Maxwell Lectures at King's College London

Monday 2pm in Lucas Lecture Theatre S-2.18

Mo 19 Jan Jon Butterworth, Physics and Astronomy Department, University College London

<u>The LHC and the Higgs Boson: Smashing Physics</u>

The past few years have been an amazing time in particle physics. As the CERN Large Hadron Collider prepares to return for "Run 2" at even higher energy, I will talk about some of the things we learned from Run 1. This will include the discovery of the Higgs boson, how it was done, what it means, and also something about what it felt like to do science under the glare of public attention.

Mo 26 Jan Neal Graneau, Hydrodynamics Division, Applied Physics, Atomic Weapons Establishment, Aldermaston

<u>What would Maxwell have concluded if only he had a computer ?</u>

The history of physics had a dramatic half century between 1855 and 1905 and much of it centred on the birth, promotion and defence of the fledgling field theory of James Clerk Maxwell and its corresponding electromagnetic force laws that came to be known as the Lorentz force. The prediction and measurement of forces due to electric currents has always had an ambiguous nature due to the many historical conceptions of a “current element”, difficulties of defining velocity and the issue of divergence from Newton’s third law. There were several pre-Maxwellian, Newtonian force laws devised mainly by French and German scientists including Ampere and Weber and their predictions and underlying philosophy were subtly different from the laws we use today. Only in the last 50 years have we actually gained the experimental abilities to attempt to detect these divergent predictions. Maxwell appears to have resigned from King’s College in 1865 because he felt that at that time, there were no acceptable texts with which to teach the very important subject of electricity and magnetism and that his efforts would be best expended fully dedicated to the task of collating all known phenomena and reasonable theories in this area. His treatise was not only an exposition of his own ideas, but also an encyclopaedic account of a wide range of experiments and the contrasting and competing alternative concepts that made up the body of knowledge of electricity and magnetism in 1873. In his treatise, Maxwell recognized that some of the debates could simply not be resolved until new calculation techniques, namely what we now call “finite element analysis” had been developed to fully explore the ramifications of the French-German pre-Maxwellian theories and left it open which laws would ultimately prove to be most accurate. The English followers of Maxwell, namely Heaviside, Thompson, Fitzgerald, Lodge, Larmor and others however, were less willing to wait for the development of the computer and pressed for electromagnetic theory to be codified and taught in the Maxwellian form we know it today in which fields and currents are continuous and at least some problems could be solved in the pre-computer era. All contrasting, but equally valid theories were consequently and pro-actively written out of the textbooks. Recent application of finite element analysis to the pre-Maxwellian electrodynamics has now revealed that these laws describe transverse forces exactly as prescribed by the Lorentz law, but in addition lead to extra force components along the direction of current that leads to a more accurate description of many electromagnetic experiments including exploding wires and railguns. This talk will explore the history of the subject and conjecture how Maxwell may have decided on the most appropriate form of the electromagnetic force law if only he had a computer and possibly a 10 kiloamp power supply !

Mo 2 Feb Alvaro Blanco Montes, Instituto de Ciencia de Materiales de Madrid, ICMM-CSIC

<u>Photonic Materials or how to tame light</u>

2015 has been declared by the United Nations as The International Year of Light and Light Related Technologies, as if welcoming the *Photon Century.* Electrons will no longer be the universal elements in future technologies. *Optical communications Life Sciences and Health Care*, *Lighting and Displays*, *Security, etc* will benefit from the unique photon properties. These emerging technologies underline the enormous potential of this field: Novel materials and novel phenomena will bring novel devices to light from which society will benefit in the incoming 21st century.

Nanophotonics, the photonics technology at the nanoscale, has been evolving in the last decades in parallel with nanoelectronics. Current microelectronics, as we know nowadays, will in the near future see its potential limited by restrictions rooting in parameters such us size, dissipation, dimensionality, and so on. Several contingency plans are being invoked to face those difficulties (*spintronics, molecular electronics, quantum computing*, etc) and among them, nanophotonics, is trying to change the information carriers from electron to photons, with all the consequences it carries in, for example, *materials issues*. The key to the development of electronics in the second half the 20th century was the invention of devices based on silicon (electron semiconductors) and, among them, the transistor; in a similar manner, the new photonics technologies will require analogous semiconducting materials for photons with which to build the future photonic circuitry. In this heading, *photonic crystals* (PCs), materials capable of molding the flow of light, can be called to pave the way to 21st century technology. With them we can control *Light Emission, Light Propagation and Light Absorption* and by doing this, we try to tame light.

Mo 9 Feb Jonathan Leach, Institute of Photonics and Quantum Sciences, Heriot-Watt University

<u>Imaging at the speed of light</u>

How do you take images so fast that you can see light travelling through air? And how do you use the latest technology to look around corners and see objects hidden from view? These are the questions that we are looking to answer at Heriot-Watt University. Our research is focused on developing new strategies for imaging which allow us to see the world in a new perspective.

I will talk about our recent research using a very specialised camera with some very important features. The first is its sensitivity to single photons – each pixel is around ten times more sensitive than a human eye; the second is its speed – each pixel can be activated for just 67 picoseconds, that's more than a billion times faster than you or I can blink. The camera allows us to film at the speed of light – we can video pulses of light as they travel through air. One application of this technology is looking around corners to see objects hidden from view.

Mo 16 Feb – reading week

Mo 23 Feb Alex O'Connor, Senior policy manager, Physics Policy Centre, The Institute of Physics

How to change laws with physics

Physics knowledge and expertise are at the heart of the great challenges of our age - everything from climate change mitigation to supporting an aging population to ensuring international security - and physicists are involved at almost every level. So why does it sometimes seem as though the policies governments choose have so little basis in science?

To understand the roles that science and scientists play in influencing and developing policies we must first understand the wider landscape of government and the evolving role of scientific advice. The often conflicting pressures of politics and the limitations of evidence can make the equations complex, but fortunately we have a wealth of past successes and failures on which to base our approach.

Finally, the 2015 UK general election and spending round will soon be upon us; in times of budget cuts, what more can the physics community do to make the case for investing in science ?

Mo 2 Mar Carol Trager-Cowan, Department of Physics, University of Strathclyde

Nitrides – The Rainbow Material

While you can now buy LED based white lights in the supermarket, these are a fairly new 21st century lighting source.

I will tell the story of how the blue and hence the white LED was invented and how a young Japanese researcher, Shuji Nakamura, working for a small company, Nichia, did what the electronic giants could not do: produce an efficient blue LED. A green LED soon followed, now found in LED traffic lights; and a blue laser, now the basis of the blu-ray player. The blue LED together with a yellow phosphor is the basis of today's white LEDs; there is presently intense competitive research being undertaken world-wide to make these LEDs brighter, better and cheaper so that we may finally have an efficient, attractive and effective alternative to the tungsten filament light bulb.

Their future use for lighting in homes and offices will significantly reduce our energy consumption. Using LEDs for lighting will reduce the world's electricity bill for lighting by around 50%, and reduce CO2 emission by the order of 2000 million tonnes worldwide. Their potential impact was recognised in 2014 by the award of The Nobel Prize in Physics, it was awarded jointly to Isamu Akasaki, Hiroshi Amano and Shuji Nakamura "for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources".

Mo 9 Mar Philippa Browning, Jodrell Bank Centre for Astrophysics, University of Manchester

Solar flares - the most energetic explosions in the solar system

Solar flares are a rapid release of stored magnetic energy in the outer atmosphere of the Sun, the corona, resulting in emission across the electromagnetic spectrum. These events - the most energetic "explosions" in the solar system - are a manifestation of the fundamental physical process of magnetic reconnection, which is also important in many other astrophysical and laboratory plasmas. Flares have significant practical consequences as they can affect the Earth and our space environment, with a major space weather event triggered by a large flare now regarded as a serious national risk.

I will outline our current understanding of how energy is stored and released in solar flares, based on observations from space and theoretical modelling. There are many unanswered questions, such as explaining the origin of the large numbers of high-energy electrons and ions emitted in flares. Recently developed theoretical models of magnetic reconnection in unstable twisted magnetic fields or "flux ropes" shed new light on flare energy release and the acceleration of particles. Furthermore, it is likely that the high temperature of the solar corona itself - over 1 million degrees Kelvin - is a consequence of many small flare-like events. Hence, a better understanding of flares is providing new insights into the long-standing coronal heating problem. Finally, some implications for space weather will be presented.

Mo 16 Mar George Booth, Department of Physics, King's College London

Why is quantum mechanics so difficult?!

It has been said that if you say 'why?' more than once or twice about a feature of the physical world, you have to come face-to-face with quantum theory. Unfortunately, only rarely does this end well: There are only a few systems for which we can solve quantum mechanical problems exactly, and simulation of more complicated systems rapidly spirals into the impossible. While engineers can use computer-aided design to build planes with huge reliability, in physics, we still struggle to describe more than a few interacting particles in a quantum mechanical way. Why is this the case, and how is the research in King's hoping to redress this imbalance?

Mo 23 Mar – last week of semester, no Maxwell lecture