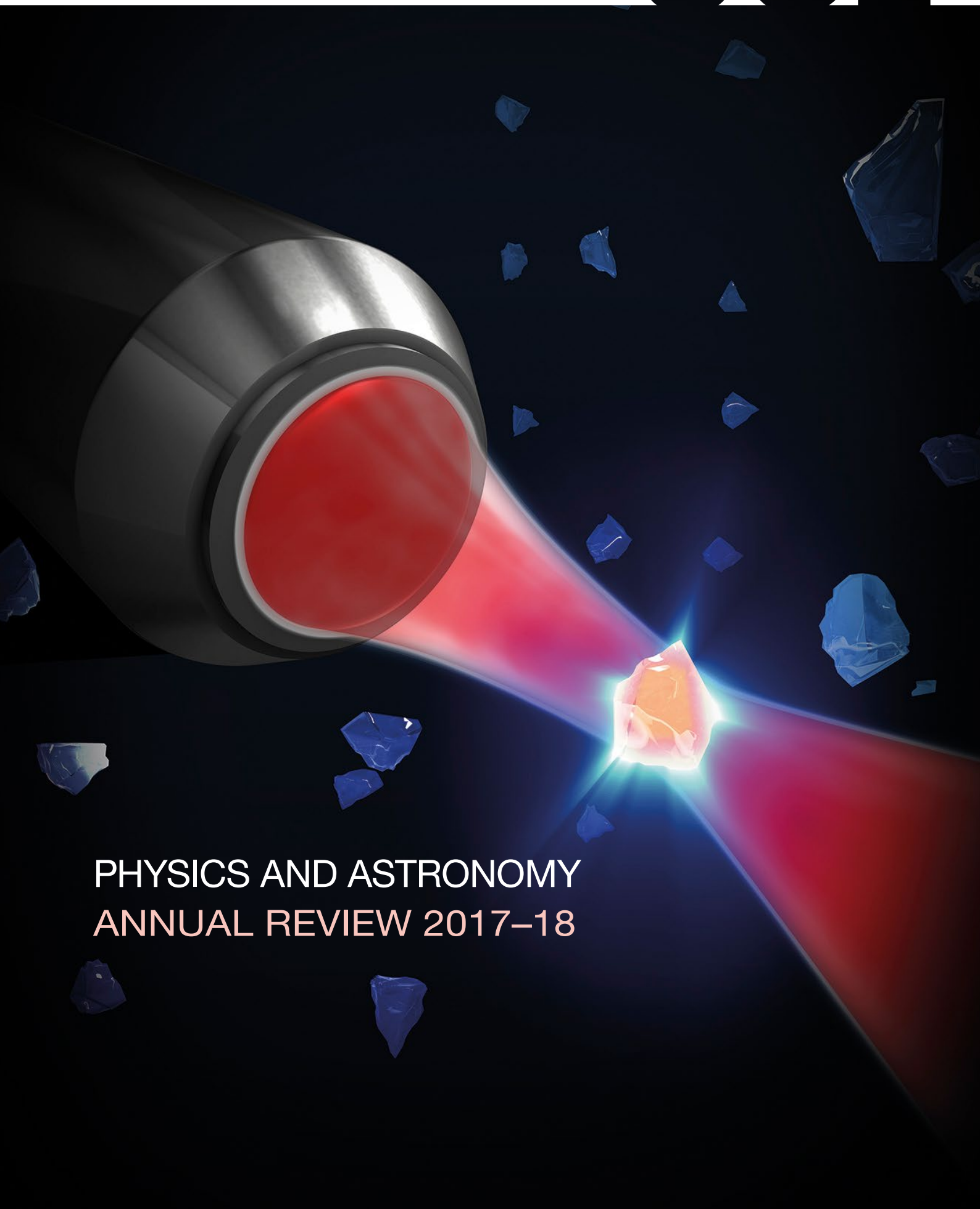
UCL DEPARTMENT OF PHYSICS AND ASTRONOMY

UCL



PHYSICS AND ASTRONOMY
ANNUAL REVIEW 2017–18

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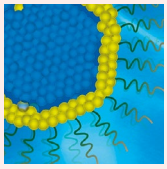

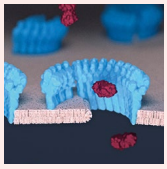

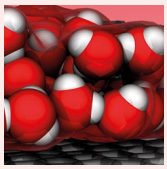

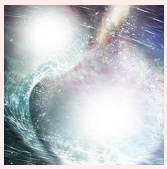

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Image backcover:
UCL Portico. **Credit: UCL Digital Media**

Review edited by **Bonita Carboo**, b.carboo@ucl.ac.uk

Welcome

Welcome to another annual review of UCL's Department of Physics and Astronomy.

Over the past year we have seen members of the department extend our knowledge of physics at the energy frontier, probe early galaxies, distant planets and exotic materials, devise new tests of quantum gravity, investigate the nature of dark matter and dark energy and fundamentals of quantum mechanics, develop new detectors for cancer therapy, and study the physics of life. We have seen the approval of ARIEL, a new ESA mission under UCL leadership to study planetary atmospheres beyond our solar system. We have inaugurated a new doctoral training centre in "Data Intensive Science", have grown our Biophysics group with three new appointments, and have continued to attract other outstanding staff including a number of European Research Council, UKRI and Royal Society research fellows. We have a new fellow of the Royal Society, who is also the first female particle physics FRS anywhere, ever.

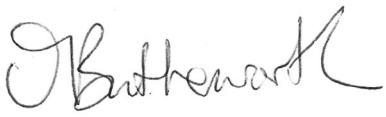
These are just a selection of the highlights. More details of some of these (with names!) and of still other achievements await your attention inside, and I will not detain you much longer. However, please bear with me a few more minutes.

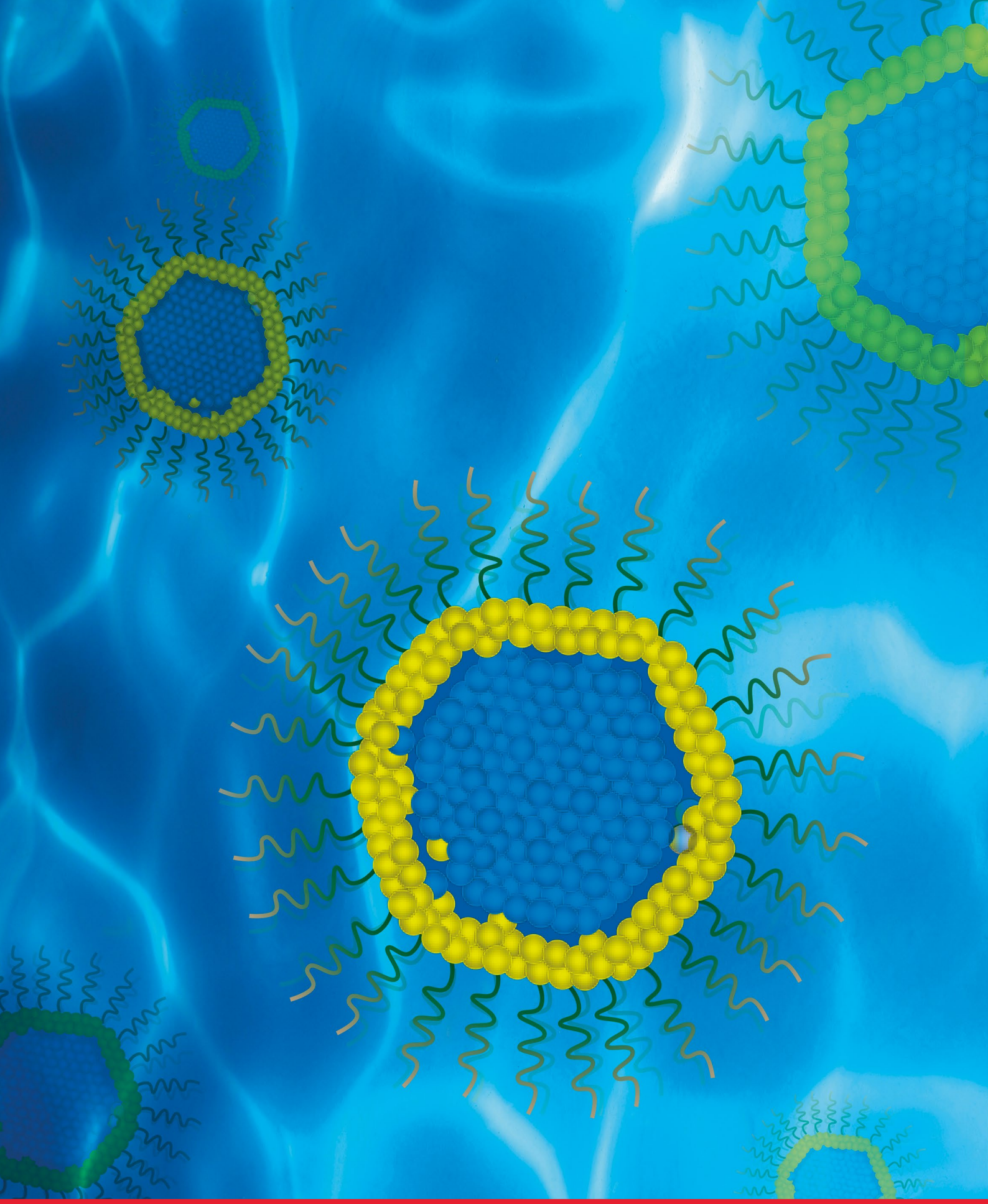
This is the last review I will introduce as Head of Department before handing the role over to Prof Raman Prinja in September.

It has been an honour and a privilege, and most of the time it has also been a pleasure, to lead the department for the past seven years. I am proud of what we have achieved over that time, and I believe I am handing over a department that is academically and educationally stronger and more confident than ever before, as well as being on a financially sound footing, continuing a long upward trend begun by my predecessors.

That success comes from the hard work and ability of staff and students, and supporting and encouraging that, as head of department, has been rewarding and exciting. It also requires trust and support from staff across the board: from professional services, technical staff, educators and researchers. I am immensely grateful for the support I have received over the past years, and I am very confident that Raman will receive the same. He, and all of us, will need it. While the department is indeed strong, there is always room for improvement and there are always new challenges around the corner to meet, as well as new physics to teach and learn. I wish Raman, and all of us, continued success!

Professor Jonathan Butterworth
Head of Department

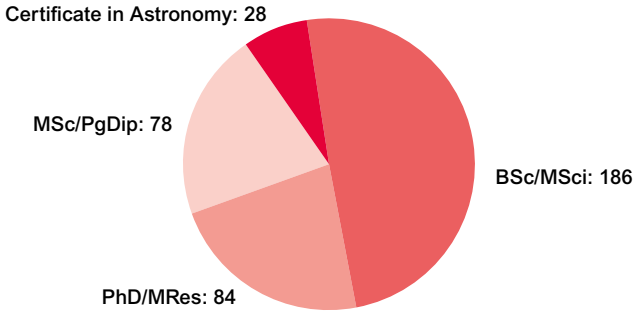




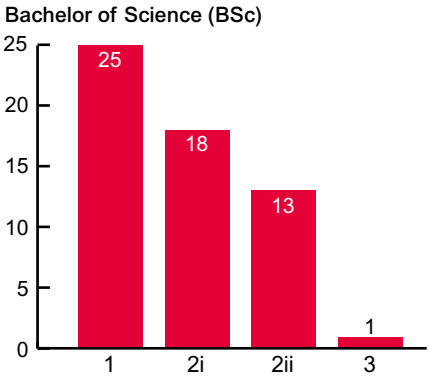
Community Focus

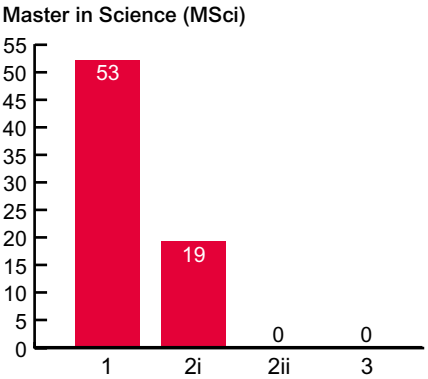
Teaching Lowdown

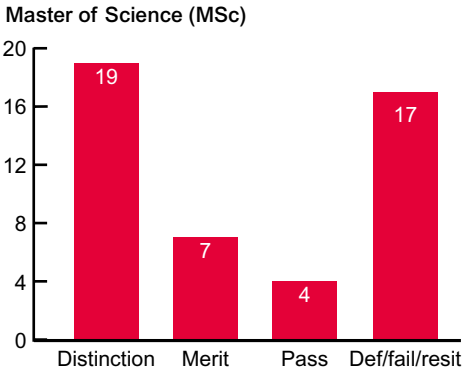
Intake

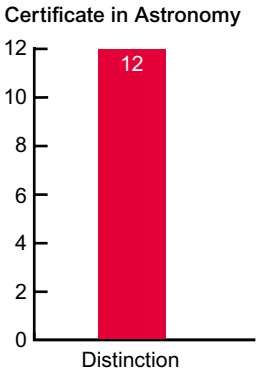


Awards









Teaching in the Physics and Astronomy Department

Among the teaching highlights this year, six students from the Department (Anusha Gupta, Lukas Kikuchi, Jakub Mrozek, Xiaoxi Song, Cameron Voisey and Kai Yip) were placed on the Dean's list, which commends outstanding academic performance by graduating students, equivalent to the top 5% of student achievement. Congratulations also to our recipients of UCL Education Awards, Daven Armoogum (whose "infectious enthusiasm, innovation & dedication to the student experience exemplifies the Connected Curriculum and makes Physics fun!") and Raman Prinja (for his "outstanding lifetime achievement and career contributions to student learning and education leadership"). The Department welcomed the first cohort to our Biological Physics MSc, and we are very pleased to note that our undergraduate degree programmes have been granted continued accreditation by the Institute of Physics.

Professor Neal Skipper

Headline Research

Study Sheds Light on What Triggers Bacterial Replication

What causes a rapidly growing bacterium to divide into two cells is a longstanding question. Studying bacteria in large numbers, researchers have learned that a growing population of bacteria doubles in mass at regular intervals. However, in a recent study published in the journal Nature Microbiology, Dr. Shiladitya Banerjee (BioP) working with collaborators at the University of Chicago found that single bacterial cells don't double in mass before dividing. Using a novel combination of imaging, microfluidics and mathematical modelling, Banerjee and coworkers discovered that bacterial cell division is a two-step process in which cells elongate for a fixed period of time, followed by a constant mass increment regardless of the cell's initial mass. Following this rule, a bacterial population quickly converges to a narrow size distribution. This new paradigm suggests unique targets for inhibiting bacterial growth and replication, raising hopes for new antibacterial drugs that can fight antibiotic resistant infections.

https://www.nature.com/articles/nmicrobiol2017116

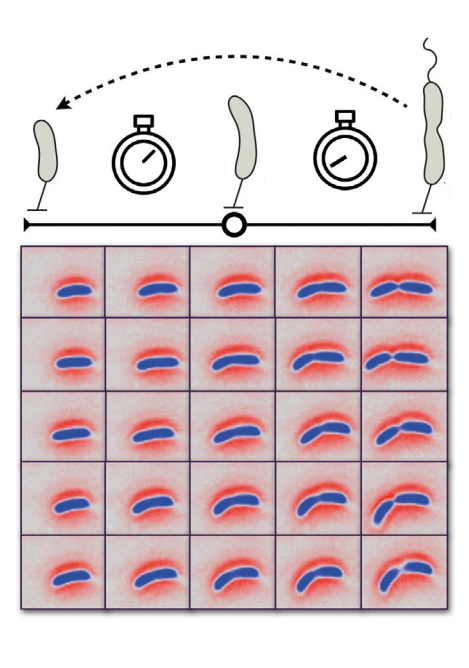


Illustration of bacterial growth and cell division.

Student Accolades

Undergraduate Awards

Departmental Awards

Oliver Lodge Prize
Best performance 1st year Physics
Mr James Puleston

Halley Prize
Best performance 1st year Astrophysics
Ms Sicen Guo

C.A.R. Tayler Prize
Best performance in Comm. Skills, based on 1st+2nd year
Mr Alexander Nico-Katz

Wood Prize
Best performance 2nd year Physics
Mr Guillermo Herrera Sanchez

Huggins Prize
Best performance 2nd year Astrophysics
Mr Roman Gerasimov

David Ponter Prize
Most improved performance 1st to 2nd year
Ms Khadeejah Jalil Bepari

Dr Sydney Corrigan Prize
Best performance in experimental 2nd year work – PHAS2440
Mr Guillermo Herrera Sanchez

Best Performance Prize
Third year Physics
Mr Amir Shamsubarov

Best Performance Prize
Third year Astrophysics
Ms Xiaoxi Song

Additional Sessional Prize for Merit
Best 4th year Physics project achieving a balance between theoretical and practical Physics
Mr William Franks

Burhop Prize
Best performance 4th year Physics
Mr Joe Read

Herschel Prize
Best performance 4th year Astrophysics
Mr Kai Hou Yip

Brian Duff Memorial Prize
Best 4th year project
Mr Liam Eloie

William Bragg Prize
Best overall undergraduate
Ms Xiaoxi Song

Tessella Prize for Software
Best use of software in final year (Astro) Physics project – Jointly awarded
Ms Dina Traykova and Mr Samuel Wright

Postgraduate Awards

Harrie Massey Prize
Best overall MSc student
Ahmed Al-Jawahiry

HEP Prize
Outstanding postgraduate physics research in HEP
Sally Shaw

Carey Foster Prize
Outstanding postgraduate physics research in AMOPP
Alec Owens

Marshall Stoneham Prize
Outstanding postgraduate physics research in CMMP (Jointly awarded)
Yasmine Al-Hamdani and James Vale

Jon Darius Memorial Prize
Outstanding postgraduate physics research in Astrophysics
Daniela Saadeh

BioP Prize
Outstanding postgraduate physics research in Biological Physics
Roger Moltó Pallarés

Physics and Astronomy prize winners 2016

Equality and Diversity Committee

This has been a particularly busy year for the Equality and Diversity committee. In November 2017 we were visited by a panel from the Institute of Physics Juno team to assess and advise on our progress towards renewal of Juno Champion award, for which we will be submitting in November 2018. The panel were particularly impressed by the department's commitment to Equality and Diversity at all levels, and have made a number of suggestions and recommendations which we are now in the process of implementing. Additionally, we have some "beacon" actions, designed to propagate good practice to other institutions, which we hope to use as part of a future Institute of Physics Juno Excellence proposal.

One of these "beacon" actions is our gender balance at undergraduate level. This continues to surpass the UK average, with nearly 26% of our 2017-18 first year intake being women, well above the UK average of 22%. This is maintained from the applications stage right through the selection and offers process. We're looking at ways we can further improve this, as well as analysing our admissions data to find ways of increasing our BME participation rate.

At present our gender balance at PhD level is rather lower than the national average, so we are putting effort into investigating the causes of this, and in addition we are looking at how we can improve our PhD admissions process to encourage more female applicants. This summer we'll also be running a survey of our current PhD students, following on from the 2016 survey, with the intention that these surveys will run every two years. Our 2017 staff survey revealed that overall the department is a very friendly place to work, and we hope that our Equality and Diversity initiatives will further enhance the community ethos within the department.

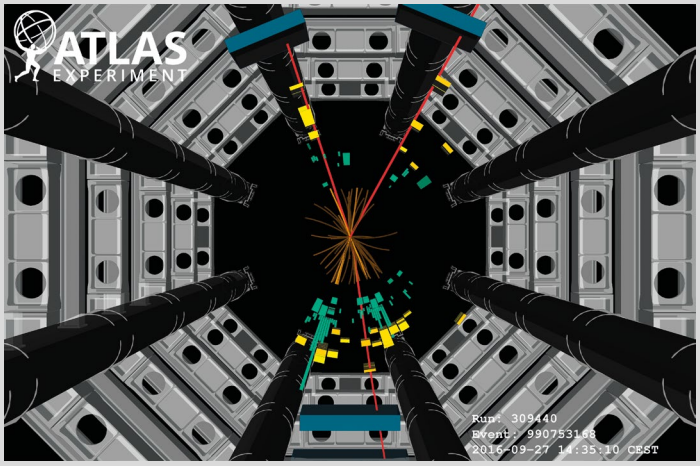
Dr Louise Dash
Chair of the E&D committee

Headline Research

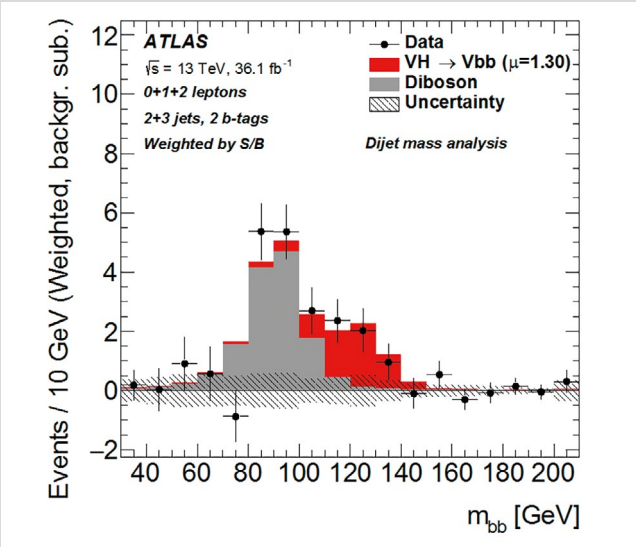
The Higgs Boson and Its Favourite Decay

The Higgs boson has been observed at the LHC via its decays to photons, tau-leptons, Z- and W-bosons. However, they only represent around 30% of the Higgs boson's decays and its favoured decay to a pair of b-quarks (H->bb), which happens around 58% of the time, has remained elusive. Observing this decay will fill in one of the big missing pieces of our knowledge of the Higgs boson.

The background processes that mimic this signal are large, complex and difficult to model. Ultimately what we are hoping to see is an excess of collision events over our background prediction (a bump) which appears at the mass of the Higgs boson. Dr Scanlon from the UCL HEP group has led the search for H->bb with the ATLAS detector. In 2017 ATLAS have published the first 3σ evidence for the process. Seeing H->bb is however only the beginning, as studying this new decay will open a whole new window onto the Higgs boson and perhaps also provide hints of new physics beyond our current theories.



An event display showing a H → bb candidate event.



A comparison of the excess of collision data (black points) over the background processes (which have been subtracted from the data), which clearly shows the H→bb decays (filled red area) and the well understood diboson Z→bb decay (grey area) used to validate the result.

Science in Action

Original Research By Young Twinkle Students (ORBYTS)

2017 saw the continuation and substantial expansion of the Original Research By Young Twinkle Scientists (ORBYTS) program, linked to the education branch of the Twinkle space mission. The focus of both the program and the mission is on the characterisation of exoplanet atmospheres. As a result, young PhD and post-doc scientists work with groups of secondary school students to perform original research associated with this exciting area of exoplanetary research.

ORBYTS was founded in 2016 by Dr Clara Sousa-Silva (who is currently working as a postdoc at MIT) with three pilot groups at one school involving a total of 15 students. This was expanded to 5 teams with 45 students from 8 different schools in the subsequent year (with Dr Laura McKemmish taking on the role of ORBYTS organiser), while the current 2017-18 cohort, lead by Dr Will Dunn, numbers 90 students from 12 schools. UCL has hosted a variety of exciting events for the ORBYTS students, including presenting their work to a range of academics and the chance to meet and ask questions to the first British astronaut Dr Helen Sharman!

In August 2017, UCL Physics and Astronomy hosted an ORBYTS summer school where 25 students learnt university level material and explored spectroscopic data on unusual diatomic molecules.

As well as a large increase in the number of tutors and students participating in the 2017-2018 cohort of ORBYTS teams, we have been joined by tutors from other universities across London and new projects have been introduced. This includes one on exoplanet transit observations, where the students research exoplanet systems that would be of interest to the Twinkle space mission and plan and arrange observations using the Faulkes telescope network, followed by analysing the data. Another new project is in identifying sulfur bearing molecules in star forming regions.

Previous projects on spectroscopic data, which have been successfully run since 2016 have been continued. Theses projects resulted in two scientific papers published in peer-reviewed journals last year using research from the 2016 pilot program, with the school students as co-authors. The papers considered the spectroscopy of titanium oxide and acetylene, both molecules expected to be abundant in particular exoplanetary atmospheres. Papers with results based on the 2017 program have been submitted for review. The team also published a science education article on the program, with a brief highlighted report in the Royal Astronomy Society's journal Astronomy and Geophysics. Further physics research papers are currently submitted or in preparation based on research results from other ORBYTS teams, and a graduation ceremony is planned to be held at UCL in July 2018 to give all the teams the chance to present their work to an audience including friends and family, senior academics, PhDs, postdocs and special guests.

Katy Chubb, William Dunn, and Laura McKemmish.

UCL tutors at the ORBYTS team event at UCL, Feb 2018
(left to right): Romain Mayer, Sian Brannan, Jon Holdship, Maria Niculescu-Duvaz

Students in Action

Women's Lunch

Professor Shastri speaking at a Women's Lunch

The Women's Lunch provides an informal and supportive atmosphere to discuss issues relating to women working in physics and astronomy. All genders are welcome, facilitating engagement across the wide range of research groups spanning astrophysics to high energy physics and many more. The founder of the women's lunch was Emily Milner in 2014, with Anna Ploszajski in charge from 2015 before I took over in 2017. Their legacy and the continued support from Professor Dorothy Duffy has created this unique platform where I've met more female scientists than during my entire PhD!

Meetings usually revolve around a topic varying from career progression, workplace professionalism and scientific networking. For example, engaging with members of the steering committees who contribute to the Juno and Athena SWAN award applications has allowed us to understand how to communicate with HR and distribute the results from staff/student surveys. No subject is off-limits and I am proud to be more aware of the various campaigns within the department relating to bullying, harassment, and mental health. Tea, coffee and cake kindly funded by the department help fuel this dialogue, with some lunches extending to 2 or 3 hours!

This year we have had some prominent guest speakers from outside the department. In July 2017 Professor Shastri Prajval from the Indian Institute of Astrophysics gave a talk about gender imbalance within science, breaking down the perceived reasons for this gap whilst using clear statistical evidence on which drivers still contribute to a lack of representation. With over 40 people in attendance this ignited a debate that is still being discussed to this day. In February 2018 we welcomed Dr. Leonie Mueck, Division Editor for Physical Sciences at the esteemed journal PLOS One, who discussed the ethos behind open-source publishing, her career experiences leaving academia to work for Nature publishing prior to PLOS One, and an inspirational post from PLOS One's CEO Alison Mudditt regarding the #MeToo movement.

In addition to the lunches, a newsletter summarising the minutes of each meeting is distributed to the mailing list, allowing dissemination of information and points of contact for further advice. This can be especially useful for navigating resources on funding or maternity rights but also a way for newcomers to find friends and a support network.

Ying Lia Li

Event Horizon

As this academic year is drawing to a close, the UCL Physics Society committee would first like to thank the department for their support throughout the year.

Here is a summary of our key events over the past few months, and we hope this will inspire the next batch of physicists to take this society to new heights.

Freshers week

Freshers week boasted a multitude of events from an escape room to challenge the freshers' intellect to a refreshing English breakfast, we made sure there was something for everyone! The biggest of all was Kick-Off, where teams were created and each team had to complete a wide variety of challenges across campus to find the location of the welcome party.

Fresher's week : The Escape Room

Spectrum lectures

The Spectrum lectures were a series of guest lectures with speakers spanning university professors to science writers with the objective to offer to our members a wider perspective of the recent developments in the world of physics. We had the pleasure to host a number of speakers including, Professor Jim Al-Khalili in a joint event with King's College London, Professor Jeff Forshaw from Manchester University, and Professor Mark Lancaster from UCL!

Winter Ball and Boat Party

In December and in January, we held our two biggest social events, respectively a winter ball and a boat party. It was the occasion for students from all years to dress up and enjoy an evening of meeting each other and relaxing.

Joint Undergraduate Research Conference

A joint research conference with Imperial College London was held in January, for the third year. The conference involved a series of talks given by a combination of PhD and undergraduate students from UCL and ICL who presented the research they have been undertaking.

Careers events

This was our first year having Careers and Sponsorships officers, who organised a series of events, with the major one being the "Careers Speed Dating". It provided an opportunity to interact and network with UCL alumni in a casual setting over a few drinks.

Spectrum lectures: Jim Al-Khalili

The Winter Ball

Trip to Cyprus

After La Palma in 2017, we decided to seek the sun out again and are heading for Cyprus this Easter! The trip will involve a visit to an observatory that works in conjunction with NASA and the ESA. We also intend to explore some of the main cities such as Paphos and Larnaca, hike up the mountains and recharge ourselves before the exams!

Trip to the National Physical Laboratory (NPL)

In June 2018, the society will be visiting the NPL. This will be an exciting opportunity to discover one of the most renowned physics laboratories in Europe and meet the scientists working there.

As the committee, it has been an absolute pleasure to serve our members, whom we would like to thank for expressing interest in our various events. We would like to wish the next committee the best of luck and we look forward to attending their events.

Marion Thomas
President

Jaime Ruiz-Zapatero
Academic Officer

and the 2017/18 committee

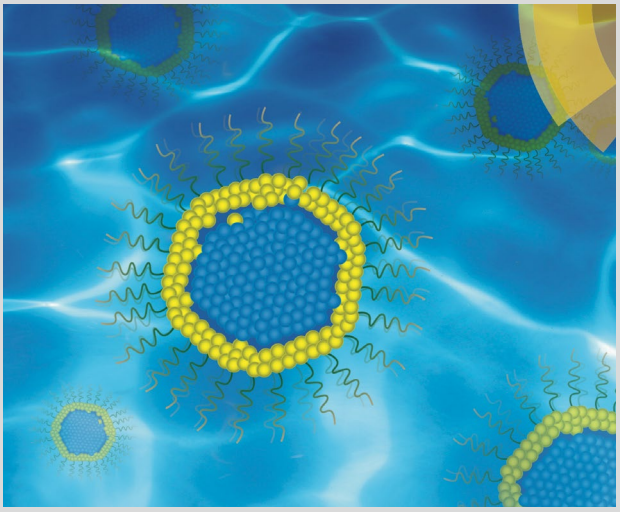
The Boat Party

Headline Research

Synthesising high-quality magnetic nanoparticles

High magnetisation nanoparticles are desired for a wide range of bio-medical applications such as magnetic separation, magnetic resonance imaging (MRI), surface enhanced Raman scattering (SERS) sensing and hyperthermia cancer treatment. Prof Thanh Nguyen's lab (BioP) synthesised such nanoparticles from a cobalt-iron alloy, which is known to exhibit the highest saturation magnetisation in its bulk form. To make these particles inert, they were prepared with a platinum shell. The resulting nanoparticles exhibited tuneable magnetic properties with a high saturation magnetisation value, even when exposed to air for several months. The nanoparticles were transferred into water by encapsulation with a hydrophilic material (poly(maleic-anhydride-alt-1-octadecene)). Thus prepared nanoparticles were found to be colloidally stable in water over a wide range of pH and salt concentrations. Published in the journal Nanoscale, the demonstrated method has opened a new approach in synthesising high magnetic moment nanoparticles with a biocompatible coating, with potential applications in bio-medical research and therapeutic approaches.

http://pubs.rsc.org/en/content/articlelanding/2017/nr/c6nr09325f#!divAbstract



Magnetic nanoparticles with biocompatible coating.

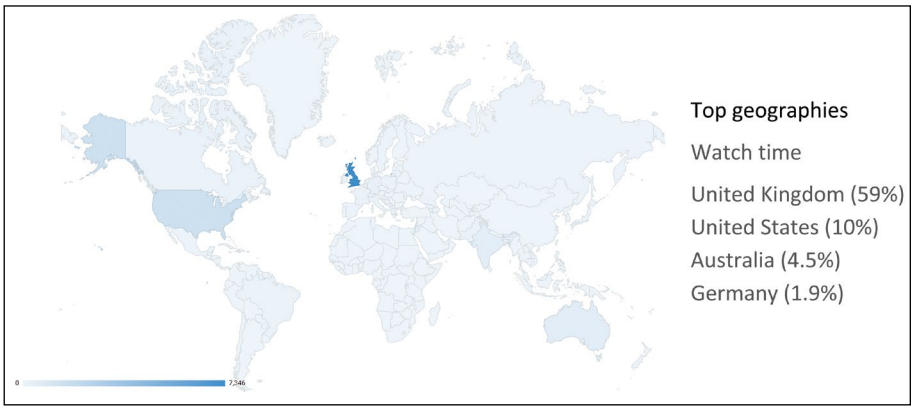
Phys FilmMakers

Physicist Laura McKemmish and Communications Specialist Rebecca Coates jointly devised the Physics Film Makers (PFM) concept in 2016. The idea was to connect Physicists and Film Makers to produce high quality short films about research carried out in the department. UCL strongly supports these arrangements under the Connected Curriculum programme and provides funding for them. PFM connects students and researchers, promotes workplace learning and produces a tangible output that is shared both internally and with a wider public audience.

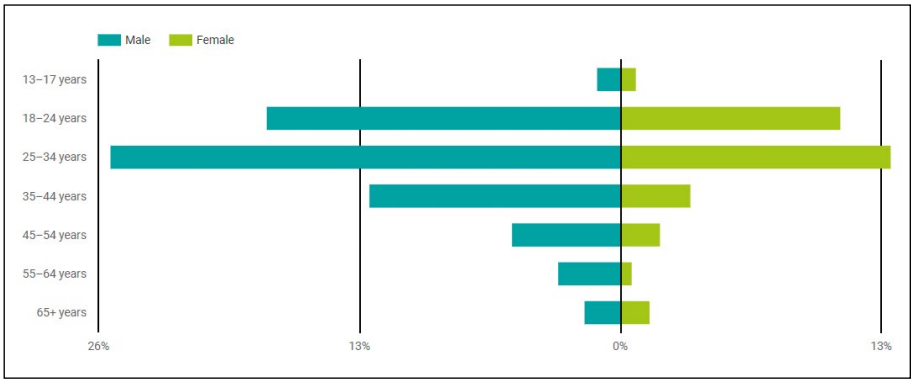
Short educational videos are quickly becoming a powerful tool for learning. They serve as inspiration and generate engagement with both the subject and setting. The success of YouTube and online learning services such as Lynda.com demonstrates this. Films produced by the PFM have been uploaded to YouTube (just search for Phys Film Makers). They serve to educate, inform and showcase the research undertaken at UCL to viewers across the globe informing viewers of research conducted in the department in an engaging way that can be understood by viewers without a background in physics.

Connected Curriculum funded several Film Making Courses for both undergraduate and postgraduate students in 2016 and 2017. So far, two voluntary courses for undergraduates and one for PhD students have been successfully executed. A summer programme funded by UCL Access Initiatives and Widening Participation was run in 2017.

A total of 22 videos have been produced and uploaded to the FPM YouTube page covering topics from fusion to qbits. Because students have produced the videos, the style appeals to fellow students, prospective students and others in the target age group. 4,704 views have been recorded to date totalling 11,505 minutes of watch time. Views come from all over the world with the UK, United States, Australia, India and Germany topping the list. 18-24 year old viewers are well represented with a slight skew towards male viewers in this age range.



Watch time by country



Views by age group and gender

2017 Summer school participants

We have secured funding for another PFM summer programme in July 2018 to improve access and outcomes for under-represented groups. We will accommodate twenty students from under-represented groups and the course will be run in partnership with the Physics Department Summer School. This not only allows for the sharing of resources but also increases the exposure of both sets of students to each other's work.

Although funding for film making equipment has been sourced specifically for the Phys Film Makers Programme, the equipment has been made available to undergraduate and postgraduate students as well as research groups who would like to make their own films. The equipment and skills learnt thus becomes a shared departmental resource at the end of the course and benefits everyone.

This year we have collaborated with IMOTION MEDIA, a commercial production house that produces high quality films for the education sector. Dishad Husain, Director and past UCL student, has agreed to loan us some professional equipment and staff to teach the students how to use it.

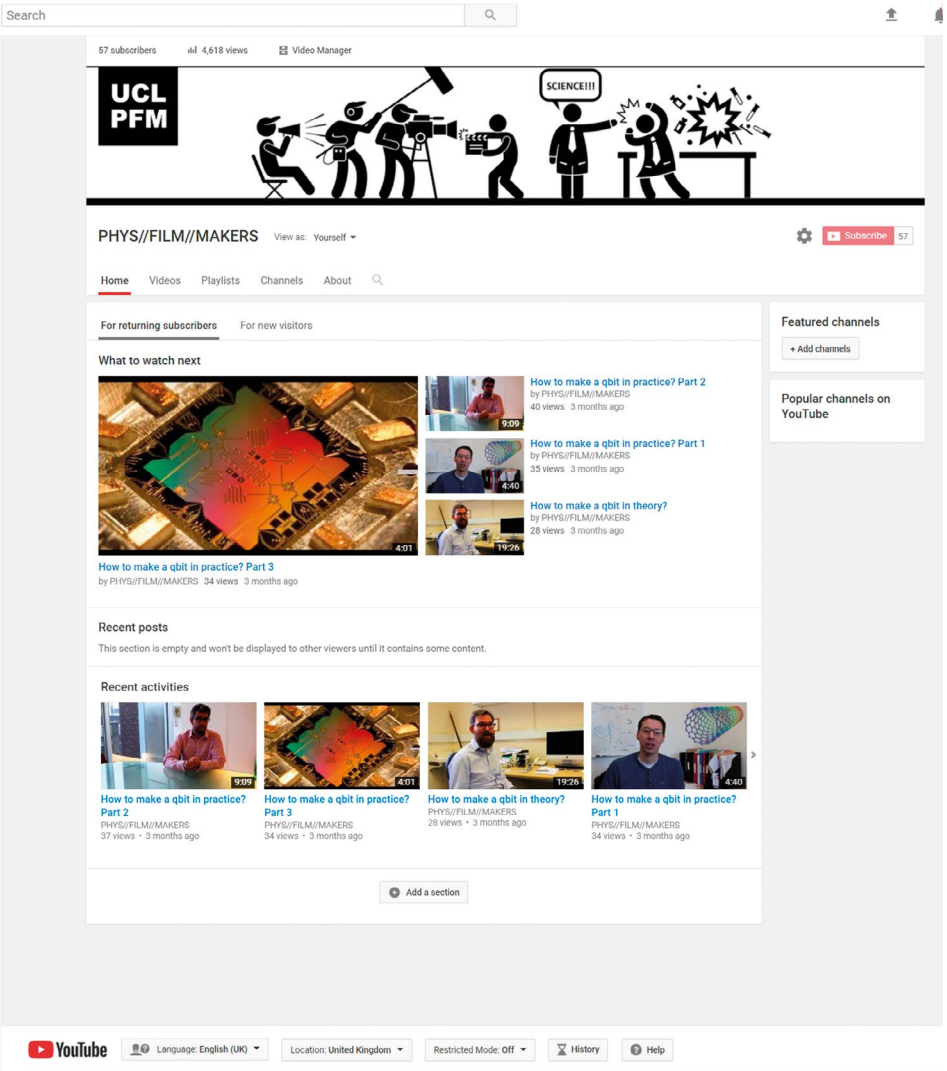
As we continue to get funding to invest in more film making equipment, the quality of our product will improve. This year we plan to acquire a further two cameras to improve the experience of the students as well as to be able to accommodate a larger cohort. As we expand, we have an ever-increasing opportunity to affect the lives of students, promote learning, collaboration within our department and spread knowledge and understanding of Physics across the globe.

Kelvin Vine
PFM Coordinator

PFM participants hard at work filming in Lab 2

PFM participants hard at work editing videos

Screenshot from a PFM Summer School film demonstrating plasma



The PFM YouTube page

Physics Postgraduate Committee

It's a busy life for PhD students in the Physics and Astronomy department. Between supervisor meetings, writing code, tweaking experiments, reading papers and arguing with our office mates over the best place for a coffee in UCL (obviously the Bartlett building), do we ever find time to venture out of the office?

Over the last year, as in previous years, the Postgraduate Physics Committee has aimed to provide a space for students across all disciplines in the Physics and Astronomy department to meet, share ideas, relax and create a sense of community amongst postgraduates.

As well as our continuing series of postgraduate talks given by students in the department on their own research and other projects, the committee has organised quiz and puzzle nights, picnics, and invited guest speakers from outside UCL to share their knowledge with us. At each event, a few drinks, pizza and most of all the company of our fellow students has created an atmosphere where we can get to know one another and find out what's happening in the corridors beyond our own small enclosures. As well as having fun, the conversation tends to be stimulating and interesting for all those in attendance.

As well as this, 2017's Hackathon, a two day event where PhD students are put into groups to competitively tackle various hardware and software related problems in a mad dash of technological prowess, innovation and copious amounts of coffee, was a resounding success. Groups came up with everything from robotic arms that could assist immobilised patients to artificial intelligence that could predict political affiliation from Twitter data.

It also gave students an important chance to liaise with contacts from industry and push beyond the limits of our everyday research, as well as making connections with those we may not otherwise meet.

This year's Hackathon is also currently being organised and promises to deliver another frantic yet fun two days of competition and hacks from our participants in the pursuit of prizes and the recognition of our peers.

All in all, it has been a busy but productive year for the Postgraduate Committee and we hope to deliver much the same and more in the coming year.

Ricky Nathvani
on behalf of The Postgraduate Physics Committee

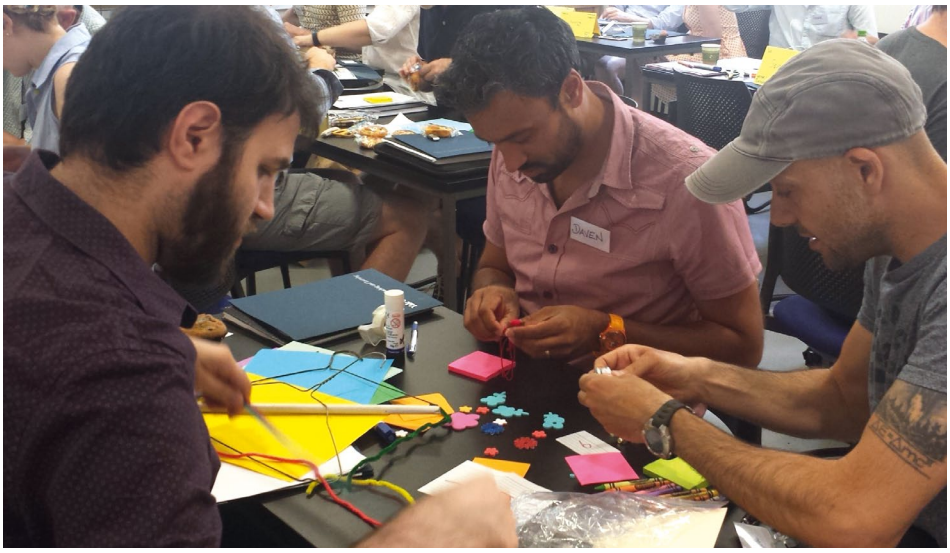
Teaching Fellows

Organised locally by Elinor Bailey, Jasvir Bhamrah and Louise Dash and delivered by academics from the universities of Yale, Harvard and Delaware, UCL held their first Summer Institute on Scientific Teaching in June 2017 with over 30 attendees from Physics and MAPS.

The workshop covered scientific teaching principles of active learning, assessment, and inclusive teaching. Participants spent three very full days on reflective writing, planning, researching, discussing teaching methods and philosophy, interactive presentations, and developing teaching materials.

By the end, we had observed, evaluated, and collected a portfolio of innovative teaching approaches and instructional materials, ready to apply them to our own teaching environments. Armed with evidence-based knowledge, we aim to contribute to national STEM education initiatives and disseminate our teaching efforts and research through publications. An initiative launched by Raman Prinja, the Summer Institute was part funded by the UCL Global Engagement Fund.

Jasvir Bhamrah
Teaching Fellow



Drs Mozzafari, Armoogum and Nicolaou take part in Yale's Summer Institute workshop exercise designed to highlight the challenges faced by students with different resource levels.

UCL's first Summer Institute on Scientific Teaching

Outreach

Outreach Efforts

The Department of Physics and Astronomy is continuing to reach out to schools and communities with the appointment of a Dr Mark Fuller as Outreach Coordinator and Ogden Science Officer in November. He is keen to enhance the opportunities given to young people from a diverse range of backgrounds and help boost the understanding of physics with links back to everyday context.

Key to this strategy is setting up long term relationships with schools and UCL, increasing how teachers, parents and pupils feel about physics and their own identity within the subject. When we put people into regular contact with an actual Physicist at UCL it demystifies the study of Physics and hopefully inspires a whole new generation to take up the opportunity to study with us.

Our current Undergraduates and Postgraduate students are vital to this effort, as Ambassadors and Mentors to school pupils of all ages (who truly benefit from talking to real people, not that much older than they, involved in Physics). Maintaining this contact via letters to and from the class, "Ask a Physicist" email communication and follow up visits both to and from UCL and the Mill Hill Observatory.

Our students at UCL gain from the experience too, being able to communicate their passion and knowledge to others is a key skill that will serve them in later life. If we could convince a few of them to become future school teachers, even better, with programs like the Teach Physics Internships from the Ogden Trust and the Institute of Physics Teacher Training Scholarships, offering funding and support to aspiring teachers from our Undergraduate and Postgraduate ranks.

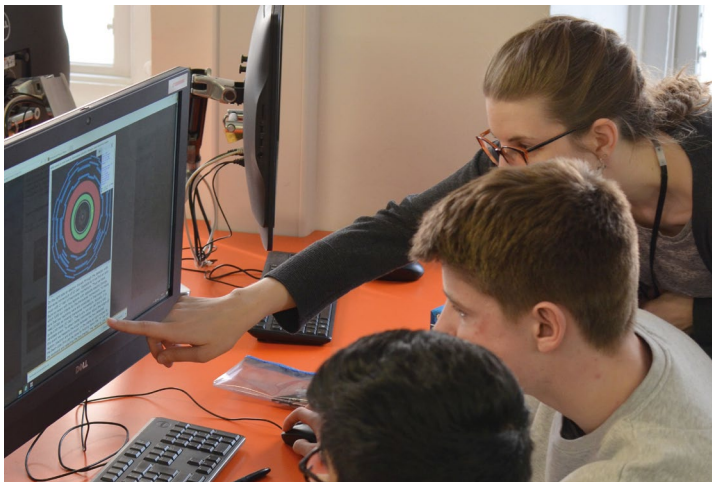
Starting young is important too, we want to work with primary school children and teachers, so that they can learn what makes Physics special. In association with the Ogden Trust we offer continuing professional development for specialist and non-specialists teaching physics. Supporting them within a network of fellow teachers, placing them in touch with the cutting edge research that happens inside the department and maintaining their passion for the subject so that they like us can continue to inspire future generations.

CASE STUDY

On the 23rd Jan 2018 a team of our 1st Year Undergraduates known as NeutriKnow, arranged a special event for pupils as part of their Developing Effective Communication Module. The team arranged three activities to stretch and entertain the pupils of King Solomon High School with great success. Feedback was fantastic and our students hope to run more activities for school soon.

CASE STUDY

Born out of the Physics and Astronomy department, the hackingScience collaboration aims to end barriers to science by addressing inequities derived from the intersections of race, class and gender through student-centred learning that encourages independent research amongst young people fuelling their curiosity about the universe.



CASE STUDY

Our Year 12 Particle Physics Masterclass has continued from strength to strength. This year an additional session coinciding with International Day of Women and Girls in Science was held on 12th February alongside another event on the 28th March. Pupils get an opportunity to experience short talks by research physicists, discussion sessions and hands-on activities, culminating in a video conference led by scientists at CERN.

On 15th May, UCL Mullard Space Science Laboratory organised a secondary schools event to celebrate UNESCO's International Day of Light. The event was sponsored by Nature Communications as well as Nature, the international journal of science, and was attended by 240 Year 7 and 8 students.

Organisers Professor Lucie Green (UCL Mullard Space Science Laboratory) and Dr Will Dunn (UCL Physics & Astronomy) were joined by a cross-disciplinary team for a series of mini lectures including Professor Andrea Sella (UCL Chemistry), [photograph below].

The day had the opportunity for pupils to get hands on with demonstrations of all aspects of light and the electromagnetic spectrum.

Dr Will Dunn said, "*We wanted to show just how diverse our scientists and engineers are. Giving school students the opportunity to really interact with the people carrying out the research, and giving them the chance to have a go themselves, is a great way to have a lasting positive impact.*"

Mark Fuller
Outreach Co-ordinator and Ogden Science Officer

Your Universe, the UCL festival of astronomy and particle physics

This annual outreach festival is the UCL legacy of the International Year of Astronomy 2009, which celebrated the 400th anniversary of the invention of the astronomical telescope.

The festival is provided free of charge to school groups and to the general public.

The format takes advantage of the specific environments offered by the UCL Bloomsbury campus. After several years, the format has evolved and currently covers four venues: the south cloisters, the garden room, the front quad and the Gustave Tuck lecture theatre. The dates are chosen as the Thursday, Friday and Saturday closest to a first quarter moon in the early spring, when the moon is best placed in the evening sky for telescope observing. Weekdays are for school groups and Saturday is for general public.

The 13th edition of Your Universe took place on March 22, 23 and 24, 2018. In this occasion the exhibits were:

South cloisters (open spaces): Time line of the Universe, cosmology, telescope optics, TWINKLE exo planet mission, lives of stars (includes Velcro HR diagram), the Large Hadron Collider, ATLAS detector and use of robotic telescopes.

Garden room (dark environment): presentations on the northern lights, the magic planet and extra solar planets.

Exhibits are usually conceived, implemented and presented by undergraduate and postgraduate students from the Department of Physics and Astronomy. Each presentation lasts for 10 to 15 minutes, so audiences of 12 to 15 people can visit all exhibits in a couple of hours.

Front Quad: we had portable telescopes available to look at the Sun and Venus during the day and the Moon during the evening, but this year the sky was cloudy.

In the evenings, we had lectures and panel discussions in the Gustave Tuck lecture theatre.

On Thursday the 22nd, our friend Alom Shaha presented a few imaginative physics experiments that can be done at home, to a family audience.

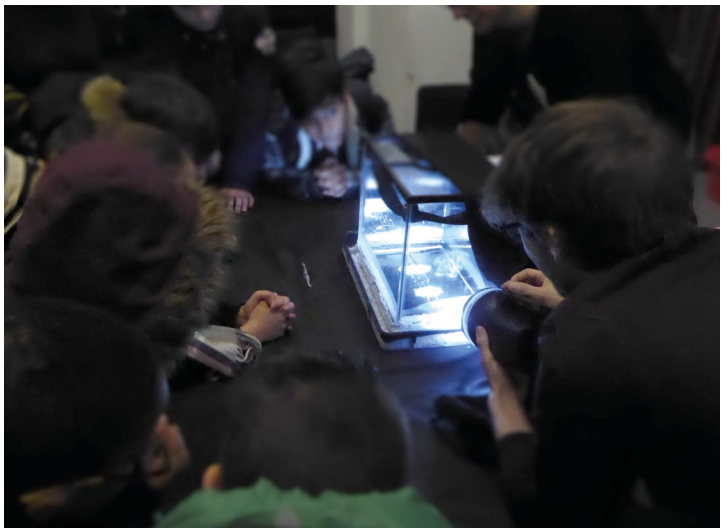
On Friday the 23rd we had a panel discussion on the relevant topic of gravitational waves, with invited panellists Laura Nutall (LIGO, Cardiff), Prof Nils Andersson (Gravity group in Southampton) and Prof Ofer Lahav (Cosmology group at UCL).

On Saturday 24th we have another panel discussion on the Cassini and Juno missions to the giant planets, with Katie Grocott (UCL alumna), Richard Molineux (UCL alumnus) and Prof Nick Achilleos.

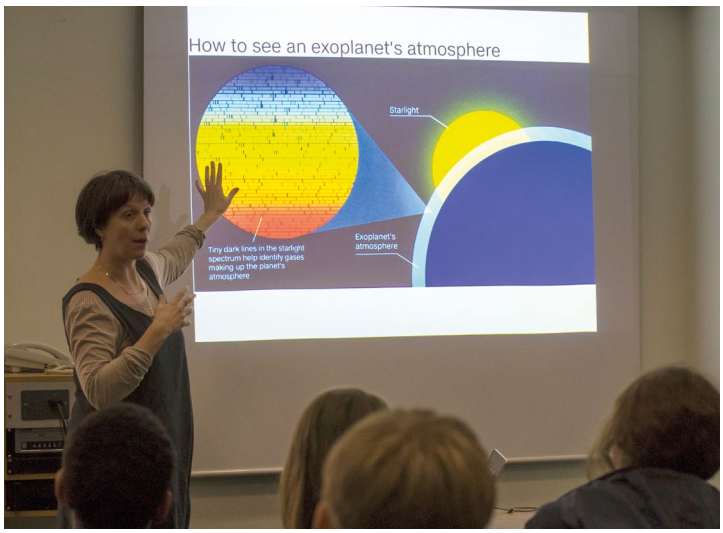
This year, most of our demonstrators were mature students and alumni from the UCL Certificate of Higher Education in Astronomy.

The festival is now a UCL outreach flagship. Total audience numbers are above 7,000 and their feedback is extremely positive. In addition, our student demonstrators have a unique opportunity to develop their public speaking skills (in addition to a modest financial reward).

Francisco Diego,
Senior Teaching Fellow




The Dark Side of the Universe
Dark Matter
Dark Energy


How to see an exoplanet's atmosphere
Starlight
Tiny dark lines in the starlight spectrum help identify gases making up the planet's atmosphere
Exoplanet's atmosphere

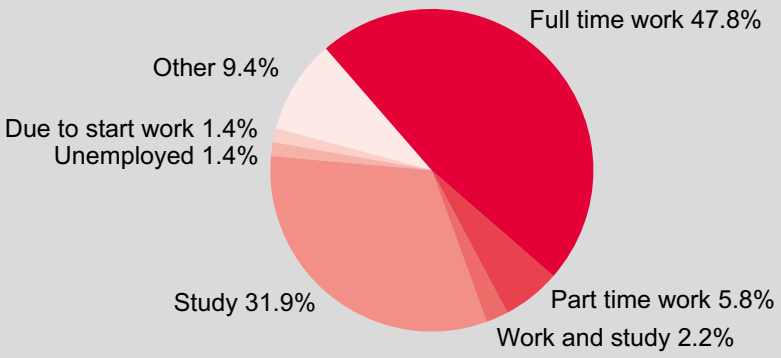
Career Profiles

Graduate Destinations

Total Number of Graduates: 180

Response Rate: 77.22%

Median Salary: £32,000
(full time employment)



The data is for the 2016 graduating cohort, for all students

Alex Rutherford

"…I have set up a social enterprise called Data Apparel which seeks to combine data, visualisation and fashion to promote empathy with vulnerable populations."

I recall quite vividly the moment that I submitted my beautifully bound PhD thesis to the UCL registry on a rainy day back in 2008. This was the culmination of a lot of hard work and as it turned out, would be my last Physics project. That might seem an odd sentiment for an alumnus article, but my PhD has proved to be a wonderful springboard into working for the UN Headquarters in New York and entrepreneurship.

Between 2005-08 I studied radiation damage in fusion reactor materials. I spent long days thinking very hard about how to model complex processes in computer code and make sense of huge sets of numbers. As much as I enjoyed this, I had many interests outside of Physics from travelling, current affairs, Arabic language classes in the evening and volunteer work with the UCL Volunteering Service. These twin interests positioned me well to join the United Nations Secretariat as a data scientist to work on analysing novel data sources to help the UN provide assistance after natural disasters and provide better services.

More recently I have set up a social enterprise called Data Apparel which seeks to combine data, visualisation and fashion to promote empathy with vulnerable populations. Our clothing represents data about our world in order to spark a conversation about inequality and development and makes ethical gifts. The line from computational physics to fashion was not obvious, but if I can trace it then you can too!

Ben Cooper

Putting the Science into Data Science

"Experimental HEP is about rigorously applying the scientific method to make precise measurements of quantum processes in challenging conditions."

From an early age I felt drawn to science and research. My grandfather was a successful physicist, and my parents both biochemists who, through homemade demonstrations, showed me how rewarding it could be to understand the natural world through experiment. I don't remember exactly when it was that I decided physics would be my science of choice, but I was young, and I wanted to get close to the fundamentals of how the physical world worked.

After completing a degree in Physics with Astrophysics at the University of Bristol, I was lucky enough to be offered the chance to study for a PhD in the High Energy Physics (HEP) group at UCL. Working with the largest and most complex experiments mankind has constructed, searching for answers to the most fundamental questions in science – I felt hugely privileged. Experimental HEP is about rigorously applying the scientific method to make precise measurements of quantum processes in challenging conditions, sifting through enormous datasets to find that needle-in-a-haystack. I was lucky enough to do this in what was then, as now, one of the strongest HEP research groups in the country.

These are hard times for building an academic research career, with permanent positions being ever harder to come by. However, students who undertake PhDs in data intensive sciences like HEP can be sure that, should they chose to, they will leave academia with skills that are highly valued by employers in today's increasingly data-driven world. I am now a Data Scientist at TfL, applying the skills in big data analysis that I acquired in my PhD to try and improve the reliability of London's transport system. Plenty of people understand how to handle big data, but businesses are crying out for researchers who can put the science into Data Science. My PhD at UCL has given me the foundations to build a new career, and hopefully make a real difference to the lives of Londoners.

Daniel Burgarth

"In all beginnings dwells a magic force" ("Stufen", Hermann Hesse)

"It was fascinating to connect blue-sky research with practical applications"

After graduating in the south-west of Germany I knew that I wanted a bit of an adventure, a new challenge, perhaps study abroad. I still remember the tingling in my stomach when I saw the advertisement of a PhD position with Prof. Sougato Bose: I recognized his name from my final year project. London calling! I felt a connection and instinctively applied. A few weeks later, a phone call (yes, this was before the age of Skype!), and all was sorted: I was going to move to the UK! To be honest, I hadn't heard of UCL then (lucky coincidence that it turned out to be one of the top universities…). I was scared of living in London. And I'd never met my supervisor in person.

I arrived on the first of April. Was I a fool to do this? The transition from a small town to the big city wasn't easy. The new subject was unfamiliar. But Sougato guided me, and he inspired me. My decision to come to UCL was not a rational one, and perhaps that is why I had deep trust and felt this kind of "magic force" that Hesse speaks about in his poem. The goal of the PhD was to bring together established results from condensed matter physics with the emerging field of quantum technology. It was fascinating to connect blue-sky research with practical applications, and I quickly started publishing, visiting conferences and building up collaborations.

It was the start of an academic career in the UK: after a few years of postdoc at Oxford and Imperial I took a permanent position as a Reader at Aberystwyth University. Now the transition from the big city to a small town wasn't easy, but then I get to swim with dolphins in the summer! I now have my own PhD students and try to pass on some of Sougato's rich intuition and inspiration onto them.

Peter Reid

And what has a physics degree done for me?

Peter Reid and Mike Charlton

> "Physics teaches how to build a model that represents the world and allows you to predict and extrapolate to the unknown."

At first glance, nothing! I've had a very varied and unpredictable career since leaving UCL (1978) going through systems analyst/programmer, sales director then managing director of an engineering firm (which I sold), start and then sell a metal finishing firm, start an automotive security firm and finally (is it finally?) start four different not-for-profits each focussed on helping scientific R&D have more (and more positive) impact on society.

So no physics then… and doing six start-ups might imply that physics makes you unemployable, but…

Physics teaches how to build a model that represents the world and allows you to predict and extrapolate to the unknown. While models must make useful predictions, there are limits to how far you can extrapolate from what you know to what you wished you knew and understanding a model's fundamental assumptions is crucial. Above all, physics teaches that you must be more sensitive to where evidence denies your model than where it confirms it.

It is hard to think of a better approach to any entrepreneurial opportunity than this model-driven process. Decisions are made using models that challenge existing assumptions and "best practice" while the evidence base is a mixture of hard fact, implied fact and supposition. Entrepreneurship is a genuinely empirical science driven by skills taught in 2nd year quantum mechanics ... without some of the vector and probabilistic maths.

and… there's another parallel.

To become a leading academic scientist (I'm thinking of Mike) you need to create a vision for future research, inspire colleagues to risk their careers by devoting years to delivering it, access resources formally (grants) and informally (borrowed from others) that are essential to the research, build networks with external groups to partner on a vast range of promotion, funding and community building activities. Change a few words and you have defined an entrepreneurial leader!

So, on reflection the answer to "What has physics done for me?" is perhaps "Given me a really exciting career based on key analytical skills developed during three fun years in Gower Street".

By the way, how can you not be excited by imagining that space/time is like a fluid and the Big Bang was perhaps a phase change (condensation) where space/time quanta took a form where space and time suddenly have meaning… physics is so much fun!

Mike Charlton

And what has a physics degree done for me?

Well… I am a physicist and physics has helped to define my life. Coming to UCL in 1975 was a turning point for me. Just over five years after arriving, I already had a PhD, and was launched onto an academic and research career in which I am still avidly engaged. In all, I stayed at UCL for 24 wonderful and fruitful years, before leaving in 1999 for a Chair in Experimental Physics at Swansea University: a position I still occupy.

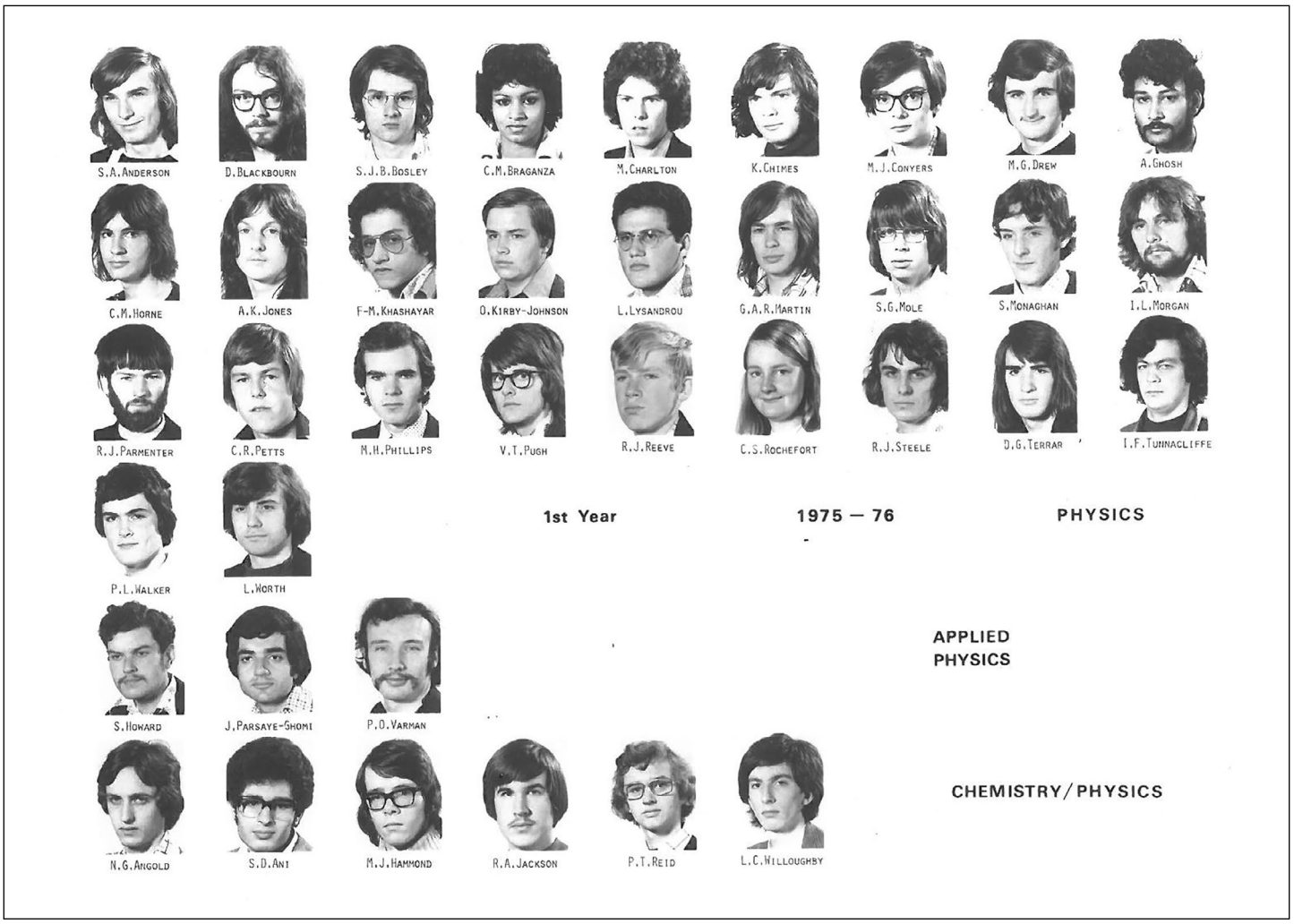
My PhD research was in the then very young field of physics with low energy positron beams, an activity still very important at UCL. By the mid-1980s we were alerted to the existence of a unique facility at the European Particle Physics Laboratory, CERN, which produced low energy antiprotons. The possibility that the antiparticles could be combined to create antihydrogen, the simplest anti-atom, was irresistible, and we began to contribute to this nascent area.

Thirty years on, and the dreams we had at the start are beginning to come true. Now antihydrogen is routinely made and stored for many hours (in a kind of magnetic bottle). Once held, its atomic structure can be interrogated using microwaves or lasers, and with the latter the ALPHA collaboration* has recently reached parts in a thousandth of a billion in its quest to compare antihydrogen and hydrogen to test some of the fundamental symmetries of nature. These are my research highlights, and they are achievements of which I am immensely proud.

Over the years chatting with Peter about my progress from being a post-doc to a Vice President of the Learned Society of Wales, and from junior researcher to starting a major research collaboration, has so often revealed parallels between our apparently divergent careers: career physicist and serial entrepreneur. For both one needs to innovate on many levels, have the self-belief to push on through bleak periods and build and fund your enterprise.

I have been fortunate that with research success, I was able to grow our team at Swansea, and we have made many crucial contributions to ALPHA's success. A particular pleasure has been watching my younger colleagues develop and flourish – and it all started at UCL Physics.

* See **http://alpha.web.cern.ch/**



Jason Ward

Favourite quote:

"In the field of discovery, chance only favours the prepared mind."

When I was 11 years old I had written a long project simply entitled "Energy". It was a reflection of the deep-seated curiosity that is the constant driver through life to understand how things work.

A crucial moment happened as a final year Cambridge undergraduate. I was doing a short data analysis project on old bubble chamber pictures. I was thrilled to realise first hand what data can say, and how much it demands care and skill to interpret properly. Professor Andy Parker, now Head of the Cavendish in Cambridge, himself a UCL PhD alumnus, pointed me towards the UCL High Energy Physics group to do a PhD.

I came to UCL in 1992 and was catapulted into the world of CERN and international scientific collaborations. I joined the OPAL experiment, one of the detectors at the Large Electron Positron (LEP) collider, and studied data from photon-photon collisions under the supervision of Professor David J. Miller. It was a challenging measurement, rewarded with many lessons carried forward.

From 1996-2002 I held two postdoctoral positions, including a CERN fellowship, both involving the ALEPH experiment at LEP. These were amazing years doing what was, at the time, the most precise measurement of the mass of the W Boson. It was the measurement du jour, because it helped constrain how heavy the Higgs Boson was expected to be.

I since disappeared into the world of quantitative hedge funds for a long time. That period was notable for the role it played in honing my ability to work with data in a business setting, long before "Data Science" emerged as a job title.

I am now a Principal Data Scientist at Valtech, an international consultancy business. One of the highlights so far was being involved with the Office of National Statistics, with a direct contribution to data analytical work recently incorporated in the production of GDP figures.

Doing the PhD at UCL was a way I could express what I love doing, and an amazing opportunity that profoundly shaped the rest of my career.

Connected Curriculum

The Connected Curriculum initiative advocates a research-led approach to the way that UCL students learn. Here I report on more exciting Connected Curriculum developments in our Gower Street teaching laboratories.

This year we have embarked upon a radical renovation of our interferometer experiment in Lab 2. The timing for this upgrade is apt, given the public interest in physics generated by the detection of gravitational waves using laser interferometry.

Rather than using bespoke and inflexible teaching equipment, some Year 2 undergraduates had the opportunity to build their own interferometers using research grade optics and opto-mechanics. Students conducting "Experiment X1" had to assemble their experiment upon optical breadboards identical to those found in many of our department's research labs.

With the only written guidance coming from technical manuals rather than prescriptive scripts, the importance of a clear contemporaneous account was never higher to these Year 2 pioneers, who learnt vital research skills in the process.

Converting the optics darkroom into a research-style environment offers a tantalizing glimpse into the future of the teaching labs. An optical breadboard approach offers tremendous flexibility and potential for many new experiments – watch this space…

Finally, an update: last year I wrote about a student-led project to introduce Biological Physics into our experimental roster, trialled successfully with eight students. One of those students (Guillermo Herrera Sanchez) went on to spend 10 weeks at the LCN within Prof Hoogenboom's BioPhysics group on a Wellcome Trust research bursary, modelling pathways of nanopore assembly by bacterial toxins and immune effectors. With the procurement of additional kit, many more of our students can now conduct the Biological Physics investigation in Lab 2 and perhaps, like Guillermo, discover a passion for research.

Dr Daven Armoogum
Senior Teaching Fellow

Thoughts from year 2 students

"Building an interferometer was the most exciting thing I have done this year. An important concept in physics came to life when we were given the opportunity to create and work on an interferometer ourselves."

Elizabeth Pasatembou

"Experiment X1 was undoubtedly the highlight of my second year and a great introduction to the world of optics. Not being restricted by a lab script was like a breath of fresh air."

Konstantinos Konstantinou

"Building our own interferometer made us feel like we were undertaking real research. Having such an experience relatively early in the degree has left me feeling well prepared for Lab 3 and beyond, eager to investigate similar open-ended experiments."

Kumail Kermalli

"X1 was extremely good and realistic training for what lies ahead. It was also very exciting to use high-tech equipment trying to recreate a fundamental Physics experiment. It's what most of us come to uni for!"

Ali Arslan

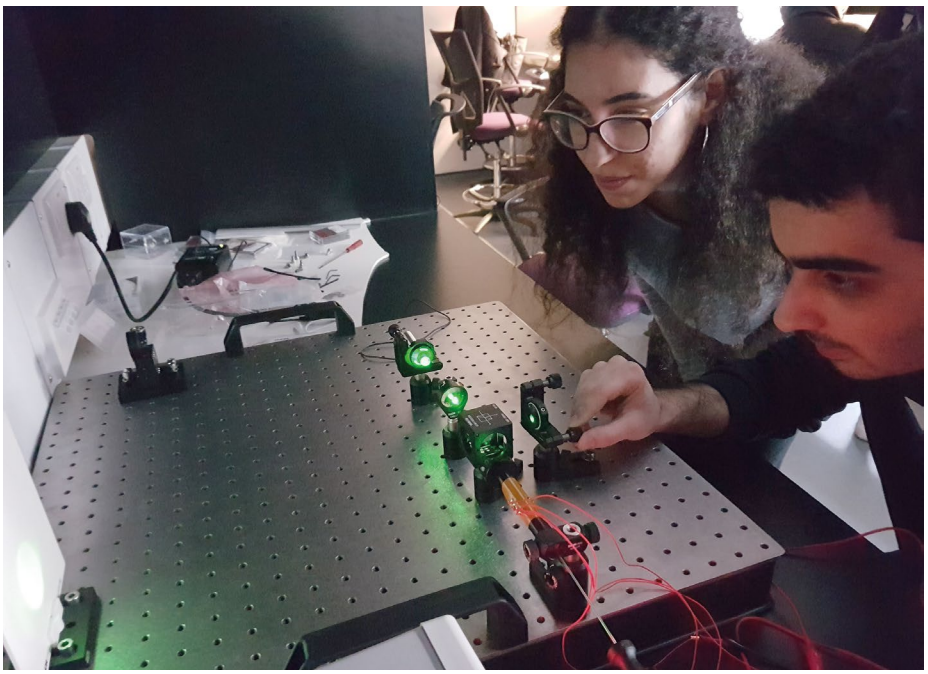
"Doing the X1 experiment was the most fun I've had in labs whilst at UCL. It felt a lot closer to what I imagine real life research to be like. Whilst this meant it was more challenging, it allowed me to develop a variety of skills that will come in extremely handy for my third year project - and my future after UCL!"

George Horner

Thoughts from research staff:

"The new interferometer experiment in Teaching Lab 2 gives students a superb opportunity to learn essential scientific skills using the same state-of-the-art equipment as found in many of the research laboratories in the Atomic, Molecular, Optical and Positron Physics group. It's great that second year undergraduates are getting the chance to acquire practical expertise more commonly associated with postgraduate study and research."

Prof Peter Barker
Head of AMOPP Group



Having assembled an interferometer from scratch, Year 2 students Elizabeth Pasatembou and Konstantinos Konstantinou investigate thermal expansion in an aluminium rod.

Alumni Matters

The Physics and Astronomy Gala Dinner aims to bring together our alumni, students and staff for a celebration. The 2017–18 programme of events on 20 October 2017 began with our Annual Physics Lecture at 4.15pm which was followed by a Drinks Reception before moving to the Ambassadors Hotel in Bloomsbury for the evening. The Gala Dinner was well attended by Alumni, members of staff, prize winners, benefactors, members of the undergraduate UCL Physics Society, and guests.

Dr Alexandra Olaya-Castro gave the Annual Physics & Astronomy Lecture, Alexandra is a member of the department's Atomic, Molecular, Optical and Positron Physics (AMOPP) group. The title of her lecture was 'Bridging Quantum Science and Biology', and she discussed the remarkable theoretical and experimental advances in quantum science which allow us to predict, quantify and probe "quantumness" in a variety of atomic, solid state, and optical scenarios. Technological advances enable us to zoom into the biological world, down to the biomolecular scale to investigate the domain where quantum phenomena cannot be neglected. The dialog between Quatum Science and Biology, at times full of scepticism, has given strength to the field of quantum effects in biology. She discussed how this field is helping to draw a sophisticated picture of fundamental processes in biology such as photosynthesis. The insight promises to open avenues to transform life processes on Earth by understanding and modifying them at the quantum level. It was an exciting and engaging lecture which was much appreciated.

We would like to thank Dishad Husain (Imotion Media), an Alumnus who volunteered to film Alexandra's lecture. The lecture and question & answer session can be viewed on the Physics and Astronomy website. One positive comment from a viewer is: 'It is fantastic for Colombians to watch an academy presentation led by a woman. This means the beginning of science awareness we expect in our Colombian citizens. I feel proud.'

The Gala Dinner opened with welcome drinks. Jon Butterworth and Neal Skipper then went on to present the awards to the prize winners. The after-dinner speech was given by Dr Gillian Peach, Emeritus Reader in Physics, who completed her PhD in Theoretical Physics in 1961. Professor Jenny Thomas was the guest of honour, in celebration of her election in 2017 as a Fellow of the Royal Society.

Professor Jenny Thomas

We are very excited to announce that the after-dinner speaker at the 2018 Gala Dinner to be held on 19 October will be Professor Mark Thomson, Executive Chair of the Science and Technology Funding Council, STFC. Mark Thomson is Professor of Experimental Particle Physics at the University of Cambridge, and was spokesperson of the DUNE neutrino collaboration until taking over at STFC. His main research interests are in electron-positron collider physics, neutrino physics and the development of novel and powerful reconstruction techniques for cutting edge detector technologies. In addition to his research activities, he is the author of "Modern Particle Physics", which is a major new undergraduate textbook covering all areas of contemporary particle physics. In the 1990s he was a postdoc at UCL working on the OPAL experiment with David Miller.

The 2018 Annual Physics & Astronomy Lecture will be given by Professor Giovanna Tinetti, leader of the ARIEL mission to study the atmosphere of planets beyond our Solar System and a member of the department's Astrophysics group. The title of her lecture is: "A chemical survey of planets in our galaxy".

Stan Zochowski is the new Alumni relations head for 2018–19, you can contact Stan directly: **s.zochowski@ucl.ac.uk** if you have any comments/suggestions.

Observatory News

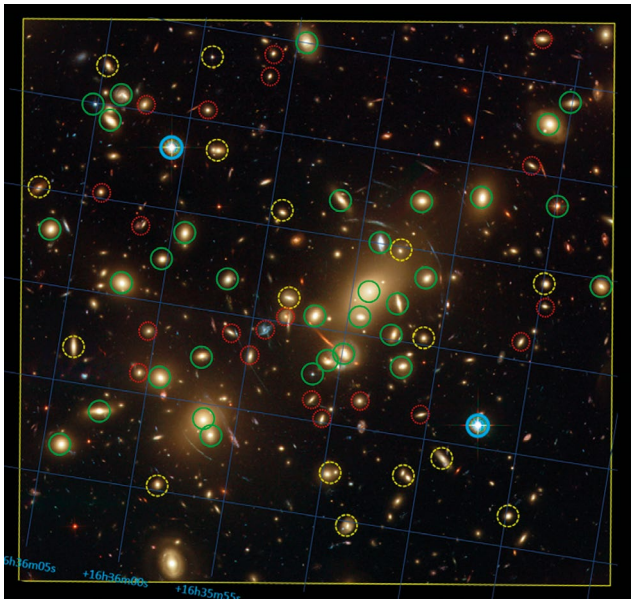
Research while learning at the UCL Observatory…

At the UCL Observatory in Mill Hill we have kept in the tradition of training students by teaching astronomical observation techniques with a variety of skills necessary to engage with ongoing research. At UCLO, students apply the computing techniques learnt in class to astronomical problems as well as acquiring new and state-of-the-art tools to analyse images, reduce data and perform statistical analysis of the objects of interest. Students make use of the observatory in different fashion every year and by Year 3 they have the necessary knowledge and skills to submit telescope observations which can contribute to ongoing observation campaigns in a variety of fields such as: exo-planet characterization, fast-rotating stars, trans-Neptunian objects, near-Earth objects and supernova follow-up. Our digital archives allow students to add their observations to a wealth of existing data (as well as connecting to publicly available image databases), which have been used in recent years by students and staff to perform authentic scientific discoveries[1,2].

Deep Sky Observing from London

As Director of the Observatory I am often asked about the observing capabilities of an observatory placed within the M25, which I myself was sceptical about when I first joined UCL. However, the power of methodical observations and integration never fails to amaze me, witnessing the images that students and staff acquire on a daily basis.

In particular, we have looked at some recent data taken by one of our Astronomy Certificate students, to create our own "deep field" to pair with an existing Hubble Space Telescope deep field (that of the Cluster of Galaxies, Abell 2218). Professor Richard Ellis of UCL, using HST, identified in 2004 what was then the most distant known galaxy in the Universe[3], lensed by this cluster. The cluster field can be seen in the two images on the right. The multi-coloured picture from HST above is the result of hours of integration from the 2.4 metre telescope in space in three different colour filters. We compare the details of the inner field with the result of a 3.5 hour observation of one of our two robotic C14s (~35cm) from Mill Hill in a wide band clear filter below.



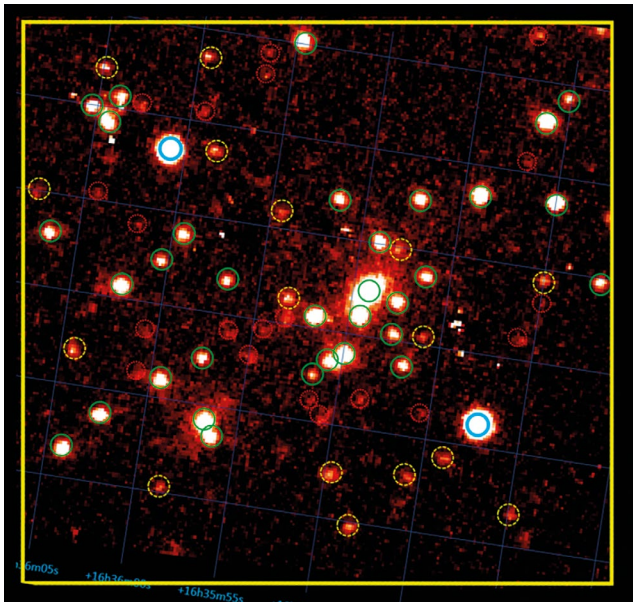


Figure: The layout of all the galaxies in the cluster can be seen (aided with circles placed around common sources). We compare our high, medium and low (but detectable) S/N source detections to the magnitudes of the objects in the HST field and are pleased to point out that sources of magnitude between 20 and 22 are easily detected.

[1] S.Fossey, I.P.Waldmann, D.M.Kipping, MNRAS Lett. V.396,1 L16-20.(2009)

[2] www.ucl.ac.uk/mathematical-physical-sciences/news-events/maps-news-publication/maps1405

[3] www.esa.int/Our_Activities/Space_Science/Exploring_space/Hubble_and_Keck_find_farthest_known_galaxy_in_the_Universe/

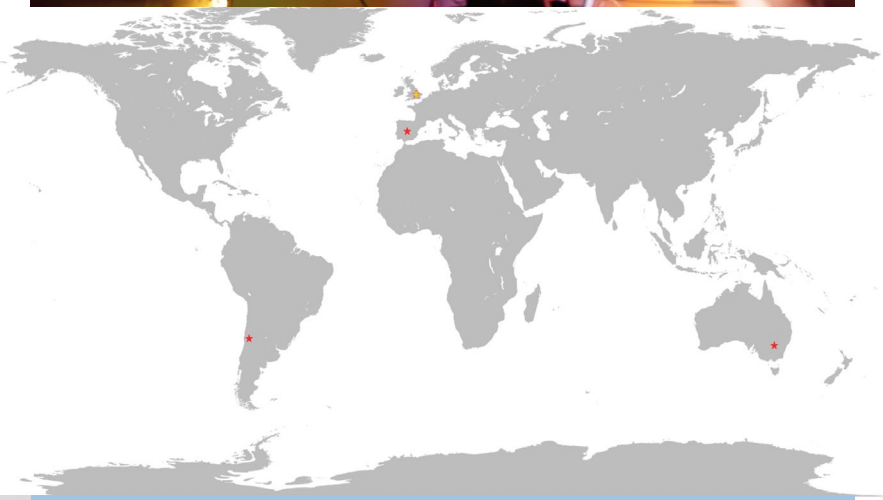
...recent and planned upgrades

Partnership with Konica-Minolta Laboratory Europe

This year we have partnered with Konica-Minolta Laboratory Europe, a London-based subsidiary of the Japanese giant Konica Minolta, researching e-solutions for the office, to investigate the role of Big Data and cloud-based distributed computing by looking at how complex networks of robotic telescopes operate, and analysing the data of the telescopes and their many house-keeping sensors.

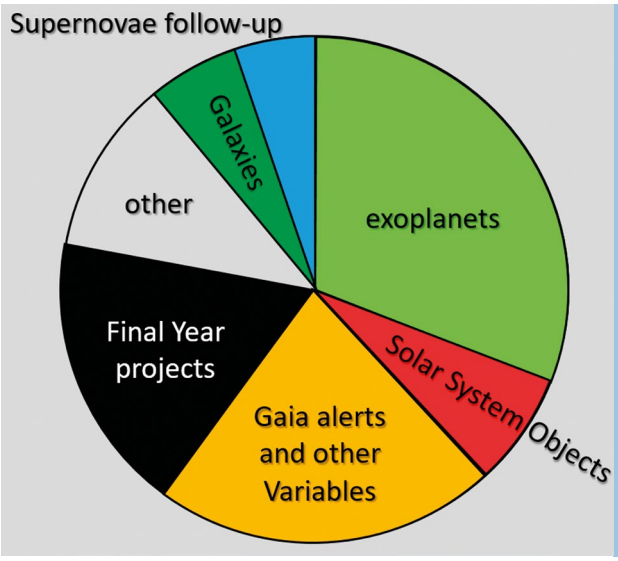
As part of this activity, KMLE have invested by installing three remote telescopes (60cm in Chile – figure on the right - 40cm in Spain and 35cm in Australia) which we will have access to via an e-platform allowing robotic operation.

Our collaboration will seek to develop tools for robotic network coordination and local data-processing pipelines.



UCL's Robo1 and Robo2.

Since the beginning of term up to mid-February this year, our two robotic facilities (the second only just online since 2017) have churned out large amounts of data (>11000 images), the majority of which have been submitted by Astrophysics undergraduate students as well as Astronomy Certificate students.

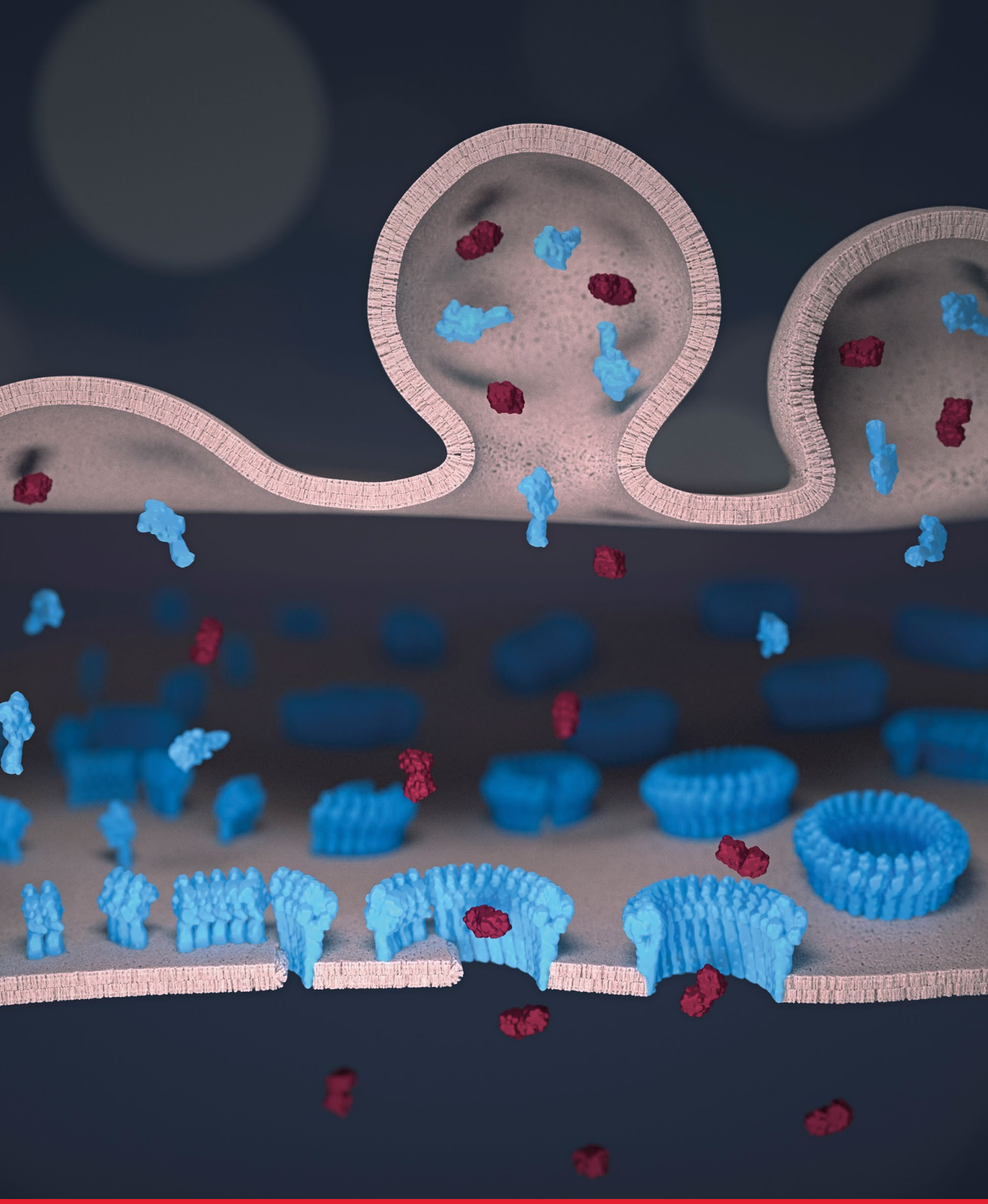


Preparations for the 80cm

The work to host our new 80cm fully robotic telescope is underway.

- **The Wilson dome site has been freed by removing the Allen 60cm reflector (one of our 5 running telescopes) which has served UCL faithfully for 43 years!**
- **Design for the new telescope plinth is completed and work is taking place to extend the existing supports, with the arrival of the new telescope scheduled before 2018-19 term.**
- **In the meanwhile, all our other telescopes are fully operational and delivering amazing science and images.**

By Giorgio Savini, Director of UCLO



Academic Showcase

Staff News

Promotions

We are very pleased to announce the latest round of senior promotions; congratulations to the staff listed below on their well-deserved achievements:

Promotion to Professor

Professor Nick Achilleos (Astro)
Professor of Planetary Physics

Professor Dan Browne (AMOPP)
Professor of Physics

Professor Stephen Hogan (AMOPP)
Professor of Atomic and Molecular Physics

Professor Philip Jones (AMOPP)
Professor of Physics

Professor Cyrus Hirjibehedin
(London Centre for Nanotechnology and CMMP)
Professor of Physics, Chemistry and Nanotechnology

Promotion to Reader

Dr Jay Farihi (Astro)
Reader in Astrophysics

Dr Keith Hamilton (HEP)
Reader in Physics

Dr Benjamin Joachimi (Astro)
Reader in Astrophysics

Dr Andreas Korn (HEP)
Reader in Physics

Dr Andrew Pontzen (Astro)
Reader in Cosmology

Dr Amelie Saintonge (Astro)
Reader in Extragalactic Astrophysics

Dr Pavlo Zubko
(London Centre for Nanotechnology and CMMP)
Reader in Physics

Promotion to Senior Lecturer

Dr Hidekazu Kurebayashi
(London Centre for Nanotechnology)
Senior Lecturer

Promotion to Principal Research Associate\Fellow

Dr Robert Flack (HEP)
Principal Research Associate

Retirements

John Benbow

John started in the MAPS workshop in May 2002. He has worked extensively for both Physics and Chemistry and also the London Centre for Nanotechnology (LCN). He has been an invaluable member of the workshop over the years always tackling some of the more taxing jobs speedily. He will be sorely missed.

Headline Research

Neutrino oscillations with NOvA

The NOvA experiment studies the transformations of neutrinos from one 'flavour' to another as they travel 810km from their source at the Fermi National Accelerator Laboratory (Fermilab) near Chicago to a huge 14,000 ton detector in Minnesota, probing the fundamental properties of these illusive particles by comparing the observed neutrinos against the initial flux at Fermilab.

The experimental collaboration consists of over 200 scientists from 48 institutions. UCL physicists (Dr Backhouse, Professor Nichol) co-lead two core analysis groups, and groups dedicated to simulations of the neutrino flux and detector calibrations (Dr Holin, Professor Nichol).

NOvA recently released new measurements using neutrinos collected since 2014. In February 2017 the beam was switched to produce antineutrinos and the first results, due to be announced at the Neutrino 2018 conference in June, are eagerly anticipated. A difference between neutrinos and antineutrinos could be the key to resolving a major astrophysical mystery – how the universe came to be dominated by matter.

The NOvA collaboration in front of a 14 kT Far Detector in Minnesota

Portrait of…

Alexander Shluger

Alexander Shluger was trained in Theoretical Physics at the Latvia State University in Riga, then USSR. When he graduated in 1976, Quantum Chemistry was a vibrant branch of research which had just started to benefit from the development of computers and scientific programming and to predict molecular properties. Alex was one of the first to apply the methods of Quantum Chemistry to calculations of properties of defects in solids. He joined the radiation chemistry group in the Department of Chemistry of Latvia State University and worked on understanding the structure and properties of radiation defects in insulators, such as NaCl and SiO2. This pioneering work earned him a PhD in 1981 and then the Doctor of Science degree in Chemical Physics in 1988. He organized an Institute of Chemical Physics of Condensed Matter at Latvia University in 1988 and became its first director. By that time perestroika was in full swing and Alex was allowed to visit scientific labs in other countries. He forged very close relations with researchers in Japan and Turin University in Italy where he also met Richard Catlow and Marshall Stoneham, who played important roles in his later career.

Prof Richard Catlow, who had just become the Wolfson Professor of Natural Philosophy at the Royal Institution of Great Britain, invited Alex to visit the RI in 1990: this was followed by the Royal Society visiting scholarship at the RI in 1991. Alex remained at the RI till 1996 during turbulent years in the USSR and Latvia, first as one of the first Cannon Foundation Fellows and then as a postdoctoral fellow. He was appointed as a Senior Research Fellow at UCL following the appointment of Prof Marshall Stoneham in the Condensed Matter and Materials Physics (CMMP) group in 1995, where he started the second phase of his career.

After enjoying several years of productive research as Senior and Principal Research Fellow, Alex was promoted to the Academic position of a Reader in 2002 and became a Professor in 2004. He served as Postgraduate Admissions Tutor and in 2006 - 2012 was a Head of the CMMP group. Since 2014 he has been the Chair of the Board of Examiners in the Department. His tenure as the head of CMMP coincided with the creation of the London Centre for Nanotechnology, which brought lasting changes to the roles and appointments of CMMP members. He was instrumental in shaping the CMMP group as it is now and initiated and promoted a review which led to the creation of a Bio-Physics group. His tenure as the Chair of the Board of Examiners coincided with large changes in student numbers and in Academic Regulations of student assessment in the College.

Alex enjoys very active research in several areas of materials science. He maintained strong collaboration with several groups in Japan and in 2007 became a PI at the World Premier Research Centre at Tohoku University, where he regularly spends one month per annum. The very successful collaboration with the group of Prof. H. Hosono at TokyoTech has been recognised by the award in 2013 of the Daiwa Adrian Prize for Exploration of Active Functionality in Abundant Oxide Materials Utilizing Unique Nanostructure (together with P. Sushko, H. Hosono, K. Hayashi). Alex is now leading a big collaborative project which involves many researchers from UCL, TokyoTech and McGill University in Montreal. After a period of very extensive collaboration with microelectronics industry, his research is developing in the direction of applying lessons from biology to create electronic devices and systems that exploit memristance in non-Von Neumann computational architectures.

> “Alex’s combination of intellect, energy and good humour make him a wonderful colleague.”

Tony Harker writes: I first had the pleasure of working with Alex in the early 1990s, while he was at the Royal Institution and I was at the Atomic Energy Research Establishment at Harwell: neither of us at the time realised that we would end up in the same group at UCL. Alex’s combination of intellect, energy and good humour make him a wonderful colleague. He has a wonderful range of contacts worldwide, both in academia and in industry, and his broad range of research brings cutting-edge computational methods to bear on real-world problems. He was one of the prime movers in establishing the Thomas Young Centre, a London-wide congregation of materials modellers. He is a dedicated teacher, both at the undergraduate and postgraduate level, and many of his research students have gone on to pursue academic careers after first-class training in his group. Alex does not shirk administrative roles in the department: somehow, I think he has found the trick of finding more hours in the day than the rest of us!

Catching the first light from a gravitational-wave event

The Dark Energy Survey, in which UCL scientists play a key role, played a significant part in the birth of 'multimessenger astrophysics'.

On 14 September 2015 the first detection of a gravitational-wave event was made by the Laser Interferometer Gravitational-Wave Observatory (LIGO), almost 100 years after these ripples in space–time were predicted by Einstein on the basis of his General Theory of Relativity; the 2017 Nobel Prize in Physics was awarded to Barish, Thorne, and Weiss for their role in the discovery.

Measurements of this first event, and four subsequent discoveries, can be explained in exquisite detail as mergers of two black holes, each with a mass of order ten times that of the Sun. While this interpretation appears secure, black-hole mergers are 'dark' – they leave no trace in the electromagnetic spectrum.

All that changed when a sixth gravitational-wave detection was made, on 17 August 2017, by the LIGO and Virgo collaborations. From their three detectors, widely distributed across the Earth, a rough position on the sky could be quickly triangulated, with the relatively long duration of the event (around 100s) suggesting the merger of two neutron stars, rather than black holes. An alert was issued, and both space missions and ground-based facilities were turned to observe the patch of sky where the signals arose. Among them was the camera used by the Dark Energy Survey – which, thanks to its wide field of view, was able to locate an associated visible glow, in spite of the relatively large uncertainty in the initial position.

The event was subsequently followed intensively, with some 70 observatories on the ground and in space eventually contributing observations right across the electromagnetic (EM) spectrum, from radio wavelengths to gamma rays, initiating a new discipline of 'multimessenger' astrophysics, in which gravitational waves and EM radiation each bring complementary information. For example, the gravitational waves from binary mergers afford what have become known as 'standard sirens', by analogy with the 'standard candles' used as distance indicators in traditional astronomy, while optical spectroscopy can give the redshifts.

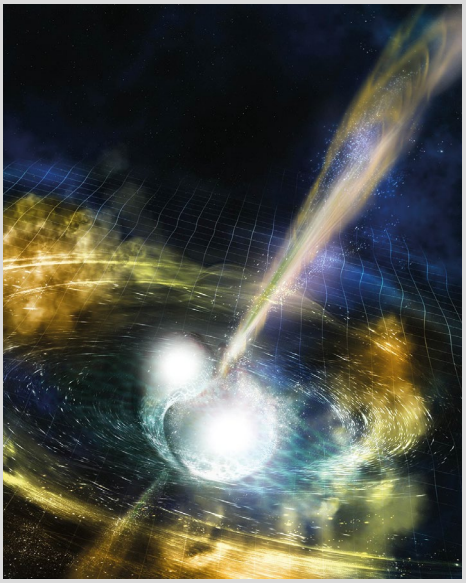


Fig 2. Artist's illustration of two merging neutron stars. The narrow beams represent the gamma-ray burst while the rippling spacetime grid indicates the gravitational waves that characterize the merger. Swirling clouds of material ejected from the merging stars are a possible source of the light that was seen at lower energies.

Credit: National Science Foundation/LIGO/Sonoma State University/A. Simonnet.

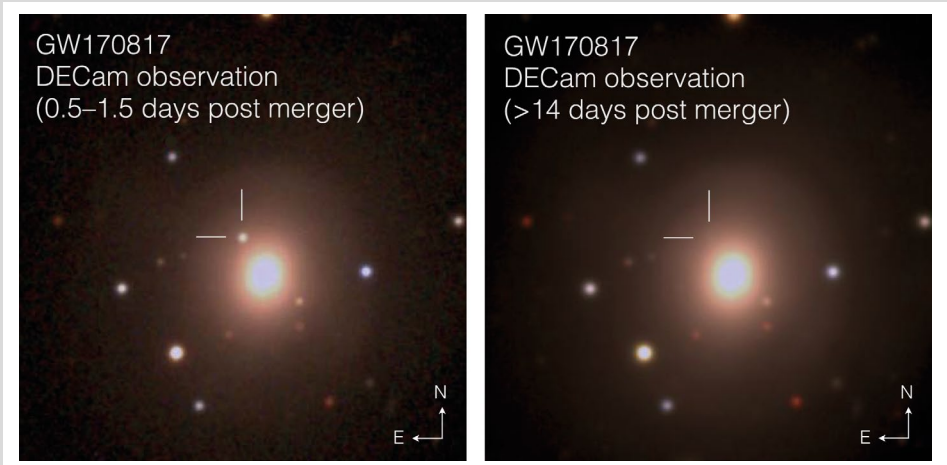


Fig 1. Left: Discovery image taken with the DES camera (2017 August 18, additional colour information from August 19). Right: The same area two weeks later, after the fireball had faded.

Credit: Soares-Santos et al. and DES Collaboration.

The general nature of the merger is now reasonably well understood: as the two neutron stars, each around one and a half times the mass of the sun, orbited each other at high speed, they stretched and distorting the surrounding space–time, losing energy through gravitational waves and so falling together until they merged into a single object, emitting a fireball of gamma rays, creating new heavy elements like lead, gold, and platinum, and generating a 'kilonova' in which the left-over material was hurled into space. The enormous energy generated in the collision, and the decay of newly manufactured radioactive elements, powered the afterglow seen with optical telescopes. Within this basic framework, future observations and analysis should shed new light on topics as diverse as the production of precious metals and the rate of expansion of the universe.

Staff Accolades

Breakthrough Prize in Fundamental Physics

Professor Hiranya Peiris shares the Breakthrough Prize for early universe mapping. Professor Hiranya Peiris worked as a PhD student on the NASA satellite known as Wilkinson Microwave Anisotropy Probe (WMAP), which helped shape our understanding of the origin, evolution and nature of the cosmos. The mission mapped the cosmic microwave background – the light left over from the Big Bang – to allow scientists to work out the age of the Universe, its rate of expansion and its basic composition. Professor Peiris' work involved analysing the first round of data from the experiment for cosmological interpretation. In particular, her research led to a significant understanding of the origin of cosmic structure in the very early Universe.

The Breakthrough Prize will be shared among the 27 member-strong WMAP Science Team. The Prize in Fundamental Physics recognises major insights into the deepest questions of the Universe.

EPSRC Early Career Fellowship

Awarded to **Dr Lluis Masanes**

The project title is *Scrambling of Quantum Information in Many-Body Systems*. The team of theoretical physicists will address the following fundamental questions. How much can quantum information be scrambled in naturally-occurring systems? What are the relevant time scales? This research will provide new tools for developing quantum information software, it will bring light into the poorly-understood phenomena of Thermalisation and Localisation, and it will demonstrate the sharpness of the Black-Hole Complementarity Principle

EPSRC Doctoral Prize

Awarded to **Dr Cip Pruteanu**

Dr Cip Pruteanu has been awarded an EPSRC Doctoral Fellowship

Fellow and Corresponding Member of the Australian Academy of Science

Congratulations to distinguished astronomer **Professor Richard Ellis** who has been admitted as a Fellow and Corresponding Member to the Australian Academy of Science for outstanding contributions to his field.

Professor Richard Ellis is a distinguished astronomer who has made landmark discoveries over several decades. His main area of research is in observational cosmology, studying the origin and evolution of galaxies, the growth of large scale structure in the universe and the nature and distribution of dark matter.

Australian astronomy has benefited greatly from Professor Ellis's intellectual leadership and generous support. In the early 1990's, he conceived and developed the science case for the award-winning '2 degree Field' facility on the Anglo-Australian Telescope that produced some of the highest cited papers in cosmology.

This instrument continues to advance Australian astronomy 25 years on. His observational campaigns and creative style opened up the distant Universe to direct observation, inspiring three generations of Australian astronomers to follow in his path.

Fellowship of the American Physical Society

Awarded to **Dr David Cassidy**

Citation: For sustained accomplishments in the field of experimental positronium atomic physics, including the discovery of the di-positronium molecule and the optical excitation of its first excited state.

Nominated by: Division of Atomic, Molecular & Optical Physics

UCL Centre for Neuroimaging Techniques Annual Early Career Prize

The UCL Centre for Neuroimaging Techniques is very proud to award its Annual Early Career Prize (2017) to Dr Thomas Blacker who is Research Associate at UCL's Department of Physics & Astronomy.

The award aims to reward an exceptional contribution by a UCL student or staff member in the early stages of their career in the field of Neuroimaging.

Tom is the annual award's 10th winner; the award is sponsored by Brain Products GmbH and Brain Products UK and consists of a cheque for £1000, trophy and certificate. The award was presented to Tom at the CNT seminar given by Dr Jeff Duyn of the NIH/NINDS on 3rd May 2018.

MAPS Faculty Teaching Awards

Awarded to **Dr Elinor Bailey** (Teaching Staff Category).

Elinor Bailey is a Senior Teaching Fellow in the Physics department. She is interested in lecturing techniques which move away from the standard lecture format to increase engagement in large classes.

She says: "*I have been trying to help the students to learn during the lectures, rather than just copying down notes and doing the learning later (often in the revision period...). So that students can properly follow the material we go very slowly, allowing for lots of questions, and I don't ask students to listen and read or write at the same time (I always struggled with this!). Giving out full notes at the start of the course allows us to use the lectures to discuss difficult concepts with lots of pair work, quizzes and active learning.*"

Provost's Excellence Scheme

Awarded to **Dr Patrick Guio**

Patrick Guio of the Planetary Plasmas group is one of the winners of the UCL Provost's Excellence scheme. This scheme was set up to recognise exceptional contributions from across UCL. This award to Patrick is a very well-deserved recognition of his exceptional and impressive contributions to research and teaching at UCL. The Planetary Plasmas group, our international collaborators and UCL in general have benefited greatly from Patrick's wealth of experience in plasmas and computational physics, his scientific diligence and creativity, and his talents as a teacher and supervisor.

Headline Research

Royal Astronomical Society Fowler Award

Dr Amelie Saintonge was awarded the 2018 Fowler Award for Astronomy for her research discoveries that are reshaping our thoughts about how galaxies evolve.

She is a leading observational astronomer and has made “invaluable contributions to our understanding of the cycling of gas in and out of galaxies, and the relation between the gas content and star formation”

Over the past few years, Dr Saintonge has led the scientific interpretation of the largest systematic study of the atomic and molecular gas content in galaxies.

Using these datasets, she demonstrated that there is a connection between the efficiency of the star formation process on small scales and the large scale physical properties of the host galaxies; work which has been transformative for the field.

Dr Saintonge is recognised as a leader in the field of gas and star formation in galaxies. She plays a leading role in assuring UK commitment to the James Clerk Maxwell Telescope as both a member of the JCMT executive committee and leads the JINGLE survey of dust and molecular gas in the nearby Universe.

UCL Physics & Astronomy Teaching

Awarded to **Dr Alexandra Olaya-Castro.**

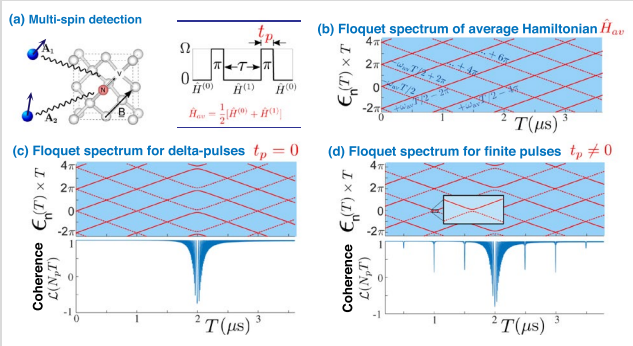
The Physics and Astronomy Departmental Teaching Prize for 2015/16 has been awarded to Dr Alexandra Olaya-Castro. Her lecture course PHASM/G426 “Advanced Quantum Theory” has consistently attracted large cohorts of students from a variety of backgrounds, and has been extremely well-received and enjoyed. Her methods of delivery, clarity, and interactive approach have been much appreciated by her classes, and the course has repeatedly been singled out for praise. Along with this, results have been excellent. We are therefore very pleased to recognise and reward Dr Olaya-Castro’s success, and her ongoing commitment to our teaching.

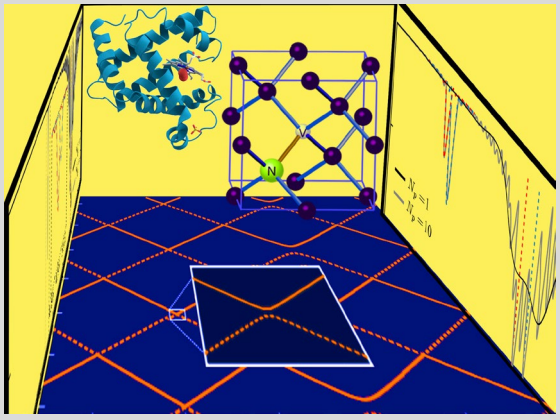
The nitrogen vacancy (NV)

The nitrogen vacancy (NV) in diamond is a type of impurity which gives diamonds their colour. In the last few years the NV colour centre has emerged as an important platform for the development of new quantum technologies, including quantum sensors; these offer the prospect of NMR and even MRI at the single molecule level.

Detection of weak single-spin signals is greatly enhanced by repeated sequences of microwave pulses. The work showed that the pulse duration and shape also offers a powerful additional control parameter. While previously, a non-negligible pulse-width has been considered simply a source of experimental error, the work elucidated the underlying quantum dynamics: a landscape of quantum-state crossings which are usually closed (inactive) but may be controllably activated (opened) by adjusting the pulse-width from zero. These avoided crossings (pictured) were identified with recently observed but unexpected dips in the quantum coherence of the NV sensor spin. With this new understanding, both the position and strength of these sharp features may be accurately controlled; they co-exist with the usual broader coherence dips of short-duration microwave pulses, but their sharpness allows for higher resolution spectroscopy with quantum diamond sensors, or their analogues.

J. E. Lang, J. Casanova, Z.-Y. Wang, M. B. Plenio, T. S. Monteiro. Physical Review Applied 7, 054009 (2017)





Research Degrees

December 2016 – December 2017

Giuseppe Morello
A machine learning approach to exoplanet spectroscopy
(Prof I. D. Howarth)

Sally Shaw
Dark matter searches with the LUX and LZ experiments
(Dr C. Ghag)

Ludovica Intilla
Study of ZnO properties applied to thin film transistors
(Prof F. Cacialli)

George Kelly
Molecular emission in active centres of nearby galaxies
(Prof S. Viti)

Jacob J. H. Spencer
Modelling charge transport in organic semiconductors with a fragment-orbital based surface hopping method
(Prof J. Blumberger)

Marco Rocchetto
Characterisation of exoplanetary atmospheres and planetary systems
(Prof G. Tinetti)

David Barnes
Forecasting and modelling the terrestrial effects of space weather using STEREO and CMAT2
(Prof A. Aylward)

Brendan Darrer
Electromagnetic induction imaging through metallic shields
(Prof F. Renzoni)

Benjamin A. F. Strutt
A search for ultra-high energy neutrinos and cosmic rays with ANITA-3
(Prof N. Konstantinidis)

Nicolas G. G. Burdet
X-ray Bragg projection ptychography for nanomaterials
(Prof I.K. Robinson)

Daniel Underwood
Variationally computed line lists for SO2 and SO3
(Prof J. Tennyson)

James Vale
The nature of the metal-insulator transition in 5d transition metal oxides
(Prof D. F. McMorrow)

Fruszina Gajdos
Electronic coupling calculations for modelling charge transport in organic semiconductors
(Prof J. Blumberger)

Thomas G. Catling
Actuation of thin glass for grazing incidence X-ray mirrors
(Prof A. P. Doel)

Oliver T. Gindele
Atomistic simulations of ferroelectric lead zirconate titanate
(Prof D. M. Duffy)

Daniela Saadeh
Testing the isotropy of the universe with the cosmic microwave background
(Dr A Pontzen)

Toni Das
Quantum-orbit analysis of laser-matter interactions in intense orthogonally polarised fields
(Dr C. Figueira De Morisson Faria)

Konstantinos Konstantinou
Computational modelling of structural, dynamical and electronic properties of multicomponent silicate glasses
(Prof D. M. Duffy)

Xin Ran Liu
Low background techniques for the SuperNEMO experiment
(Prof R. Saakyan)

Valentina Robbiano
Nano- and Micro-structures for organic/hybrid photonics and optoelectronics
(Prof F. Cacialli)

Philip J. D. Crowley
Entanglement and thermalization in many body quantum systems
(Prof A. G. Green)

Jack C. Morford
The e-MERLIN L-Band legacy survey of Cygnus OB2
(Prof R. K. Prinja)

Stefan P. Gosuly
Neutron scattering studies of low-dimensional quantum spin systems
(Prof D. F. McMorrow)

Robert L. Schuhmann
Cosmology in the presence of non-gaussianity
(Dr B. Joachimi)

Andrew J. Perch
Three flavour neutrino oscillations with Minos and chips
(Prof J. A. Thomas)

Giuseppe M. Paternò
Nanoscale characterisation and neutron damage testing of organic semiconductors
(Prof F. Cacialli)

Maria Civita
Measurements of phase changes in crystals using ptychographic x-ray imaging
(Prof I. K. Robinson)

Alec T. Owens
Variational calculations of rotation-vibration spectra for small molecules of astrophysical interest
(Dr S. Yurchenko)

Anasua Chatterjee
Silicon nanodevice qubits based on quantum dots and dopants
(Prof J. J. L. Morton)

Andrea Loreti
Positron and positronium scattering from atoms and molecules
(Prof G. Laricchia)

Manveer S. Munde
Oxygen dynamics in amorphous silicon suboxide resistive switches
(Prof A. Shluger)

Piergiacomo Zucconi Galli Fonseca
Levitated optomechanics in a hybrid electro-optical trap
(Prof P. Barker)

Marc P. Ross
Bound exciton-assisted spin-to-change conversion of donors in silicon
(Prof J. J. L. Morton)

Ashley B. Joy
Simulations of the physics and electronics in 2D semiconductor pixel detectors
(Prof M. Wing)

Aziliz M. M. Hervault
Development of a doxorubicin-loaded dual pH- and thermo-responsive magnetic nanocarrier for application in magnetic hyperthermia and drug delivery in cancer therapy
(Prof T. T. K. Nguyen)

Angelos Tsiaras
Towards a population of exoplanetary atmospheres
(Prof G. Tinetti)

Guido F. Von Rudorff
Structure and dynamics of the hematite/liquid water interface
(Prof J. Blumberger)

Nicolas Clarke
A novel space based telescope for the investigation of exoplanets
(Prof S. Viti)

Ahai Chen
Multi-centre molecules driven by intense laser fields
(Dr A. Emmanouilidou)

Jonathan R. Holdship
Shock chemistry in star forming environments
(Prof S. Viti)

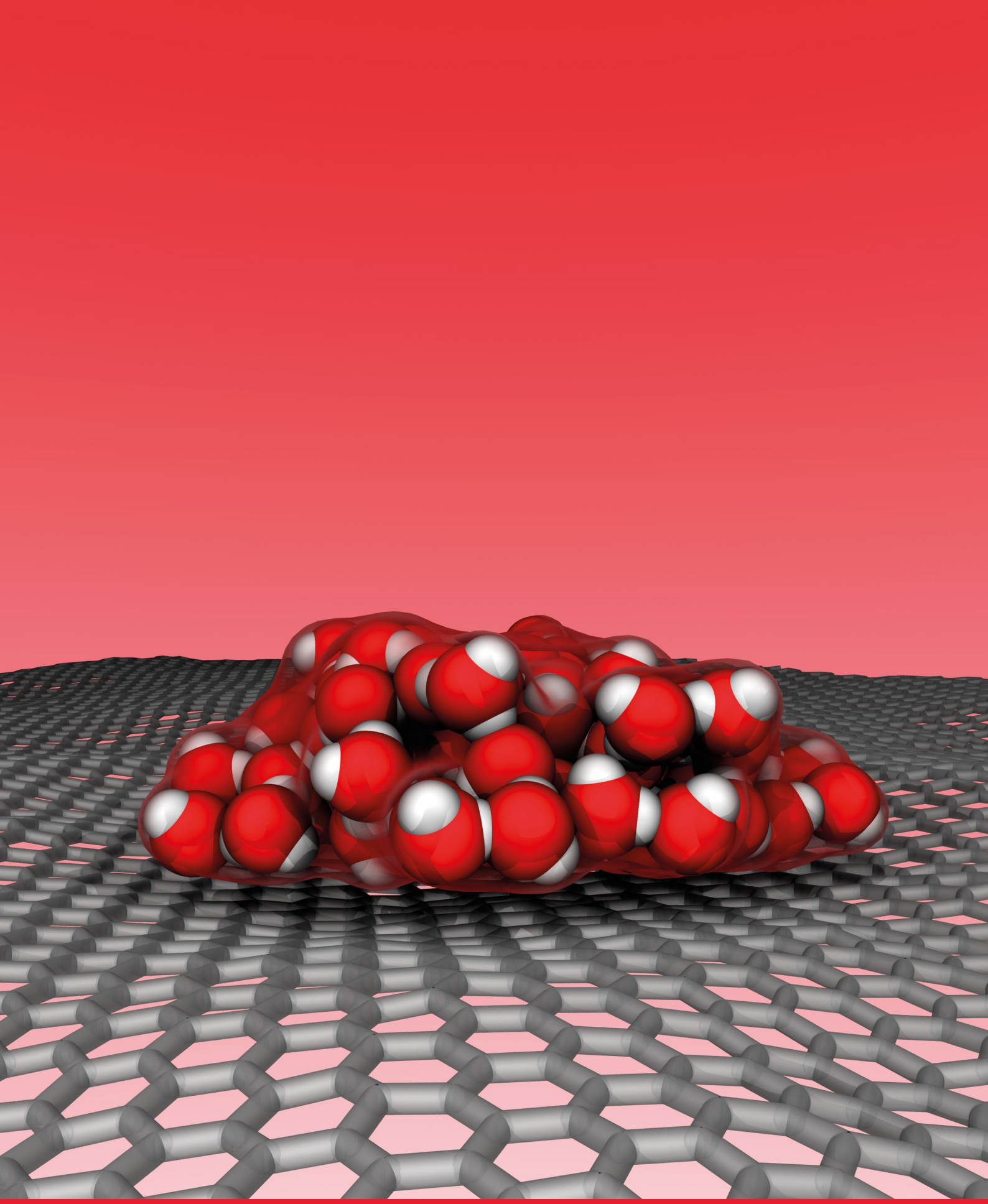
Peter A. Bebbington
Studies in informational price formation, prediction markets, and trading
(Prof I. J. Ford)

Alvaro Martin Alhambra
Non-equilibrium fluctuations and athermality as quantum resources
(Prof J. Oppenheim)

Emil J. Zak
Theoretical rotational-vibrational and rotational-vibrational-electronic spectroscopy of triatomic molecules
(Prof J. Tennyson)

Asif M. Suleman
Atomic-scale studies of confined and correlated electron states on semiconductor surfaces
(Dr S. R. Schofield)

Valentinos Christodoulou
Search for dark matter in events containing jets and missing transverse momentum using ratio measurements
(Dr E. L. Nurse)



Research Spotlight

Astrophysics

Astrophysics embodies the endeavour to understand the Universe on all scales, encompassing everything from the quantum mechanics of atomic and molecular transitions to the dynamics and evolution of the entire cosmos, pushing at the boundaries of fundamental physics and technological development. Astronomers in the Department are involved in understanding planets, both in our solar system and those orbiting the distant stars ('exoplanets'); the birth, evolution, and death of stars; the properties of galaxies; and the content and fate of the Universe. The questions that these studies raise require increasingly sophisticated instruments and international collaboration, and we are active in building the equipment, both ground-based and space-borne, needed to seek answers – and new questions.

To begin within our Solar System, the Cassini spacecraft executed an end-of-life 'Grand Finale' mission that culminated in its entry into Saturn's atmosphere, and consequent destruction, in September 2017. Launched some 20 years earlier, this joint NASA-ESA mission was hugely successful, exploring the Saturnian system, including its rings and moons, for 13 years. UCL astronomers, led by Professor Nick Achilleos (a co-investigator on the magnetometer, or 'MAG', team), have been particularly interested in using the spacecraft data to study Saturn's unique magnetic field. The UCL group's models and observations of the planet's magnetic field have helped us understand how the magnetosphere reacts to changes in the solar wind, as well as the properties of the particles inside the magnetosphere itself. The data from the final plunge into the atmosphere are still being analysed by the wider international MAG team, but already hint at unexpected results, indicating a need to account for the field generated within the planet itself as well as the external 'perturbation' field, associated with rotating current systems which transport energy between the planet's atmosphere and magnetosphere.

While we believe that we understand reasonably well how a star like our Sun evolves, our knowledge of the birth, life, and death of more massive stars – those weighing at around 10 to 100 times the solar mass, which will end their lives as supernovae – is less secure. One complication is that many of these stars rotate so quickly that their shapes are predicted to become distorted, with concomitant changes to their internal structure and surface properties. These distortions are very difficult to measure directly, but by observing the polarization of light from the bright star Regulus an international team including UCL's Ian Howarth have been able to study its properties in unprecedented detail, showing that its surface layers would be flung into space by inertial forces if it rotated only 3% faster. The measurements require extraordinary precision, equivalent to measuring the star's brightness through two orthogonal positions of a polaroid filter to an accuracy of a few parts per million, at several wavelengths across the visual spectrum. They confirm, for the first time, theoretical predictions of stellar polarization made almost a half-century previously by the Nobel-prize-winning Indian–American astrophysicist Subrahmanyan Chandrasekhar.

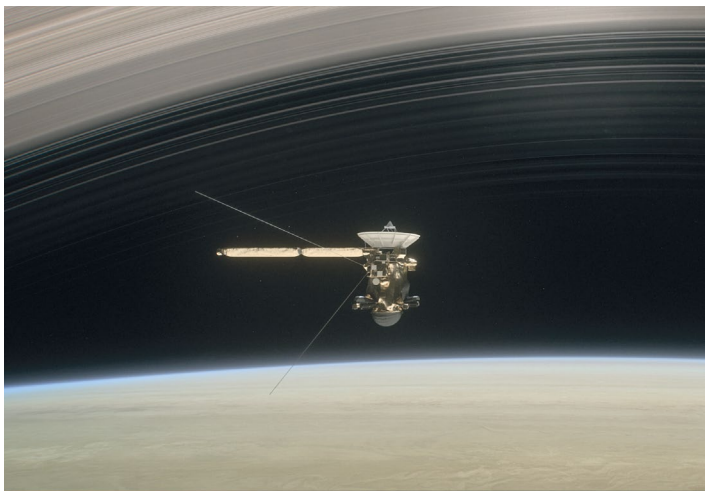


Figure 1. Artist's impression of the Cassini spacecraft diving between Saturn's innermost ring and the planet's surface during mission 'Grand Finale'. The magnetometer is at the end of the 11-m-long boom extending to left in this image. Credit: NASA/JPL-Caltech

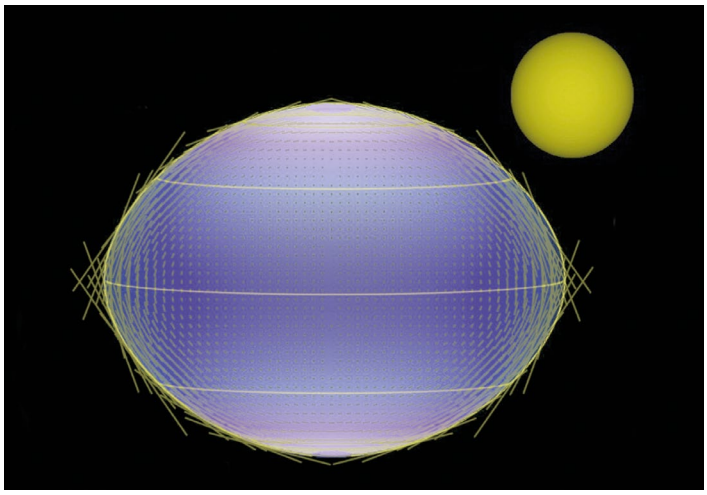


Figure 2. Computer model of Regulus showing its distorted shape and relatively dark equatorial regions – both consequences of its rapid rotation. The Sun is shown to scale, for comparison, and the colours reflect the stars' temperatures (Regulus is hotter by more than a factor of 2). The lines concentrated around the edge of the star show the local strength and direction of linear polarization.

Massive stars also play an important role in the early Universe. Another international team, led by UCL's Nicolas Laporte and Richard Ellis, have used the Atacama Large Millimeter/submillimeter Array (ALMA) to study the galaxy 'A2744 YD4'. Virtually invisible at optical wavelengths, even with the Hubble Space Telescope, but glowing faintly in the infrared, the observations set a new record for the youngest (and hence most distant) galaxy observed with ALMA. The surprise is that the galaxy contains large quantities of dust (which is what allows it to be detected with ALMA) and heavy elements, which can only have been formed by the earliest generations of stars. The system is seen when the Universe was 'only' around 600 million years old – 4% of its present age of 13.8 billion years – and those stars must have completed their short lives in less than that time. This is therefore a limit on when the first supernovae exploded, and on the time at which the first hot stars bathed the Universe in light. Determining the timing of this 'cosmic dawn' is one of the holy grails of modern astronomy, and it can be probed through these studies of early interstellar dust.

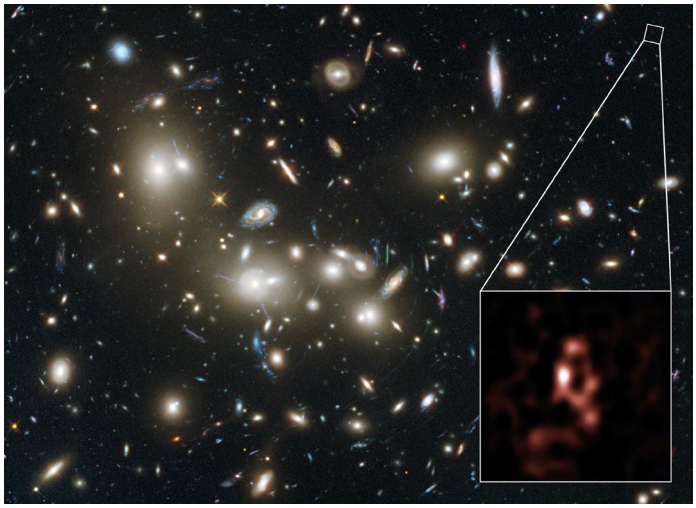


Figure 3a. This image is dominated by a spectacular view of the rich galaxy cluster Abell 2744 taken with the Hubble Space Telescope, but far beyond this cluster lies the faint galaxy A2744_YD4. Though almost invisible with HST, cool dust in the galaxy is clearly visible in new ALMA observations (inset) Credit: ALMA (ESO/NAOJ/NRAO), NASA, ESA, ESO and D. Coe (STScI)/ J. Merten (Heidelberg/Bologna)]

Figure 3b. Artist's impression of what the galaxy A2744_YD4 might look like. Credit: ESO/M. Kornmesser

Gravitational lensing of the galaxy – an effect predicted by Einstein's theory of gravity – helped make these observations feasible. The same process allows astronomers to chart the distribution of dark matter in the Universe, and a new map released by the Dark Energy Survey (DES) consortium, derived from measurements of 26 million galaxies and several billion light years in extent, does this in greater detail than previously possible from the ground. DECam, the giant camera at the heart of the DES project was assembled at UCL by David Brooks and Peter Doel with the scientific input of Ofer Lahav, chair of the DES:UK consortium and co-chair of the DES Science Committee until 2016. While observations of the Cosmic Microwave Background with satellites such as Planck can provide a snapshot of the clumpiness of matter some 400,000 years following the Big Bang, the new map, based on just the first year's observations, traces in great detail how the gravitational pull of dark matter has subsequently shaped the Universe. A consistent picture emerges from these observations, in which around 26% of the Universe is made up of dark matter; the even more mysterious dark energy, which is believed to cause the accelerating expansion of the universe, makes up a further 70% of the content of space. It is only for the remaining 4%, making up the 'baryonic' matter familiar from everyday experience, that we have a good understanding.

> "...the next few years should be even more exciting"

The foregoing notes mention no more than a brief selection of the observational, modelling, and theoretical studies reported by UCL scientists in 2017, and were chosen to illustrate the wide scope of research conducted under the aegis of the astrophysics group. With exploitation of new facilities, such as ALMA; ongoing projects, like DES; and leadership roles in, e.g., the forthcoming Twinkle mission and the Dark Energy Spectroscopic Instrument (both described elsewhere in this report), the next few years should be even more exciting.

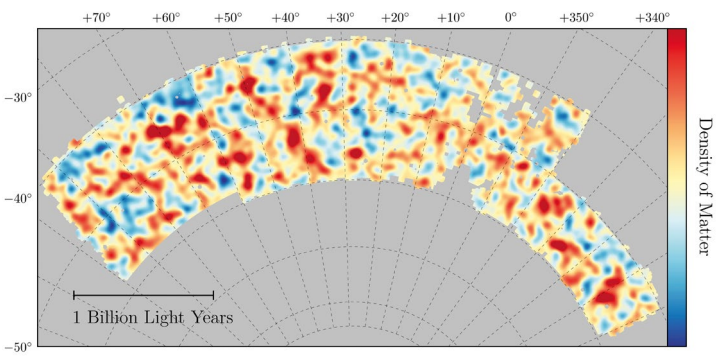


Figure 4. Map of the distribution of dark matter on the sky, from the Dark Energy Survey. Red regions have more dark matter than average, blue regions less. Credit: Chihway Chang of the Kavli Institute for Cosmological Physics at the University of Chicago, and the DES collaboration.

Atomic, Molecular, Optical and Positron Physics (AMOPP)

The Atomic, Molecular, Optical and Positron Physics (AMOPP) group at UCL is one of the largest of its type within the UK. It has a diverse range of research activities that range from studies in foundational physics to the development of computational and experimental solutions to real world problems. Research topics span from quantum gravity and quantum technology to theoretical and experimental atomic and molecular physics. The large scientific diversity of our group is reflected in the 17 principal investigators, some of whom are also engaged with the HEP, Astrophysics, CMMP and BioPhysics groups at UCL Physics. The AMOPP group consists of 88 academic staff, PhD students, research fellows, postdoctoral researchers and technical staff.

> "…new research programme within the AMOPP group is to test quantum mechanics in a largely unexplored new regime."

A significant new research programme within the AMOPP group is to test quantum mechanics in a largely unexplored new regime. Although quantum mechanics very successfully describes microscopic processes at the level of a single of few atoms it's validity at macroscopic scales is not so clear. For example, can a quantum superposition exist for macroscopic systems which consist of billions of atoms?

Within an EU collaborative research programme, Professor Peter Barker's group aims to test the quantum superposition principle indirectly by carefully measuring and analysing the noise that affects the centre-of-mass motion of a trapped nanocrystal. The nanocrystal is levitated and isolated in high vacuum and the measured noise will be compared to theoretical predictions. A key component of this research is to cool the centre-of-mass motion and the internal temperature to minimise conventional noise sources so that quantum noise dominates the motion of the particle. While methods to cool the centre-of-mass motion are now established, Prof Barker's group demonstrated this year that levitated nanocrystals can also be cooled internally using a technique called laser refrigeration (Nature Photonics 11, 634–638 (2017)). In their experiments nanocrystals of yttrium lithium fluoride were doped with ytterbium ions (Yb3+) demonstrating refrigeration down to temperatures of 130 K. While lower temperatures are attainable, these low temperatures are suitable for our macroscopic quantum experiments. Figure 1 shows how refrigeration and levitation is attained using a single tightly focused laser beam. The inset diagram illustrates the process that when this laser is tuned between the ground and excited state of the ions they are promoted to the bottom of excited state. Thermal vibrations of the crystal give further energy to the Yb3+ ion in the excited state before it eventually decays back to the ground state. The emitted photon has greater energy than used for the excitation process and net energy is lost from the crystal. This continual removal of energy, with many excitation and decay processes, leads to rapid cooling of the internal temperature of the levitated crystal.

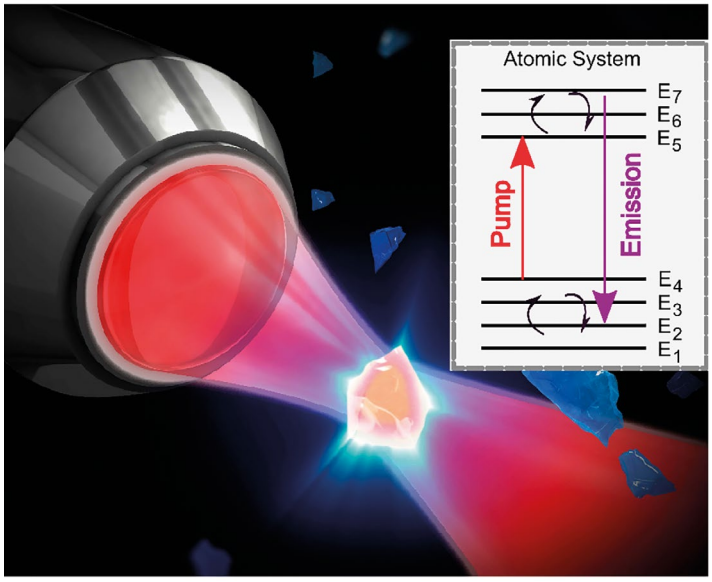


Figure 1
Laser refrigeration of levitated nanocrystals. The inset shows the excitation and emission of the embedded atomic ions used for cooling.

Professor Sougato Bose is one of the pioneers in this relatively new field. Most recently, he and co-workers have asked the question. Is a quantum ball "somewhere" when no one looks? The states of everyday objects around us are considered to be "real" in the sense that they exist even before an act of observation. On the other hand, microscopic objects following quantum mechanics are known to disobey the above notion of realism. Bose and his collaborators show that for a trapped nanocrystal (a "quantum" ball in a bowl as shown in figure 2), simply by looking on "which-side" of a trapping well it is (which can be done simply by shining light on one side of the well), one can demonstrate that it is not a classical object.

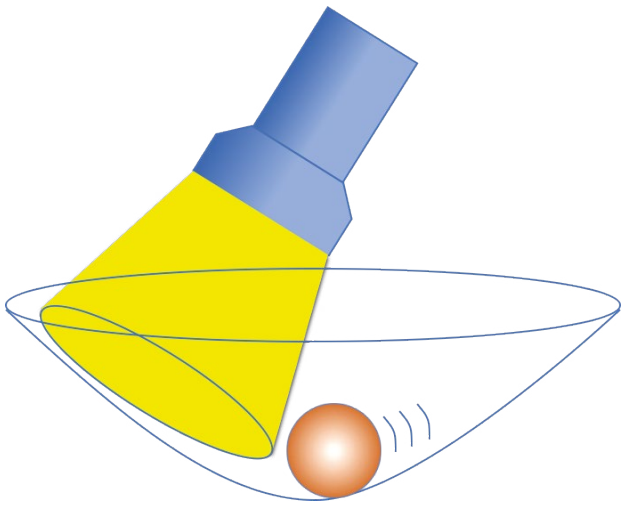


Figure 2
Observing non-classicality by 'which side' observation of motion in a harmonic potential well.

This idea has the potential to hugely enhance the domain of the quantum world in a very simple way, even without going through the challenging task of creating non-classical superpositions.

Our theoretical work opens the door to experimentally probe Einstein's intriguing and much debated question "Is the moon there when nobody looks at it?" This work entitled Nonclassicality of the Harmonic-Oscillator Coherent State Persisting up to the Macroscopic Domain" was published in Physical Review Letters , S. Bose, D. Home, and S. Mal, Phys. Rev. Lett. 120, 210402 (2018).

This year major new funding has been awarded to the AMOPP group to support a wide range of new and ongoing research. This includes the quantum technology programmes of Dr Marzena Szymanska and Prof Browne. Dr Marzena's project InterPol aims to implement polariton lattices in semiconductor microcavities for creating photonic-based solid-state platforms for quantum simulations, while Prof Browne's project, QCDA, will design a new generation of codes and protocols for fault-tolerant quantum computation. Dr Agapi Emmanouilidou's new programme ' Exotic Forms of Matter in Molecules driven by Free-Electron Lasers (FELs)' will incorporate nuclear motion in molecular interactions with FELs. Her group will develop hybrid state-of-the-art theoretical techniques where the electrons are treated fully quantum mechanically while the nuclear motion is treated classically. Professor Jonathan Tennyson's new project, UK AMOR, is building on the expertise of his group to develop software to explore the physics of light-matter interactions, electron collisions with atoms, ions and molecules and even cold molecule physics. Applications include understanding key processes in fusion plasmas and radiation damage in biomolecules. Finally, Dr David Cassidy and Stephen Hogan have started a new programme that will undertake experiments to control the motion of the composite matter-antimatter atom positronium. This work will enable future experiments that will explore how antimatter behaves in a gravitational fields. These represent only some of our research programmes but information on other research within the group can be found on the group's webpages (**www.ucl.ac.uk/amopp**).

Finally, AMOPP staff member Dr David Cassidy was elected a Fellow of the American Physical Society for his sustained accomplishments in the field of experimental positronium atomic physics, including the discovery of the di-positronium molecule and the optical excitation of its first excited state.

High Energy Physics (HEP)

Project in focus

g-2 Experiment at Fermilab

Aim

Measuring muon magnetic moment to a precision of 140 parts per billion. The last measurement from the E821 experiment at Brookhaven observed a 3.5 sigma deviation of their result from the Standard Model. The g-2 experiment is aimed at settling this matter and, possibly, discovering new physics.

Results to date

In June 2017 g-2 took its first data and demonstrated that all detector and accelerator systems are working, a major milestone for the collaboration. The physics data taking has recently started and a dataset 3 times the size of that accumulated by Brookhaven is expected in the summer of 2018.

UCL Involvement

UCL has designed and delivered a high-speed data acquisition electronics for a UK-built straw-tracking detector, which was successfully tested during the June 2017 run.

Research carried out by the UCL High Energy Physics (HEP) covers a very broad range of topics spanning experiment and theory, software development and applications outside academia. In 2017 the group continued to grow and attract new talent. Dr Christopher Backhouse joined the group in October as Royal Society University Research Fellow to work on flagship neutrino physics projects, NOvA and DUNE. Dr Tim Scanlon, one of the leaders of the Higgs boson physics analyses in the ATLAS experiment at the LHC, was appointed as Lecturer in experimental particle physics at the Department. Currently the group has 50 academic, research and technical staff and over 40 PhD students.

2017 has been an exciting year for the group. Below a few selected developments are highlighted. For the list of all group activities please follow **www.hep.ucl.ac.uk/research.shtml**

CDT in Data Intensive Science

The establishment of a new Centre for Doctoral Training (CDT) in Data Intensive Science (DIS) and Technologies in 2017 is an event that will have a profound longstanding effect on the future of the group (and the Department). After a very competitive selection process UCL has been chosen by the Science and Technology Facilities Council (STFC) to host the CDT. The bid was led by Professor Konstantinidis (HEP) and Professor Lahav (Astrophysics) who are now co-Directors of the Centre.

The CDT's vision is to provide a unique studentship experience that will produce highly trained and employable PhD graduates with advanced and widely applicable skills in DIS, who will ultimately become the future leaders of this field in both academia and industry.

The Centre launched in September 2017 with a first cohort of 17 students, 7 of them on HEP projects. A similar intake is expected in subsequent years. There are currently 20 partners directly engaged with the Centre, which span a broad range of sectors, from computing and publishing to banking, security and transportation. As well as offering secondment opportunities to the students, the partners also act as mentors, provide industry focussed training sessions and give feedback on the overall training programme to ensure it is tailored to fulfil the requirements of all sectors.

Energy Frontier (ATLAS)

Half of the UCL group is involved and hold leadership positions in the ATLAS experiment at the LHC with Professor Konstantinidis being the UK ATLAS Principal Investigator. 2017 was the most successful year to date for the LHC and ATLAS. The LHC broke many new performance records and overall delivered to ATLAS more than 50 fb-1 at centre-of-mass energy of 13 TeV, a ~30% increase compared to 2016. This performance came at the price of high pile-up (simultaneous pp collisions in a bunch crossing), which reached an average of 60 at the start of fill. This presented great challenges to the detector readout, trigger, reconstruction/identification/calibration of physics objects, and computing, but thanks to the dedication, hard work and novel ideas from the collaboration, the data collected were of high quality and it was possible to minimize or eliminate the impact of pile-up on physics analyses. The UCL ATLAS team was heavily involved both in the data taking and the physics analyses, with a major highlight of the first evidence for the Higgs decays to a pair of b-quarks, where Dr Scanlon led the analysis, and numerous publications of results from searches for new physics at 13TeV coordinated by Dr Facini.

In parallel with the successful data taking and analysis, 2017 was a landmark year for the long-term planning of the High Luminosity (HL-) LHC programme, planned to start in 2026 and deliver to the LHC experiments about 100 times more data that in 2017, up to 4000 fb-1 by the late 2030s. At the same time, the ATLAS collaboration finalised the plans for the detector upgrades for HL-LHC, producing Technical Design Reports (TDRs) for each sub-system. The UCL ATLAS team was heavily involved in two of these documents: the Silicon Tracker (ITk) upgrade TDR and the Trigger & DAQ (TDAQ) system upgrade TDR. In the former, UCL continued to provide key expertise in the development of the ITk readout architecture, particularly for the ITk Strips, while in the latter, we maintained our leadership role and provided significant inputs to the design of the Hardware Tracking Trigger system, which is a central component of the proposed TDAQ upgrades.

Neutrino Physics and Dark Matter

The Group has a long history of leadership in neutrino oscillation experiments based on our key contributions to the MINOS project that produced one of the first pieces of convincing evidence for physics beyond the Standard Model – the non-zero neutrino mass. We are involved in one currently running experiment – NovA and two construction/R&D projects – DUNE and CHIPS. We are also looking for ultra-high-energy interactions of astrophysical neutrinos in Antarctic ice with the ANITA experiment.

After several years of construction, including here in the Department of Physics & Astronomy and the Mullard Space Science Laboratory, a UCL-led experiment, SuperNEMO, is on the threshold of turning on. SuperNEMO comprises a 16 cubic-metre Geiger counter, coupled with sensitive scintillation detectors. It will be able to measure extremely rare nuclear double-beta decays of 82Se with half-lives billions of times longer than the age of the universe. If double-beta decays are observed without the usual pair of neutrinos being produced, it could indicate that neutrino annihilation can take place within the nucleus. This is a theoretically elegant prediction which, if confirmed experimentally, could shed light on the nature of neutrinos and the origin of the cosmic matter-antimatter asymmetry, and measure the value of the neutrino mass. UCL continues to play a leading role in this international collaboration with Professor Waters taking over from Professor Saakyan as Co-Spokesperson from 1 Jan 2018.

Ultra-low background techniques employed in SuperNEMO have a lot in common with searching for extremely rare dark matter particle interactions here on earth. UCL is leading an international project, LZ, which uses a large quantity of liquid Xenon at a deep underground laboratory in South Dakota, USA.

Low background experiments require bespoke facilities capable of screening the tiniest traces of radioactive contaminants in the materials of their detectors. UCL physicists led by Dr Ghag have played a key role in the establishment of a state-of-the-art undergraduate laboratory at Boulby, North Yorkshire. It includes five high-purity Germanium detectors and a new XIA alpha detector to measure surface contaminations.

Figure 1
The Boulby Underground Germanium Suite (BUGS) – a state-of-the-art underground facility for measuring ultra low contaminations of radioactive elements in materials.

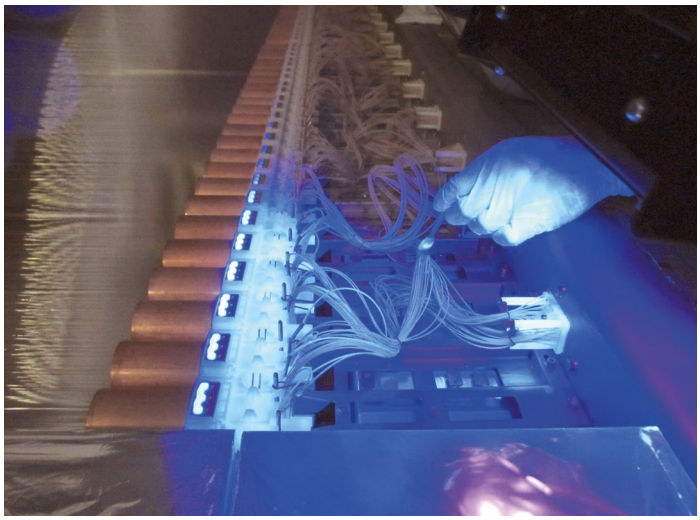


Figure 2
The SuperNEMO Tracking Detector being connected to readout electronics.

> "The group has a strong tradition of developing new technologies for future particle physics"

Accelerators

The group has a strong tradition of developing new technologies for future particle physics experiments and applications outside academia. The AWAKE experiments will use very high electric fields generated in a plasma with a driver beam to generate field gradients up to 100 GV/m, thus creating a very compact, almost a "table-top" accelerator for very high energies. Professor Wing is Deputy-Spokesperson of the AWAKE collaboration and the UCL group is responsible for the design and production of an electron spectrometer. The first electrons will be accelerated using this technology in 2018 and their energy will be measured by the UCL spectrometer.

The group is also involved in medical applications of accelerator and detector technologies. In particularly, the technology developed for the SuperNEMO scintillator calorimeter is currently being applied to solve the problem of proton range verification in proton beam therapy.

Theory

Experimental studies at the LHC are going hand in hand with theoretical advances in understanding the Standard Model (SM) of particle physics and uncovering the complex, entangled distributions of quarks and gluons inside the protons colliding at the LHC led by UCL's Professor Thorne and Dr Hamilton. There is a number of hints that the SM does not fully describe the world around us (neutrinos, dark matter, dark energy). Dr Frank Deppisch is working closely with the experimentalists of the group to build models beyond the SM and relate them to experimental observations.

Condensed Matter and Materials Physics (CMMP)

The Condensed Matter and Materials Physics (CMMP) section comprises many independent research groups spanning diverse themes including materials modelling, many body theory, neutron and X-ray scattering, materials discovery and beyond. The following is a small selection of some of the highlights of CMMP published research for this year.

How to liberate natural gas

Hydrates of gases are ice-like structures in which gas molecules are trapped inside water molecules that form under conditions of high pressure and low temperature. They are potentially the world's largest natural gas resource, and yet, far from being beneficial to mankind, they instead cause severe problems in oil and gas pipelines and are a significant source of greenhouse gases.

There is understandably much interest in elucidating the mechanisms by which gas hydrates form, with a view to the design of future inhibitor technologies. New research, involving Profs. Neal Skipper and Angelos Michaelides of the CMMP, in collaboration with scientists at ISIS Neutron and Muon Source and BP Exploration Operating Co. Ltd, have applied neutron scattering and molecular dynamic simulations to study a prototypical natural gas hydrate – methane hydrate.

> "The researchers investigated the effect of dissolved solid impurity particles made of clay and silica…"

The researchers investigated the effect of dissolved solid impurity particles made of clay and silica – typical particles found under natural and industrial conditions -- on the formation of methane hydrate. They used neutron scattering in conjunction with hydrogen-deuterium isotopic labelling to study the formation process of methane hydrate. The surprise was that the formation of methane hydrate was found to be insensitive to the addition of the nanoparticle impurities. This is unexpected because small particles generally enhance ice formation by orders of magnitude.

The explanation highlights the different chemical natures of methane and water. While water molecules are polar and form relatively strong hydrogen bonds, methane molecules are non-polar and interact through much weaker interactions. The different chemical natures of methane and water mean it is unlikely that the surface of a dissolved particle will display a strong affinity for both water and methane, and it therefore won't promote mixing and hydrate formation.

The experimental work was backed up by molecular dynamic simulations which showed how methane hydrate forms away from the solid impurity/liquid interface - a useful result for the design of inhibitor technologies. As hydrate formation occurs away from mineral surfaces it was suggested that future studies could focus on weakening the affinity of inhibitors to mineral surfaces to improve their effectiveness.

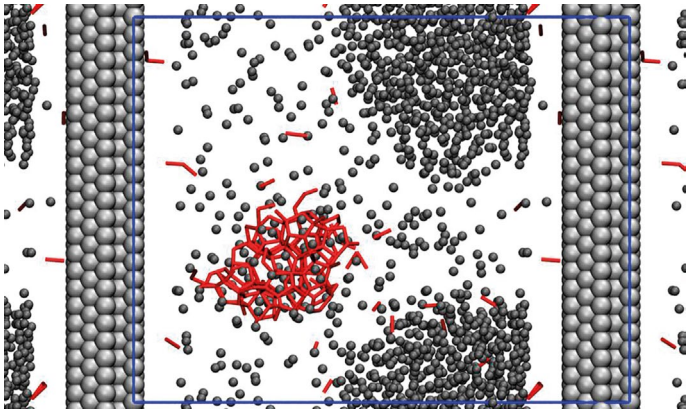


Figure 1. A snapshot from a molecular dynamics simulation of clathrate formation.

Light-emitting solutions

The modern world is very much lit by light emitting diodes (LED's) and along with the related technology of solar cells, this creates an ever-present demand for new and efficient materials that have these properties. In particular, there is great interest in materials that emit light in the near infrared region, as these can be of use in everything form night vision devices to intracellular imaging in medicine. A CMMP research team lead by Dr. Chris Howard has teamed up with a broad international collaboration, funded in part by the European Union's Graphene Flagship programme, to demonstrate near-infra-red LED's based on organic chemicals. These are produced through the simple, but unconventional, method of spontaneous dissolution. Two-dimensional nanomaterials based on carbon nitride were shown to produce solutions containing fluorescent solutes that are defect-free, hexagonally-shaped two-dimensional nanosheets. The production method strongly contrasts standard alternatives and may be industrially-scalable. The work is part of an ongoing research programme that creates true solutions of nanomaterials (analogous to salt or sugar dissolving in water), rather than colloidal suspensions (like paint) that can separate over time. The process has been patented and UCL will be supporting the commercialisation process.

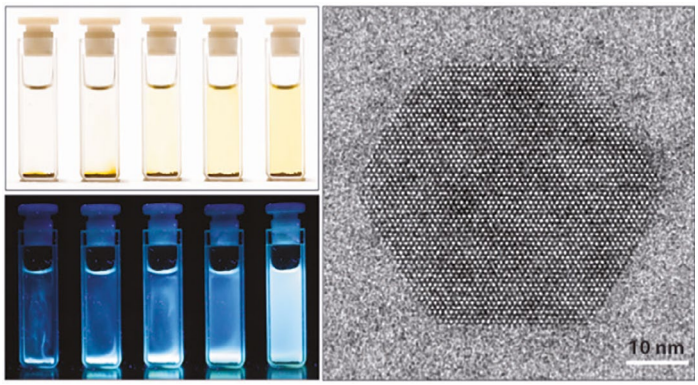


Figure 2. Hexagonal carbon nitride nanosheets gently dissolve into solution over time (left), producing luminescent, defect free 2d-nanosheets (right)

Disappearing ice

CMMP scientist Prof. Steve Bramwell has collaborated with Dr. Christoph Salzmann and Dr. Ben Slater at UCL Chemistry, as well as the UK's ISIS Neutron and Muon Source to unlock the secrets of ice's high pressure phase diagram. The work has shed light on the origin of many of water's unusual properties and is important to understand how ice coexists with other materials in nature, for example on Jupiter's icy moons. The team discovered that the addition of only a tiny amount of ammonium fluoride impurity caused an important phase of ice, ice II, to completely disappear from the water phase diagram. The researchers attributed this behaviour to a special property of ice II's connectedness or topology, which means that ammonium fluoride can only be absorbed only at extremely high energy cost. The work points to a new explanation for many of water's well-known anomalies.

Special temperatures in special magnets

The ability to reach low temperature – a few kelvin for example -- is taken for granted in modern science, but what underpins it is a subtle balancing of very weak forces between the molecules in gases. Such forces are barely discernible at room temperature, but play a crucial role in our ability to cool things down to very low temperatures. This was first understood by the celebrated nineteenth century scientists James Joule and William Thomson who identified a special temperature below which gases can be cooled by expansion. The effect was later exploited by the technologists Carl von Linde and William Hampson as a practical means of reaching very low temperature, which is still the basic method used today.

New work in the LCN and CMMP by Dr. Laura Bovo and Prof. Steve Bramwell has shown that special temperatures, marking related changes in physical properties are not confined to gases, but also occur in certain magnetic materials that the workers have called "inverting magnets". The special temperatures of the magnets – as in the case of gases – can be used as a diagnostic of very weak and competing interactions in the material. They give a surprising insight into how the magnets eventually behave in the approach to absolute zero of temperatures, for example if the magnet is going to become an ordinary magnet (a ferromagnet) or enter an exotic state such as a so-called spin liquid or spin ice.

Figure 3 Spheres of the magnetic material "spin ice" used in the study in front of a large-scale model of the atomic connections in the material. Credit: Laura Bovo.

Superfluid light

Superfluid helium can flow without any friction and even escape up and over its container walls. In a helium film the transition between superfluid (say at low temperature) and normal behavior (at high temperature) is dramatic, being caused by the appearance of a large number vortices in the flow that destroy the superfluid state. The vortices are known as topological defects because they cannot be removed by stretching or bending the field lines of the flow, reflecting only the connectivity or topology of the field lines.

Is such a transition may be possible for particles of light (the photons), but these cannot be perfectly trapped in any container and their inevitable escape has to be counterbalanced by an external influx to keep the situation steady. New research involving Dr. Marzena Szymanska of the CMMP and AMOPP has found that, nevertheless, a transition analogous to that of a superfluid is indeed still caused by proliferating vortices. This was made possible by the creation of a long-lived fluid of light in specially engineered semiconductor microstructures. The elementary particles present in these structures are called exciton-polaritons and are half-light half-matter particles. The confined photons have non-zero mass and they interact via the matter component of polaritons forming a quantum fluid very similar to liquid helium.

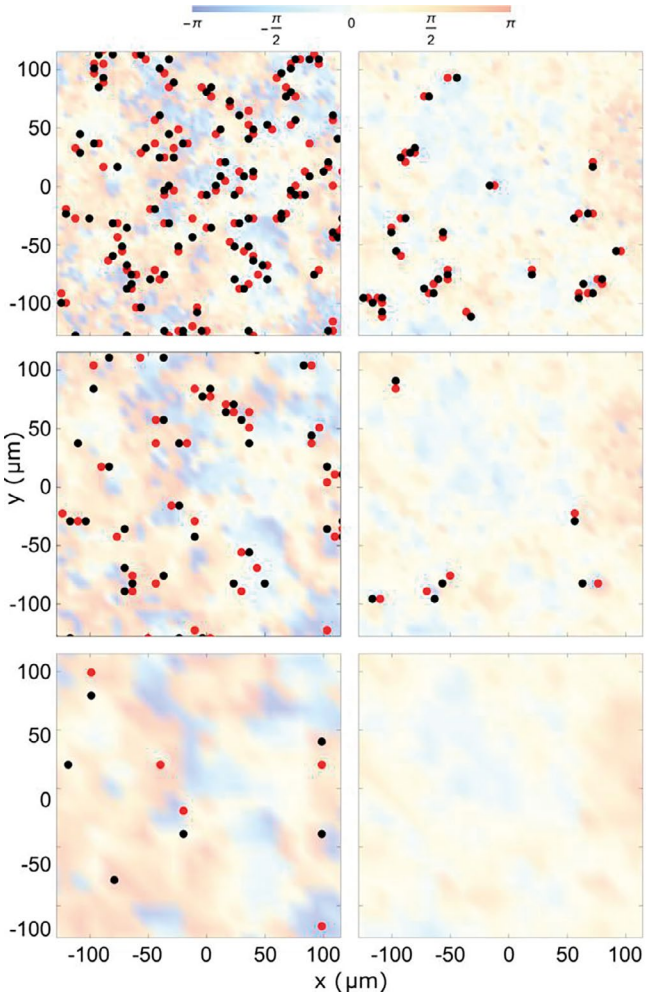


Figure 4. Vortex–antivortex distribution map. Top: vortices (V) in red and anti-vortices (AV) in black just before (left) and after (right) the superfluid transition.

Biological Physics (BioP)

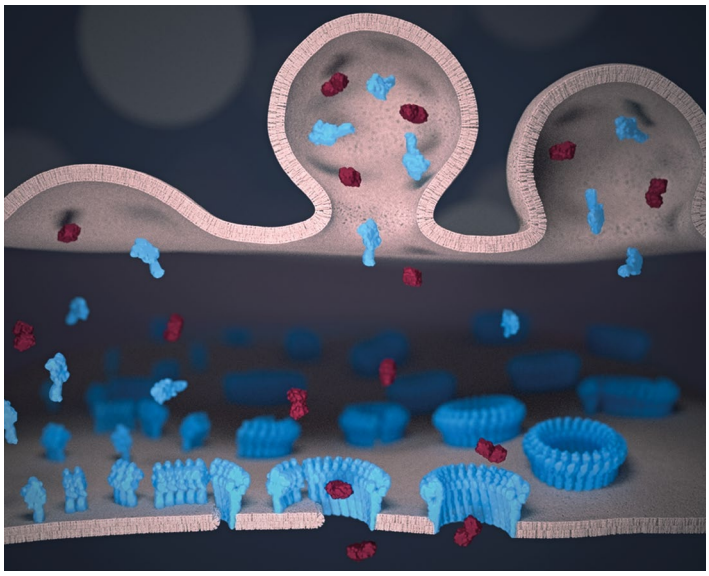
The Biological Physics group focuses on solving key intellectual and practical problems in the physics of biological systems and the underlying properties of soft matter, from molecular to cellular length scales, by using experimental, computational and theoretical methods. It overlaps with the cross-faculty UCL Institute for the Physics of Living Systems (IPLS), which promotes interdisciplinary approaches that combine physics and biology to understand fundamental properties of living systems. The following article illustrates how we use physical methods to better understand molecular interactions between our body and invading pathogens.

Nanodrills in bacterial attack and immune defense

Many disease-causing bacteria secrete toxic proteins that drill holes into our cells to kill them. For instance, in diseases such as pneumonia, meningitis and septicaemia, so-called cholesterol-dependent cytolysins (CDCs) bind to the membrane that surrounds each of our cells and next assemble in rings that grind their way into the cell surface, resulting in large pores – some tens of nanometres across – that are lethal for the cell under attack.

However harmful such attacks may be, our body too has developed devastating weapons, to defend itself against invading bacteria and rogue cells. In various cases, this involves similarly operating nanodrills. For example, immune proteins in our blood can assemble membrane attack complexes that kill bacteria. And some of our white blood cells first perforate virus-infected and cancerous cells by so-called perforins, to next inject poisonous enzymes that rid our body from disease.

The bacterial CDCs, the proteins in the membrane attack complex, and perforin act as the Lego bricks of rather sophisticated building sets. These bricks somehow transform into complete drilling machines that terminate target cells. Hence, rather unusually from the perspective of our macroscopic daily-life experience, they do not need a builder, but self-assemble on their targets. This raises the scientific question how this self-assembly works; and – beyond the purely scientific interest – one may hope that the answers to this question will provides guidance for developing new therapies against infectious diseases and cancer.



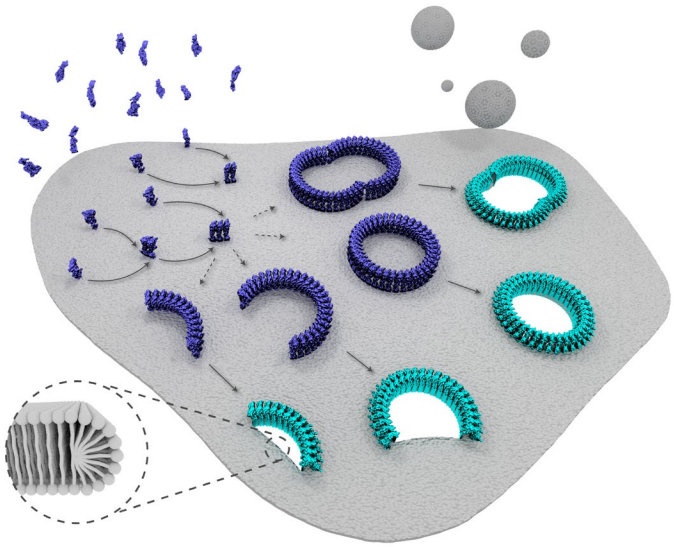
Schematic view of the immune synapse between a lymphocyte (top) and a target cell (bottom). Perforin (blue) and granzymes (red) are delivered to the synapse via storage vesicles. Once released, perforin binds the target cell membrane and initially forms short, intermediate assemblies. These assemblies can insert into the membrane, and recruit further assemblies from the membrane surface to grow the pore diameter. Perforin pores of sufficient size allow passage of granzymes to rapidly induce target cell death. Courtesy of Adrian Hodel.

Self-assembling Lego bricks in action

For these reasons, Bart Hoogenboom's lab carries out an extensive research programme focussed on these 'pore forming proteins', primarily with funding from the Biotechnology and Biological Sciences and Medical Research Councils (BBSRC and MRC). This programme relies on a combination of various techniques, but one of its preferred tools is atomic force microscopy. This type of microscopy uses an ultrafine needle to feel rather than see proteins on a target membrane, similar to a blind person reading Braille. The needle repeatedly scans the surface to produce an image that can – under appropriate conditions – refresh fast enough to track how proteins get together and cut holes in the membrane.

For the bacterial CDCs, such experiments have now firmly established that these proteins first assemble on top of the target membrane and only later – at a much slower time scale – collectively act as cookie cutters that slice into the membrane. By real-time microscopy experiments, it could next be shown that "cookies" of membrane material (consisting of lipids) are indeed spat out of the membrane once the bacterial proteins are triggered to action.

At first sight, the immune protein perforin appeared less effective in building assemblies on its target membranes. A priori, this could be problematic for the immune system, since its rogue targets can repair their membranes before they are killed. To prevent this from happening, however, perforin pulls another trick from its sleeve. Unlike the bacterial CDCs, perforin proteins can continue to assemble also once they are inserted into the membrane. Moreover, upon their insertion into the membrane, small perforin assemblies act as nucleation sites for rapid continuation of the assembly process and pore growth, thus greatly enhancing the efficacy of perforin-dependent immune function.



Schematic of assembly and membrane assembly of bacterial CDCs on a target membrane, from Leung et al., eLife 3, e04247 (2014).

Cocktail party model of self-assembly

All the here mentioned proteins can build ring-shaped, symmetric assemblies that form pores in membranes. Surprisingly, however, it was found that incomplete, arc-shaped assemblies are similarly effective in perforating membranes. And interestingly, these incomplete assemblies can be used to – based on physical models – infer further information on how they are formed.

Such models can take into account that a system of many self-assembling molecules may find itself trapped in configurations that are not necessarily the most favourable. To understand this, one may imagine a cocktail party with hugely attractive persons, such that once these persons start talking to each other, they will not come loose again and be stuck for life. In the limit of a rapid arrival of such visitors and a slow initiation of conversations, visitors will start talking to the person closest to them and upon meeting lose interest for anyone else, with many couples as a result. On the other hand, with visitors slowly dripping in, each new visitor will focus his/her attention to an already present group of party-goers and join it to thus increase the group size, leading to predominantly larger 'assemblies'. Cast into mathematical equations, such a model was found to accurately fit distributions of pore forming protein assemblies, with only a single free parameter that depends on the rate of protein binding to the membrane and the rate of protein assembly on the membrane.

> "…on-going research focuses on experiments with life bacteria, with the potential to contribute to the development of future antimicrobial therapies."

Outlook

Much of our understanding of pore forming proteins relies on experiments with model membranes. This offers the advantage of excellent control over the experimental system but does not necessarily explain how these proteins disturb more complicated membranes, such as bacterial envelopes targeted by the membrane attack complex. Hence on-going research focuses, among other things, on experiments with life bacteria, with the potential to contribute to the development of future antimicrobial therapies.

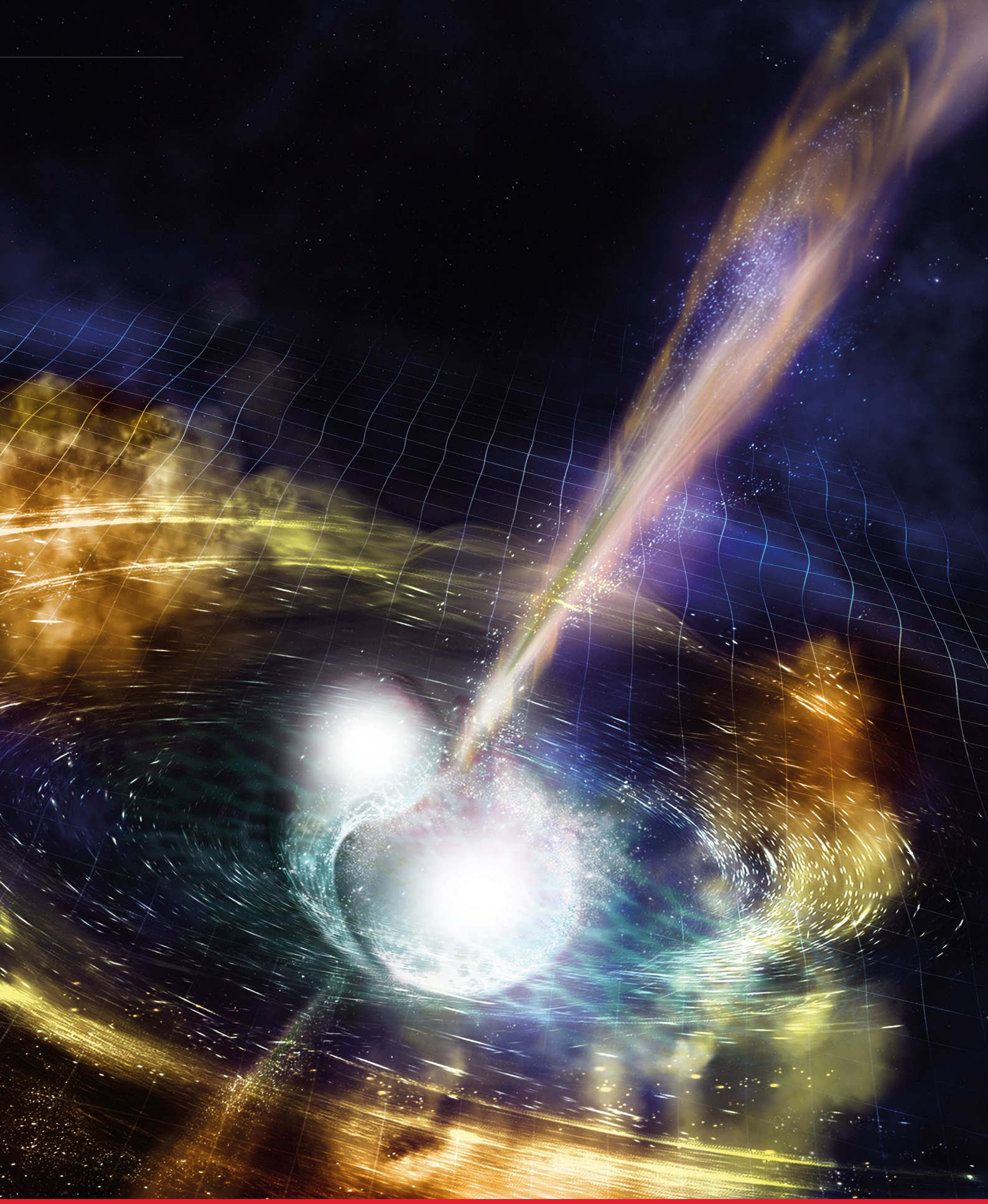
Key References

Leung et al., Stepwise visualization of membrane pore formation by suilysin, a bacterial cholesterol-dependent cytolysin, eLife 3, e04247 (2014).

Hodel et al., Atomic force microscopy of membrane pore formation by cholesterol dependent cytolysins, Curr. Opin. Struct. Biol. 39, 8–15 (2016).

Lukoyanova et al., The membrane attack complex, perforin and cholesterol-dependent cytolysin superfamily of pore-forming proteins, J. Cell Sci. 129, 2125–2133 (2016).

Leung et al., Real-time visualization of perforin nanopore assembly, Nat. Nanotechnol. 12 467–473 (2017).

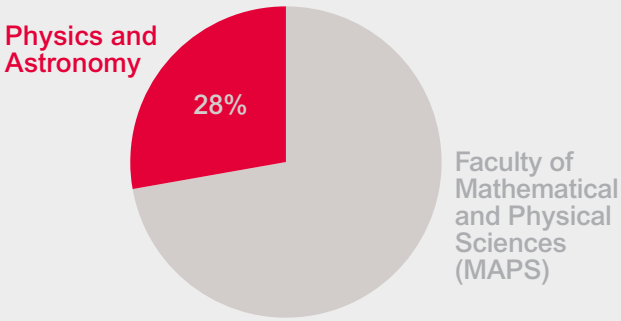


Research Statistics

Research Statistics

Active Grants and Contracts

In the last financial year (Aug 2016 – Jul 2017), the MAPS faculty as a whole yielded £56.3 million, with the Department of Physics and Astronomy contributing £15.6 million (28%) of the total research income for the MAPS faculty.



Astrophysics

University Research Fellowship Renewal (Royal Society) PI: Dr Filipe Abdalla, £318,537

SKA preconstruction phase at UCL (STFC) PI: Dr Filipe Abdalla, £281,909

SKA preconstruction phase continuation at UCL (STFC) PI: Dr Filipe Abdalla, £274,814

UCL Astrophysics consolidated grant 2015 - 2018 (STFC) PI: Dr Filipe Abdalla, £252,696

DEDALE Data learning on manifolds and future challenges (European Commission H2020) PI: Dr Filipe Abdalla, £315,508

MSSL Solar and Planetary Physics Consolidated Grant 2016 -2019 (STFC) PI: Prof Nick Achilleos, £392,682

Europlanet 2020 research infrastructure – EPN2020-RI (European Commission H2020) PI: Prof Nick Achilleos, £247,980

Observations of thermospheric winds in the presence of TIDs (Royal Society) PI: Dr Anasuya Aruliah, £67,940

Variability of Neutral Temperature in the High-Latitude Upper Atmosphere (NERC) PI: Dr Anasuya Aruliah, £32,933

Time-variability of the ionospheric electric field (NERC) PI: Dr Anasuya Aruliah, £88,611

Auroral thermosphere density study (Office of Naval Research) PI: Dr Anasuya Aruliah, £64,907

UCL Astrophysics consolidated grant 2015–2018 (STFC) PI: Prof Michael Barlow, £540,456

SNDUST: Supernova Dust: Production and Survival Rates (European Commission H2020) PI: Prof Michael Barlow, £2,028,620

Additive manufacturing of space-based optics (UKSA) PI: Dr David Brooks, £7,910

Think Universe! Fundamental science master classes for school teachers at KS2 (STFC) PI: Dr Francisco Diego, £9,481

The dark energy spectroscopic instrument (STFC) PI: Prof Peter Doel, £742,939

UCL Astrophysics consolidated grant 2015–2018 (STFC) PI: Prof Peter Doel, £351,112

Fellowship: Nature versus nurture – the effect of stellar irradiation on atmospheric evolution (Royal Astronomical Society) PI: Dr Jo Barstow Eberhardt, £165,219

Early star-forming galaxies and cosmic reionisation (European Commission H2020) PI: Prof Richard Ellis, £1,843,803.75

Archaeology of exo-terrestrial planetary systems and a search for water (STFC) PI: Dr Jay Farihi, £318,089

Fellowship: Precision cosmology at high redshift with the lyman-alpha forest (STFC) PI: Dr Andreu Font Ribera, £491,529

IOSPOT: Monitoring the IO plasma torus (RAS) PI: Dr Stephen Fossey, £2,000

Career Acceleration Fellowship (CAF): Star formation and the ism evolution of galaxies across cosmic time (STFC) PI: Dr Thomas Greve, £471,898

UCL Astronomy Group Travel Grant (STFC) PI: Dr Thomas Greve, £60,731

Fellowship: Massive star formation with new generation interferometers (STFC) PI: Dr Izaksun Jimenez-Serra, £451,297

Chemical pathways to life: amino acids and their precursors in the ISM (STFC) PI: Dr Izaksun Jimenez-Serra, £241,742

Ernest Rutherford Fellowship: Advancing weak lensing and intrinsic galaxy alignment studies to the era of precision cosmology (STFC) PI: Dr Benjamin Joachimi, £351,642

A multi-probe strategy to pin down the nature of gravity and dark energy (STFC) PI: Dr Benjamin Joachimi, £218,171

EUCLID Implementation Phase 2015-2020 (STFC) PI: Dr Benjamin Joachimi, £654,666

TESTDE: Testing the dark energy paradigm and measuring neutrino mass with the dark energy survey (European Commission FP7) PI: Prof Ofer Lahav, £1,844,558

UCL Astrophysics consolidated grant 2015-2018 (STFC) PI: Prof Ofer Lahav, £122,431

Studentship: Weighting the stellar content of galaxies as a tool of precision dark energy measurements (Universities Research Association) PI: Prof Ofer Lahav, £9,677

Fellowship: Glimpse - Understanding the dark universe through 3D weak lensing reconstructions (European Commission FP7) PI: Dr Adrienne Leonard, £166,205

Daphne Jackson Fellowship (Daphne Jackson Fellowship Trust) PI: Dr Maria Mendes Marcha, £77,401

Cosmic Dawn – understanding the origins of cosmic structure (EU FP7) PI: Prof Hiranya Peiris, £1,119,800

UK Involvement in LSST: PHASE A (STFC) PI: Prof Hiranya Peiris, £92,666

Fellowship: Connecting physics and galaxy formation (Royal Society University Research Fellowship) PI: Dr Andrew Pontzen, £454,692

UCL Astrophysics consolidated grant: 2015–2018 (STFC) PI: Prof Raman Prinja, £393,273

UCL Astrophysics consolidated grant: 2015–2018 (STFC) PI: Prof Jonathan Rawlings, £355,311

University Research Fellowship (Royal Society) PI: Dr Amelie Saintonge, £467,973

Cold gas and the chemical evolution of galaxies (Royal Society) PI: Dr Amelie Saintonge, £69,577

Self-consistent modelling of the interstellar medium of galactic scales (Royal Society) PI: Dr Amelie Saintonge, £14,205

Critical technology advancement of the locus mission: toward future space light (UK Space Agency) PI: Dr Giorgio Savini, £702,991

University Research Fellowship Renewal: The exoplanet revolution (Royal Society) PI: Prof Giovanna Tinetti, £311,958

ExoLights – Decoding lights from exotic worlds (European Research Council) PI: Prof Giovanna Tinetti, £1,385,754.95

ESA M4 Mission Candidate Ariel Phase A Study May 2016-Mar 2017 (STFC) PI: Prof Giovanna Tinetti, £26,498

Studentship: Exoplanet spectroscopic observations from space and ground-telescopes and data reduction (Instituto Nazionale di Astrofiscia) PI: Prof Giovanna Tinetti, £24,358

Studentship: The science of ARIEL (Instituto Nazionale di Astrofiscia) PI: Prof Giovanna Tinetti, £24,358

STFC DiRAC Project Office 2014 – 2017 (STFC) PI: Dr Jeremy Yates, £422,439

A Pathfinder Project for a National AAAI (STFC) PI: Dr Jeremy Yates, £155,625

Studentship: Accelerated 3D general purpose radiative transfer codes (Intel) PI: Dr Jeremy Yates, £27,144

AMOPP

In situ quantification of metabolic function using florescence lifetime imaging (BBSRC) PI: Dr Angus Bain, £218,061

Cavity optomechanics: Towards sensing at the quantum limit (EPSRC) PI: Prof Peter Barker, £814,269

Quantum cavity optomechanics of levitated nanoparticles (EPSRC) PI: Prof Peter Barker, £869,905

Nonclassicalities and quantum control at the nanoscale (EPSRC) PI: Prof Sougato Bose, £1,166,350

Nanoelectronic based quantum physics – technology and applications (EPSRC) PI: Prof Sougato Bose, £441,672

PACOMANEDIA: Partially coherent many-body non-equilibrium dynamics for information applications (European Commission FP7) PI: Prof Sougato Bose, £947,605

Gravitational free fall experiments with positronium (Leverhulme Trust) PI: Dr David Cassidy, £147,622

Production and manipulation of Rydberg positronium for a matter-antimatter gravitational freefall measurement (EPSRC) PI: Dr David Cassidy, £693,517

Spectroscopy of Positronium: Atom control and gravity measurments (European Commission) PI: Dr David Cassidy, £75,000

Semi classical models for ultra-fast multi electron phenomena in intense electromagnetic laser fields (EPSRC) PI: Dr Agapi Emmanouilidou, £336,665

Control and imaging of processes triggered by x-ray pulses in multi-centre molecules (EPSRC) PI: Dr Agapi Emmanouilidou, £309,665

Orbit-based methods for multi-electron systems in strong fields (EPSRC) PI: Dr Carla Figueira De Morisson Faria, £313,960

Hybrid cavity-QED with Rydberg atoms and microwave circuits (EPSRC) PI: Prof Stephen Hogan, £524,578

CATLOMCHIP: Cold atmospheric molecules on a chip (European Commission H2020) PI: Prof Stephen Hogan, £1,290,609

Doctoral Prize Fellowship (EPSRC) Fellow: Dr Ciarán Lee, £97,177

A fast fluorescence and photonic force microscope with nanometre and femtonewton resolution (MRC) PI: Dr Isabel Llorente Garcia, £50,000

Fellowship: Luca Marmugi – Gammalas towards gamma-ray lasers via super-radiance in a Bose-Einstein condesate of 135mCs isomers (European Commission H2020) PI: Prof Ferruccio Renzoni, £128,418

Fellowship: RMAT3 theoretical study of cold and ultracold collisions intriatomic systems using inner-Region nuclear motions wave functions and outer-region R-matrix propagation (European Commission) Fellow: Dr Laura McKemmish £127,046

Phonon-assisted processes for energy transfer and sensing (EU FP7) PI: Dr Alexandra Olaya-Castro, £184,320

Quantum secrets of photosynthesis at the Royal Society Summer Science Exhibition (EPSRC) PI: Dr Alexandra Olaya-Castro, £2,500

Fellowship: Quantum information science: Tools and applications for fundamental physics (EPSRC) PI: Prof Jonathan Oppenheim, £984,329

Wolfson Research Merit Award (Royal Society) PI: Prof Jonathan Oppenheim, £60,000

Studentship: What are the laws of quantum thermodynamics? (FQXi) PI: Prof Jonathan Oppenheim, £40,360

IT from QUBIT: quantum fields, gravity and information (Simons Foundation) PI: Prof Jonathan Oppenheim, £251,429

Control of atomic motion with AC fields (Royal Society) PI: Prof Ferruccio Renzoni, £12,000

Exploring stochastic thermodynamics with optical traps (Leverhulme Trust) PI: Prof Ferruccio Renzoni, £149,040

Studentship: Identifying and characterising materials using magnetic field interrogation (AWE) PI: Prof Ferruccio Renzoni, £66,035

COSMA – coherent optics sensors for medical applications (European Commission FP7) PI: Prof Ferruccio Renzoni, £23,550

Impact Studentship: Atomic magnetometers for medical applications (NPL Management Ltd) PI: Prof Ferruccio Renzoni, £32,583

Studentship: Application of quantum magnetometers to security and defence screening (Defence Science and Technology Laboratory) PI: Prof Ferruccio Renzoni, £124,662

Studentship: Cylindrical magnetic imaging tomography (AWE) PI: Prof Ferruccio Renzoni, £61,500

Studentship: Magnetic sensor systems for the detection of metallic objects (AWE) PI: Prof Ferruccio Renzoni, £75,035

Localisation of arrythmogenic foci with a radio-frequency atomic magnetometer (Wellcome Trust) PI: Prof Ferruccio Renzoni, £44,688

Ultra-low frequency magnetic induction tomography with atomic magnetometers for security and defence applications (EPSRC) PI: Prof Ferruccio Renzoni, £76,135

What's Inside The Building Challenge 1: Detection – detection and identification using electromagnetic induction with atomic magnetometers (Thales) PI: Prof Ferruccio Renzoni, £28,123

Gamma-Ray nuclear super-radiance in a Bose-Einstein condensate (Royal Society) PI: Prof Ferruccio Renzoni, £12,000

Threat detection fast parcels (Home Office) PI: Prof Ferruccio Renzoni, £13,358

Coherent quantum matter out of equilibrium from fundamental physics towards applications (EPSRC Fellowship) Fellow: Dr Marzena Szymanska, £1,222,168

Novel superfluid phenomena in semiconductor microcavities (EPSRC) PI: Dr Marzena Szymanska, £295,981

The UK theory of condensed matter summer school (EPSRC) PI: Dr Marzena Szymanska, £170,029

ExoMol - molecular line lists for exoplanet atmospheres (European Commission FP7) PI: Prof Jonathan Tennyson FRS, £1,878,425

Wolfson Research Merit Award: Molecular line lists for extra solar planet and other hot bodies (Royal Society) PI: Prof Jonathan Tennyson FRS, £72,000

Studentship: James Hamilton – Electronic impact vibrational excitation of water molecules (Quantemol Ltd.) PI: Prof Jonathan Tennyson FRS, £12,900

Studentship: Modelling of spectra of hot molecules (Servomex Ltd.) PI: Prof Jonathan Tennyson FRS, £18,150

Atomic and molecular data services for astrophysics (STFC) PI: Prof Jonathan Tennyson FRS, £47,110

Studentship: Emma Burton – Line lists for hot chlorine containing molecules (Danish Technical University) PI: Prof Jonathan Tennyson FRS, £32,583

High accuracy transition intensities for ozone (NERC) PI: Prof Jonathan Tennyson FRS, £347,048

ExoData: a commercially supported space telescope (European Commission H2020) PI: Prof Jonathan Tennyson FRS, £90,645

Commercial space science service provision (EPSRC) PI: Prof Jonathan Tennyson FRS, £7,800

Support for theoretical molecular physics research at the University of Douala Cameroon (Institute of Physics) PI: Prof Jonathan Tennyson FRS, £1,936

Studentship: Daniel Darby: r-matrix calculation of electron collisional excitation rates of jet and iter relevant molecules (UK Atomic Energy) PI: Prof Jonathan Tennyson FRS, £23,000

Fellowship: RichMol – Optical activity of molecules with rotational chirality (European Commission) PI: Dr Sergey Yurchenko, £173,462

UCL Astrophysics Consolidated Grant 2015–2018 (STFC) PI: Dr Sergey Yurchenko, £234,536

CMMP

Many CMMP grants are held through the London Centre for Nanotechnology (LCN)

Characterisation of electron transport in bacterial nano-wire proteins through high performance computing and experimentation (EPSRC) PI: Prof Jochen Blumberger, £321,327

Impact Studentship: Exploration of the performance of a CDFT for the calculation of parameters that govern the thermodynamics and kinetics of interfacial ET reactions (PNNL) PI: Prof Jochen Blumberger, £27,168

SOFTCHARGE: charge carrier transport in soft matter: from fundamentals to high performance materials (European Commission H2020) PI: Prof Jochen Blumberger, £1,492,491

CONTEST: Collaborative network for training in electronic skin technology (European Commission FP7) PI: Prof Franco Cacialli, £480,418

SYNCHRONICS: Supramolecularly engineered architectures for optoelectrics and photonics: a multi-site initial training action (European Commission H2020) PI: Prof Franco Cacialli, £802,338

Fellowship: Semiconducting Nanostructures (Royal Society) PI: Prof Franco Cacialli, £62,500

MARVEL: Multifunctional polymer light-emitting diodes with visible light communications (EPSRC) PI: Prof Franco Cacialli, £372,355

Centre for advanced materials for integrated energy systems (CAM- IES) (EPSRC) PI: Prof Franco Cacialli, £83,733

Modelling nano-ferroelectrics (NPL Management Ltd) PI: Prof Dorothy Duffy, £30,000

Studies of domain dynamics in nano-ferroelectrics (NPL Management Ltd) £31,505 PI: Prof Dorothy Duffy

Consequence analysis postdoctoral research associate 1 (Ministry of Defence) PI: Prof Ian Ford, £227,288

Consequence analysis postdoctoral research associate 2 (Ministry of Defence) PI: Prof Ian Ford, £227,288

Graphenecore1 - graphene-based disruptive technologies (European Commission H2020) PI: Dr Chris Howard, £68,933

Enabling the realisation of truly flexible displays through the use of carbon nanotube technologies (EPSRC) PI: Dr Chris Howard, £48,304

Wolfson Research Merit: A paragidm shift in the accuracy of simulations at water-solid interfaces (Royal Society) PI: Prof Angelos Michaelides, £75,000

Support for the UKCP Consortium (EPSRC) PI: Prof Angelos Michaelides, £9,985.26

HETEROICE – Towards a molecular-level understanding of heterogeneous ice nucleation (European Commission H2020) PI: Prof Angelos Michaelides, £1,436,312.25

Tier 2 hub in materials and molecular modelling (EPSRC) PI: Prof Angelos Michaelides, £4,000,000

Materials and molecular modelling high performance (HPC) hub (OCF Plc) PI: Prof Angelos Michaelides, £140,000

Quantum feedback control of levitating opto-mechanics (EPSRC) PI: Dr Alessio Serafini, £579,937

EngD Studentship: Advanced gate stack and dielectric in resistive memory material (International Sematech) PI: Prof Alexander Shluger, £48,047

EngD Studentship: Jonathan Cottom – ab-initio simulations in bulk and interface defects (Infineon Technologies Austria AG) PI: Prof Alexander Shluger, £30,000

EngD Studentship: Oliver Dicks – Tuning electronic properties of thin films and interfaces using defects (Argonne National Laboratory) PI: Prof Alexander Shluger, £58,412

Impact Studentship: Ashley Garvin - laser materials interaction (PNNL) PI: Prof Alexander Shluger, £45,400

Studentship: Atomistic modelling of reliability limiting point defects in silicon carbide and near the interface to silicon dioxide or contacting metals (Infineon Technologies Austria AG) PI: Prof Alexander Shluger, £35,000

Exploring polaronic effects in oxides using range-separated hybrid density functional theory (Weizman Institute of Science) PI: Prof Alexander Shluger, £7,059

Understand and controlling dynamic functional oxides (Leverhulme Trust) PI: Prof Alexander Shluger, £147,817

Studentship: Absorption self-assembly (University of Hamburg) PI: Prof Alexander Shluger, £32,000

Structural dynamics of amorphous functional oxides (EPSRC) PI: Prof Alex Shluger, £338,952

Studentship: David Ingram – Regeneration of H2 storage materials (CELLA Acquisition Ltd) PI: Prof Neal Skipper, £36,000

Studentship: Enoardo Maria Zatterin – Probing the static and dynamic properties of nanoscale ferroelectric domains (European Synchrotron Radiation Facility) PI: Dr Pavlo Zubko, £45,475

HEP

Development and maintenance of ATLAS run time tester (STFC) PI: Prof Jonathan Butterworth, £327,246

Giving Physics a boost at RUN-II of the LHC (Durham University) PI: Prof Jonathan Butterworth, £5,000

MCnetITN3: Innovative network for Monte Carlo event generators for LHC physics (European Commission H2020) PI: Prof Jonathan Butterworth, £290,252

South-eastern particle theory alliance Sussex – RHUL – UCL 2017 -2020 (STFC) PI: Dr Frank Deppisch, £118,375

Exotic contributions to double beta decay (Royal Society) PI: Dr Frank Deppisch, £12,000

Fellowship: Searches for beyond the standard model physics with hadronic topologies (STFC) PI: Dr Gabriel Facini, £489,070

Meeting radioactivity requirements for the discovery of dark matter (Royal Society) PI: Dr Chamkaur Ghag, £11,029

The LUX-ZEPLIN (LZ) dark matter search (STFC) PI: Dr Chamkaur Ghag, £377,011

Joint cryogenic radon emanation measurement facility (STFC) PI: Dr Chamkaur Ghag, £103,901

Laboratory of dark matters (STFC) PI: Dr Chamkaur Ghag, £3,600

Fellowship: Discovering the True Nature of the Higgs Boson at the LHC (Royal Society) PI: Dr Gavin Hesketh, £319,583

Mu3e: a proposal to extend the sensitivity to charged lepton flavour violations by 4 orders of magnitude (STFC) PI: Dr Gavin Hesketh, £4,536

Dorothy Hodgkin Fellowship: Investigating the neutrino with MINOS and liquid argon detector technology (Royal Society) PI: Dr Anna Holin, £466,676

Studentship: A calorimeter for proton therapy (NPL Management Ltd.) PI: Dr Simon Jolly, £34,107

OMA: optimization of medical accelerators (EU H2020) PI: Dr Simon Jolly, £177,637

Water equivalent calorimeter for quality assurance in proton beam therapy (STFC) PI: Dr Simon Jolly, £119,149

ATLAS upgrade (Phase 1) (STFC) PI: Prof Nikos Konstantinidis, £245,246

Ernest Rutherford Fellowship: Heavy quarks a window into new physics at ATLAS (STFC) PI: Dr Andreas Korn, £363,285

Measurement of the anomalous magnetic moment of the muon to 0.14ppm using the FNAL G-2 experiment (STFC) PI: Prof Mark Lancaster, £246,429

MUSE: muon campus in US and Europe contribution (EU H2020) PI: Prof Mark Lancaster, £135,000

A proposal to extend the sensitivity to charged lepton flavour violation by 4 orders of magnitude (STFC) PI: Prof Mark Lancaster, £64,887

LBNE and the Fermilab liquid argon detector programme (STFC) PI: Prof Ryan Nichol, £4,058

Probing the ultra-high energy universe with ANITA and ARA (Leverhulme Trust) PI: Prof Ryan Nichol, £220,205

Investigating the nature of the neutrino with MINOS (+) and LAR detector development for DUNE (URA) PI: Prof Ryan Nichol, £12,914

UCL experimental particle physics consolidated grant: 2015-2019 (STFC) PI: Prof Ryan Nichol, £4,763,816

Training network for Monte Carlo event generators for LHC physics (EU FP7) PI: Dr Emily Nurse, £177,938

University Research Fellowship: Search for a vector boson fusion produced Higgs boson at ATLAS (Royal Society) Fellow: Dr Emily Nurse, £406,633

University Research Fellowship Renewal: Higgs studies and a search for dark matter at the ATLAS experiment (Royal Society) Fellow: Dr Emily Nurse, £274,703

A novel technique to search for dark matter at the Large Hadron Collider (Leverhulme Trust) PI: Dr Emily Nurse, £288,386

Studentship: Determining the properties of the Higgs Boson (Royal Society) PI: Dr Emily Nurse, £1,264

Low background techniques for particle physics and astrophysics (STFC) PI: Prof Ruben Saakyan, £33,310

High resolution fast detector for quality assurance in proton beam therapy (STFC) PI: Prof Ruben Saakyan, £118,042

University Research Fellowship: Determining the true nature of the Higgs-like particle (Royal Society) PI: Dr Tim Scanlon, £483,706

Determining the true nature of the Higgs-like particle (Royal Society), PI: Dr Tim Scanlon, £85,277

The path to CP violation in the neutrino sector: mega-ton water detectors (Leverhulme Trust) PI: Prof Jennifer Thomas CBE, £383,431

CHROMIUM (European Commission H2020) PI: Prof Jennifer Thomas CBE, £1,912,500

Theory Consolidated Grant – Standard Model Phenomenology and beyond (STFC) PI: Prof Robert Thorne, £410,047

Particle Phenomenology, QCD and the standard model (STFC) PI: Prof Robert Thorne, £433,272

Experimental Particle Physics Consolidated Grant 2012 – 2016 (STFC) PI: Prof David Waters £4,340,016

Supernemo commissioning and sensitivity demonstration (STFC) PI: Prof David Waters, £420,768

Enhanced European coordination for accelerator research and development (EU FP7) PI: Prof Matthew Wing, £93,794

AIDA 2020: Advanced European structure for detectors and accelerators (European Commission H2020) PI: Prof Matthew Wing, £245,000

AWAKE: a proton-driven plasma Wakefield acceleration experiment at CERN (STFC) PI: Prof Matthew Wing, £253,098

AWAKE: a proton-driven plasma Wakefield acceleration experiment at CERN (STFC) PI: Prof Matthew Wing, £179,279

Biophysics

Several BioP grants are held through the London Centre for Nanotechnology (LCN).

In situ quantification of metabolic function using florescence lifetime imaging (BBSRC) PI: Dr Angus Bain, £218,061

New Approaches To Studying Redox Metabolism Using Time-Resolved Nad(P)H Fluorescence And Anisotropy (BBSRC) PI: Dr Angus Bain, £574,160

Manipulation and destruction of cancer cells using cavitation bubbles generated by optical and acoustic tweezers (British Council) PI: Prof Philip Jones, £99,415

A fast fluorescence and photonic force microscope with nanometre and femtonewton resolution (MRC) PI: Dr Isabel Llorente Garcia, £50,000

Direct probing of molecular interactions relevant to virus entry via force spectroscopy with optical tweezers in live cells (EPSRC) PI: Dr Isabel Llorente Garcia, £91,041

Nanoscale magnetism in next generation magnetic nanoparticles (Air Force Office of Scientific Research) PI: Prof Thanh Nguyen, £46,397

Fellowship: Tan Kuan Boone – Carbon nanotube-magnetic nanoparticle hybrid system for expansion of umbilical cord blood stem cells (Royal Society) PI: Prof Thanh Nguyen, £101,000

Advanced flow technology for healthcare materials manufacturing (EPSRC) PI: Prof Thanh Nguyen, £324,223

Magnetic nanoparticle engineering via microreaction (EPSRC) PI: Prof Thanh Nguyen, £403,869

Infra-red florescence imaging for noninvasive detection of in vivo biomaterial (Royal Society) PI: Prof Thanh Nguyen, £12,000

Engineering hydrogel nanoparticles to enhance transdermal local anaesthetic delivery (Royal Academy of Engineering) PI: Prof Thanh Nguyen, £24,000

Staff Snapshot

Head of Department
Professor J. M. Butterworth

Deputy Head of Department
Professor R. K. Prinja

Astrophysics
Head of Group: Professor S. Viti

Professors:
N. Achilleos, M. J. Barlow, A. P. Doel, R. Ellis, I. D. Howarth, O. Lahav, H. Peiris, R. K. Prinja, J. M. C. Rawlings, G. Tinetti, S. Viti

Readers and Senior Lecturers:
F. Abdalla, A. L. Aruliah, J. Farihi, B. Joachimi, A. Pontzen, A. Saintonge, G. Savini

Lecturers:
T. Greve

Senior Research Fellows:
A. Font-Ribera, I. Waldmann

Research Fellows:
J. Barstow

Senior Research Associates:
F. Diego, P. Guio, J. Yates

Research Associates:
H. Baghsiahi, A. Bevan, S. Bosman, J. Braden, I. Carucci, D. Cooke, I. De Looze, W. Dunn, D. Fenech, W. Hartley, J. Holdship, K. Kakiichi, F. Kirchschlager, N. Laporte, B. Moraes, M. Rivi, M. Tessenyi, A. Tsiaras, R. Wesson, L. Whiteway, L. Whittaker

Support Staff:
S. Boyle, D. Brooks, J. Deacon, E. Edmondson, J. Fabbri, S. Fossey, C. Jenner, A. Maguire, R. Martin, M. Pearson, K. Nakum, M. Rangrej, T. Schlichter

Atomic, Molecular, Optical and Positron Physics
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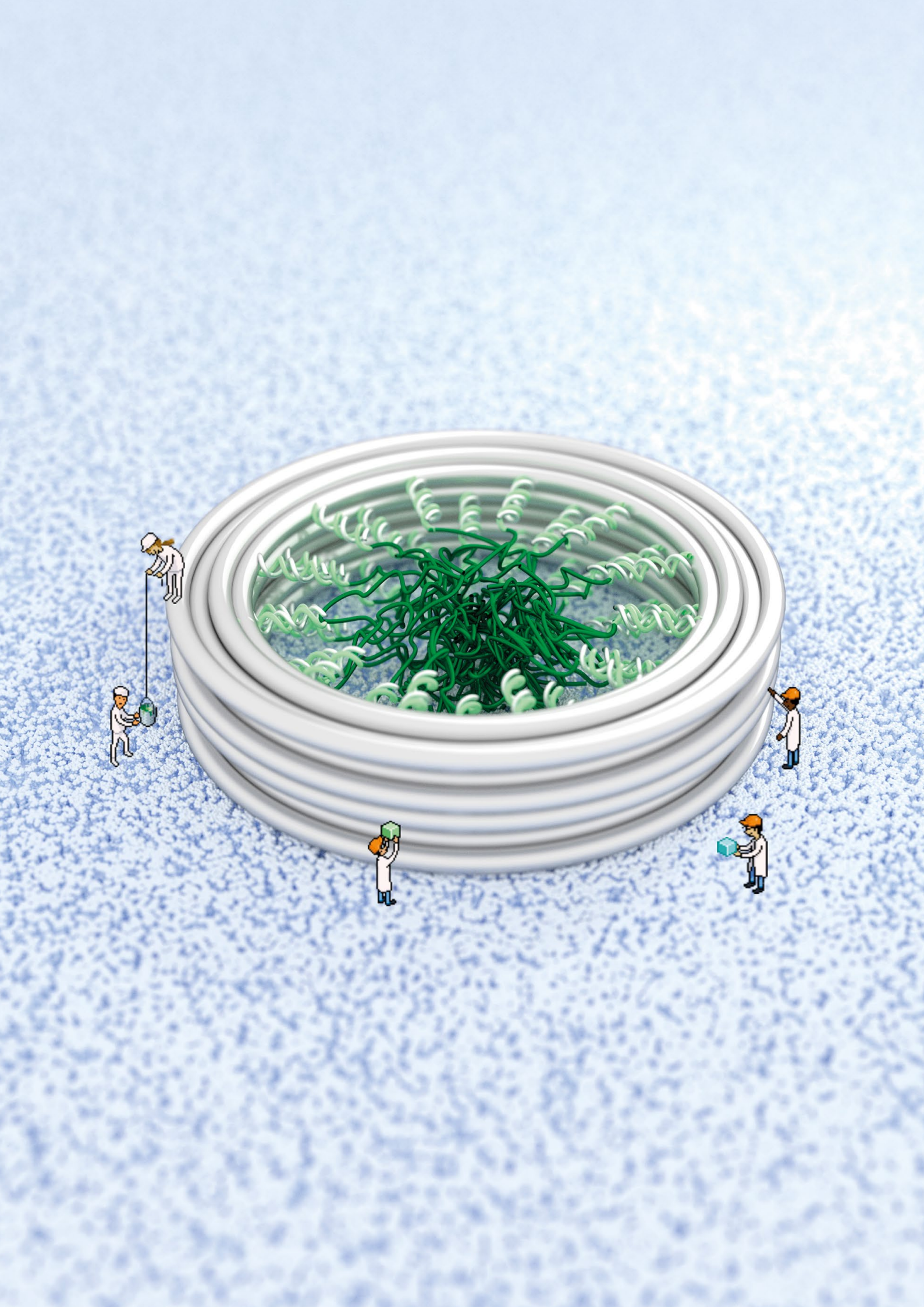

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