Australian Institute of Physics NSW Branch

2009

Postgraduate

Awards

Event

The 2009 Awards Event are sponsored by:

The Australian Institute of Physics and the Astronomical Society of Australia as the International Year of Astronomy (IYA)

CAMPUS REVIEW

CSIRO

Darlington Centre, Tuesday 24 November 09

Prepared by: Dr Frederick Osman
2009 Awards Day Coordinator

2009 Postgraduate Programme

- ***2.15pm*** **Welcome and Introduction by Dr Frederick Osman (AIP Branch Chair)**
- ***2.25pm*** **Julian King, University of New South Wales**
  Probing the Fundamental Constants of Nature with Quasar Spectroscopy
- ***2.50pm*** **Steven Lade, Australian National University**
  Directed Transport without Net Bias in Physics and Biology
- ***3.15pm*** **Eduardo Granados, Macquarie University**
  Ultrafast Lasers Go Ultraviolet
- ***3.40pm*** **Afternoon Tea**
- ***4.15pm*** **Felix Lawrence, University of Sydney**
  Impedance and Photonic Crystals
- ***4.40pm*** **Martin Blaber, University of Technology Sydney**
  Determining Ideal Plasmonic Materials
- ***5.05pm*** **Stuart Hargreaves, University of Wollongong**
  THz Emission Mechanisms in Semiconductor
- ***5.30pm*** **Refreshments**
- ***6.00pm*** **AIP Annual General Meeting (AGM)**
- ***6.35pm*** **2009 Invited Speaker: Dr Marc Duldig**
  Particle Astronomy – the Second Window
- ***8.00pm*** **2009 Annual Dinner: Buon Gusto – 368 Abercrombie St Chippendale**
  Presentations of Awards and Prizes

Prepared by: Dr Frederick Osman
2009 Awards Day Coordinator

Probing the Fundamental Constants of Nature with Quasar Spectroscopy

Julian King

School of Physics
University of New South Wales

Abstract

Modern physics finds itself at a terrible juncture – we know that one or more of our fundamental theories cannot be correct, but are merely approximations that seem to be very good in the circumstances we have probed. Attempts to create a Grand Unified Theory (whether through String Theory or otherwise) are well known for being mathematically difficult, and these theories generally produce few, if any, presently testable predictions. Nevertheless, many of these theories predict that dimensionless constants of nature, such as the fine structure constant or the proton-to-electron mass ratio, may vary over cosmological timescales. Confirmation of variation in any of these constants would conclusively demonstrate physics beyond the Standard Model, and provide constraints on Grand Unified Theories. This talk presents my constraints on the proton-to-electron mass ratio, derived from quasar spectroscopy, where I find that the fractional change in the proton-to-electron mass ratio is limited to (2.6 +/- 3.0) x 10^(-6) over the last 11 gigayears.

This result is the most stringent published constraint on this quantity from this time period. If this work and the previous work of Webb & Murphy (regarding the fine structure constant) are both correct, we have already ruled out large numbers of Grand Unified Theories. I also present the second stage of my research, which aims to constrain the fractional change in the fine structure constant since the early universe with more precision than any previous analysis. We have also utilised Markov Chain Monte Carlo methods to verify that our stated statistical uncertainties are correct.

Prepared by: Dr Frederick Osman
2009 Awards Day Coordinator

Directed Transport without Net Bias in Physics and Biology

Steven Lade

Nonlinear Physics Centre,
Research School of Physics and Engineering
Australian National University

Abstract

Ratchets and molecular motors are two means of achieving directed transport without net bias. While valid at all scales, such motors are particularly relevant in the micro and nano worlds, where the objects to be transported often move in an overdamped environment or are otherwise difficult to access and control.

A type of ratchet is optimised for maximum velocity, and it is demonstrated numerically that a ratchet-based magnetic micropump could be engineered for cold atom wires. Methods of time series analysis are introduced and extended for inferring mechanics of biological molecular motors and preliminary results using experimental data are discussed.

Ultrafast Lasers Go Ultraviolet

Eduardo Granados

Department of Physics & Engineering
Macquarie University

Abstract

In the twelve decades since Muybridge used high speed photography to resolve a long standing question of the motion of a galloping horse, the shortest measurable interval of time has been reduced by more than 14orders of magnitude. Ultrashort light pulses now enable snapshots in the attosecond domain (less than 10^{-15} s), revealing the most fundamental mechanisms of molecular, atomic, and electron interactions. Researchers can follow the motion of electrons within a single atom, and can control the paths of rapid chemical reactions. The science of the ultrafast is mainly dominated by the titanium-doped sapphire laser; this is the platform generating the shortest pulses and the highest powers, and is a robust commercialised technology. These lasers operate in the infrared and can produce pulses as short as 2.7 femtoseconds, only limited by the time taken for one single cycle of the electric and magnetic fields.

Despite Ti:Sapphire's dominance, there are upcoming challengers. One way to improve on the performance is to produce pulses at shorter wavelengths: this permits generation of even shorter pulses because the single cycle limit gets shorter as the wavelength is decreased. Cerium lasers hold the prospect of generating ultrafast pulses in the ultraviolet, offering a broad spectrum of laser gain around ultraviolet wavelengths of 290 nm. At this new wavelength, it is possible to generate pulses shorter than one femtosecond directly from a laser oscillator. Until recently cerium lasers had only been developed for nanosecond-pulsed applications, and the promise offered by cerium for generating ultrafast laser pulses was entirely untapped. This is now beginning to change: we have demonstrated the first mode locked cerium laser generating picosecond pulses at 290 nm. This is the first step on the road to unlocking the full potential of cerium to generate the shortest pulses ever from a laser oscillator.

Impedance and Photonic Crystals

Felix Lawrence

School of Physics
University of Sydney

Abstract

A photonic crystal (PC) has a periodic variation in refractive index, e.g. regularly spaced air holes. 2D PCs have many interesting properties: light may be slowed down, guided around tight bends, self-collimated, spilt into multiple frequencies much more effectively than by using a prism, or even excluded from the PC entirely, over a range of frequencies (a "photonic band gap"). Clearly most of these properties require light to be coupled into the PC, but often this is not easy to do. Indeed, some of these effects occur close to a band gap, where coupling reflection losses are inherently large. In other fields, such as acoustics, transmission lines and conventional optics, these losses are under-stood through the concept of *impedance*, which allows simple calculation of reflection and transmission coefficients. Once an impedance has been defined it may be used to design *antireflection coatings*: thin, carefully chosen layers in front of the target medium, that introduce additional reflections which interfere destructively and eliminate all net reflection. For PCs, which have been an active topic of research for two decades, it is much harder to define impedance. The problem arises due to the fact that when light is incident from one PC onto another, it is scattered into many Bloch modes (PC eigenstates) in each medium. In contrast, for fields in which impedance is well-understood, such as acoustics, transmission lines and uniform dielectrics, each incident wave is only scattered into one transmitted and one reflected wave. The additional complexity for PCs means that in any meaningful treatment of PC reflections, many modes must be considered simultaneously in each medium. Thus reflection and transmission coefficients must become reflection and transmission *matrices*, and impedances should become matrices too. We provide a rigorous, semi-analytic definition of impedance for square and triangular lattice PCs. Our impedance is a small matrix defined using PC Bloch modes. We demonstrate our definition's utility by applying it to design antireflection coating for several PCs successfully and efficiently.

Determining Ideal Plasmonic Materials

Martin Blaber

School of Physics and Advanced Materials
University of Technology Sydney

Abstract

Investigations of the optical properties of metallic nanostructures are becoming ever more popular due to the advent of superlensing, cloaking and waveguiding. Unfortunately, losses in metals from interband transitions and electron-phonon scattering deteriorate the optical performance of most metals.

We have performed an analysis of the plasmonic performance of the elements and concluded that although gold and silver are the most commonly used metals, the alkali metals provide enhanced performance over a range of frequencies. In light of this development, we have developed a series of geometry specific plasmonic metrics to compare the performance of different materials. In order to minimise both loss and excessive reactivity in the elements, we decided to calculate, from first principles, the optical properties of a series of alkali-noble intermetallic compounds. Importantly, we use density functional perturbation theory to calculate the electron-phonon interaction and from there use a first order solution to the Boltzmann equation to estimate the phenomenological damping frequency in the Drude dielectric function. We also discuss the necessary electronic features of a plasmonic material and investigate the optical properties of the alkali-noble intermetallics in terms of some generic plasmonic system quality factors. Notably, KAu has the property that the onset of interband transitions occurs above the plasma frequency, resulting in plasmonic resonances that cannot decay into e-h pairs as they do in elemental gold.

Intermetallic compounds show promise as a replacement for the elements in a range of plasmonic applications; in addition, their manufacture is not as complex as some plasmonic systems that use gain media to mitigate loss.

THz Emission Mechanisms in Semiconductor Materials

Stuart Hargreaves

School of Engineering Physics
University of Wollongong

Abstract

Terahertz-frequency radiation has long proven to be inaccessible to the technologies of microwave radiation at lower frequencies and infrared radiation at higher frequencies. With a primary focus on time-domain spectroscopy of pulsed terahertz emitters under excitation from ultra-short optical pulses, a description of several semiconductor terahertz emitter technologies is presented.

This includes a theoretical analysis of optical rectification in $\bar{4}3m$ zinc blende crystals, which has been greatly expanded to cover arbitrary (hkl) crystallographic faces. Experimental results have also been obtained for several (11N) GaAs crystals and compared with the newly developed theory.

2009 Invited Speaker

Particle Astronomy – the Second Window

Dr Marc Duldig

Vice President of the Australian Institute of Physics &

Australian Antarctic Division

Abstract

Traditional astronomy relies on light to bring information to the observer. This covers the whole electromagnetic spectrum from radio and infra-red through the familiar visible night sky to ultra-violet, X-rays and gamma rays. However, there is another spectrum available to astronomers – the cosmic ray spectrum.

Cosmic rays are particles travelling almost at the speed of light and they carry different kinds of information about their sources and where they have been in their travels to Earth. We will talk about what they are, how they come to travel so fast and what they are telling about the universe around us.

We will hear a little history about several Nobel Prizes they led to, how they tell us about the sun and its surroundings, and how, even today, they are still interacting with the big bang!

Finally we will hear some aspects of cosmic ray effects that are used every day for practical purposes like sample dating, climate change research and why you increase your radiation dose every time you fly in a jet plane.

2009 Invited Speaker

Brief Biography of the Speaker

Dr Marc Duldig is a world leader in Cosmic Ray modulation research and is responsible for cosmic ray observatories in Australia and Antarctica. He is a member of several key international cosmic ray global network collaborations.

Marc is a Senior Principal Research Scientist with the Australian Antarctic Division where he manages the atmospheric component of the Division's climate program as well as the cosmic ray observatories.

He is Vice President of the Australian Institute of Physics and Secretary of the Astronomical Society of Australia.

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Buon Gusto

ENTRÉE

Variety of home-made pasta served
- Fettuccine Boscaiola – Ham, Mushroom & Shallots in a cream sauce
- Penne Siciliana – Eggplant in a rich Neapolitan sauce with a touch of chilli
- Tortellini Primavera – 3 colour cream sauce

ITALIAN SALAD – GARLIC BREAD – ARANCINI – BRUSCHETTA

MAIN COURSE

BBQ Seafood Platters marinated in olive oil, white wine & garlic
*Crabs, Prawns, Calamari, Fish Fillet, Mussels, Moreton Bay Bugs
+
Side dish of Veals & Vegetables
- Scallopine – Mushrooms, shallots, white wine & cream
- Pizzaiola – Fresh tomato, basil & garlic

DESSERT

- Home-made Traditional Tiramisu Torte
- Italian Aroma Coffee on order (not incl.)
- Soft Drinks (not included)

B.Y.O (wine only)
NO corkage charge