Research Impact awards

The purpose of these awards is to celebrate success in publishing exciting scholarly work in high-quality publications.

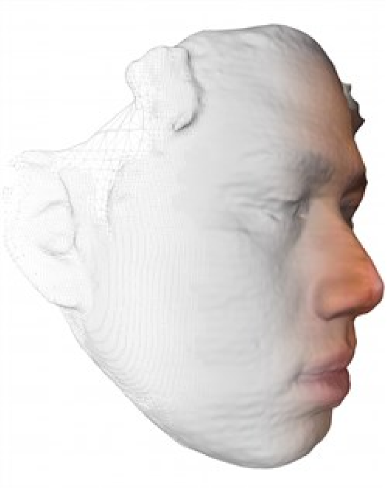
This award will go to a researcher (or group of researchers) who have published a high impact paper and should be spent towards the costs of attending a conference.

You can read about past winners below.

Open all sections

High resolution, low cost 3D imaging using patterned light (March 2013)

By **Dr Iain Styles (http://www.cs.bham.ac.uk/about/people/Iain%20Styles)** , School of Computer Science



The measurement and recording of the size of shape of three-dimensional objects is important in a wide variety of areas: from historical artefacts in archaeology through to surgical reconstruction. The rising popularity of 3D printing techniques is also driving considerable interest in accurate and cost-effective methods for obtaining this information.

The project, which was led by Dr Iain Styles and Dr Hamid Dehghani from the Medical Imaging research group in the School of Computer Science, together with Hector Basevi and James Guggenheim from the EPSRC-funded PSIBS (Physical Sciences of Imaging in the Biomedical Sciences) Doctoral Training Centre, originated from work on the design of an imaging system for diffuse optical imaging, a technique that is similar to X-ray Computed Tomography, but using infrared light instead of X-rays. Optical radiation is gaining increasing traction as a biological imaging technique as it is uniquely sensitive to the tissue's function through interactions with haemoglobin, lipids, and the tissue micro-structure which is largely invisible to X-ray radiation. This can give you information about, for example, activation in the brain's visual cortex in response to a visual stimulus, or about the inflammatory processes that occur in rheumatoid arthritis. However, unlike X-rays, light is strongly scattered in the tissue and it is much harder to compute the interior structure of the tissue from images of the propagation of light. In order to get the most accurate reconstruction of the tissue's interior, it is desirable to know as much as possible about the tissue in advance, including its exterior shape.

There are many existing techniques for measuring surface geometry, such as scanning laser-based techniques which are very accurate, but are time-consuming, expensive, and often require the subject to be rotated around for the scanning process. The Birmingham researchers wanted a system that was compact enough to be integrated into an existing imaging system with no moving parts, and of low-cost whilst retaining sufficient (sub-millimetre) accuracy. The new system is based on the use of patterned light which is projected onto an object using an off-the-shelf mini-projector. The patterns consist of repeating light and dark "fringes" which are deformed by the object, and the amount of deformation is a measure of the height of the object. By using a set of patterns with different fringe separation, a complete profile of the object can be reconstructed in just a few seconds.

A key feature of the new system is the use of a generalised optical model that removes many of the restrictions associated with existing techniques. This allows for the use of multiple cameras or strategically placed mirrors which can be treated as "virtual" cameras and is often much more convenient than having multiple real cameras. The minimal system consists of one camera and one projector (and costs no more than a few hundred pounds), but extra projectors, mirrors, and cameras can be added as required in order to maximise coverage of the object. Once a system has been constructed and calibrated (a simple, automated procedure), it is capable of measuring the surface of an object to within an accuracy of a few 10's of microns—small enough to measure, for example, the features on the surface of a two pence coin.

Although the idea was originally developed for medical imaging, there are many possible applications for the new technology. A 3D facial profiling system was recently taken to the Birmingham Thinktank and used to capture 3D profiles of the faces of several hundred rather excitable children as part of a meet-the-scientist event, and this has potential applications in computer games and biometrics. A UK patent application has been filed on the technology underpinning the new method, and the team are working with Alta Innovations on exploring and developing new areas.

The full paper is openly accessible at **www.opticsinfobase.org/oe/abstract.cfm?uri=oe-21-6-7222 (http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-21-6-7222)** .

Music of the stars: Asteroseismology, and exoplanets (February 2013)

By **Professor William Chaplin (http://www.birmingham.ac.uk/staff/profiles/physics/chaplin-william.aspx)** , Professor of Astrophysics

When you look up at the sky on a clear night do you ever ask yourself: how many of the twinkling stars have planets, like the planets orbiting our own Sun? And did you know that stars like the Sun ring, like musical instruments?

Thanks to the launch of the NASA *Kepler* Mission the past three years has seen dramatic progress in the study of other stellar systems in our galaxy, and scientists at Birmingham are playing a leading role in this exciting work. Kepler has been continuously monitoring the brightness of around 150,000 stars in our galaxy and has to date discovered over 2,000 candidate planets by the miniscule dimming of light from the stars as planets transit, or pass across, their visible faces. In order to properly understand the formation, the evolution over time, and the frequency of habitable systems like our own, we must not only find and measure the properties of small rocky planets, but also fully characterise the properties of their host stars. Kepler's exquisite data have revolutionized the study of stars, in particular thanks to the application of a powerful new technique called asteroseismology, the study of stars by observation of their natural resonances which manifest as surface oscillations.

Asteroseismology is a rapidly growing field of astronomy, and over 500 scientists are using Kepler data to study stars as part of the international Kepler Asteroseismic Science Consortium (KASC). Professor Chaplin has been leading the 200-strong part of the KASC which is responsible for the study of stars similar to our own Sun; and also a smaller team which has been working directly with the Kepler Mission's exoplanet Science Team to use asteroseismology to constrain the properties of stars that are newly discovered exoplanet hosts. Professor Elsworth and Dr Miglio lead international research using data from Kepler, and another space telescope called CoRoT, on studies of red giants, stars like the Sun nearing the end of their life cycles.

Star symphony

Stars resonate like musical instruments. Sound is made naturally in the outermost layers of Sun-like stars. This sound is trapped, with some sound waves penetrating all the way to the centres of the stars. The sound waves are able to reinforce to make the stars resonate at their natural frequencies, like waves inside a wind instrument. The compressions of the trapped sound makes the stars oscillate and we are able to detect this gentle breathing by observing small, periodic changes in brightness as stars get slightly hotter as they are compressed, and then cooler as they relax. By measuring the properties of the oscillations, we may use this "music of the spheres" to not only estimate the fundamental properties of the stars (e.g., size, mass and age, to level of precision and accuracy that cannot usually be reached in astrophysical observations) but we may also peel away their surface layers to probe the structure and dynamics of their normally hidden interiors.

When a planet is discovered by the transit method the tiny dip in the amount of light received from the star provides a measure only of the size of the planet *relative* to the star. Thanks to asteroseismology, we can measure the size of the star extremely precisely, allowing the size of the planet to be fixed with a high level of confidence.

The international team, led by Professor Chaplin, performed the stellar characterisation work of the planet-hosting star Kepler-37, which in turn led to confirmation of the extremely small size of one of its planets, as reported in 'A sub-Mercury-sized exoplanet' published in *Nature* (Volume 494, Issue 7438, pp. 452–454). The host star is smaller and cooler than the Sun, and hosts three planets. Because it is so small, one of the planets was barely detected by the Kepler space telescope.

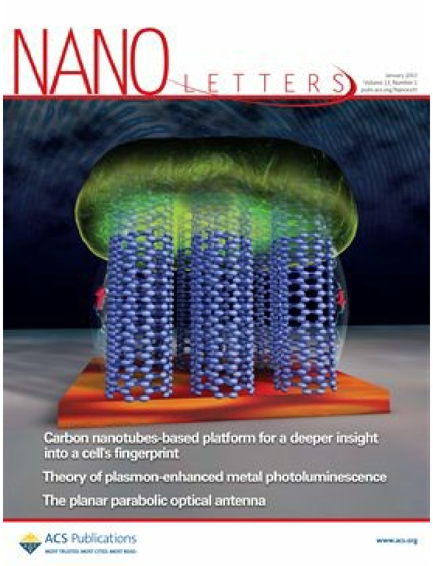
Thanks to asteroseismology, it was possible to measure the radius of the star to a level of uncertainty of just a few per cent; and only with those tight constraints was it then possible to say with some confidence that the tiny planet orbiting Kepler-37 has a radius that is smaller than Mercury, and not much larger than our Moon. This research shows for the first time that other stellar systems host planets smaller than anything in our solar system, providing further information for scientists working on the formation and evolution of planetary systems, and also helping to place our own solar system in a wider context.

*The Best Publication of the Month for February was awarded to Professors Bill Chaplin and Yvonne Elsworth and Dr Andrea Miglio, for the paper '**A sub-Mercury-sized exoplanet' published (http://www.nature.com/nature/journal/v494/n7438/full/nature11914.html?WT.ec_id=NATURE-20130228)** ' in* Nature *(Volume 494, Issue 7438, pp. 452–454).*

For staff: If you wish to learn more or apply for these awards, click **here (https://intranet.birmingham.ac.uk/eps/research-knowledge-transfer/awards/Research-awards.aspx)** .

Nanoelectrochemical communication with the inside of cells (January 2013)

By **Dr Paula Mendes (http://www.birmingham.ac.uk/staff/profiles/chemical-engineering/mendes-paula.aspx)** , School of Chemical Engineering



Technology for understanding the real-time molecular events occurring within cells that underpins their behaviour is currently lacking. Despite important developments, the biochemical processes in a cell can be only poorly quantified, limiting the ability to resolve the dynamic molecular processes that underlie important cell-fate decisions such as differentiation, cell division and cell death. The regulation of cell fate lies at the core of most aspects of cell biology from normal development to malignancy. Many human diseases, such as cancer, are caused by incorrect cell fate decisions. It is only by a detailed knowledge of how cells work, independently and together, in healthy and disease states that one will be capable of understanding and anticipating the onset and effects of disease, and therefore creating appropriate and effective means to prevent and treat disease.

In the last few years, research groups across the world have begun to focus their efforts towards development of various types of nanosensors in addressing this grand challenge. The technology has the potential to monitor spatial and temporal changes of cellular chemistry, which can shed new light on cell's function, as they sense on an equivalent molecular scale.

Mendes and her team, based in the School of Chemical Engineering, have reported in *Nano Letters* (2013. 13(1): p. 1–8) the first intracellular electrochemical sensor based on carbon nanotubes. The technology developed provides an alluring platform to monitor and determine the precise location of redox activities occurring within the cell and its importance to the field has been recognised by being selected to feature as a cover article.

Preventing and treating diseases

Electrochemical detection – monitoring electricity from a chemical reaction – inside the cells offers several advantages over conventional fluorescence measurements. It includes less expensive components with simple sample preparation steps, and of utmost importance, the capability of measuring quantities down to the zeptomole level – allowing detection of trace levels of electroactive species – in complex turbid environments. Electroactive species such as reactive oxygen species (ROS) play a dual role in biological systems since they are tightly involved in normal cell functions as well in the development of a wide variety of pathologies (e.g. atherosclerosis, cancer, sepsis). Despite this, there is a lack of understanding of the mechanisms by which ROS function in both normal physiological and disease states, hindering the rational design of new strategies for preventing and/or treating ROS-related diseases. In turn, using ROS sensing in future clinical settings will also provide invaluable information on the patients' disease progression and response to therapeutic agents.

Their electrochemical sensing platform was fabricated using indium tin oxide, which is the underlying conducting surface. The surface was modified with a molecular building block, acting as an anchor, allowing for the self-assembly of highly conductive vertically aligned carbon nanotubes (CNTs). The CNTs, which were shown to be approximately 60 nm in height, were further modified with DNA. The DNA modification allowed the CNTs to be naturally taken up by an immune cell - macrophage cell line. With CNTs having dimensions down to a few nanometers, these 3D nanostructured surfaces are unparalleled as high spatial resolution tools for cell biology.

The group is continuing their research on developing and exploiting the technology and are investigating, in collaboration with University of Plymouth, the ability to electrochemically delineate immune cell signalling induced by bacteria. The knowledge being generated from these studies has the potential to lead to new therapeutic targets and diagnostic sensing tools for point-of-care use. Furthermore, this emerging cell-nanosensor construct is providing a better understanding of the biochemistry that underpins an immune response.

Getting on the cover of Nano Letters is only the beginning for the Nanoengineering and Surface Chemistry team, as the research will lead to a new generation of single-cell assays with sensitivity to perturb and monitor diverse intracellular processes simultaneously. Platforms offering such capabilities will take us closer to the ultimate goal of mapping out and understanding at all levels the structure and function of a living cell.

You can read more about their work **here (http://www.birmingham.ac.uk/research/activity/chemical-engineering/energy-chemical/nanoengineering-surface-chemistry/index.aspx)** .

*The Best Publication of the Month for papers published in January was awarded to Dr Paula Mendes, School of Chemical Engineering, for her publication: '**Tailoring 3D Single-Walled Carbon Nanotubes Anchored to Indium Tin Oxide for Natural Cellular Uptake and Intracellular Sensing (http://pubs.acs.org/doi/full/10.1021/nl203780d)** ', published in* Nano Letters *13(2013)1.*

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