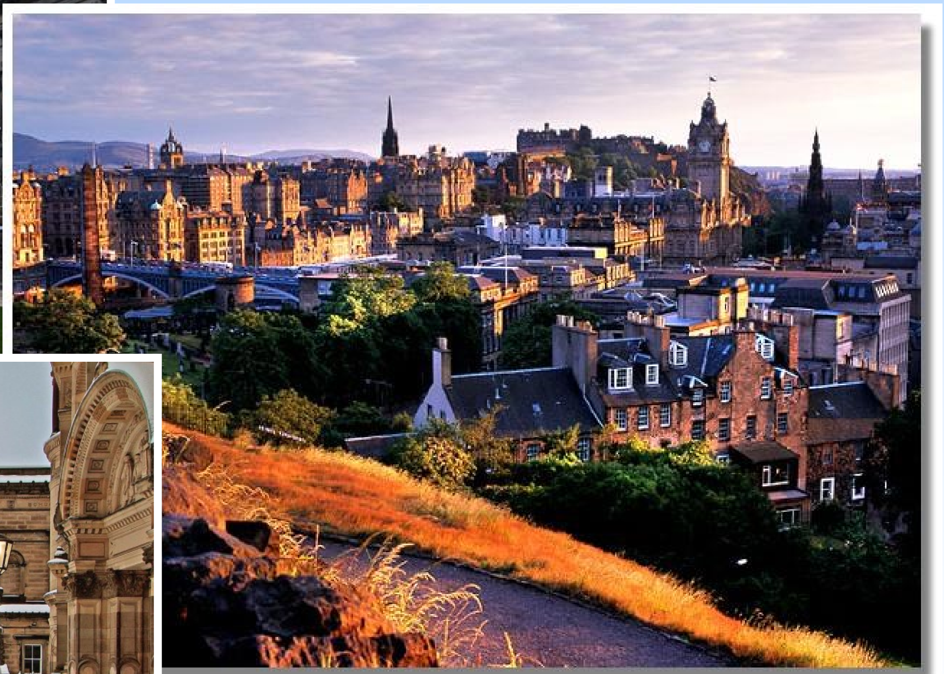
# Outline

- Project characteristics
- Example project topics
- Logistics
- Advantages and challenges

# Context: UK universities

- Bachelor's degree (BSc) in 3 years
  - (4 years in Scotland and Northern Ireland)
- Integrated Master's degree (MSci or MPhys) in 4 years
  - (5 years in Scotland and Northern Ireland)
- 'Major'-focussed courses only
- Graduating class sizes ~ 15-150 students

# Context: UK universities



# Context: UK universities

# Project Characteristics

- *All* students do a research project (and some do multiple projects) for course credit
- Usually in final year of program
- Usually one student per project, occasionally pairs
- Typical durations:
  - BSc: ~ 200 hours over 1 semester
  - MSci/MPhys: ~ 400-600 hours over ~ 2 semesters

# Project Characteristics

- Project work *required* for degree accreditation by Institute of Physics
- Expectation of (some) original content
- Three broad areas:
  - Experimental (lab-based) – most common
  - Computational – also common
  - Theoretical – rather rarer

# Project Characteristics

- *Not* donkey-work
- *Not* simply a chunk of a larger research project
- Self-contained, with outcomes and conclusions

# Example Project Topics

Properties of materials under irradiation in a fusion reactor

Computer simulations of colloid-liquid crystal composites

Statistical physics of DNA-protein systems

Applying item response theory to diagnostic tests in physics

The impact of solar forcing on climate of the last millennium

Squeezing particle-stabilized emulsions into electrically conducting foams

Using aircraft and satellite data to estimate sources of CO, $CO_2$ and $CH_4$ from Canadian forest fires during summer 2011

Theory of Jamming and Real Space Condensation

# Example Project Topics

In-depth study of a nuclear reaction process for Nuclear Astrophysics

Response of Microorganisms to Space Conditions

Long-distance singularities in QCD scattering amplitudes

Radiative Transfer on a GPU

Automated classification of near infrared variables in large synoptic surveys

The evolution of general cosmological perturbations

CP Violation with Bs Mesons Decays at the LHCb Experiment

# Indicative Project Work

- Orientation and introduction
- Literature review
- Planning
- Project ‘execution’:
  - Running existing code on new data
  - Performing a particular sub-set of an experimental program
  - Modifying code or writing limited code from scratch
  - Applying existing theoretical techniques to new context
- Evaluation and report write-up

# Project Allocation

- Project supervisors (faculty) propose project topics
- Available projects communicated to students
- Students discuss project(s) with supervisors
- Students submit ranked choices of projects
- Students allocated to projects (ties usually broken using students' academic record)
- Supervisors have final veto

# Project Supervision

- Projects embedded within research groups
- All projects have a faculty member as (first) supervisor
- At least 1 hour per week per student contact time (usually more)
- ~ 2-3 students per supervisor
- Additional supervision from post-docs / PhD students

# Project Assessment

- Usually by a range of methods:
  - Supervisor’s judgement of project conduct
  - Formal report (usually double-marked)
  - Oral presentation
  - Viva examination
  - Lay report
  - Wiki / web page
  - Etc.

# Physics Education Research
## The University of Edinburgh

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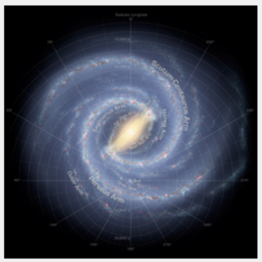
## Samuel Irvine - Collisional dark matter

5 Added by Keith Brunton, last edited by Samuel Irvine on Mar 28, 2014 (view change)

**What is Dark Matter?**

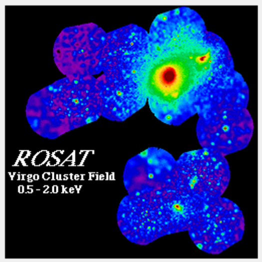
Simply put, dark matter is matter we cannot see. It has a mass, interacts gravitationally and makes up around 85% of the total matter content of the universe.

**Evidence for Dark Matter**



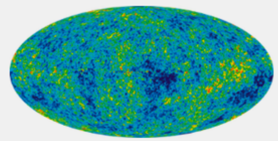
**Galactic Rotation Curves.**

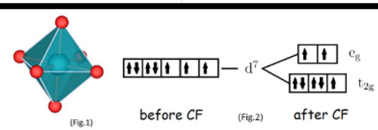
If we measure the velocity of objects bound to a host Galaxy and compare to its travel too fast. Without ext orbit, they would quickly e host galaxy.




**Galaxy Clusters.**

We can deduce the mass of galaxy clusters through measurin as. The hotter the gas, the required to contain it must be he mass we would require to minosity, there is a deficit.

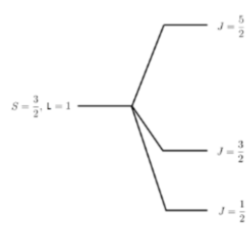





***Spin-Orbit Coupling***

The system's next energy contribution comes from the interactio by the total effective angular momentum, J, where J = |S - L|, S, (Fig.3). We knew that the previous ground state was twelve-fold interaction some of that degeneracy is lifted. This new orbital tri

Following the detection of spin in the 1920's, it was assumed th have an effect on this dipole moment, and therefore the overall

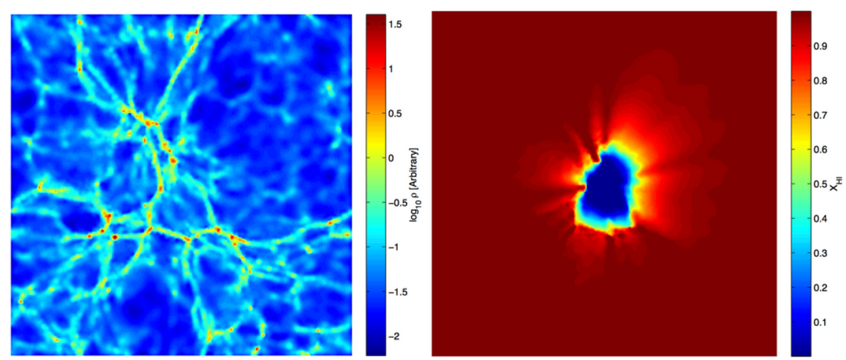



(Fig.3)

**What are the results?**

Since computational results (graphs) are relatively boring to look at they won't be shown here, however as discussed the calculation of the column density works with minor error created from the interpolation of the kernel values in dense areas of the simulations. The performance of the algorithm is greatly increased due to the acceleration structure used. The algorithm was shown to be extremely scalable due to the independence of each ray and only secondary effects from cache memory limits are present. More information can be found in the project report available at the RTSPH Git Repository.

While the actual application of the algorithm is not part of the project it produces very nice pictures and these are therefore shown below. The first image shows the shows the density of the gas in the central slice of the cosmological simulation. It shows the structure with dense galaxy like areas and very sparse areas where not much gas is present anymore. The second image shows the ionization fraction of hydrogen which can be calculated from the radiative transfer within this simulation data. A single ionizing source was placed at the center of the slice. The interesting effects shown are the shadowing created from the dense areas close to the source which ionize slowly compared to the sparse areas. From this you can see how different parts of the cosmological simulations can now be ionized and heated using radiative transfer, which then gives feedback into the hydrodynamic forces in the cosmological simulations.



# Pre-Project Preparation

- Most departments offer some form of ‘Research Methods’ course:
  - How to use a bibliographic database / give citations
  - How to ‘read’ a journal article
  - Practice literature review
  - How to use data analysis software
- Lab courses tend to ‘taper’ in terms of support and structure:
  - Students need greater initiative and self-reliance

# Advantages for students

- Realistic impression of research environment
- Realistic appraisal of suitability for PhD
- ‘Change of pace’ from exam-based courses
- Useful transferable / employability skills:
  - Planning / self-regulation
  - Problem solving / working in a team
  - Report writing
  - Etc.
- Interesting and fun!

# Advantages for faculty

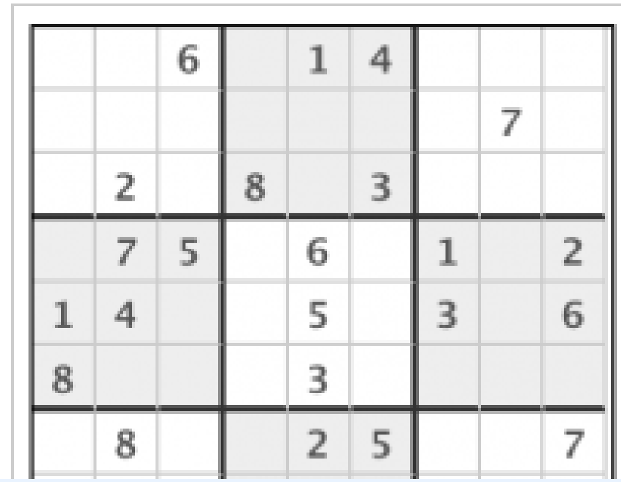
- Assistance with research
- Occasional publication-quality work
- Opportunities to evaluate / recruit potential PhD students
- Interesting and fun!

# Paramagnetic and glass transitions in sudoku

Published on Thursday, 4 October 2012 - 10:15am

Senior Honours student Alex Williams' project has been published in leading journal Physical Review.

His paper "Paramagnetic and glass transitions in sudoku" involved a study of the statistical mechanics of a model glassy system based on sudoku. Defining an energy and temperature based on the number of errors on a sudoku grid, Alex used methods devised at Los Alamos in the Manhattan project to reveal similarities between properties of sudoku puzzles and magnetic systems.



# Challenges

- High faculty workload (supervision and marking)
- Need many (all) faculty to contribute
- Need supply of fresh projects
- Lab space / resource implications
- Some students have limited ability
- Poor project performance can be unrecoverable for students

# Summary

- Undergraduate research projects are an integral component of all Physics degrees in the U.K.
- They are popular and valued by students and impart vital skills and experience.
- They are useful and rewarding for staff but require substantial time and resources.

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