Titles and abstracts for Physics Across Disciplines event May 30, 2014

Speaker: Dr Mark Baxendale
Center for Condensed Matter and Materials Physics (CCMMP)
School of Physics and Astronomy, QMUL

Title: From Microelectronics to Cancer Therapy

Abstract :
Solid-state physics has contributed to the spectacular success of microelectronics, from the quantum theory of solids as the basis for contemporary silicon-based CMOS technology to the conceptualisation of qubits for the quantum computation of the future. In some senses, microelectronics is a perfect world: silicon can be made to a degree of order that is as good as anything else on Earth, circuits can be created through a top-down process with a degree of fidelity that is within one order of magnitude of that typical of a chemical reaction, and a transistor can be switched with just tens of electrons. Ultimately, the integrity of a circuit is determined by the natural fluctuations in the fabrication process and the stability by the thermal fluctuations created by local energy dissipation. To those schooled in this (almost) perfectly ordered world, the biosphere is a very different place: bottom-up, self-organised structures and non-equilibrium thermodynamics imposed by solar irradiation are the rule rather than the exception. I expect that most of those involved in what is now termed condensed matter physics has at some point asked themselves the question: What is the source of order in organisms? Schrdinger had a stab at the question in 1944 in his book What is Life? [1] Using the statistical and quantum physics of the time, he deduced that the carrier of genetic information must be an aperiodic crystal: ten years before Crick & Watson discovered the (aperiodic) double helix structure of DNA. Biologists might argue that physics has had nothing so say since then. The question for now is: Has physics got anything to say about the source of order on the microscopic scale in organisms? This talk explores the tools for thought required to address the question of self-organisation in complex far-from-equilibrium systems and illustrates usefulness of these concepts when considering cancer and cancer therapy as a physics problem [2].

[1] E. Schrödinger, What is Life? (Cambridge University Press, 1944)

[2] J. H. Grossman and S.E. McNeil, Nanotechnology in Cancer Medicine, Phys. Today 65, 8, 38 (2012)

Speaker: Dr. Adrian Bevan
Particle Physics Research Centre (PPRC)
School of Physics and Astronomy, QMUL

Title: How many particle physicists does it take to make a particle physics experiment?

Abstract: The question is not as stupid as it sounds at first, and is of course a pun on the gag: How many physicists does it take to change a lightbulb? The answer may be slightly surprising for some of you: not be as many as you think.

Particle physics has been in the zeitgeist for a number of years, especially with the start of the LHC in 2008 and the search for that ... particle aka the Higgs boson. I will talk about what it takes to make a particle physics experiment. Physicists mostly analyse the data, and so while a few are needed to understand what to build and why from the outset, a much more important component in the early development of a project comes from people with rather different skill sets: material scientists, engineers, computing experts, and one or two very organised people who can project manage a collaboration of people who are not directly under your line management.

To build an experiment that works we need an international collaboration of engineers, scientists, computing support staff, and quite a bit of funding. It all goes well then when we switch the experiment on we need technical experts working alongside a small army of particle physicists in order to study the fundamentals of nature. We also need large arrays of computing farms and hundreds of petabytes of storage space to store the data that will be created. When we finally switch the experiment off we need to find the engineers that helped build the experiment so that we can help take it apart for possible re-use somewhere else.

I will talk about the many faces of the design problem of a particle physics experiment and draw on examples from my current work on an upgrade of one of the detectors of the ATLAS experiment. In 2012 ATLAS was one of two experiments to discover the Higgs boson and an international effort is working toward replacing the heart of this monolithic system circa 2025, for a decade of precision studies of the Higgs boson.

Speaker : Prof. John Allen
School of Biological and Chemical Sciences (SBCS)
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Title: Coupling between information processing and redox chemistry in the emergence of life, photosynthesis, and free molecular oxygen

Abstract: Life is the harnessing of energy in such a way that the energy-harnessing device makes a copy of itself. Biological electron transfer harnesses energy and provides information on the external and internal environment. Redox regulatory systems connect electron carriers with DNA promoter binding sites, refined by natural selection to provide coupling between information processing and redox chemistry. A similar coupling must have been present in the Last Universal Common Ancestor (LUCA) of all life on Earth. Earths prominent signature of life is now a surface redox and thermodynamic disequilibrium that is maintained by solar radiation and converted into chemical potential during photosynthesis. A redox switch hypothesis predicts a novel, non-oxygen-evolving photosynthetic bacterium retaining genes for both type I and type II photochemical reaction centres. These genes are switched on and off in order to provide a versatile and flexible metabolism that allows the bacterium to grow either with or without hydrogen sulphide as its electron donor. This bacterium may have flourished prior to the origin of the oxygen-evolving cyanobacteria to which it gave rise, and its two modes of metabolism may have produced the laminar structure of ancient stromatolites. Expression of type I reaction centre genes in the presence of hydrogen sulphide was accompanied by silent type II reaction centre genes. Type II reaction centre genes were themselves induced under non-reducing conditions, when type I genes became repressed. Loss of redox regulatory control of gene expression allowed co-existence of type I and type II reaction centres, with complementary functions. In place of hydrogen sulphide, the type II centre, as photosystem II, oxidised manganese, and then water. At about 2.4 Gyr, electron transfer from water began to liberate free oxygen, changing Earths biology and surface geochemistry irreversibly.