SCHOOL OF PHYSICS & ASTRONOMY
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INDEX OF POSTERS

ASTRONOMY

Star Formation over the Last 10 Billion Years - A Mysterious Correlation in Galaxies' Light
Nathan Bourne

There are numerous ways of observing star formation in galaxies over much of the history of the universe, although relating the results given by different methods is not always so simple. A tight correlation between the far-infrared and radio luminosities of galaxies with a large range of properties has been widely observed, and seems to result from some process associated with star formation. We investigate how the correlation evolves from the early universe to today, for a large unbiased sample of massive galaxies. We find evidence that some mysterious mechanism governs the production of both synchrotron radiation and thermal dust emission in the galaxies, and maintains the correlation from the formation epoch of the galaxy up to the present day.

AGN Outflows at High Redshift
Emma Bradshaw

In the local Universe, there is a tight relation between the mass of a galaxy's supermassive black hole (SMBH) and its stellar velocity distribution which suggests a joint evolution of the two. There is also evidence to suggest a link between quasar activity and star formation induced by galaxy mergers, but the relationship between the two is not well understood. The interplay between an active galactic nuclei (AGN) and the properties of its host galaxy may therefore provide important information to further our understanding of galaxy evolution.

In this poster I show that by stacking individual galaxy spectra, it is possible to see what could be AGN driven winds. This could help explain the colour bimodality of galaxies which appears at redshifts ($1.0<z<2.0$).

Galaxy Environments in the Distant Universe
Rob Chuter

It has long been known that red galaxies reside in denser environments than blue galaxies. Many groups have studied this in the local universe but few have studied it in the more distant universe. We study the environments of galaxies using the Ultra Deep Survey (UDS) utilising infrared observations to probe deeper into the universe. We find that the colour-density relation holds out to high redshifts. We also study a subset of passive/star forming galaxies and see that passive galaxies are in denser environments than even the red galaxies. I also discuss a recent redshift survey (UDSz) that I have been working on.

The environmental dependence of the stellar mass-size relation in STAGES galaxies
David Maltby

We present the stellar mass-size relations for elliptical, lenticular and spiral galaxies in the field and cluster environment using Hubble Space Telescope imaging data from the Space Telescope A901/1 Galaxy Evolution Survey. We find no evidence to suggest an environmental dependence suggesting the environment plays little role in the evolution of the size of a galaxy.

Comparing the STAGES supercluster with numerical simulations
Rhys Rhodes

We utilise a large cosmological simulation that includes both the dark matter structure of the Universe and a population of galaxies obtained using semi-analytical techniques to aid our interpretation of the multiwavelength observations of the STAGES field.

Models of galaxy formation predict a tight correlation between cluster mass and galaxy population. Observations using the Hubble Space Telescope of the STAGES multiple cluster system appears to violate this relation. We show that such differences in fact arise naturally within semi-analytic models when projection effects and the observing procedures are taken into account. We also find that it is highly likely that on of the objects observed is in fact (at least) two groups seen in projection. We use analogues of the observations to draw insights into the current physical state and past history of A901/902.

H-alpha measures of Star Formation in Massive Galaxies at z~1
Jonathan Twite

Massive galaxies are thought to stop forming stars at around z=1, before smaller galaxies finish their own star formation. However as there are different tracers of a galaxy's star formation rate (SFR), it is not always easy to compare surveys at different redshifts. Further to this, at redshifts near 1, there can be extreme difficulty in identifying galaxies with obscured active galactic nuclei (AGN) which then look as if they have high SFRs. We take a sample of massive galaxies from the POWIR survey and observe their H-alpha emission line with near-Infrared spectroscopy to get a reliable SFR or SFR upper limit independent of whether the galaxy hosts an AGN or not. By comparing with rest-frame 24 micron emission we can look for potential AGN candidates; and comparing with other SFR tracers, we can estimate the amount of obscuration by dust. We compare several recent models designed to estimate the dust content of galaxies. We finally look at the SFR and specific star formation rate (SSFR) as a function of color and mass.

CONDENSED MATTER THEORY GROUP

A dramatic Effect of the Semi-classical Stochastic Web on Quantised Eigenfunctions in Superlattice

Wang Feiran

Superlattice is a periodic structure of layers of two (or more) materials. With a tilted magnetic field applied, the system exhibits non-KAM chaos. The semi-classical model is used to give the orbit and poincare section, while the quantum-mechanical model is to give the probability distribution and Wigner Functions. The results of two models are compared and analogue has been done, especially in explaining the width of the probability distribution (corresponding to the semi-classical orbit).

Dynamical study of a lattice protein

Antonia Mey

Lattice models are widely used to study folding behaviour of proteins, making them essential to our understanding of many biological processes. In these models nearest neighbours on the lattice dictate the interactions of the amino acids along the polypeptide chain. Especially models neglecting interactions of amino acids not present in the native state (biologically active state), like the Gō model [1], have been studied extensively. Recent work suggests that Gō-like models with heterogeneous amino acid sequences exhibit different folding mechanisms for a large variety of sequences but all folding into one native state [2]. One fast folding 48mer sequence in particular, which shows the first order like transition from a random unfolded state to a folded state, has been studied in great detail. By introducing "native activity" as an observable for a dynamic order parameter a phase coexistence at the critical temperature in equilibrium can be observed. This suggest a dynamical phase transition in this system, which can be found though out of equilibrium computational studies by introducing a "field s" conjugate to the order parameter and biasing the system in the usual Boltzmann fashion, where s takes the role of the inverse temperature. It can be reported, that for the 48mer lattice system studied such a dynamical phase transition in s using "native activity" as an order parameter is observed.

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Fractal Design and Additive Manufacture of Novel Microstructures
Daniel Rayneau-Kirkhope

Fractals, or objects with a self-similar, size invariant structure, are found throughout nature in fields varying from percolation [1] to that of transport networks [2] and colloid flocculation [3]. More recently studies have linked the fractal nature of some materials with high mechanical efficiency [4]. This link has been further investigated with great success in a number of theoretical physics papers [5, 6]. Following the successes of fractal designs for high mechanical efficiency in the regime of gentle loading a design, first proposed in "Fractal space frames and meta-materials for high mechanical efficiency" [7], is manufactured through recently developed additive processes [8]. The design is then analysed computationally in order to model the extent of the shortening due to compressive loading and to pinpoint the theoretical maximum loading for the specific material and geometry. This is done through a "freely-hinged" model and a more sophisticated finite element simulation in order to predict more accurately the non-linear effects of the fractal design. The possibility of physical testing is an exciting prospect to validate the growing field of fractal design.

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EXPERIMENTAL CONDENSED MATTER & NANOSCIENCE GROUP

RAMAN AGAINST CANCER: Towards automated detection and imaging of basal cell carcinoma (BCC)

M Larraona-Puy[1], A Ghita[1], A Zoladek[1]; W Perkins[2], S Varma[2], I Leach[3], H Williams[4], A A. Koloydenko[5] and I Notingher[1]

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[2:] Dermatology Department. [3:] Histopathology Department, [4:] Centre of Evidence-Based Dermatology, Nottingham University Hospital NHS Trust. [5:] Mathematics Department, Royal Holloway University of London.

An automated method for imaging and diagnosis of the most common skin cancer, basal cell carcinoma (BCC), with Raman micro-spectroscopy (RMS) during surgery has been developed. The RMS images showed extremely high correlation with traditional methods. The introduction of a generalization of the proposed technique into a real clinical scenario will help in a fast and accurate location of tumour margins and may improve the feasibility and efficiency of the current state of the art treatment for difficult BCCs.

Acknowledgements

The authors would like to acknowledge the Journal of Biomedical Optics for the publication of this work in Larraona-Puy; A Ghita, A Zoladek ,W Perkins, S Varma, I Leach, H Williams , AA Koloydenko and I Notingher, "Development of Raman micro-spectroscopy for automated detection and imaging of Basal Cell Carcinoma", *Journal of Biomedical Optic*s, *Journal of Biomedical Optic*s, **14** (5), 054031 1-10 (2009) .

The project had the financial support of the UK National Institute for Health Research (NEAT FSG004), the University of Nottingham Hospitals Charity and the Engineering and Physical Sciences Research Council (Bridging the Gaps grant EP/E018580/1).

A fibre interferometer for the measurement of MEMS and NEMS below 1 K

MJ Patton, CJ Mellor, AD Armour and J Owers-Bradley

Fibre interferometers have been used to study nanomechanical systems to temperatures as low as 1 K [1]. Here we present measurements of the sensitivity of a fibre interferometer recently constructed for the study of nanomechanical systems at temperatures below 1 K. The interferometer comprises a fibre directional coupler into which a 633 nm HeNe laser is coupled. The coupled light is split across two arms, one of which is used to monitor the laser irradiance, whilst the other runs to the mixing chamber of a dilution refrigerator. A Fabry-Perot cavity is formed between the end of the fibre and the sample. Light emerging from the fibre is focused onto the sample by two aspheric lenses. The samples' mechanical motion modulates the reflected light. By monitoring the ac component of the reflected light the amplitude of oscillation can be determined.

Commercially available quartz tuning forks with frequencies of $f_0 \sim 2^{15}$ Hz and quality factors of $Q \sim 10^4$ are used as sensors in a range of physical systems and have been widely studied [2]. One low temperature application of these mechanical resonators is the study of quantum turbulence [3]. To demonstrate the performance of the interferometer we present measurements on a quartz tuning fork carried out at 4.2 K. These measurements are used to calculate the detection limit of the system.

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Adsorption of guest molecules into an entropically stabilised molecular rhombus tiling

JC Russell†, MO Blunt†, M del Carmen Giménez-López‡, JP Garrahan†, X Lin‡, M Schröder‡, NR Champness‡, PH Beton†

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We have studied the properties of a two-dimensional supramolecular network which has a structure that may be mapped onto a random rhombus tiling [1]. These networks are formed by the adsorption of p-terphenyl-3,5,3',5'-tetracarboxylic acid molecules at the interface between a highly orientated graphite surface and nonanoic acid solvent. Scanning tunneling microscopy is used to image these networks in-situ at the liquid-solid interface. There are an exponentially large number of near-degenerate molecular arrangements. We discuss the changes in the network observed when the porous nature of the networks is utilized for the introduction of a coronene guest molecule. In particular we show that coronene leads to the enhanced stabilization of a specific sub-set of molecular vertices reducing the number of degenerate ground states of the system. This change has the effect of inducing long-range order in the molecular network. We also demonstrate that kinetic effects are significant and lead to different statistical properties of the network [2].

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2. J. C. Russell, M. O. Blunt, M. del Carmen Giménez-López, J. P. Garrahan, X. Lin, M. Schröder, N. R. Champness, P. H. Beton. In preparation

Conformational control of porphyrin oligomeric and polymeric assemblies on a Au(111) substrate

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We have investigated porphyrin oligomers and polymers, with lengths greater than ~60nm, on an Au(111) surface under ultra-high vacuum (UHV) conditions. The molecules were deposited using an electrospray technique [1-2] and were subsequently characterized by scanning tunnelling microscopy (STM), X-ray photoemission spectroscopy (XPS) and near edge X-ray absorption fine structure (NEXAFS). These porphyrin based polymers are of considerable interest due to their potential application as molecular wires [3].

Oligomers consisting of 4 and 6 porphyrin units (7.5nm and 10.5nm in length) are observed to self-assemble into close-packed arrays with typical domains sizes of the order of 100nm^2. The structural arrangement of molecular arrays has been determined using high resolution STM, showing the interlocking of alkane chains. Angle resolved NEXAFS studies confirm that the porphyrin units lie parallel to the Au(111) plane. A similar inter-molecular bonding motif is observed for polymers consisting of an average of 42 porphyrin sub units (66.5nm in length). Structures where a large proportion of each polymer is in a close-packed arrangement with features such as polymers crossing and bending are also observed.

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MAGNETIC RESONANCE IMAGING & SPECTROSCOPY

Arterial Spin Labelling (ASL) at Ultra-High Field (7T)
Emma Hall, Roman Wesolowski, Penny Gowland, Sue Francis
Sir Peter Mansfield Magnetic Resonance Centre, The University of Nottingham

Arterial spin labelling (ASL) is a non-invasive technique for the quantitative measurement of perfusion. The ASL signal change is typically of the order of 1 – 2 % at 3 T. Ultra-high field (≥7T) provides increased signal-to-noise ratio (SNR) and increased contrast-to-noise ratio (CNR) of ASL measurements.

ASL data is typically acquired at coarse spatial resolution ($3x3x5mm^3$). We demonstrate that the improved SNR and CNR at ultra-high field can be used to acquire ASL data at high spatial resolution ($1.5x1.5x3mm^3$). Background suppression methods, in which perfusion images are acquired at the static signal null point, are used to reduce physiological noise. High resolution scans are shown to reduce partial volume effects improving the estimation of grey matter perfusion within the brain.

ASL can be applied to study functional changes. However, the use of background suppression to reduce physiological noise in ASL studies prevents the simultaneous acquisition of BOLD data. A new approach, double acquisition background suppressed (DABS), is developed for the simultaneous acquisition of high resolution ASL and BOLD data during functional studies. This technique improves the detection of perfusion changes whilst maintaining high BOLD sensitivity.

The combination of ASL with Look-Locker EPI acquisition (LLEPI) provides a technique for the rapid measurement of arterial blood volume (CBVa) and perfusion. Using this technique at 7T, changes in CBVa and CBF can be detected from a single fMRI cycle.

MRI and MRS monitoring of gastrointestinal distribution, physiological effects and absorption of fat emulsions
M. Hussein, The Sir Peter Mansfield Magnetic Resonance Centre

Magnetic resonance imaging can monitor gastrointestinal function and visualise the water and fat components of food in the GI tract separately and non-invasively. Proton magnetic resonance spectroscopy (MRS) can also be used to monitor the absorption of fat in the liver and skeletal muscle. This study describes development work aimed to combine these MRI and MRS techniques to provide a unique, non-invasive, method of complete, serial monitoring of the delivery to the intestine and absorption of fat in the human skeletal muscle and liver.

Two healthy volunteers were fed two different fat emulsions of different droplet sizes (one fine and one coarse) and they were scanned at intervals for up to 6 hours to follow the fate of the fat meals. The two different fat emulsions triggered a diverse duodenal response which affected gastric emptying (fine droplets slower), gallbladder contraction (fine droplets greater) and small bowel secretion (fine droplets greater). MRS showed promise for monitoring postprandial changes in both liver and calf lipid/water ratios. MRI and MRS can provide comprehensive insight into the body's handling of a fatty meal.

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Travelling Wave MRI
Daniel Lee

Travelling Wave MRI is a new technique for imaging the body which has only started to emerge over the past two years and is only possible with the largest MRI systems (7T or above). Here at Nottingham we have been investigating different methods of generating travelling waves, comparing a patch antenna to an end-fire helix design.

Fast DNP enhanced NMR spectroscopy in conjunction with rapid mixing

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DNP has proved to provide an enhancement in the signal-to-noise ratio of a factor of approximately 10^4 for single-scan liquid-state NMR spectroscopy. The drawback is that this massive polarization decays with the longitudinal relaxation time constant *T*1 which limits the time period during which the signal can be detected with an appreciable enhancement (after 5 × *T*1 only 0.7% of the signal is left). On the other hand strong signal enhancement allows to overcome a limitation of low sensitivity and directly observe those nuclei which otherwise would have been too time consuming to study. DNP-NMR seems ideally suited for a study of unstable or quickly changing molecular systems, their dynamics, intra- and intermolecular interactions in real time, for example like protein binding.

Here, we present the potential of time-resolved NMR spectroscopy by using DNP polarized uniformly 13C-labelled glucose for the example of monitoring mixing process.

To extend dissolution DNP spectroscopy to the study of dynamical changes on the molecular level it is frequently necessary to rapidly mix two liquids immediately before the NMR signal is acquired. While the first liquid contains the highly polarised spin system, which may be a ligand or a protein, the other solution could contain either receptor molecules or small molecules that trigger a particular dynamical process of the hyperpolarised molecule. Combined with techniques for fast data acquisition this strategy could make measurements of molecular dynamics with time constants in the millisecond regime possible. For this strategy, there are two time constraint. First, the decay of the non-thermal high polarisation with the characteristic T1 time constants and second the time constant of the molecular dynamic process to be monitored.

Here, we demonstrate the potential of time-resolved NMR spectroscopy by using DNP polarised uniformly 13C-labelled glucose for monitoring the mixing process.

Dynamic Nuclear Polarisation in Nottingham

Sir Peter Mansfield Magnetic Resonance Centre,
School of Physics & Astronomy, University of Nottingham, UK
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Nuclear Magnetic Resonance (NMR) is a technique based on the interaction of the magnetic moments of nuclei with an external magnetic field. This allows NMR to be widely used for structure determination of chemical compounds and proteins as well as for medical imaging (MRI).

An important feature is that this technique is non-invasive. NMR can study compounds in their natural environment without destroying them, unlike structure determination methods such as x-ray and mass spectroscopy. This opens up the possibility to study dynamics and conformational changes, for example of proteins.

The sensitivity of this technique is limited by the thermal spin polarisation at the start of the experiment. At room temperature this is very small, around one in a million. Consequently, in order to increase the efficacy of this technique, it is advantageous to examine methods that can enhance the initial spin polarisation.

We are exploring one approach called Dynamic Nuclear Polarisation (DNP) for signal enhancement. This method has been shown to increase the signal by a factor of up to 10,000. The same signal increase would be achieved if the experiment were to be repeated and averaged 10^8 times.

This makes it possible to study small concentrations and low abundance nuclei otherwise not accessible on a short time scale with any other NMR method.

PARTICLE THEORY GROUP

Oscillons whatever that means, in particular, for scalar field theories
Paul Tognarelli

A look at the spatially localised, long-lived, oscillatory field structures labelled Oscillons, uncovered through numerical and empirical research.

My poster briefly introduces this phenomenon through its definition and examples in familiar contexts. These occurrences across varied contexts and an example of their physical impact motivate their examination.

The majority of the poster discusses my numerical studies of Oscillons in scalar-field theories. My work uncovers Oscillons in the classical theory. Then broaches the question, whether their counterparts exist in the associated quantum, scalar-field theory.

My poster, ultimately, postulates future, possible investigations into quantum Oscillons.

Phase Space Analysis on f(G) Dark Energy Models
Shuang-Yong Zhou

Modified gravity theories with the Gauss-Bonnet term have recently gained a lot of attention as a possible explanation of dark energy. We perform a thorough phase space analysis on the so-called f(G) models, where f(G) is a general function of the Gauss-Bonnet term, and derive conditions for the cosmological viability of f(G) dark energy models. Following the f(R) case, we show that these conditions can be nicely presented as some geometrical constraints on the derivatives of f(G). We find that for general f(G) models there are two kinds of stable accelerated solutions, a de Sitter solution and a phantom-like solution. Several toy models are explored and cosmologically viable trajectories that mimic the LCDM model in the radiation and matter dominated periods, but have distinctive signatures at late times, are obtained.

ULTRACOLD ATOMS

Bloch-Q-Bit: Multiphoton Coherent Manipulations of an Atomic Two State System

G Aviv, M Giveon, A Waxman, D Grosswasser, R Folman

Neutral atoms are of major interest for studies of fundamental physics and allow precise measurements of fundamental constants such as the atomic hyperfine constant. The ability to accurately control the atoms has been utilized in producing accurate atomic frequency standard devices and magnetometers. The same properties make them promising candidates for QIP devices [1] and significant experimental progress towards the implementation of qubits has been achieved in recent years [2].

In this experiment, we investigate the properties and differences among several magnetic transitions in the 87Rb hyperfine ground-state manifold.

The transition |F=1,m_F=0>→|F=2,m_F=0> is commonly used for atomic clocks because the Zeeman shift of both states vanishes to first order at Zero magnetic field. For |F=1,m_F=-1>→|F=2,m_F=+1>, the differential Zeeman shift vanishes at the magic field value of 3.23G, which makes this transition insensitive to magnetic field fluctuations also. As an additional advantage, both states are magnetically trappable, but they require a two-photon transition.

We designed and constructed a novel dual frequency cavity for two photon transitions, which enables high-power homogenous microwave, RF, and laser fields on atoms in a vapor cell [3]. In this poster we present experimental results and discuss the design of future studies.

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