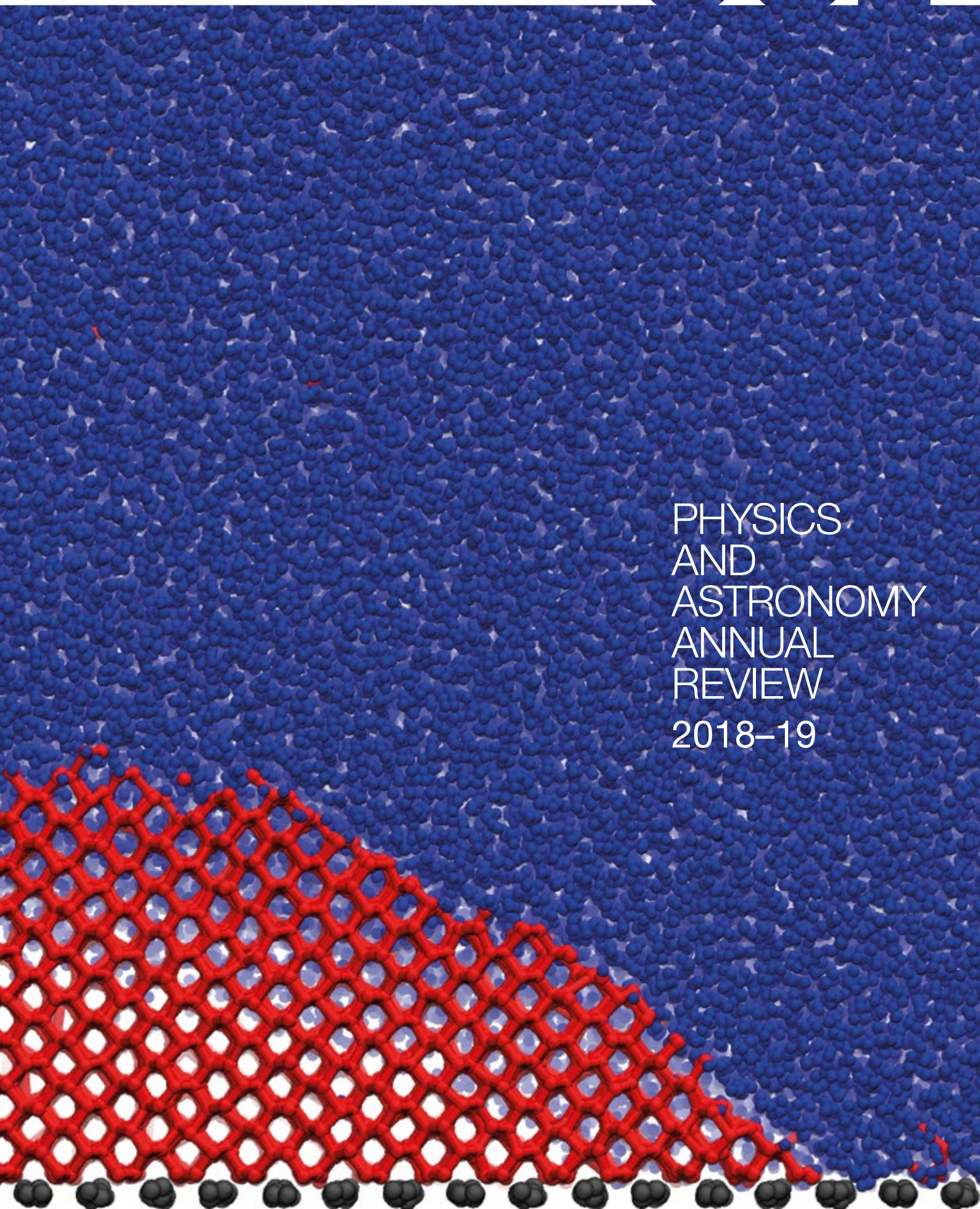
UCL DEPARTMENT OF PHYSICS AND ASTRONOMY

UCL



PHYSICS AND ASTRONOMY ANNUAL REVIEW 2018–19

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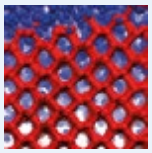
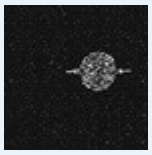
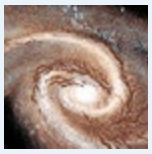
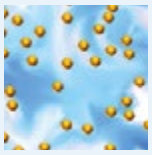





Cover image:
Ic nucleus.

Image page 2:
Card sent by the UCL Women in Physics Group to Prof Dame Jocelyn Bell Burnell.
Credit: TheMiddleOfTheNight

Image page 20:
Illustration of colliding galaxies from Raman Prinja and Chris Wormell's outreach book 'Planetarium'

Image page 26:
The Eagle Nebula, a young open cluster of stars in the constellation Serpens.
Image from the Telescope Live (Chile) UCLO robotic network. Obtained by undergraduate students. Processed by Ian Howarth

Image page 35:
Southern Pinwheel Galaxy, a barred spiral galaxy approximately 15 million light-years away in the constellation Hydra.
Image from the Telescope Live (Chile) UCLO robotic network. Obtained by undergraduate students. Processed by Ian Howarth

Image page 46:
The role of mass transfer on the synthesis of silver and gold nanoparticles.
Credit: M.O. Besenhard, A. Gavriilidis and N. T. K. Thanh

Image page 51:
Illustration of the Orion Nebula from Raman Prinja and Chris Wormell's outreach book 'Planetarium'.

Review edited by **Khadija Bouzgan, k.bouzgan@ucl.ac.uk**

Welcome

It is an honour to write this welcome as the new Head of Department, having taken up the 'hot seat' in September 2018, and following the outstanding previous stewardship of the Department by Jon Butterworth. Against a backdrop of changing landscapes and diverse challenges ahead, my vision is for the Department to remain deeply engaged in innovative world class research, while educating the next generation of leading physicists, and relentlessly promoting a respectful, fair and inclusive environment for all its students and staff.

Inside this Review, you will find an overview of the remarkable breadth of our activities over the past year in research, teaching and public engagement. Highlighting these recent successes here also provides an opportunity to express an appreciation to staff and students who have contributed strongly to the Department. Founded on the excellence of our 5 research super-groups and a sustained healthy grants portfolio, there have been very exciting new lectureship appointments in High-energy physics, astrophysics and condensed matter and materials physics. The Department continues to attract outstanding young scientists on long-term Fellowships (Royal Society and Research Councils) and our research successes have continued to be reflected by the awards of prestigious prizes.

Meanwhile, the UK research funding landscape is changing rapidly, with UK Research Innovation (UKRI) as the 'new boss in town', and providing the latest layer between the Research Councils and the Department of Business, Energy and Industrial Strategy (BEIS). The Department is well placed to exploit new funding opportunities and initiatives arising from these changes. Over the next 12 months, I anticipate heightened activity in our preparation for the REF2021 exercise, with a strong outcome being crucial to the future ambitions of the Department. I will not dwell on Brexit here, but at the time of writing, there of course remain impactful uncertainties connected to it, spanning from political and personal, to research funding (e.g. schemes to replace Horizon 2020).

On the teaching side, we are attracting highly qualified students from around the world. Our undergraduate intake (across the Physics, Theoretical Physics and Astrophysics BSc/MSci degrees) remains steady at 170 students arriving each year. The Department is on a strategic mission to strengthen and expand our taught postgraduate degrees and we now offers 6 distinct MScs in Physics, Astrophysics, Planetary Science, Quantum Technologies, Biological Physics and Scientific Computing. In early 2019, the Institute of Physics updated its accreditation of our degree programmes and we successfully went through an Internal Quality Review of our teaching delivery. I look forward to seeing changes we are currently embedding in academic support, student voice, assessment and feedback, and research-led teaching leading to a very positive impact on student experience in the Department over the next few years. Our graduates are highly employable, and in diverse posts offering excellent starting salaries. Also very impressive is the fact that over the past 3 years, 35 of our undergraduate students were authors on peer reviewed research papers as a result of their undergraduate project work. Meanwhile, as if preparations for REF2021 were not already hectic enough, we are also now preparing for the Teaching Excellence and Student Outcomes Framework (TEF) exercise in 2019-20, when we expect that the quality of our teaching and learning will be assessed at subject level.

The perennial problem of a lack of suitable space at the Gower Street sites looks set to get more challenging. The size of our undergraduate intake is tightly limited by the capacity of the practical physics teaching laboratories. Discussions will also be needed on how we can provide an outstanding interdisciplinary research environment with state of the art research equipment and lab space, that will allow the Department to retain and recruit the best people, and for that talent to grow the funded research.

Finally, I am very pleased to take this opportunity to acknowledge generous donations made in support of the Department by separate legacy gifts from two former member of the Department, Dr Brian Duff and Dr Gordon Lush. This generosity has enabled us to provide new summer research internships for our undergraduate students and allowed for the development of new bespoke teaching experiments that provide advanced, research-driven, experimental skills for our students.

Professor Raman Prinja
Head of Department

Community Focus

Teaching Lowdown

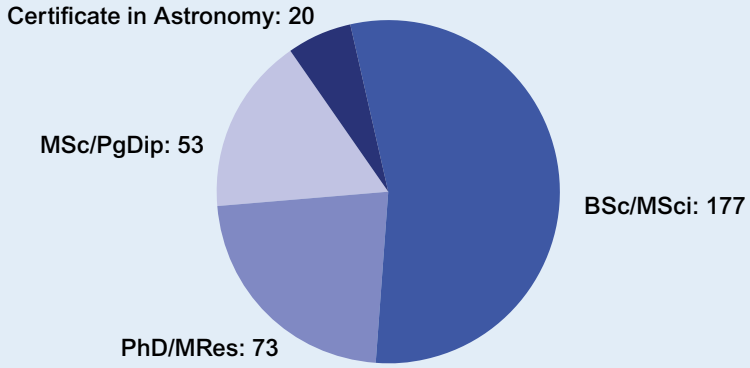
Teaching in the Physics and Astronomy Department

Among the teaching highlights this year, nine students from the Department (Andrei Barbuta, Alexander Nagen, Konstantinos Konstantinou, Jonathan Xue, Abel Beregi, Khadeejah Bepari, Aiham

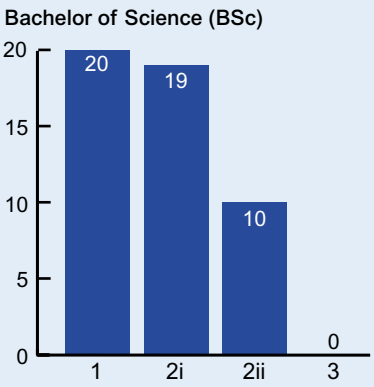
Al-Musalhi, Alexander Predko, Alexander Nico-Katz) were placed on the Dean's list, which commends outstanding academic performance by graduating students, equivalent to the top 5% of student achievement. In addition, James Puleston was awarded the Jackson Lewis Scholarship for the best progressing year 3 student in the Faculty, and Matthew Rayment the Kathleen Lonsdale Medal for the best finalist in the Faculty. Our students have also made outstanding contributions to research: in the last four years, 38 peer reviewed publications have included our undergraduates as authors due to work conducted during their final year projects. Congratulations also to Selina Lovell (Senior Teaching & Learning Administrator) who won the Faculty Education Award for support staff, and to Dr Louise Dash for her promotion to Principal Teaching Fellow.

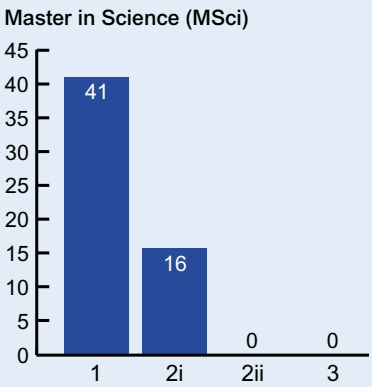
Professor Neal Skipper
Director of Teaching

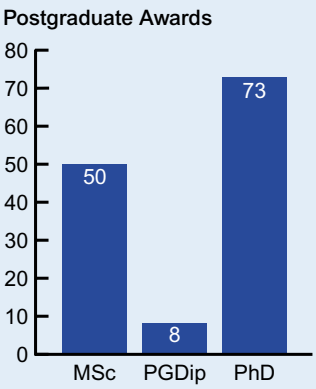
Intake

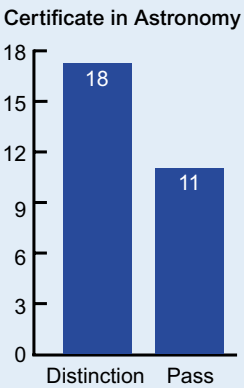


Awards









Student Accolades

Undergraduate Prizes

Oliver Lodge Prize
Best performance 1st year Physics
Mr Yijun Tang

Halley Prize
Best performance 1st year Astrophysics
Mr James Marsden

C.A.R. Tayler Prize
Best performance in Comm. Skills, based on 1st+2nd year
Mr Tobin Holtmann

Wood Prize
Best performance 2nd year Physics
Mr Scott Woolnough

Huggins Prize
Best performance 2nd year Astrophysics
Mr Maxime Redstone Leclerc

David Ponter Prize
Most improved performance 1st to 2nd year
Mr Hezhe Li

Dr Sydney Corrigan Prize
Best performance in experimental 2nd year work – PHAS2440
Mr Konstantinos Konstantinou

Best Performance Prize
Third year Physics
Mr Matthew Rayment

Best Performance Prize
Third year Astrophysics
Mr Roman Gerasimov

Additional Sessional Prize for Merit
Best 4th year Physics project achieving a balance between theoretical and practical Physics
Ms Joanna Lis

Burhop Prize
Best performance 4th year Physics
Ms Joanna Lis

Herschel Prize
Best performance 4th year Astrophysics
Ms Paula Sahd Soares

Brian Duff Memorial Prize
Best 4th year project
Ms Sabrina Shah

William Bragg Prize
Best overall undergraduate
Mr Ang Yu Jian

Tessella Prize for Software
Best use of software in final year (Astro) Physics project
Mr Manish Vuyyur

Postgraduate Prizes

Harrie Massey Prize
Best overall MSc student
Constantina Nicolaou

HEP Prize
Outstanding postgraduate physics research in HEP (Jointly awarded)
Andrew Bell and Stefan Richter

Carey Foster Prize
Outstanding postgraduate physics research in AMOPP (Jointly awarded)
Alberto Munoz Alonso and Emil Zak

Marshall Stoneham Prize
Outstanding postgraduate physics research in CMMP (Jointly awarded)
Jacob Chapman and Anna Ploszajski

Jon Darius Memorial Prize
Outstanding postgraduate physics research in Astrophysics
Jonathan Holdship

BioP Prize
Outstanding postgraduate physics research in Biological Physics
Thomas Smart

Physics and Astronomy prize winners 2017/18

Equality and Diversity Committee

In November the Equality and Diversity Committee submitted our application to renew our Institute of Physics Juno Champion award, and in February we were extremely pleased to receive our feedback and the news that the renewal had been successful. The Institute of Physics Juno scheme is now very well-established, and exists to reward Physics departments that can demonstrate the impact of actions taken in order to address gender inequality in physics and encourage better practice throughout. Awards are issued at "Supporter", "Practitioner", and "Champion", with Champion status awarded to departments demonstrating both a sustained impact and that Project Juno's principles for good practice are firmly embedded in the department at all levels. The Institute of Physics has now created a further "Juno Excellence" programme intended to demonstrate a broader impact at national level and encourage a community-led approach to furthering equality in physics. We have identified some actions that are potential Excellence initiatives, including, for example, better understanding our already excellent gender balance at undergraduate level so that we can share good practice with other departments.

Of course, Equality, Diversity, and Inclusion matters cover much more than just physics' problem with gender representation, and we need to ensure that all under-represented minority groups are included, have their voices heard, and are enabled to succeed at all levels. For example, the department has been actively engaging with the UCL-wide BME Attainment Gap project, which aims to address the alarming gap in award outcomes between white and BME undergraduates. This issue is not exclusive to either physics as a discipline or UCL as an institution, but is sector-wide. For the Department of Physics and Astronomy the gap is smaller than many other UCL departments, and UCL is already one of the better universities in this respect. Nonetheless, the gap persists and we hope that our engagement with initiatives such as the Inclusive Curriculum Healthcheck will be effective in narrowing, and eventually eliminating, this gap.

In addition the departmental Welfare Committee has now become fully established. This started as an initiative within the Astrophysics group, and has been formed to ensure that the department maintains the welfare and wellbeing of all staff and students in the department.

At UCL more broadly there are further initiatives already having an impact, and we are delighted that Professor Alexandra Olaya Castro has been appointed as the Faculty of Mathematics and Physical Sciences Vice-Dean for Equality, Diversity, and Inclusion.

While we can take pride in what we have achieved, numerous issues persist that have, at best, only been partially addressed. Much work remains.

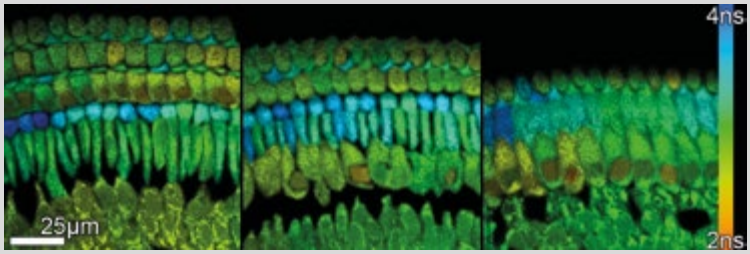
Dr Louise Dash
Chair of the E&D committee

Headline Research

UCL Centre for Neuroimaging Techniques rewards biophysics researcher with Early Career Prize

Working across the laboratories of both Angus Bain (BioP and AMOPP) and Michael Duchen (UCL Cell & Developmental Biology), Tom Blacker has been awarded the Early Career Prize by the UCL Centre for Neuroimaging Techniques, for his research on intrinsic fluorescence in health and disease. This research focuses on the weak fluorescence that emerges from living tissues when exposed to near-UV light. Tom has studied the molecules responsible for this emission, the redox cofactors NADH and NADPH, to reveal how it reports on the health of the tissue. Using ultrashort laser pulses (less than 200 femtoseconds), the excited-state lifetime of these molecules can be measured using the technique of time-correlated single-photon counting (TCSPC). By observing how the polarisation of the detected photons evolved on a time-scale of tens of nanoseconds between pulses, it was demonstrated that NADH and NADPH dissipated energy less efficiently upon binding of enzymes inside cells, as observed via their increased fluorescence lifetime. Tom and colleagues then used fluorescence lifetime imaging microscopy (FLIM) to show – inside living cells – that pro- and anti-oxidative enzyme systems increase the fluorescence lifetime by differing amounts. Thanks to these findings, the role of so-called "oxidative stress" can now be studied in a range of diseases, including cancer, heart disease, hearing loss and diabetes, all without introducing external probes.

Key paper: Blacker et al. Nature Communications 5 (2014): 3936.



FLIM of NADH and NADPH in the inner ear

Science in Action

ORBYTS outreach programme

2018 was another year of expansion for the Original Research By Young Twinkle Scientists (ORBYTS) program. ORBYTS is a educational program designed to get secondary school pupils to do original research as part of the Twinkle space mission. ORBYTS sends PhD and post-doctoral scientists to secondary schools to guide the pupils in their research. Since a pilot year at one school in 2016, we have expanded to reach 17 schools and approximately 120 pupils.

UCL hosted the students for a launch event in October and end of year conference in March. At the launch event, ORBYTS students were given lectures by academics such as our own Head of Department and Imperial's Dr Jessica Wade. At the closing conference, the students presented their work to each other and to academics from UCL.

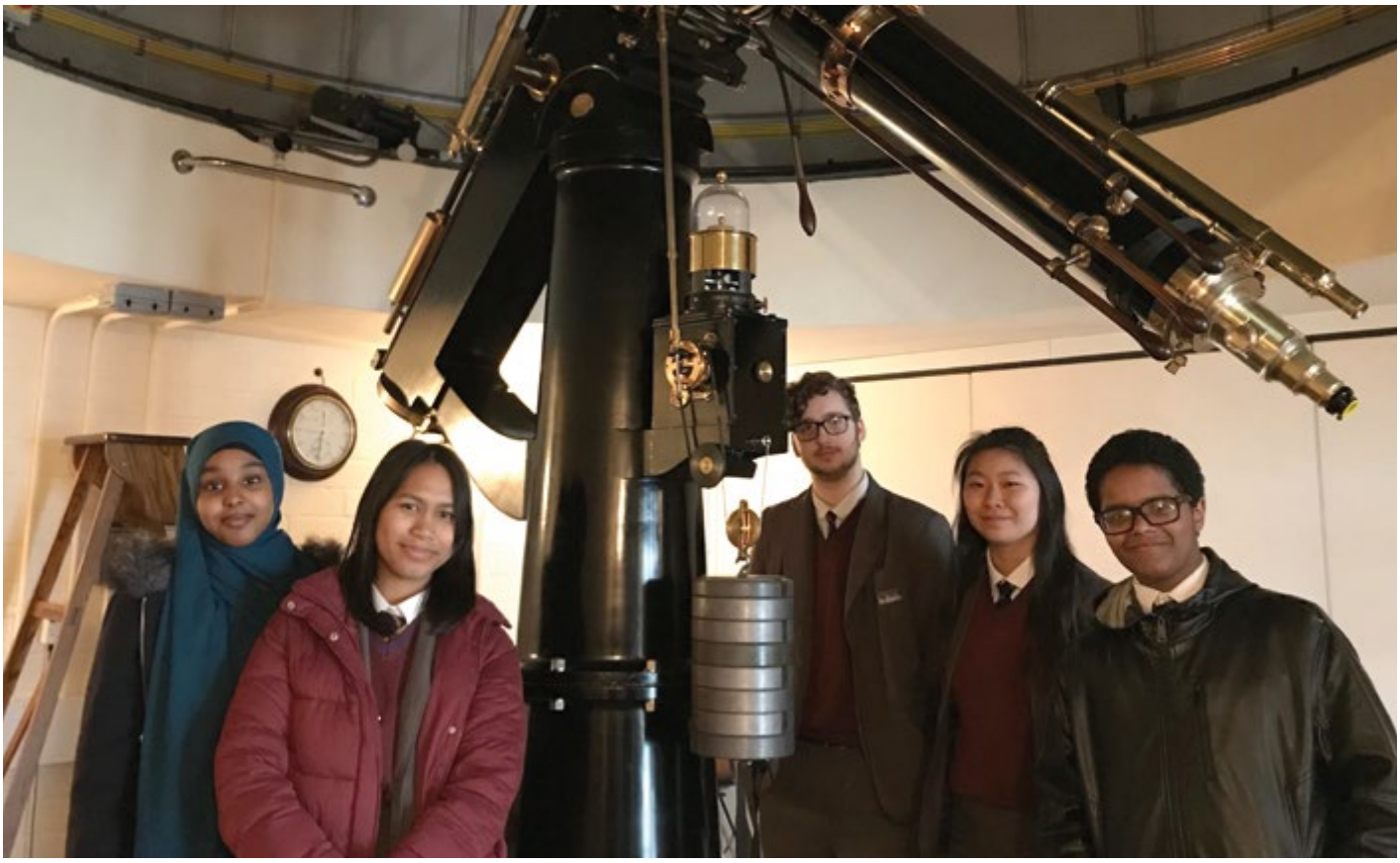
The University of London Observatory also provided an excellent opportunity to demonstrate to the pupils how the data they work with was obtained. In March, one school went on a tour of the facility allowing them to see an real astronomical observatory and understand where their data came from. This will be expanded next year so that all students taking part in ORBYTs get a chance to visit the observatory.

Projects centre around spectroscopic data and exoplanetary research. The Faulkes Telescope Network has kindly donated observing time to allow our young exoplanet researchers to confirm exoplanet candiates and derive their orbital properties. Beyond our strong exoplanet interests, ORBYTS has embraced new projects such as analysing spectral observations of high redshift galaxies. These new projects have been created by our tutors based on their own research interests.

The ORBYTS program is having a great impact. For example, a number of papers have been published based on the research the students have performed. So far this year, one paper on the origin of methanol and acetaldehyde in shocked regions around a protostar has been submitted to the Astrophyiscal Journal.

Beyond these achievements, it is hoped ORBYTS will increase the students' enthusiasm for science. To understand the effect of such programs on pupils, a systematic evaluation of the program, interviewing pupils and teachers on the changes in attitudes ORBYTS catalyses has been undertaken. Data obtained from this process should help improve similar outreach projects in the future.

Jon Holdship



From left to right we have: Amal, Angelita, George, Vivien and Hozyfa.

Students in Action

Women in physics

The Women's Lunch is organised by the Women in Physics Group (WIPG) and provides an informal and supportive atmosphere to inspire and motivate female researchers in the Physics & Astronomy Department. All genders are welcome, facilitating engagement across the wide range of research groups spanning astrophysics to quantum physics and many more. The founder of the WIPG was Emily Milner in 2014, with Anna Ploszajski in charge from 2015 before I took over in 2017. Throughout this time, Prof. Dorothy Duffy has provided fantastic support and mentorship.

In the summer of 2018, the WIPG started holding Wikithons every term, inspired by the work of Dr Jess Wade at Imperial College – she has written over 500 Wikipedia biographies on underrepresented scientists, a truly positive contribution not only for the history of science (Wikipedia is the 5th most visited site in the world!), but also for providing recognition. We had the

The UCL Women in Physics Group's first Wikithon, July 2018

pleasure of hosting Jess and Dr. Alice White (Wellcome Trust, Wikimedian in residence) who gave passionate talks and helped train new Wikipedia editors. This year we've had prominent guest speakers from outside the department. In November 2018 Dr. Jelena Trbovic from Zurich Instruments spoke about leaving academia to work in industry. We were pleased to see so many undergraduates, with discussions continuing for a further two hours and potential summer internships organised! In December we hosted Prof. Peter Main, Head of Physics at Kings College and previously the Director of Science and Education at the Institute of Physics (IoP). It was refreshing to hear Prof. Main explain, with huge amounts of data collected by the IoP and the Institute of Education, that over 20 years of traditional outreach had little effect on the uptake of physics by girls. He advised that tackling gender stereotypes should be a core aspect of future engagement and talks to schools should be humanised to avoid accidently causing imposter syndrome.

For International Women's Day, we sent a thank you card to Professor Dame Jocelyn Bell Burnell as she has donated her £2.3 million Special Breakthrough Prize to the IoP to fund underrepresented students in their Ph.D. studies, including women. This card was signed by over 100 staff and students, with a foreword by the Provost and a special note from the Head of Physics and Astronomy (**www.tinyurl.com/uclbellburnell**). Jocelyn discovered radio pulsars, missing out on the Nobel Prize which was awarded to her supervisors, but has continued to have a prosperous academic career and often speaks about the realities of research and the need for inclusion – she previously spoke at a WIPG event in 2016.

We also created 'I am a physicist' profiles for International Women's Day, inspired by the IoP initiative (www.tinyurl.com/uclwipgday). Content creation using the artistic skills of those at UCL is something we will continue going forward, and as allies to the BAME, disabled and LGBTQ+ communities, we can't wait to showcase other scientists, no matter their gender, in future profiles.

Dr Ying Lia Li (Lia)

Celebrating International Womens Day by recognising a handful of the amazing women in the physics department. To read these in detail, please visit: ***www.tinyurl.com/uclwipgday***

Event Horizon

What a fantastic year it has been for the UCL Physics Society! The committee would like to thank all those who expressed an interest in our various events and especially the department for their continual support throughout the year. What follows is a rundown of some of our biggest events from the past few months, which we hope will inspire the next cohort of physicists in what lies ahead for the society.

Freshers Week

We dived into the academic year with a jam-packed schedule of events. An English breakfast and a tour of London were among the events designed to welcome students before the 4th annual Kick-Off, an infamous rite of passage for physics freshers.

Spectrum Lectures

We were delighted to host a number of guest speakers this year, including Professor Steven Balbus (Oxford University) and Zach Weinersmith (American comic artist) to talk about their research and experience related to the world of physics. This was part of our Spectrum Lecture series, designed to offer members a wider perspective on recent developments in the field.

Winter Ball and Boat Party

To celebrate the end of first term, we held our much-anticipated Winter Ball in collaboration with the biology and chemistry societies. This, along with the Boat Party in second term, was a chance for all students to relax and mingle before the stress of exams.

Joint Undergraduate Research Conference

One of our biggest academic events of the year was the joint undergraduate research conference with Imperial College London, held in January. The conference involved an afternoon of talks by PhD and undergraduate students from ICL, UCL and KCL who showcased their research, followed by an informal social.

Careers events

One of our objectives as a society is to provide members with opportunities to network with employers. As a result, we worked closely with our sponsors on our main careers event: the Science & Technology Fair attended by a range of companies interested in recruiting physics graduates.

Trip to the ISIS Neutron and Muon Source

In February, the society undertook an exciting day trip to ISIS at the Rutherford Appleton Laboratory in Oxfordshire. We were given a tour of the particle accelerator and met scientists who gave a talk on the work undertaken there.

As the committee, it has been an honour to serve both our members and the department, without whom the society would not exist. We wish next year's committee the best of luck and look forward to attending their events.

Sufia Hashim IT Officer
on behalf of the 2018/19 committee

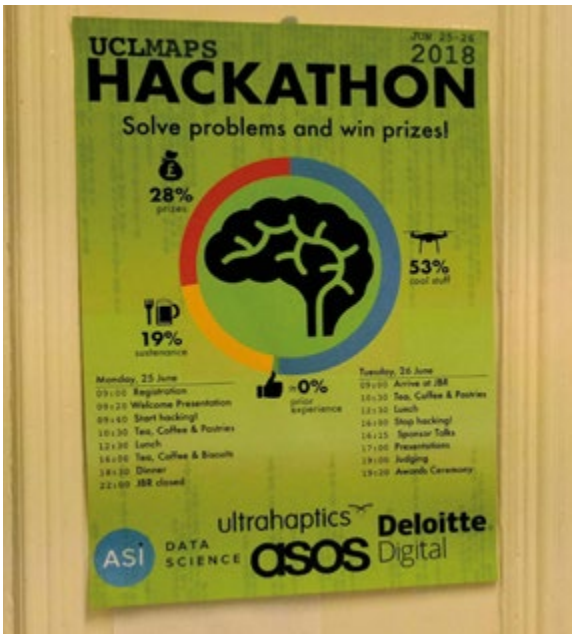
From left to right standing: Simon Liu, Lodovico Scarpa, Iman Sanai, Khush Thakur, Brian Hong, Irene Leftaki, Jun Lee, Sai Samendra, Sean Moshe Nassimiha
Left to right seated: Meghali Banerjee, Sufia Hashim, Michael Schick

Hackathon

On the 25-26th June 2018 the UCL Postgraduate Physics Society (PhysSoc) hosted their fourth annual hackathon. Given the success of the previous years, the scope of the event was expanded to include not only the Physics department but the entire Mathematics & Physical Sciences (MAPS) faculty. In total 32 PhD students from Physics & Astronomy, Chemistry, Earth Sciences, Space & Climate Science, and Mathematics competed, forming eight teams of four.

The hackathon benefited from our recurring sponsor, Deloitte Digital, who provided much of the hardware, as well as new sponsors including ASOS, ASI Data Science (now Faculty AI), and Ultrahaptics. The latter very kindly provided two of their experimental boards and a member of their team to help the contestants with the equipment. Deloitte Digital, ASOS, and ASI Data Science organised pre-hackathon tours/talks.

The teams undertook a wide range of projects including; a sensor-packed buggy controlled blindfolded using hand gestures and ultra-haptic feedback, a simulation of TfL cycle network to optimise bike redistribution, and a series of VR experiences to help people overcome phobias. The winning team, Plant Doctors, demonstrated an AI system which could diagnose unhealthy plants using a range of sensors, and even recommend ideal plants given your environments conditions.



Phys FilmMakers

Film makers summer school performance

The Phys Film Makers programme conceived in 2016, continues to evolve as the concept matures. The past three years has been characterised by cycles of continuous improvement where we learn from our successes and failures and apply this knowledge going forward. 2019 is an opportune time to reflect on these and present a strategy for the future.

The Phys Film Makers programme currently consists of two elements. The first is within the department where Physics and Astronomy students are provided with equipment and training required to produce science documentaries. This has come to be known informally as the Phys Film Makers course and has been funded by Connected Curriculum. The second element involves outreach where the equipment and expertise, in both science and film making, are provided to 16 to 17 year olds from disadvantaged backgrounds as part of a Summer School. This has received funding from Access and Widening Participation.

So far we have 26 documentary style videos on the YouTube page made by our students and outreach participants. In the last year, we had 6,187 minutes of viewing time from 3,053 views. The most popular video by far has been Positronium: What's the matter with anti-matter, with nearly twice the number of views as the second most popular video. Viewership is predominantly UK based with 22.8%, Australia 1.8% and all other countries contributing less than 1% each. Viewers are between 25 and 34 years old with a gender ratio of 67% Female to 33% Male.

Achievement of goals – learning – modifying the approach

Over the last year, we have increased our international appeal as well as our female viewership, an important consideration in promoting diversity in STEM and a significant achievement for a science channel. Feedback received from all of the courses has been positive particularly from the Summer School where participants who were at the beginning openly stating that they had no interest in science saying that they would consider applying for science subjects after A-levels.

Filming taking place in Lab 3

Filming taking place in Lab 3

Summer school participants hard at work with their PhD supervisor

Future plans – practicalities

Videos made without production time constraints by students with proper guidance consistently attract the highest view count and retention. We will therefore retain the services of our film making expert and allow production to extend over longer periods. Resources will be focussed on students who have a need or genuine desire for learning science communication. Recruitment for this will take place during the induction for first year students. In this way, interested students can be identified early and have as much time as possible to cultivate their interests. This implementation has already produced good quality videos, examples of which can be viewed by following the QR links provided.

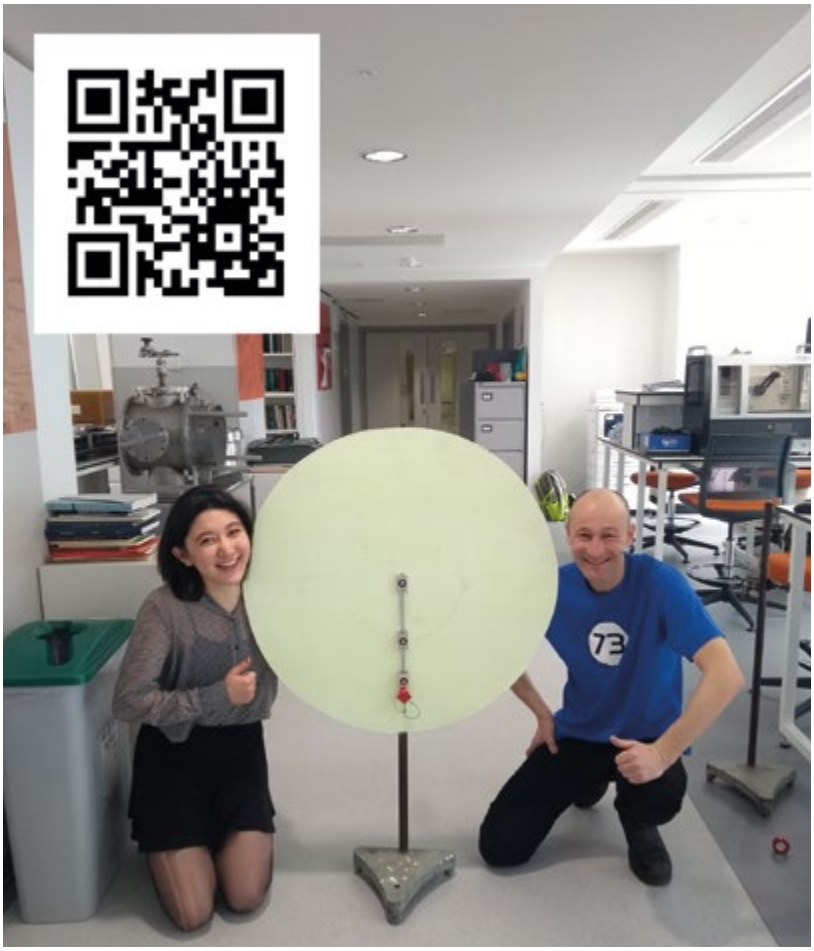
The summer school will be put on hold until a solid base of interested students is established to assist. Despite the fact that they have been overwhelmingly successful, with most attendees indicating that they were now more interested in science than before, the large amount of resources required to plan and run the summer school needs to be shared amongst more people. In addition, further changes need to be made to the structure of the programme to better balance the number of students we have with the time of the film making expert, PhD students who supervise them and the available equipment.

Over the years we have acquired a number of capable DSLR style cameras, a GoPro and associated photographic accessories. This reduces the finances required to fund future courses. Further funding will be sought for staffing, as well as to purchase at least one capable editing computer to be made available for film makers.

We are shifting focus to better support current students to produce quality material, retain a professional advisor and bid for funding from Connected Curriculum. In addition, the door is open for members of Physics and Astronomy staff to use the equipment and expertise to create research based videos with expert interviews and even lectures as other universities have successfully done. This direction will serve to educate our students, improve science communication and raise the profile of the UCL Department of Physics and Astronomy worldwide.

Kelvin Vine
PFM Coordinator

Summer School in progress featuring equipment loaned by iMotion Media



Video on chaotic oscillation made by year three student Jade

The Postgraduate Physics Society

A key ingredient in successfully completing a PhD in physics (or any subject for that matter) is a balanced diet of work and play. For many students, however, the latter is often overshadowed by constant meetings, deadlines, and broken code. So then, how about pairing the hard work we do with some pizza and drinks? That sounds like a reasonable compromise!

Here cues the entrance of the student-run Postgraduate Physics Society (PGPS). Our main goal is to provide opportunities for students across all sub-departments in physics to intermingle, share ideas, and unwind.

Throughout the academic year, the PGPS hosts monthly 'PhD Talks', where UCL students are invited to give a short 20 minute presentation about their research topic. This year, we also had guest student speakers from external universities, with similar topics to our own. These events provide a relaxed setting where a student working on neutrinos can learn about small molecule transport in proteins, and vice versa.

The PhD talks series aside, we also host bi-annual pub quizzes, where our students get a chance to show off their knowledge of film quotes and talent with dingbats. The quizzes are usually very well-attended and seem to be a favourite amongst the students.

Additionally, this year the PGPS hosted a Mathematical and Physical Sciences (MAPS) faculty heat of the UCL 3 Minute Thesis competition. We had contestants from both Physics and Chemistry, and audience members from almost every department in MAPS. The event ran successfully, and the runner-up and winner of the faculty heat moved forwards to the general UCL 3MT competition shortly after.

All things considered, it's been another great year for the Postgraduate Physics Society. We're continuously maintaining and improving the wonderful community that's been built in Physics & Astronomy, and go on doing so in the year to come!

Joanna Huang
on behalf of the
Postgraduate Physics Society

One in many of the Postgraduate PhD Talks series.

Teaching Fellows

Stockholm Visits the UCL Physics Laboratories

UCL has a growing reputation for innovation in the teaching of practical physics. Therefore, we invited academics from Stockholm University to visit us in December to see what we do here whilst also exchanging best practice with them.

Co-ordinated by Paul Bartlett (UCL) and Kirsty Dunnett (Nordita, Stockholm), Fredrik Hellberg and Andreas Rydh spend one day touring our facilities, having briefings from our teaching team including Nick Nicolaou, Andreas Korn, Derek Thomas and Raman Prinja (HoD). Finally, Vincent Tong of UCL Arena discussed wider initiatives within the University.

The following day the Stockholm group visited Lab 2, under the guidance of Daven Armoogum, where they were given the opportunity to discuss training with students who had been exposed to the UCL system.

In the afternoon, a combined Stockholm/UCL group visited Dr Simon Bland of Imperial College to see what their perspective was on teaching practical physics. The group realised the importance of creating an international discourse on practical physics in Europe. This will result in further interaction and initiatives with the UCL team at its heart.

Fredrik Hellberg said of the visit that "*It was very inspiring, and we came back (to Stockholm) with many new ideas*".

Participants in UCL's First Year Laboratory

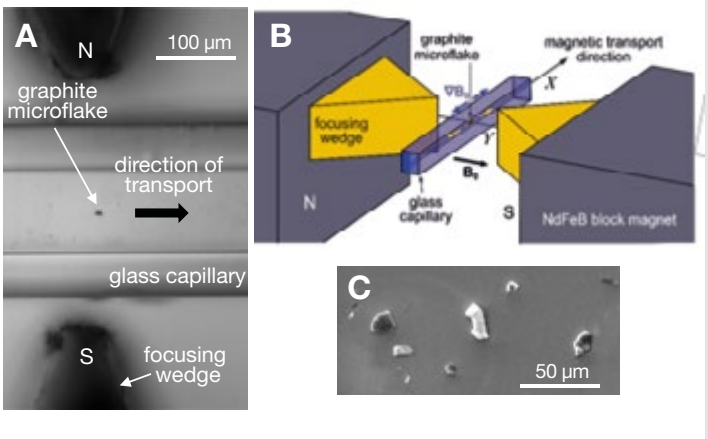
From left to right: Andreas Rydh, Fredrick Hellberg, Paul Bartlett, Kirsty Dunnett, Andreas Korn, Raman Prinja

Headline Research

Moving graphite particles in liquid using magnetism

Dr Isabel Llorente-Garcia's team at UCL Physics have demonstrated the first ever magnetic transport of diamagnetic graphite micro-particles in water solutions, including biocompatible fluids. Given the dominance of viscous drag forces at the micro-scale, moving a micro-particle that is submerged in liquid is comparably as hard as moving a macro-particle within dense honey. The new micro-manipulation method uses a weak type of magnetism – called diamagnetism – to control the position of graphite micro-flakes (of similar size to human cells) in liquid. Diamagnetism is a weak magnetic property that has been used before, e.g. to levitate living frogs with very strong magnets, but the diamagnetism of micro-graphite had never been exploited for controlled motion in aqueous fluids before now. The contactless magnetic control of biocompatible micro-graphite together with graphite's unique physical properties opens up possibilities for new ways of precisely transporting specific components in fluids, including large biomolecules, replacing the need for flow control and enabling more reliable tools and bio-sensing applications. The findings, published in *Proceedings of the National Academy of Sciences*, could have implications for improved biophysics and soft-electronic experiments, chemical analysis and synthesis and non-invasive healthcare diagnosis and drug delivery via miniaturised devices or via small-scale robotic tools.

Published paper: **https://doi.org/10.1073/pnas.1817989116**



A) Microscope image of graphite microparticle magnetically transported (from left to right) inside a glass capillary between two magnet blocks and focusing wedges. B) Schematic of experimental setup with magnet blocks, focusing wedges and glass capillary with submerged graphite microparticle. C) Scanning electron microscopy image of typical micron-sized graphite flakes.

Outreach

Outreach Days

Dark Matter Day

On Halloween the department joined institutions from around the world celebrating Dark Matter Day. Schools and the general public were treated to a free event held at the UCL Observatory exploring one of the greatest mysteries of the Universe; The Hunt for Dark Matter. With demonstrations, Q&A's by researchers in dark matter and tours of our telescopes. The event gave everyone a chance to learn not only about Dark Matter, but also the experience of where science can lead, develop their own problem-solving skills and bring a sense of wonder and awe back into the classroom for the school groups who attended.

Coding for 6th Formers

Computer coding is an important skill to have in our modern world and features in all our physics degrees at UCL. Many pupils coming through schools have yet to have the opportunity to learn how to code. Recognising this gap in knowledge two undergraduate students from UCL, Fern Pannell and Danny Gold, have begun to develop new coding lessons and successfully deliver them to Y12 pupils; who gain in knowledge and confidence to apply for physics at university. The course is gaining the attention of funders, schools and pupils alike. The aim now is to support physics teachers at schools to introduce coding into their lessons so we can reach the widest audience possible.

Physics Summer School and Phys Film Makers

The department hosted not one but two Summer Schools for A-level pupils from a widened participation background. The Phys Film Makers had five days to create and upload a YouTube video based on the physics concept aided by a PhD student and guided by an experienced video editor and science communicator, Bex Coates. Meanwhile the Physics Summer School aimed to offer an overview of the physics taught at UCL from Astronomy and High Energy Physics to lab skills and computer coding.

The department plans to continue to offer high quality experience for pupils who might not have the opportunity to be thoroughly immersed in the world of physics. Opening the eyes of these pupils and their fellow peers to the opportunities that studying physics brings.

Postgraduate Students Mekhi Dhesi and Nicolas Angelides demonstrate some of the physics behind Dark Matter and with the help of school pupils as Part of Dark Matter Day.

UCL Undergraduate mentors from the Department of Physics and Astronomy supporting a Girls in Physics workshop held at the Institute of Physics, London

Mentoring Female pupils at the Institute of Physics

A recent collaboration between the Institute of Physics, Carole Kenrick and Science for Life Islington is piloting Girls in Physics drop-in sessions to support pupils in their studies. The Department of Physics and Astronomy at UCL is heavily involved in the event with our excellent undergraduate mentors attending, encouraging pupils that Physics is accessible to all genders. The scheme is due to continue throughout May and June and support pupils through their Physics GCSE and A-Level exams.

Ogden School Physicist of the Year

Funded by the Ogden Trust and hosted at UCL for Year 10 and 7 pupils in and around London, we celebrate those who have stretched themselves and shown great progress in school physics at lessons. With a talk given by Professor Lucy Green, 24 pupils and their guest family members received their award and had the opportunity to meet each other and celebrate their successes, and hopefully inspire a few more to continue studying physics.

Professor Lucie Green and one of the award winners Muhammad Abubakar from Caterham High School at the School Physicist of the Year Celebration held annually at UCL and supported by the Ogden Trust.

Mark Fuller
Outreach Co-ordinator and Ogden Science Officer

Your Universe, the UCL festival of astronomy and particle physics

The 13th edition of Your Universe, the UCL Festival of Astronomy and Particle Physics took place on March 14, 15 and 16, 2019.

Once Again, our stands were displayed along the North Cloisters and the Garden Room. These included: the traditional linear time-line of the universe, cosmology (including the interactive space-time continuum) , the lives of stars (velcro HR diagram), telescopes, IR astronomy (using a colour IR camera), the LHC (including deflection of beta particles and a cloud chamber, short presentations about the aurora and extra solar planets and for the first time in the festival, a very practical demonstration on how to make a comet (based on dry-ice).

Unfortunately, this time the weather was not on our side for the use of our portable telescopes from the front quad.

The Saturday panel discussion in the Gustave Tuck Theatre was about the 50th anniversary of the Moon landings. Prof Chris Riley (Science author and broadcaster) gave a summary of the Apollo project and described the proposed Lunar Orbiting Platform Gateway (LOP-G) as a possible step in future lunar exploration and beyond. Dr Louise Alexander (alumna of our UCL Certificate of Higher Education in Astronomy) described her work on lunar basalts and the science behind the analysis of lunar regolith (going as far as galactic archaeology. Finally, Prof Ian Crawford (UCL-Birkbeck) explained the diverse reasons behind future lunar exploration and the need to establish a lunar colony. These presentations were followed by a lively discussion with the audience which went for more than one hour.

Following the usual format, the weekdays were dedicated to pre-booked school groups and the Saturday to the general public. In total, the festival received around 300 visitors, 80% of which were school children aged 10–16.

The demonstrations were led by our enthusiastic group of members of staff, postgraduate students and very specially certificate students and alumni.

This year we welcomed Dr Mark Fuller to our team. Mark is the outreach officer from our department and he took care of school groups and day-to-day logistics.

As the festival grows stronger, we must keep working towards sustainable and reliable sources of funding, which is the main challenge ahead. It is also necessary to attract larger audience numbers for the lectures and panel discussions, for which we need help to improve our social media activities.

The 2020 festival is planned for March 5, 6 and 7 following the same format and venues, but we welcome suggestions for new stands and presentations.

We also welcome ideas for one or two panel discussions. On 2019 we had the 50th anniversary of the moon landings. For example, 2020 is the Mars launching season, so this could be one topic.

Francisco Diego,
Senior Teaching Fellow

***Mark Fuller** explains lunar features and exploration.*

***Jo Eberhardt** in the process of producing a replica of a cometary nucleus using dry ice and dirt.*

School groups use simple optical benches to understand by experiment about the principles of optical telescopes.

Vasilis Konstantinides explains a simple 3d model of the Large Hadron Collider.

***Giorgio Savini** uses a colour infra-red camera to produce a thermal image of the heating coils embedded in the ceiling above the cloisters.*

***Hamish Caines** making a comet using dry ice and dirt.*

***Francisco Diego** demonstrates the distortions of space-time continuum produced by the presence of massive bodies. This demonstration was also useful to show the merging processes between black holes.*

Panel discussion on the Apollo landings 50th anniversary. This event took place in the Gustave Tuck lecture theatre with an audience of around 100 people, including families. After their individual presentation, the panelists engaged with the audience in a lively discussion about the legacy of the project and the next steps in human exploration of the solar system.

*L to R: **Prof Chris Riley**, **Prof Ian Crawford** and **Dr Louise Alexander**.*

The Centre for Doctoral Training (CDT) in Data Intensive Science

The Centre for Doctoral Training (CDT) in Data Intensive Science, based within UCL Physics & Astronomy is now in its second academic year of operation, and has had a busy and successful year. With the aim of becoming one of the nation's leading centres for training PhD students in this field, the CDT has already achieved some notable successes.

In July 2018, we hosted the first ever STFC funded summer school in Artificial Intelligence and Machine Learning. Over 120 PhD students from universities across the country were brought together to spend a week at UCL, learning about the forefront of AI technology. With lectures from several industry leaders; including Intel, NVidia, ASI, and Dell, the summer school aimed to give a solid grounding in the basics of machine learning before providing a glimpse into some of the latest technologies now being applied.

In September, we extended a warm welcome to the second cohort of PhD students, who will be working on Data Intensive Science projects across Astronomy and High Energy Physics. In the first term, they completed a 2-day Software Carpentry alongside their studies, and in the second term they have collaborated on group projects with some of the CDT's industrial partners: Asos, UKAEA, The Economist, ValTech and WorldRemit. Our second year students have been busy working on their research projects. We are working hard to strengthen our links and collaborations with existing & new industry partners and are pleased to report that we have forged new links with: Babylon Health, Vortexa, KageNova & ASI Data Science.

From April 2019, the CDT is rolling out a series of CDT seminars which will be delivered by industry experts within data intensive science topics. Stay informed of these and our other activities on our website which is currently hosted at: **www.hep.ucl.ac.uk/cdt-dis**

The hard work of our staff and students and peers has been recognised by our funding body STFC who recently conducted a national review of Data Intensive Science CDTs, and in this review we are pleased to announce that the UCL CDT in Data Intensive Science was one of only two to be ranked in the highest band (A).

Nikos Konstantinidis & Ofer Lahav
Co-Directors

The Summer School in Artificial Intelligence & Machine learning hosted by UCL CDT in Data Intensive Science, July 2018

in2ScienceUK at the Department of Physics and Astronomy

In the Summer of July 2017, the Department of Physics and Astronomy was proud to host, for the first time, the in2science Widening Participation Summer Programme in collaboration with the award winning charity in2scienceUK. The programme has continued every summer since, with the aim to provide the in2science students with an insight into student life at UCL, from the perspectives of both undergraduate students and postgraduate research students. This is achieved through a series of hands on laboratory sessions, workshops and research group placements.

For 2019, eighteen outstanding Year 12 students were selected by in2scienceUK to take part in the programme. in2scienceUK is a charity which promotes social mobility and diversity in science. The charity mission is "to empower students from disadvantaged backgrounds to achieve their potential and progress to STEM and research careers through high quality work placements and careers guidance".

This year students initially undertook a structured programme of learning, which included time in the 3rd year undergraduate laboratory where they carried out experiments using X-ray spectrometers and Scanning Tunneling Microscopes. During this time there was ample opportunity to encourage discussion on studying physics at UCL. Current 3rd year MSci Physics undergraduate Kumail Kermalli held a Q&A session to discuss his experience as a student at UCL. The in2science team provided workshops on personal statement and CV writing, key skills in the UCAS application process. A trip to the Science Museum was also organised.

This year's placements were provided by research groups from AMOPP, HEPP, Astrophysics, Optomechanics and Spintronics. This was a fantastic opportunity for the in2science students to gain invaluable experience of working as part of a theoretical research group, learn programming skills and also to experience research laboratory environments and be actively involved in experimentation and data analysis.

Students spent a total of three days with postgraduate research students and group supervisors. Three in2science students were based at ULO in Mill Hill with Dr Steve Fossey, whilst those students based in the Department were involved in projects ranging from the scattering of electrons from molecules to identifying new fundamental particles, which is one aspect of the research undertaken by the High Energy Physics group at UCL.

To conclude the programme students took part in group presentations, highlighting work undertaken whilst with their host. Their work was presented to invited members of academic staff and members of the In2Science team. All students were awarded certificates by the Head of Department, Professor Raman Prinja.

The Department of Physics and Astronomy at UCL is delighted to be the first and only department in the UK to host in2ScienceUK Physics students. It is clear from the testimonies that the students consider the time spent in the Department as an invaluable learning experience. The Department continues to promote diversity amongst its student population and working alongside in2scienceUK is key in achieving this. We look forward to welcoming the next group of in2science students in the summer of 2020.

Nick Nicolaou,
Senior Teaching Fellow & Programme Tutor

In2science student Ampaleni Thevakumar with Professor Jonathan Tennyson (right) and Dr Bridgette Cooper (left).

In2science students Shorub Hossain and Nabhan Misbah with Professor Stephen Hogan (left).

The 2019 In2science UCL Physics students celebrate the end of their placement on awards day, with the Head of Department Professor Raman Prinja (back row 2nd left)

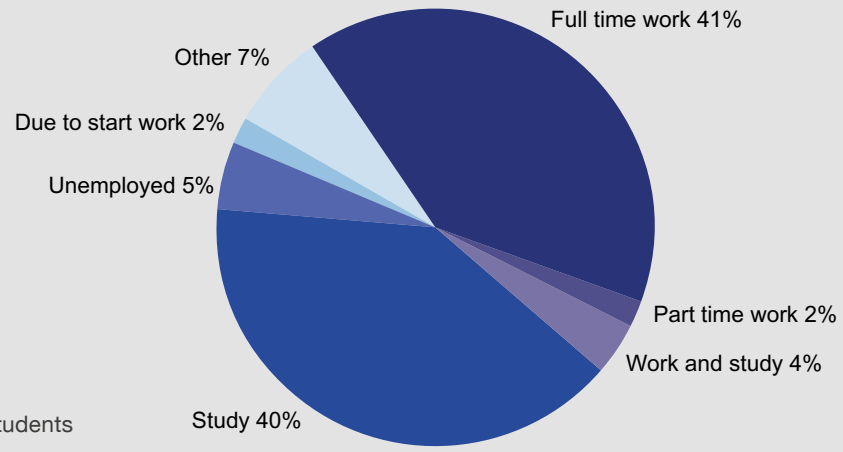
Career Profile

Graduate Destinations

Total Number of Graduates: 208

Response Rate: 71.2%

Median Salary: £31,000
(full time employment)



The data is for the 2017 graduating cohort, for all students

Prof. Stephen Hogan

I grew up in Dublin where I studied physics at University College Dublin and the french horn with Victor Malirsh at the Royal Irish Academy of Music. In 2002 I moved to London to begin my PhD in atomic physics with Prof. Jean-Patrick Connerade in the Department of Physics at Imperial College. In this period I worked on experimental studies of effects of strong electric and magnetic fields on atoms in highly-excited Rydberg states.

Between 2006 and 2012 I worked in the Laboratory of Physical Chemistry at ETH Zurich, initially as a Postdoctoral Researcher and later as an Oberassistent (Senior Researcher), in the group of Prof. Frédéric Merkt. At ETH I developed new experimental methods for preparing cold, trapped samples of Rydberg atoms and molecules for applications in low temperature scattering experiments, quantum information processing, and antimatter physics. This included the design and implementation of the first three-dimensional electrostatic traps for H, D and H2. I also made major contributions to the development of the method of multistage Zeeman deceleration for the preparation of cold paramagnetic ground-state atoms and molecules, including the first demonstrations of magnetic trapping H and D atoms following Zeeman deceleration. In 2012 I completed my habilitation at ETH with a thesis on 'Cold atoms and molecules by Zeeman deceleration and Rydberg-Stark deceleration' and a Probevortrag (test lecture) on 'Chemistry with antimatter'.

In summer 2012 I moved to UCL to establish a new laboratory within the Atomic Molecular Optical and Positron Physics (AMOPP) group in the Department of Physics and Astronomy where I am now a Professor of Atomic and Molecular Physics. Since 2013, in addition to my position at UCL I also hold a position as Privatdozent (Senior Lecturer) at ETH Zurich. At UCL my group and I continue to develop new and original methods for manipulating Rydberg atoms and molecules. Most recently this has included studies of matter-wave interferometry with atoms in high Rydberg states. The 'giant' highly excited atoms used in these quantum interference experiments are almost macroscopic objects with dimensions in excess of 300 nanometers. We exploit the experimental techniques that we develop in a range of areas. These include: (1) studies of resonant energy transfer in atom-molecule collisions at temperatures below 1 K, (2) investigations of slow decay processes of Rydberg states of small diatomic molecules, and (3) applications in quantum sensing and quantum information processing. In collaboration with Prof. David Cassidy we implement these same techniques in experiments with Rydberg positronium atoms. In 2015 I was awarded a €2M ERC Consolidator grant to support experiments in my laboratory on cold molecules in high Rydberg states. In September 2019 I will take over as head of the AMOPP group.

Alumni Matters

The Physics & Astronomy Gala Dinner took place again on 19 October 2018 in the nearby Ambassador Hotel. Well over a hundred people attended, including alumni, undergraduate and postgraduate prize-winners with their guests, members of staff, and members of the student Physics Society. In the award ceremony, presided over by the Head of Department, Professor Raman Prinja, they heard about our students' numerous achievements and successes

The traditional after-dinner speech was delivered by Mark Thomson, Professor of Experimental Particle Physics at the University of Cambridge, and newly-appointed Executive Chair of the Science and Technology Facilities Council. In the 1990s he was a postdoc at UCL, working on the OPAL experiment with David Miller. He spoke on "*The importance of collaboration in the rapidly changing research and innovation landscape*", a timely topic in the days of Brexit.

Professor Mark Thomson

Professor Giovanna Tinetti, leader of the ARIEL mission to study the atmosphere beyond our solar system and a member of the department's Astrophysics group, gave the Annual Physics & Astronomy lecture, "*Brave new worlds: the planets in our galaxy.*" This proved to be an informative and stimulating survey of the field of exoplanets. The pre-dinner wine reception in the department took place directly after the lecture.

The 7th Gala Dinner will take place on 1st November, once again at the ever-popular Ambassador Hotel.

The after-dinner speech will be given by Professor Dorothy Duffy, a member of the Condensed Matter and Materials Physics group as well as the LCN. With a PhD from Imperial College, Professor Duffy also has worked at Reading University. She applies modelling techniques to a diverse range of systems and processes, from organic-inorganic interfaces to radiation damage. She has also taken an important teaching role in the department, including project supervision, strand leadership, and her chairing of the MSc exam board.

The Annual Physics & Astronomy Lecture, given by Dr Tim Scanlon, will precede the dinner, with a brief reception afterward. Details of these events will be made available in due course.

See you there!

With over 5700 alumni in the department, spread out over more than 30 countries, with ages going well into the 90s, we have a great opportunity to create an engaging community, sharing both memories and aspirations. If you have any suggestions for initiatives that may bring us together, please let us know. And let us know if you would like to help out with anything.

Stan Zochowski, Alumni Relations head
(**stan.z@ucl.ac.uk**)









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Observatory News

Student research at the UCL Observatory

Practical and hands-on experience have always been at the forefront of the teaching philosophy at the UCL Observatory since its inception 90 years ago. In a day and age where many world-leading facilities operate robotically half a world away and much world-class astronomy discoveries are achieved through satellite observations, we need to reconcile the experimental technique training with remote operation and complement both with all the data science skills which current astronomers and astrophysicists make use of.

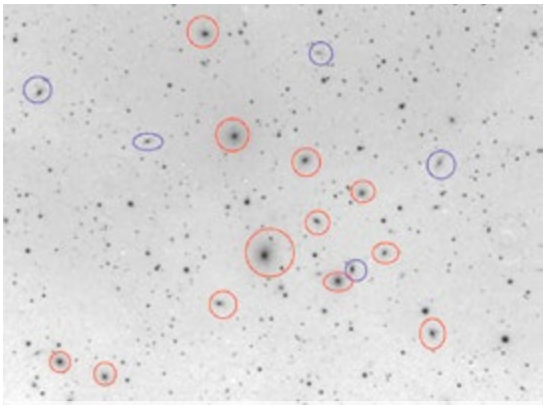
We achieve this through a complement of functioning classical telescopes and robotic units. At the same time, this year has seen full use of our new link with the TelescopeLive telescope network which have been used by second and third year students as well as MSc project students.

New year 3 Astrophysics group project module

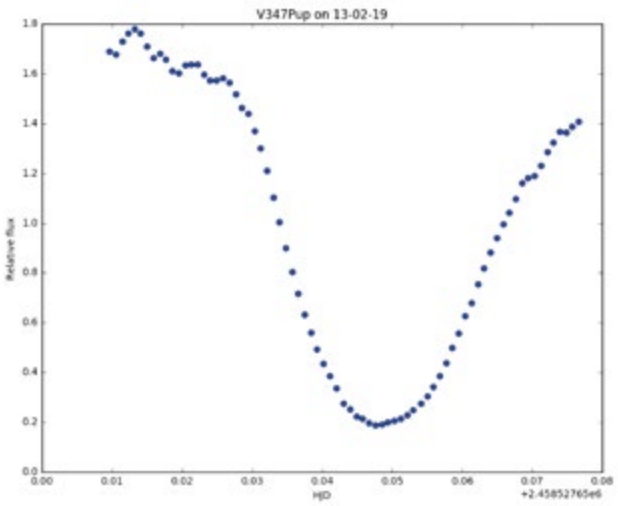
This year a new module saw groups of four and five students planning and submitting research observational proposals, analysing the acquired data and producing conclusions on specific science topics with supervision from academics in the Astrophysics Research group.

Environmental evolution in clusters of galaxies

Students investigated the mechanisms by which clusters of galaxies evolve. Observing galaxy clusters from both UCLO and TelescopeLive telescopes, the colour histogram and the luminosity function of a cluster field were compared. Students observing redder elliptical galaxies in the cluster with respect of the field support the “nurture” theory where the environment shapes the evolution of the galaxy possibly due to the merger of spiral galaxies.

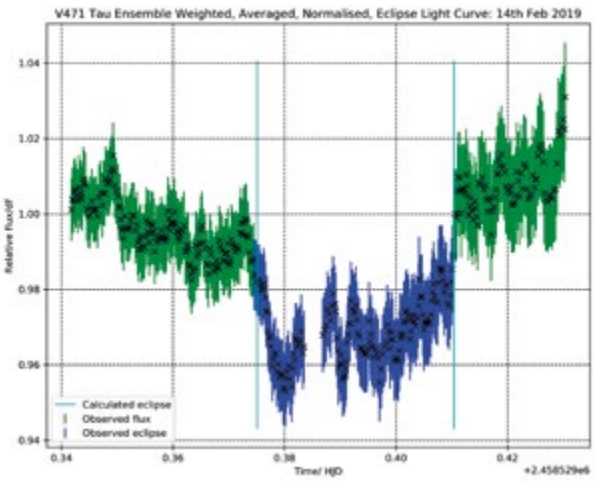


Objects visible in ACO426



Period changes and mass transfer rates in cataclysmic variables

Students investigated changes in orbital periods of cataclysmic variables to calculate limits on the mass transfer rates of three targets (U Geminorum, V347 Pup and V382 Vel). These were observed and compared with published eclipse times to produce the upper boundaries of the mass transfer limits.



Eclipse Timing Variations in V471-Tau and QS-Vir

Students investigated eclipses occurring in binary systems formed by a main sequence star and a white dwarf. The variation of mid-time eclipse measured by the group were compared to predicted time based on archive data to support or rule out potential physical mechanisms in support of the timing variation.

First Year Images

Students in Year 1 perform their own observations to create composite RGB images of astrophysical objects. This year we asked the students to poll on their preferred peer's results. The top two images are shown below:

1) M42 or "Orion Nebula" is a favourite among astronomers (amateurs and professional). This composite from Ellen James was obtained combining 3 frames each in the B, g', r' and Ha filters.

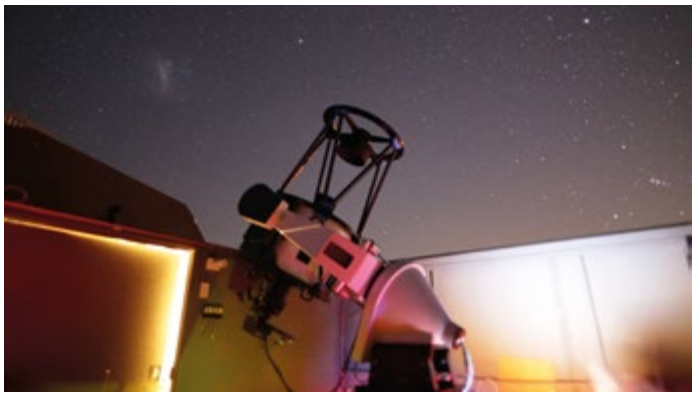
2) The "Rosette Nebula" a large HII region in Monoceros by Shreya Desai. This composite was obtained combining respectively [2,2,2,12] frames in the B, V, r' and Ha filters.

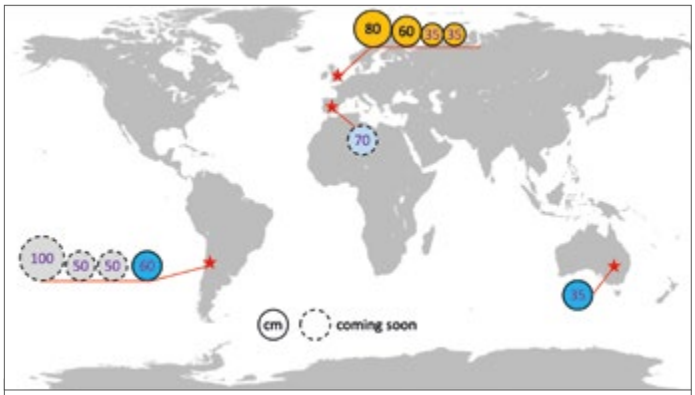
Partnership with TelescopeLive

Our partnership with the telescope network Managed by Space Flux is now in its second year. TelescopeLive researches e-solutions for businesses, 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.

In addition to our UCL telescopes, this past year our students have made use of the TelescopeLive telescopes and produced some stunning images and data for use in research projects.

This year TelescopeLive have invested in securing access to additional telescopes including a one metre telescope in Chile.





"Size" map of all telescopes accessible by UCLO students

UCL's robotic telescopes pipeline

In 2018 the UCL students using the robotic telescopes acquired a variety of targets for a total of 31000 images from the UCL telescopes on and 22000 images from the TelescopeLive telescope network.

Preparations for the 80cm

The new 80cm fully robotic telescope at the UCL Observatory to be installed this Summer will be operational for the 2019/20 academic year.

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 Frank Deppisch (HEP)
Professor of Physics

Professor Agapi Emmanouilidou (AMOPP)
Professor of Physics

Professor Chamkaur Ghag (HEP)
Professor of Physics

Professor Emily Nurse (HEP)
Professor of Physics

Professor Andrew Pontzen (ASTRO)
Professor of Cosmology

Professor Sergey Yurchenko (AMOPP)
Professor of Physics

Promotion to Associate Professor

Dr Shiladitya Banerjee (BioP)
Associate Professor

Dr Andela Saric (BioP)
Associate Professor

Dr Timothy Scanlon (HEP)
Associate Professor

Promotion to Principal Teaching Fellow

Dr Louise Dash
Principal Research Fellow

Retirement

Jim Percival

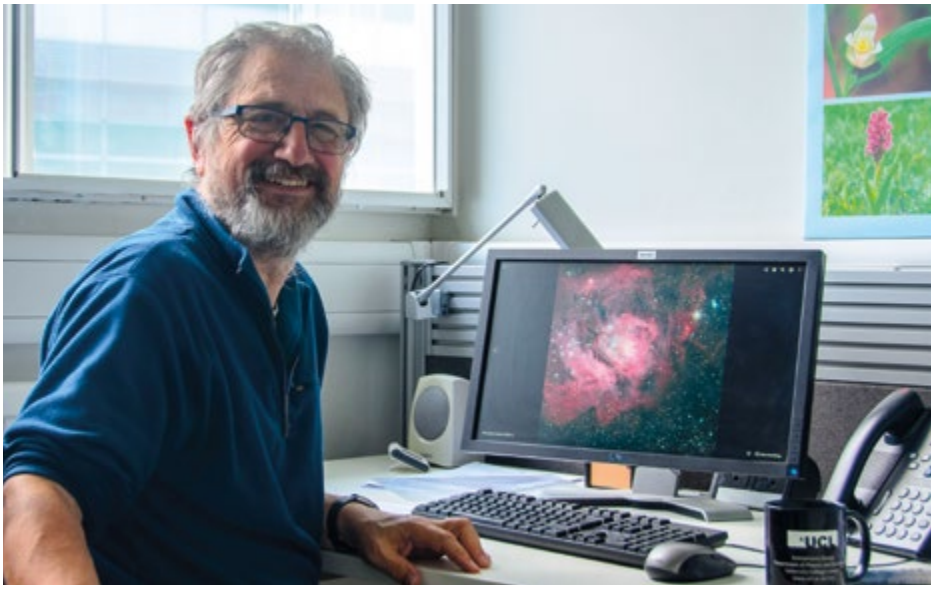
Jim joined UCL as a workshop technician in May 1980. The workshop superintendent John Pitcher convinced Jim to join the Physics and Astronomy Department instead of Mechanical Engineering, so we've been blessed with him since.

He worked in the departmental workshop (in the basement of the Physics building) till 1985, when he joined the Atmospheric Physics group run by Dai Rees. They worked in the prefabricated huts near the South Cloisters. With this group he worked on Fabry Perot interferometers, and also went on field trips. The huts were cleared and APL moved to Riding House Street, so Jim was based there for a short while.

When his funding to work with APL was running out he was found work with CMMP and worked with John Finney for a year. In 1997 a permanent position became available in the workshop again. The (now) MAPS workshop had Jim till 1998 when he was seconded to the Design Office run by Andy Charalambous. Jim was working specifically on the HROS project (a spectrograph for the Gemini South telescope) for the Optical Science Lab. He worked on HROS for 4 years, returning to the workshop in 2002. The design office was disbanded at this time, so Jim returned to the workshop to provide both machining effort and design effort for the department. A few years ago he also became workshop superintendent, covering the post after the retirement of Bob Gollay. This he did till his retirement in May 2019.

Portrait of…

Ian Howarth



Ian came to UCL as an undergraduate after a couple of false starts: first a year of physics at Oxford (too dull for him at that time) and secondly one in the heady world of insurance underwriting (made Oxford seem adrenaline-filled). Having concluded that choosing an interesting subject was more important to him than a 'marketable' one, He applied to study for a degree in astronomy, his passion. Only a handful of universities offered astro degrees back then, and UCL was the obvious choice. His undergraduate studies worked out okay, and he was invited by the then new Perren Professor, Bob (subsequently Sir Robert) Wilson, to take up a PhD to exploit data from the soon-to-be launched International Ultraviolet Explorer satellite. His naivete at that time is demonstrated by the fact that it never occurred to him that pinning a PhD on an unlaunched space mission might carry some element of risk, and his lack of gumption was underscored by his unquestioning acceptance of being barred from his formal PhD entrance interview by the Head of Department's protective personal assistant on the grounds that the HoD had an important appointment (with Ian, as it subsequently turned out).

He was nonetheless made an offer of a PhD place, and any fears about the IUE mission were quickly dispersed after its successful launch in 1978. Ian was soon engaged in analysing commissioning-phase ultraviolet spectra along with other observations from an international, multi-wavelength campaign on X-ray binaries that Sir Bob had set up. This was the first time that intermediate-dispersion UV spectra of reasonably faint sources could be obtained routinely, and it was Ian's good fortune to be in on the ground floor as this largely new spectral window was opened up. By the time the mission was finally shut down (for financial reasons) in 1996, Ian was chairing the international user's committee, and in that capacity attended a celebratory, but still quite melancholy, ceremony in which the irreversible shutdown commands were uploaded to the satellite.

Between the launch and demise of IUE Ian trod the standard path of PhD then postgrad appointments. Having had the unexpected luxury of a choice of lectureship posts, Ian opted for a 'New Blood' lectureship at his alma mater. Of the many supportive colleagues he has encountered, across the globe, the spirit of two from those early UCL career days remain particularly dear to Ian. First, Sir Bob, who, as an enabler and organizer of research, fostered and encouraged all those who came under his aegis; and secondly, Mike Seaton. Mike was the archetypal academic -- an exceptional research scientist who managed to combine a somewhat vague, genial persona with a razor-sharp mind. A world-leading atomic physicist, his interests in astrophysics meant he also left a strong mark in that field.

A sabbatical year at the Joint Institute for Laboratory Astrophysics in Boulder, Colorado cemented a growing interest in stellar winds from hot stars, for which IUE allowed novel investigations of unexpected, relatively short-timescale variability. Various aspects of hot, massive stars have been the main focus of Ian's research ever since, including some of the first uses of spectropolarimetry to investigate the geometry of outflows, pioneering studies in the now burgeoning study of magnetic fields, inquiring into the observational and physical consequences of very rapid stellar rotation, and exploiting the potential of massive-star binary systems as primary distance indicators for the nearest galaxies.

Headline Research

THE JINGLE SURVEY

JINGLE is a large programme conducted with the James Clerk Maxwell Telescope, led by UCL astronomer Amelie Saintonge. An acronym for 'JCMT dust and gas In Nearby Galaxies Legacy Exploration', it is designed to study systematically the cold interstellar material of galaxies in the local Universe. The material from which stars are born consists of both gas and dust, and so JINGLE starts with a sample of galaxies selected from the Herschel space mission, which measured the weak infra-red glow of heat from the dust.

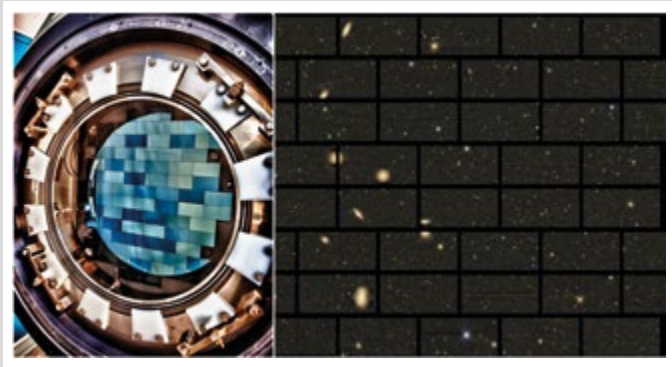
New JCMT measurements then determine the physics, dynamics, and chemistry of the gas component, to provide a complete picture of the interstellar medium. Good progress is already being made on the detailed science goals, and serendipitous discoveries include the identfication of galaxies at redshifts of 6 or greater – that is, star systems that were already in place when the Universe was less than 10% of its present age.

Some of the galaxies in the JINGLE survey, and the JCMT. (The telescope sits behind a membrane that protects it from wind and dust.) Credit: SDSS/EAO/Saintonge

THE DARK ENERGY SURVEY

Although analysis and modelling will continue for some time to come, the data-acquisition phase of DES, the Dark Energy Survey, came to an end when the project's final observations were taken on 9 Jan 2019. A major international collaboration with strong involvement by UCL scientists, this 6-year campaign used 758 nights of 4-m-telescope time to carry out a deep, wide-area imaging survey to record information on some 300 million galaxies. The survey imaged 5000 square degrees of the southern sky through five colour filters to obtain detailed information about each galaxy, in order to probe the distributions of dark matter and dark energy throughout cosmic time. It also observed smaller patches of sky roughly once a week to discover and study thousands of supernovae and other astrophysical transients (including the independent discovery of the first optical counterpart to a gravitational-wave event), as well as new minor planets and trans-Neptunian bodies.

Building on the successes of DES, the forthcoming Dark Energy Spectroscopic Instrument (DESI) will measure the effect of dark energy on the expansion of the universe. It will obtain spectra for tens of millions of galaxies and quasars, constructing a 3D map from the nearby universe to 11 billion light years. Continuing from his role in DES, Perren Professor Ofer Lahav sits on the project's Executive Committee, with instrument scientists Peter Doel and David Brooks responsible for crucial optical systems. 'First light' should take place in the coming year.



(Left) The tiled CCDs that form the DES detector; (right) part of a single DES image showing stars and galaxies. Credit: CTIO/Fermilab/DES Collaboration

In Memoriam

Professor Allan Willis
Emeritus Professor of Astronomy

Allan first came to UCL to study for a BSc in 1970, in the then Dept. of Astronomy, and was to remain for the rest of his working life.

With the arrival of Sir Robert Wilson as Perren Professor, the merger into Physics & Astronomy took place, and Allan became Bob's first PhD student here, working on some of the earliest ultraviolet spectra of Wolf-Rayet (WR) stars, obtained with the S2/68 experiment on the TD1-A spacecraft. Awarded his PhD in 1976, he went on to hold posts as an SERC Postdoctoral Research Assistant (1976–79), SERC Advanced Research Fellow (1979–84), and Royal Society University Research Fellow (1984–92). He was promoted to Reader in 1990, and Professor in 1995.

Throughout his career his research continued to revolve principally around UV spectroscopy of WR stars, generating almost 100 refereed-journal publications before he took early retirement at the end of the 2005/6 academic year. As well as supervising a series of PhD students, many of whom have themselves gone on to successful academic careers, he was active in 'astropolitics' at national and international level, and played a number of enabling roles within the Department.

Gordon Lush

Gordon joined the Department as a student in October 1953 along with Mike Esten, George Kalmus, Ken Pounds, Valerie Burke(nee Martin) and Don Davis to name but a few. Gordon & Mike were both postgraduate students in the group of the late Ceiri Griffiths working on a series of experiments using the triggered High Pressure (100 atmospheres) cloud chamber constructed in the Department. Then Mike left to take up a CERN Fellowship while Gordon remained in the Department all his working life, he obtained his PhD on p-p scattering with Ceiri Griffith his supervisor and was a member of the high energy physics group where he indulged in his passion for building apparatus. Eventually Gordon transferred from Ceiri's group to that of Franz Heymann which, at that time, was mostly working at the 600MeV synchrocyclotron at CERN – the first accelerator at CERN. Gordon's bent for the practical led him inevitably towards teaching in the labs and eventually first as the man in charge of the first year laboratory, then as director of the final year labs until his retirement.

Gordon retired to his roots, having been born in Bournemouth, and bought a house about one mile from his sister Hazel Burt in 1992. He then set about building up an extensive library. His interests were varied but soon he got the taste for local history and started researching his family history. Gordon wrote two books on this subject.

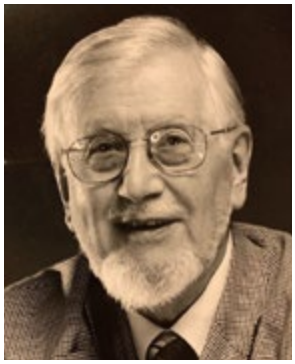
Gordon, his sister and her husband travelled quite extensively, mainly cruising. Again very varied from Alaska, the Caribbean and Russia to name a few. He was diagnosed with prostate cancer some years ago, but managed his treatment very well, celebrating his 80th birthday in 2014. He also celebrated his sister's 50th wedding anniversary with them in 2016.

Eric Strachan

Eric Strachan, ex HEP Group, passed away on 12 October 2018 aged 90. During his 42 years of continuous service on the technical staff at UCL, Eric covered many areas – firstly working in the departmental Drawing Office before moving onto heavy involvement in the design and implementation of numerous projects such as that for the British heavy Liquid Bubble Chamber.

In the Bubble Chamber Group Eric was a highly organised and firm team leader whose scanners knew very well what was expected of them. His team's work provided a large fraction of the data which the Gargamelle collaboration used to establish the existence of a weak neutral current which led to one of the greatest advances in 20th century physics; the amalgamation of the electromagnetic and weak interactions into the Electroweak Force, an intrinsic part of the current Standard Model of particle physics.

This was followed by a major role in the design of the photographic image analysis machines used to great effect by the 'Gargamelle' collaboration which made the seminal discovery of neural currents in 1972. Throughout his career, he was known by all as providing facilities which were 'a model of engineering and operational precision'. He was indeed considered to be 'one of the rocks upon which the UCL bubble Chamber group was built. He adapted from a purely technical design role to being a very effective and forceful people-manager for our team of a couple of dozen full-time scanners who found the events to be measured and counted for our Physics analyses, some of which analyses, I would argue, gave early confirmation of vital components of the Standard Model of Particle Physics.' As one ex-colleague commented, 'the diminishing band of Eric's colleagues will remember him as a remarkable person who made an enormous contribution to the UCL HEP group'.



Robert (Bertie) Buck

Robert (Bertie) Buck passed away in a tragic accident in April 2019. Bertie joined the Department in January 2019. He started as a junior mechanical engineer working for the High Energy Physics (HEP) and Atomic Molecular Optical and Positron Physics (AMOPP) groups. He immediately impressed everyone with his outstanding work ethic, creativity and positive attitude. Despite spending only a short time at UCL he managed to make a big impact on a number of projects. Bertie truly found himself at UCL and became a close friend to many of us. We will miss him greatly.

A Sample of Staff Accolades

IET Postgraduate Award

Awarded to **Loannis Leridesl**

Ioannis Ieridesl was awarded a prestigious scholarship from the Institution of Engineering and Technology (IET). The IET Postgraduate Awards are part of an awards and prizes scheme, which provides over £1,000,000 to celebrate excellence and innovation in the sector and encourage the next generation of engineers and technicians. Ioannis was awarded an IET Postgraduate Award in recognition of his outstanding engineering research in high-dielectric constant organics for high efficiency photovaltics.

Runner-up RAS Michael Penston Thesis Prize

Awarded to **Antonella Palmese**

Antonella Palmese was Runner-Up of the Royal Astronomical Society Michael Penston Thesis Prize for the best Doctoral thesis in Astronomy in 2018. One of the highlights of Antonella's thesis is the DES/ DECam follow-up of the Gravitational Wave Binary Neutron Star GW170817 event.

Membership of Academia Europaea

Election of **Prof Ofer Lahav**

Ofer Lahav has been elected as a Member of Academia Europaea (The Academy of Europe). The aim of the Academy is to promote European research, advise governments and international organisations in scientific matters, and further interdisciplinary and international research.

2019 RAS Fowler Award (Geophysics)

Awarded to **Dr Ingo Waldmann**

The 2019 Fowler Award in Geophysics was awarded to Dr Ingo Waldmann, for his role in the vanguard of developing the statistical theory of exoplanet observations and their interpretation. Analysing spectral data from exoplanets is enormously challenging, and unintended, subjective biases can adversely affect the reliability of identifying atmospheric species. Dr Waldmann has developed fully-blind machine learning techniques to extract the maximum reliable information about these planets.

2019 MAPS Faculty Teaching Award (support staff category)

Awarded to **Selina Lovell**

Selina Lovell is Senior Teaching & Learning Administrator managing the student support team in the Physics & Astronomy Department. The Award has recognised in particular Selina's outstanding support of students with different learning needs and for developing the roles of Professional Services staff.

Royal Academy of Engineering Fellowship

Awarded to **Dr Lia Li**

Dr Lia Li has been awarded the Royal Academy of Engineering Intelligence Community Postdoctoral Fellowship.

Department Teaching Prize 2017–18

Awarded to **Prof. Sergey Yurchenko**

The Physics & Astronomy Departmental Teaching Prize for 2017–18 was awarded to Prof Sergey Yurchenko. His lecture course PHAS0025 (PHAS2246) "Mathematical Methods III" is taken by an extremely large cohort of well over 200 students from a wide range of backgrounds, and is consistently popular and highly engaging, and has excellent outcomes. Beyond this, Dr Yurchenko has excelled in all aspects of his teaching and learning activities and is an outstanding project supervisor, as shown by his recent nominations for Student Choice Awards.

Rosalind Franklin Award and Lecture 2019

Awarded to **Prof. Thanh Nguyen**

Professor Nguyen has been honoured in the 2019 Rosalind Franklin Award for her achievements in the field of nanomaterials and her impactful project proposal. She leads a team doing interdisciplinary research on the design and synthesis of nanomaterials for biomedical applications, such as the studies of plasmonic and magnetic nanoparticles for diagnosis and treatment of disease.

Thanh has proposed a project to organise and deliver a residential summer science camp that is tailored to inspire and motivate Year 8 students, mainly girls from underprivileged, or ethnic minority backgrounds from deprived parts of London, who are currently underrepresented in STEM careers.

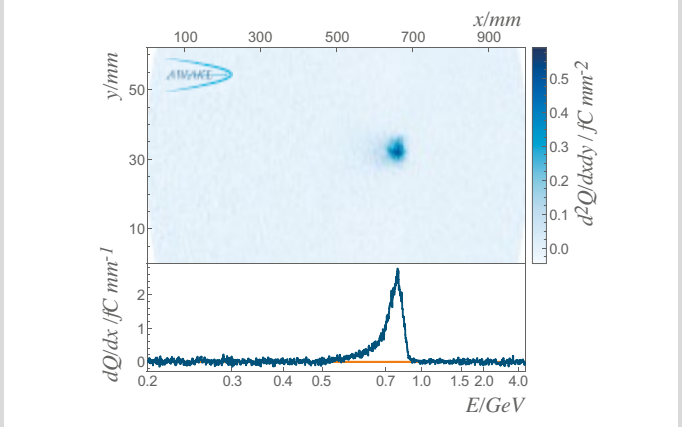
A Novel Compact Accelerator for High Energy Physics

The Advanced Wakefield (AWAKE) experiment has demonstrated proton-driven plasma wakefield acceleration for the first time. By injecting a high-charge, high-energy proton bunch into plasma, the free electrons in the plasma are set into oscillatory motion generating large electric fields. These fields can be harnessed to accelerate a witness electron bunch to high energies much more rapidly than is possible with current accelerators.

The UCL team are one of 18 member institutes of the AWAKE collaboration and were responsible for the development of a magnetic spectrometer (see photo) to measure the accelerated electrons. The electrons passed through a scintillator screen and the light generated was imaged with a high-resolution camera. The UCL group analysed the data and clear signals of electrons were seen on the imaged scintillator screen where the figure shows electrons of energy of about 0.8 GeV. By varying the conditions of the experiment, electrons could be accelerated up to 2 GeV within 10m of plasma which is about 10 times faster than conventional accelerators. The UCL-led paper was published in Nature in August.

The group is now working on a next stage in which electrons are accelerated to higher energies and higher-quality bunches are achieved. This could then lead to future particle physics experiments with much shorter accelerators.

A UCL-built magnetic spectrometer to measure accelerated electrons in AWAKE. Credit: Maximilien Brice, Julien Ordan/CERN



An image of the scintillator (top) and its projection (bottom) showing electrons accelerated to an energy of 0.8 GeV.
Reproduced from Nature ***volume 561****, pages 363–367 (2018).*

Headline Research

Hunting Neutrinos with DUNE Detector

The DUNE detector will be a very large Time-Projection chamber filled with liquid argon. It will be hosted in 4 super-modules, 10kton each, located 1.5 kilometres underground, in the Homestake mine in South Dakota.

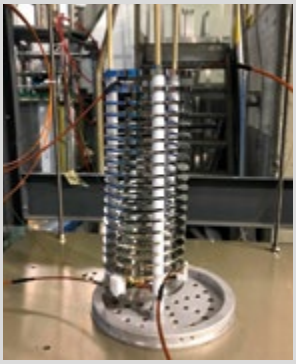
This detector has a rich physics program, ranging from searches for nucleon decay to studies of supernovae and atmospheric neutrinos. It will precisely measure neutrino oscillation parameters using a beam of neutrinos produced at a distance of 1300 km at the Fermi National Accelerator Laboratory (FNAL) near Chicago.

Particles interacting with liquid argon will ionise it, creating electrons that will drift in an electric field before reaching an anode creating electrical pulses which can then be collected and analysed to reconstruct particle tracks and energies. Two possible options for the readout have been proposed. In a single-phase configuration, the readout planes are immersed in liquid argon, while for a dual-phase configuration the readout planes are placed in gaseous argon above the liquid surface, and the electron's signal can be further amplified.

Given the size and complexity of the detector, two large prototypes (for the single- and dual-phase configurations) of about half a ton each have been built at CERN. The single-phase detector took data in a test beam at CERN at the end of 2018, while the dual-phase prototype is under construction and is expected to start taking cosmic-ray data in summer 2019. The operation of these detectors will demonstrate feasibility of the detector and the performance of both approaches.

UCL has been involved in the construction of purity monitors for the dual-phase detector, and in simulation and reconstruction work for both single- and dual-phase technologies.

(Left to right) UCL physicists Laura Manenti, Linda Cremonesi, and Anastasia Basharina-Freshville inside the ProtoDUNE detector.



A liquid argon (LAr) purity monitor built and commissioned at UCL for the dual-phase ProtoDUNE detector. The detector is sensitive to electronegative impurities in LAr at a level of 1 part in 10^{10}.

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 is remarkable for the broad range of fundamental science it embraces: high-energy physics, atomic and molecular physics, and condensed-matter physics, for example, sit alongside astrochemistry and astrobiology as topics of investigation employed in our studies of the universe. The strong interdisciplinary nature of astrophysics research at UCL benefits from the collaborative and co-operative nature of the Department within which we work, and of our colleagues throughout the Faculty of Mathematics and Physical Sciences. It is exemplified by enterprises such as the Centre for Planetary Sciences, the Centre for Space Exoplanet Data, and the Cosmoparticle Initiative, where particle physicists and cosmologists (among others) work closely together.

A good illustration of unforeseen rewards of such interdisciplinary research comes from the Cosmic Dawn project of the Cosmoparticle Initiative. The project sets out to investigate inflation – the extraordinarily rapid expansion phase believed to have occurred in the very first moments of the birth of the universe. A possible consequence of inflation is that our own universe may have been born as merely one 'bubble nucleation' within a greater multiverse, suggesting that other universes may also have formed -- like the many bubbles created in a pan of boiling water. In a paper led by postdoctoral researcher Jonathan Braden, the team showed that there are strong parallels between this bubble-nucleation model and comparable effects in Bose-Einstein condensates (a low-temperature phenomenon that can be studied in the laboratory) – in effect, opening the way to methods which could allow the origin of our Universe to be studied using benchtop experiments. This insight was awarded the 2018 Buchalter Cosmology Prize, presented by the American Astronomical Society for the development of "new theories, observations, or methods that can help illuminate the puzzle of cosmic expansion from first principles".

Figure 1. Representation of bubble nucleation – a model for the multiverse. Credit: iStockphoto

> "The strong interdisciplinary nature of astrophysics research at UCL benefits from the collaborative and co-operative nature of the Department…"

Figure 2. The star cluster Westerlund 1
Credit: ESO/D. Fenech et al.; ALMA (ESO/NAOJ/NRAO)

Within our Galaxy, the spectacular star cluster Westerlund 1 (Wd1) hosts an exceptional number of stars that are ten or more times as massive as the Sun. These are the stars that explode as supernovae at the end of their lives, giving birth to black holes in many cases, and each ejecting several solar masses of star-born elements – for example, the oxygen we breath was created in such stars. Understanding their evolution is an ongoing endeavour, but Wd1 lies hidden behind dust which obscures the view from optical telescopes. A new study led by UCL scientists Danielle Fenech and Raman Prinja used the ALMA telescopes, which observe the skies at mm wavelengths (between the infrared and radio), to examine the details of how these stars continuously shed mass at a prodigious rate through high-speed outflows. The initial focus of the study was these stellar winds, because they are crucial in determining the stars' ultimate fates. However, the observations also revealed unexpected new features, including comet-like `tails' of gas from red supergiant stars, pointing away from the core of the cluster, and probably the result of global cluster wind generated by the hundreds of hot, massive stars found towards the centre of Wd1.

Stars like our own Sun also lose mass, especially at the very late stages of their lives. Individually, their mass loss is **relatively** small (of order a tenth of the mass of the Sun, or 'only' ~100,000 times the mass of the Earth), but because they vastly outnumber high-mass stars they, too, make an important contribution to the origin of the elements; for example, they are a major source of the carbon and nitrogen in the universe. This material is mostly shed when the stars evolve through a red-giant phase, creating so-called 'planetary' nebulae, whose spectra can be analysed in order to measure their chemical composition. And yet, for over half a century, astronomers have been faced with the puzzle that different analysis techniques have yielded results for element abundances than are discordant by as much as factors of ten or more. Postdoctoral researcher Roger Wesson has shed new light on this problem by showing that the greatest apparent anomalies occur in nebulae which contain double-star systems at their centres. With colleagues, he postulates that during the red-giant phase, one of the two stars actually orbited inside the other, in a so-called 'common envelope' phase, and he is able to account for the long-standing abundance mystery with this model.

Figure 3. The Planetary Nebula NGC 5189
Credit: NASA, ESA and the Hubble Heritage Team (STScI/AURA)

Eventually, a planetary nebula will disperse, and a star like our Sun will the end its days as a white dwarf – its mass scarcely diminished, but now packed into a body the size of the Earth. In recent years, many white dwarfs have been shown to have outer layers that are unexpectedly `polluted' by elements such as calcium, magnesium, silicon, and iron. This pollution is now attributed to infalling rocky material from remnant planetary material, but the processes by which the material is accreted are ill understood. Discs of orbiting debris are generally thought to be implicated, and new research by postgraduate students Andrew Swan and Tom Wilson, together with staff member Jay Farihi, has shown that more than half of 'dusty' white dwarfs studied show variability in infrared light, which they argue indicates that dust production at most stars is an ongoing process. The challenge now is to identify the processes that are creating the dust.

Alongside such traditional approaches to observing and modelling astrophysical processes, there is a burgeoning growth in the applications of artificial intelligence, and particularly machine learning. The potential of these tools is enormous, and the Department's Centre for Doctoral Training in Data Intensive Science is taking the lead in this area.

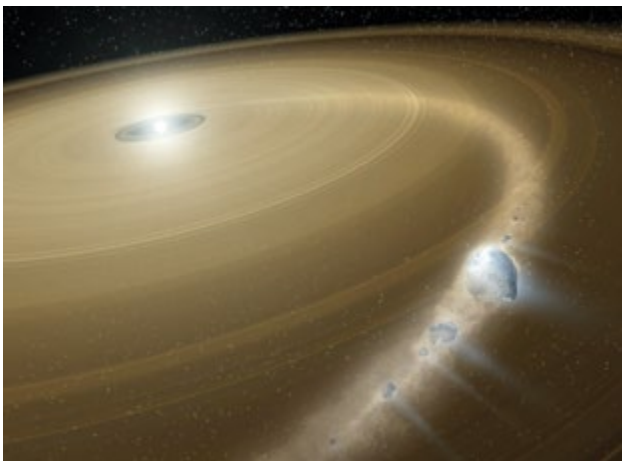


Figure 4. Artist's impression of a dusty/rocky disc around a white dwarf.
Credit: NASA/JPL-Caltech

For example, current space missions to solar-system planets produce high-quality data sets, yet the sheer amount of material handicaps detailed `by hand' analyses. A new deep-learning algorithm, PlanetNet, developed by Ingo Waldman as part of a project funded by the European Research Council, is able to map spatial and spectral features across large, heterogeneous planetary-image datasets. A first application of this hyper-spectral image classification code to previously studied images of Saturn's 2008 storm revealed new compositional and cloud variations of the vast region affected by the storm, showing regions of vertical upwelling, and diminished clouds at the centre of compact storms. This analysis quickly and accurately delineated the major components of Saturn's storm, thereby indicating regions to be studied in greater detail.

As we move forward into an era of 'big data', such intelligent algorithms will play an increasingly important part in facilitating the analysis of rich datasets across the spectrum of astrophysical interests studied in the Department: planetary and exoplanetary sciences (e.g.Juno, JWST, Ariel), galactic and stellar astrophysics (e.g., Gaia, LSST), and cosmology (e.g., DESI, Euclid).

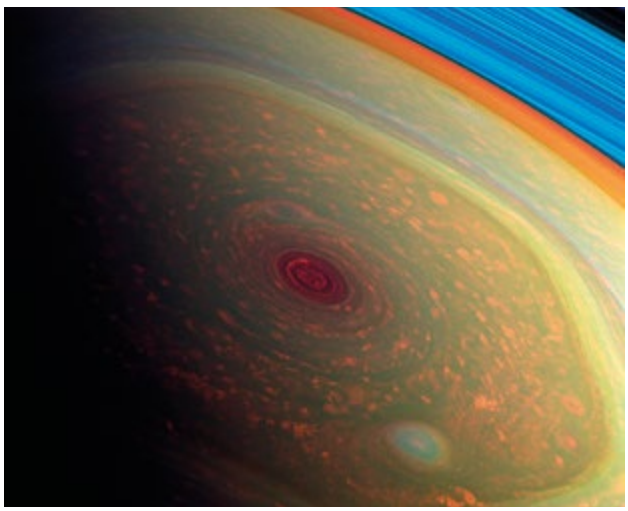


Figure 5. The stormy atmosphere of Saturn.
Credit: NASA/JPL-Caltech/SSI

Atomic, Molecular, Optical and Positron Physics (AMOPP)

The Atomic, Molecular, Optical and Positron Physics (AMOPP) Group at UCL has a wide range of research activities that span from quantum information and thermodynamics to positron and molecular physics. We engage in both applied and fundamental research with strong experimental and theoretical programmes. There are many collaborations between our research teams in AMOPP in addition to the other major groups in both Physics and Astronomy and also the London Centre for Nanotechnology at UCL. We currently have 18 academic staff with 21 research fellows and postdoctoral researchers, 60 PhD students and two technical staff.

> "…major new funding has been awarded to the AMOPP group to support a wide range of new and ongoing reserch."

This year, major new funding has been awarded to the AMOPP group to support a wide range of new and ongoing research. Our total current funding for research is in excess of £17M. One example is a new Leverhulme trust grant to fund the exploration of exotic forms of matter in molecules driven by free electron lasers; this is led by Agapi Emmanouilidou. Another exciting line of work is the development of quantum sensors for measuring magnetic fields, led by Ferruccio Renzoni and his team. This work is funded by a large range of sources including the Royal Society and the UK's Engineering and Physical Sciences Research Council. These new programmes represent only some of the research undertaken within the group and further details can be found on the group's webpages: **www.ucl.ac.uk/physics-astronomy/amopp**.

This year, in recognition of their excellence in research, teaching and administration, a significant number of our academic staff have been promoted to Professor. This includes Angus Bain, who runs the Ultrafast Laser Spectroscopy Group, David Cassidy (Positron/Positronium Physics), Carla Figueira De Morisson Faria (Strong Field Laser Interactions), Alexandra Olaya-Castro (Quantum Biology), Alessio Serafini (Continuous Variable Quantum Systems) and Marzena Szymanska (Quantum Collective Dynamics).

The Carey Foster prize for outstanding postgraduate researcher within the AMOPP group was awarded to both Emil Zak and Alberto Munoz Alonso this year. Emil's PhD project, undertaken within Jonathan Tennyson's group, produced and analysed 54 CO_2 line lists. Emil's analysis was both careful and insightful, and yielded results with a comprehensive uncertainty quantification. His results have persuaded a usually sceptical (largely experimental) audience that his data represents the best available. These results are now the new normal for the CO_2 molecule, with a range of experimental groups reporting measurements that are calibrated by how well they agree with his calculations. Alberto's prize was received for outstanding experimental work on excited states of positronium in electric and magnetic fields as part of his PhD within David Cassidy's group. His research resulted in nine publications. He showed the first selective production of positronium Rydberg Stark states as well as the control of their decay using Stark and Zeeman effects. Later in his PhD he demonstrated velocity selection of positronium by electrostatic guiding.

Marzena Szymańska, now a Professor within the AMOPP group, holds a prestigious EPSRC Research Fellowship and leads a large collaborative research programme called InterPol within the EU. Her research group explores novel emergent phenomena in far-from-equilibrium quantum systems and her theoretical work can be applied to a range of topics including circuit and cavity QED systems, semiconductor microcavities, and quantum spins, as well as cold atomic gases.

> "A recent high-proile result was the identification of a new rigid state of matter made of light. This matter exists somewhere between a solid and a superfluid."

A recent high-profile result from her group was the identification of a new rigid state of matter made of light. This matter exists somewhere between a solid and a superfluid, and they have demonstrated that it cannot be rotated or even pushed. It is built of particles called polaritons, which are composites of photons and excitons in semiconductor cavities. Because light cannot be perfectly contained in these cavities, polaritons never reach thermal equilibrium and must be driven with a laser to maintain a steady state.

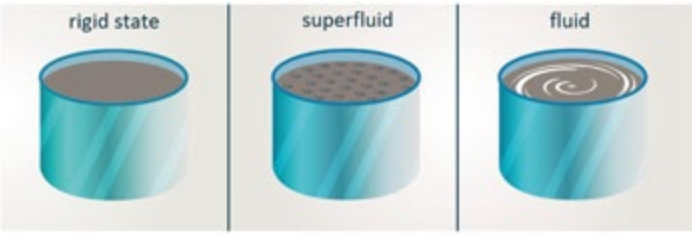


Figure 1. The diagrams illustrate that when the rigid state is rotated it is completely unresponsive, unlike a normal fluid which flows with the rotation and a superfluid which forms quantised vortices.

The rigid state was identified by calculating how a system of polaritons driven coherently, i.e. where the driving laser creates a macroscopic state at a specific energy and momentum, responds to pushing and rotating forces. Unlike superfluids, which are distinguished by their response to the former but not the latter, the rigid state is unaffected by both. It also cannot form quantised vortices. This result shows how polaritons, which in other configurations can be normal fluids or superfluids, exhibit an extremely rich array of behaviours.

Beyond furthering our understanding of macroscopic quantum states in open systems, her research is looking into the practical applications of polariton physics in quantum technologies. With her InterPol project, it is hoped that in the future a lattice of polaritons can be utilised to build a quantum simulator.

A significant portion of the AMOPP research programmes are undertaken by an extremely active group of Research and Postdoctoral Fellows. Dr Ying Lia Li is a Research Fellow within the Barker group who has recently developed a new type of extremely precise accelerometer that surpasses the sensitivity of the conventional electric devices that are used for navigation and positioning. This new device has spun out of the more basic research carried out within the group that explores the interaction between light and the mechanical motion of nano-oscillators.

This unique accelerometer uses a silica microsphere to confine laser light within optical whispering gallery mode resonance, somewhat like the audio whispering gallery modes found in St. Pauls cathedral. In this system light that is coupled into the sphere circulates around inside it for a very long time.

The amount of light that enters the sphere is determined by the separation between the sphere's surface and the light source. This exquisite sensitivity allows the measurement of displacements as small as the width of an atom. When the sphere is mounted on a small cantilever and subjected to accelerations, the measured displacements can be related to the acceleration, with sensitivities well below a millionth of earth's gravity. This device is continuing to be developed and has been funded by the UK's Defence Science and Technology Laboratory and the Engineering and Physical Sciences Research Council within the AMOPP group.

"This unique accelerometer uses a silica microsphere to confine laser light within optical whispering gallery mode resonance."

Figure 2. A schematic of the whispering gallery mode acceleration sensor. Light propagating within an optical fibre leaks into the optical whispering gallery mode of the resonator. The amount of light that is coupled into the microsphere is a precise measurement of the separation between the sphere and the optical fibre.

High Energy Physics (HEP)

Project in focus

The LUX-ZEPLIN experiment at the Sanford Underground Research Facility

Aim

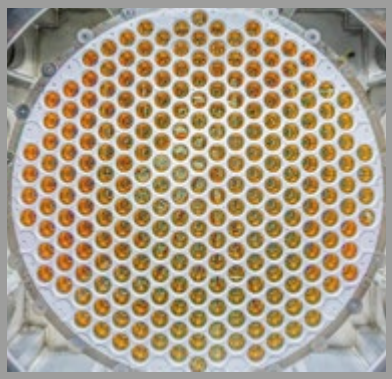
Using a 7 tonne Xe detector to search for low-energy interactions with Weakly Interacting Massive Particles (WIMPs), hypothesised to make up the dark matter in our galactic halo. Its unprecedented size and ultra-radiopure design mean Lux-Zeplin (LZ) will not only be sensitive to WIMP cross sections 20 times smaller than those probed to date but also a host of (non-WIMP) new physics.

Results to date

It takes a while to design and build the world's most sensitive dark matter detector. R&D started in 2012 and in early 2017 the design of LZ was finalised and construction of the experiment began in earnest. Right now LZ's 250 scientists and many engineers are racing to complete assembly of the detector and move it into its new home 1 mile underground ready to take first data in 2020.

UCL Involvement

UCL has played a major role in the selection of the radiopure materials used to build the detector and in developing simulations to guide the design and evaluate the performance of LZ. The focus is now on preparations for data analysis and on-site assembly of the experiment.



An assembled array (one of two) of 241 ultra-radiopure photomultiplier tubes that will image the liquified xenon target at the heart of the LUX-ZEPLIN experiment.

The LUX-ZEPLIN Titanium cryostat being inspected at the surface laboratory prior to its journey a mile underground to the Davis cavern of the Sanford Underground Research Facility, South Dakota, USA.

The UCL High Energy Physics (HEP) group is one of the largest particle physics groups in the UK with a wide range of research projects spanning energy frontier studies at the Large Hadron Collider (LHC), neutrino physics, dark matter searches, precision muon physics, theoretical physics studies and many more. Apart from research in fundamental particle physics with leading contributions to several international collaborations (the UCL HEP group has two international spokespersons and one deputy-spokesperson) we are involved in a number of interdisciplinary and knowledge exchange projects with academic and industrial partners. These include research into improving cancer treatment with precision proton beams, advancement of accelerator technologies, environmental studies.

> "The UCL High Energy Physics group is one of the largest particle physics groups in the UK…"

In 2018 members of HEP group took part in establishing a new initiative – Quantum Sensors for Fundamental Physics (QSFP) – with the aim to bridge the gap between different branching of physics and use recent advances in quantum sensors and atomic physics to address "traditional" particle physics questions such as the origin of dark matter and the neutrino mass. The HEP group collaborates closely with the UCL AMOPP and Astrophysics groups as well as with groups from other universities on the QSFP programme.

Below we report on main highlights of 2018-19.

Arrivals and Departures

Robert Buck, a new mechanical engineer, started at UCL in January 2019. Robert will support experimental programmes of the HEP and AMOPP groups. A new lecturer, Rebecca Chislett will start at UCL HEP in October 2019. Rebecca is UCL "born and bred" having completed her PhD at UCL and worked as a postdoc since 2014 on the g-2 experiment. She has secured a lectureship position after a very competitive selection process.

After 20 years at UCL Prof. Mark Lancaster will be leaving UCL to move to University of Manchester. Mark has been instrumental in making the HEP group a success. He was head of the group between 2008 and 2016 and initiated precision muon physics in the UK led by UCL. A detailed story about Mark's multiple contributions to research, teaching and life at UCL can be found here on page 15:

www.ucl.ac.uk/physics-astronomy/sites/physics-astronomy/files/annual-review_15_16.pdf

We will continue to work with Mark very closely on the g-2 and Mu2e experiments in which UCL and Manchester groups are heavily involved.

Energy Frontier (ATLAS)

The LHC and the ATLAS experiment had another very successful year of data taking in 2018. This concluded the so-called LHC Run-2 (2015-18), during which ATLAS recorded an impressive 150 fb-1 of integrated luminosity, at 13 TeV centre-of-mass energy. The ATLAS team at UCL, comprising around 30 members, continued its strong contributions to the ATLAS data taking, particularly supporting the online event selection (Trigger), and maintained its leading role in analysing the Run-2 data to produce many exciting new publications. A major milestone in the Higgs physics programme was the publication of the first observation (at 5 σ level) of the Higgs boson decay to a pair of b-quarks. This is by far the dominant decay mode of the Higgs boson, but its observation was very challenging, due to the overwhelming levels of background, and required the use of advanced machine learning techniques to optimize the sensitivity of the analysis. UCL was instrumental in this observation, with Dr Tim Scanlon the editor of the publication, and our PhD student, (now Dr.) Andrew Bell, receiving the prestigious ATLAS PhD Thesis Award for his leading work on this analysis and his major role in the optimization and calibration of the b-jet identification algorithms.

The UCL group is also a leader within ATLAS in making and exploiting model-independent measurements, both to explore the limits of the Standard Model and to probe the parameter space of possible new physics beyond it. We published the first measurement of the differential cross section as a function of the four-lepton mass in 13 TeV data, as well as measurements of Z bosons and jets containing b-quarks as part of a search for Leptoquarks. We also published a search for so-called long-lived particles, decaying within the ATLAS hadronic calorimeter, something completely novel, which cannot be addressed by conventional/generic techniques. Finally, we continued our tradition in the exploration of QCD, both regarding jet physics and the study of PDFs, and the study of jet substructure, where we hold a historical leadership.

Neutrino Physics and Dark Matter

The HEP group is involved and have provided leading contributions to several neutrino oscillation experiments that are responsible for one of the most important physics discoveries of the past decades – the observation of non-zero neutrino mass.

We are part of the largest international neutrino project DUNE (see Headline Research “Hunting Neutrinos with DUNE Detector”) and are actively involved in the NOvA experiment that is taking data with neutrinos produced at the Fermi National Accelerator Laboratory (FNAL) near Chicago and detected at a site in Minnesota.

Due to a very feeble nature of neutrino interactions with matter neutrino detectors have to be very large and consequently expensive. The CHIPS experiment funded by ERC and led by Prof. Jenny Thomas of UCL is setting out to prove a radically cheaper way to build a very large water Cherenkov neutrino detector. The deployment of a detector prototype, submerged in a flooded mine pit in the path of the same neutrino beam from FNAL received by NOvA will take place in the summer 2019. The detector parts have been constructed over the past year and will be assembled during a short deployment period in North Minnesota between May and September to avoid very cold and snowy Minnesota winters.

The SuperNEMO neutrinoless double-beta decay experiment (co-led by UCL) has achieved a major milestone in the last year with the completion of the detector and the start of commissioning in a French underground laboratory, LSM, located in the Frejus tunnel connecting Italy and France. Major components of the detector were assembled at UCL’s MSSL laboratory over the last 5 years, and the whole team is excited to begin the search for extremely rare nuclear decay modes which can help understand the nature of the neutrino and shed light on the mystery of the observed asymmetry between the matter and antimatter in the Universe.

The UCL HEP group has continued playing a leading role in an international project, LZ. The experiment’s goal is to search for dark matter using a large quantity of liquid Xenon in an ultra-low background detector located in a deep underground laboratory in South Dakota, USA (see Project in Focus).

UCL physicist Anastasia Basharina-Freshville performing final checks before the SuperNEMO detector closure. Photo credit: K.O’Sullivan.

Precision Muon Physics

The first Muon g-2 physics run started in April 2018 at Fermilab’s Muon Campus, and the experiment has already accumulated a data sample larger than that taken by the predecessor Brookhaven experiment over a 5 year period. The straw tracking detectors that were built in the UK and for which UCL provided the data acquisition system have been pivotal in the analysis of the first data, providing critical information on the spatial and temporal properties of the muon beam. A publication from this data is expected in 2019 and will hopefully determine whether the measurement of the Brookhaven experiment, which is at odds with the prediction of the Standard Model (SM) of particle physics by 3.7 standard deviations, is an indication of new physics beyond the SM or not.

The g-2 experiment muon storage ring insulated with white fiber glass blankets to stabilise the temperature.

Condensed Matter and Materials Physics (CMMP)

The Condensed Matter and Materials Physics (CMMP) section conducts high quality research in the physics of solids, liquids and other condensed matter states. This year we have welcomed a new member of the group – Dr. Arijeet Pal -- who studies the theory of quantum systems with the aim of elucidating new dynamical phenomena arising from quantum superposition and entanglement, with potential applications to quantum devices.

The general research of the group continues in very broad areas, that include materials modelling, many body theory, neutron and X-ray scattering and materials discovery. The following describes some of the highlights of CMMP published research for this year.

Phosphorene Nanoribbons

The discovery of tiny, flexible ribbons of crystalline phosphorus by Dr. Chris Howard and his group could revolutionise electronics and battery technology. Since the 2014 isolation of two- dimensional phosphorene, which is the phosphorus equivalent of graphene, more than one hundred theoretical studies have predicted that new and exciting properties could emerge by producing narrow 'ribbons' of this material. These properties could be extremely valuable to a range of industries.

The work of Dr. Howard and collaborators, published in Nature, describes how high-quality ribbons of phosphorene may be formed from crystals of black phosphorous and lithium ions. This is the first time that individual phosphorene nanoribbons have been made. The ribbons form with a typical height of one atomic layer, widths of between four and fifty nanometres and length up to nearly a tenth of a millimetre: an aspect ratio comparable to that of the cables spanning the Golden Gate Bridge's two towers. By using advanced imaging methods, the researchers characterised the ribbons and showed that they are extremely flat, crystalline and flexible.

While nanoribbons have been made from several materials, including graphene, the phosphorene nanoribbons produced in this work have a greater range of widths, heights, lengths and aspect ratios. They can be produced in a form that could be used to apply them in volume at low cost for applications, such as in batteries, solar cells, thermoelectric devices for converting waste heat to electricity, photocatalysis, nanoelectronics and quantum computing.

While continuing to study the fundamental properties of the nanoribbons, the team intends to also explore their use in energy storage, electronic transport and thermoelectric devices through new global collaborations and by working with expert teams across UCL.

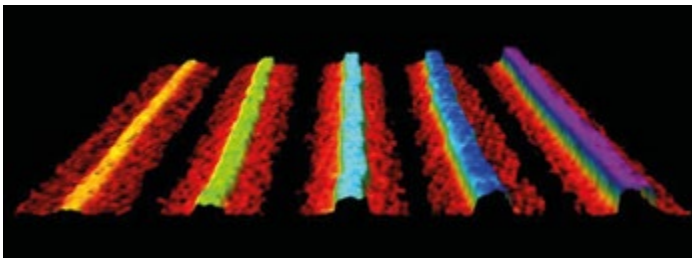


Figure 1: Individual phosphorene nanoribons.

Solar cells for light harvesting

Solar cells based on perovskite materials have attracted great attention from the scientific and industrial communities because they are able to combine high power conversion efficiencies under standard test conditions (i.e. those of the sun) with simple manufacturing processes. The films that make up the cells are in fact cast from solution: printed via inks or evaporated over large areas.

Prof. Franco Cacialli of the CMMP and collaborators have developed perovskite solar cells with a particularly high efficiency and power output. These may be the highest power output densities ever reported under illumination conditions typically found in homes and offices. The exceptional performance under indoor lighting was achieved by incorporating new solution-processed SnO_2/MgO composite electron transport layers between the perovskite semiconductor film and the bottom transparent electrode.

All layers of the cells, except for the two electrodes, were solution processed at low temperatures, making the technology easy to integrate with other printed electronic components on the same substrate, and compatible with low cost manufacturing. The research can pave the way for perovskite solar cells to contribute strongly to energy harvesting and the powering of the indoor electronics of the future.

The results have been published in Nano Energy.

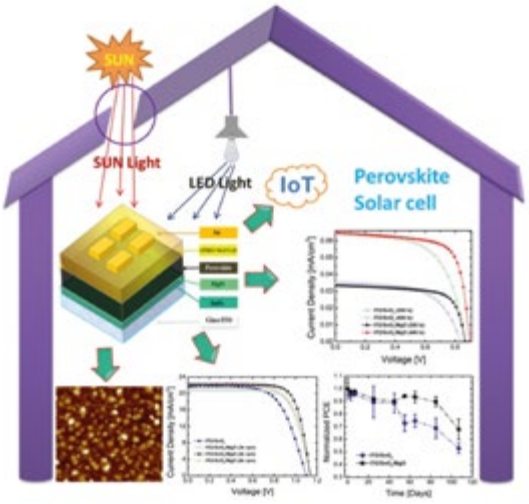


Figure 2: how perovskite solar cell technology may power electronics in smart buildings, the internet of things, and wireless sensors.

Hidden Topology Controlling Material Properties

The atoms or ions that compose a solid substance may be arranged in an ordered pattern, like in a rock salt crystal, or they may be completely disordered, like in window glass. But more common than either extreme is the intermediate situation where order and disorder coexist in the same material. To understand the properties of such partially disordered materials is a significant challenge.

The CMMP's Prof. Steve Bramwell and collaborators have published a result in Nature Physics that shows that the partial disorder of ions in a particular material is not random but instead obeys a hidden mathematical rule which determines other aspects of the material's behaviour. This rule was exposed by scattering neutrons off the ions. Because different ions scatter neutrons to different degrees and because neutrons are quantum particles that interfere like waves, the neutron scattering pattern reflects how the ions are arranged within the material.

The researchers studied a material consisting of caesium, nickel, chromium and fluoride ions. They found that the nickel and chromium ions are not ordered like a crystal, but instead connect to form closed loops of many different sizes, from the nanometer scale to the millimetre scale. In mathematics the ions are said to have a closed loop topology. It was shown that the closed loop topology of the ions goes on to determine other properties of the material: its magnetism and how all the ions move as the crystal is heated up.

Physicists refer to the closed loop topology as a "Coulomb phase". This is a reference to the fact that when a closed loop is broken, there is a line that simply terminates, just like the way that electric field lines terminate on electric charges. The French scientist Coulomb famously measured the force between electric charges in the 18th Century. Hence the closed loop topology is like a vacuum from which effective Coulomb charges emerge.

Because the Coulomb phase manifests in several different properties, the researchers named their material a "multiple Coulomb phase", which represents a new type of partially-disordered matter.

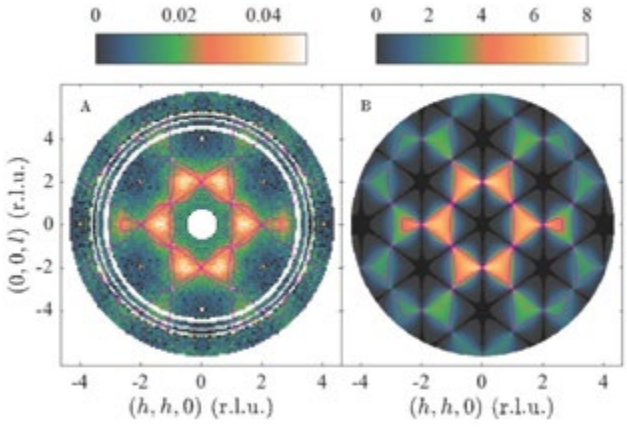


Figure 3: Neutron scattering pattern of the material CsCrNiF6 which contains a "multiple Coulomb phase". Left, experiment and right, theory. Analysis of such patterns showed that atomic positions, atomic movements and magnetic properties are all controlled by the same mathematical rule.

Towards monolayers of spin ice

Any familiar lump of matter – whether a drop of water or a grain of salt – contains a lot of atoms, typically up to a trillion trillion. Even if the atoms are arranged one atom thick on a surface there will typically be a million billion atoms over the whole surface. Although physics comprehends the properties of single atoms, to calculate the properties of so many atoms interacting together is an almost intractable problem – the so called "many-body problem" of physics. Statistical mechanics aims to solve such problems, but even when models of atomic interaction are highly simplified, there are only a few historical examples where such models of many-body behaviour can be solved exactly.

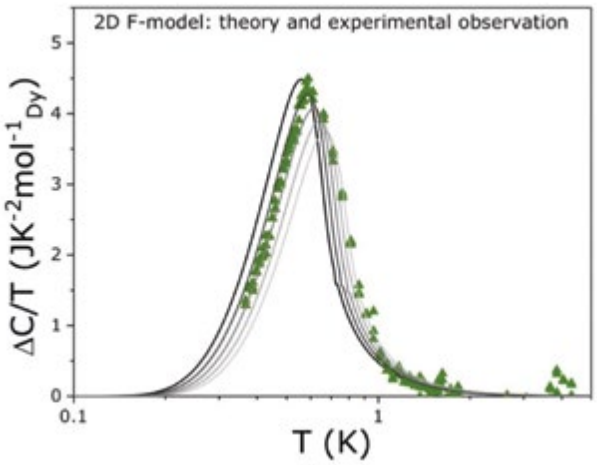


Figure 4: Comparison of exact theory and experiment for a component of the specific heat of spin ice thin films.

One such exact solution was provided in 1965 by the American theoretician Elliott Lieb. He was able to exactly calculate a familiar property -- the specific heat – of a simplified model of atomic interaction. The model (called the F-model) relates to a two-dimensional system held together by so-called "hydrogen bonds" between oxygen and hydrogen and the exact mathematical solution makes a definite prediction of how the specific heat of such a system should vary with temperature.

Dr. Laura Bovo and Prof. Steve Bramwell of the CMMP, along with collaborators, have made thin films of the magnetic material "spin ice" and shown that it is possible to make films that contain only a single atomically-thick layer. In spin ice the atoms are magnetic and these tiny atomic "compass needles" interact to create a many body problem of a million billion interacting parts.

The researchers carefully measured the specific heat of the spin ice thin films and discovered an extremely close match to the predicted exact specific heat of the F-model. The reason is that interactions between the magnetic atoms in spin ice precisely mimics that between oxygen and hydrogen in the F-model. This appears to be the first time that the exact F-model specific heat – a celebrated result in statistical mechanics – has been observed in experiment.

Biological Physics (BioP)

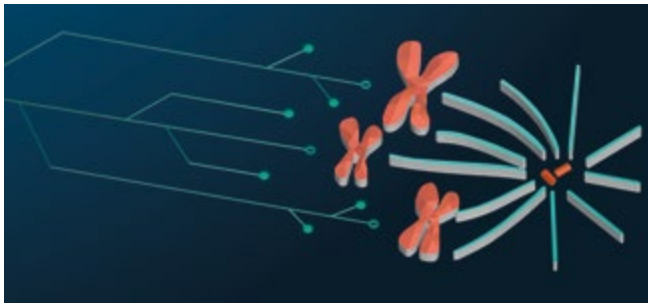
The Biological Physics group focuses on solving key intellectual and practical problems in the physics of biological systems and the underlying properties of soft matter, from molecular to cellular length scales, by using experimental, computational and theoretical methods. It overlaps with the cross-faculty 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. Our group has various links with the Francis Crick Institute. These links have now been further strengthened by the recruitment of Maxim Molodtsov as an early career group leader. Maxim has been appointed in our department January 2019, but for the next years (most of) his research will take place at the Crick, focussing on the topics outlined in the following article.

> "All life on earth depends on the ability of cells to grow and divide. Because each cell carries only one copy of DNA, successful division requires that cells first duplicate their DNA."

Mechanical forces rearrange cell interior

All life on earth depends on the ability of cells to grow and divide. Because each cell carries only one copy of DNA, successful division requires that cells first duplicate their DNA, so two exact copies of the genome exist, and then divide them equally in two new cells. To achieve this, cells need to solve a number of interesting physics problems. An important one is how to mechanically move DNA molecules precisely and accurately into newly formed cells such that each cell inherits the same genome.

Cells use two key strategies to achieve this. First, they build a mitotic spindle – a bipolar structure made of slender fibril polymers called microtubules, which organizes the cell and moves DNA by exerting mechanical forces. Second, cells keep two duplicated DNAs physically connected until they are bi-oriented, i.e., until all DNA molecules are positioned by the spindle such that all copies face opposite sides, where new cells will form. Once bi-orientation is achieved, linkages between sister DNA are cleaved and the DNA molecules are segregated.



Artistic view of chromosomes in a dividing cell and new physical tools to investigate mechanistic basis underlying chromosome movement.

At the molecular level, all rearrangements are driven by combination of motor and non-motor proteins that generate and respond to mechanical forces. The sizes of these molecules are orders of magnitude smaller than the cellular structures that they build, such as mitotic spindle, which have lengths at micrometre scale. It is not well understood how action of multiple molecules is coordinated and integrated at different spatial scales significantly larger than their sizes.

If this cellular organisation is perturbed because of mutations and other factors, this can cause disease and disorders in development. For example, errors in chromosome segregation lead to aneuploidy, which is a hallmark of all solid tumors. It is therefore important to understand the fundamental principles underlying intracellular rearrangements and their physical mechanisms.

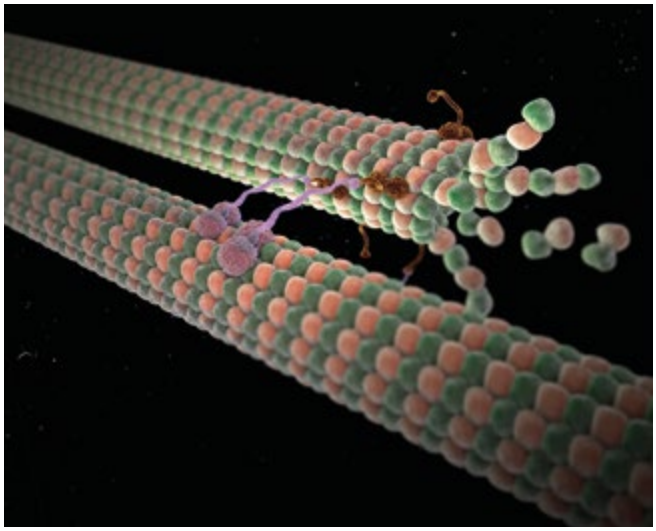
To achieve this goal, we are studying how mechanical forces are being generated, transduced and resisted by the microtubule polymers that form mitotic spindle and by cohesin proteins that form physical linkages between sister DNA molecules.

Force generation and transduction at the tips of microtubule filaments

Microtubules are linear polymers of protein called tubulin. They form the backbone of the cytoskeleton – mechanical scaffold, which gives cells their unique shapes much like the body skeleton provides a scaffold for the human body. Unlike bones, however, microtubules are dynamic – they grow and shrink continuously, which allow the cell to rearrange cytoskeleton dynamically in time and to build the mitotic spindle, which segregates DNA. Microtubules are nucleated at special sites, which grow them autonomously in any direction, and to build the mitotic spindle, it requires microtubules to be rearranged in space.

It has been long known, that isolated growing microtubules – assembled from purified proteins – can exert pushing forces against a barrier. However, it has remained unclear how this mechanism can contribute to microtubule rearrangements. We discovered that in cells there exists an elegant system consisting of just two molecular components that can harness the force generated by the microtubule to redirect the microtubule growth and guide it into formation of parallel bundles. This accounts for the generation of microtubule networks in a broad range of cellular functions such as spindle assembly or cell polarization.

Force transduction at microtubule tips is important for multiple cellular functions including nuclear and spindle positioning as well as cell growth and movement, and we continue to investigate mechanisms how different molecules can use the force that microtubules generate to rearrange the cell interior.



Growth of a microtubule is guided along existing microtubule template by interaction between proteins at its tip. Protein complex consisting of EB1 (orange) and molecular motor kinesin-14 (magenta) harnesses the force generated by the microtubule tip to redirect its growth.

Topological organization of DNA

The physical connection between duplicated DNA molecules in dividing cells is provided by molecules called cohesin. This connection is very important because it resists the forces generated by the microtubule spindle and allows chromosomes to be properly segregated such that genomes are properly inherited.

Recent research showed that cohesin has another very important function. Specifically, it organises the physical 3D structure of DNA in the nuclei of non-dividing cells. DNA is extremely long – the total length of DNA in a human cell measures up to 2 m, which is all wrapped into the micron-sized nucleus. The way DNA is folded affects important cellular functions such as gene expression, recombination and repair, and all depend on cohesin. However, the mechanism by which cohesin folds DNA remains unknown.

In a recent collaboration with Jan-Michael Peters group (IMP, Vienna), we showed for the first time that cohesin uses energy of ATP hydrolysis to perform mechanical work and compact DNA. Using combination of optical tweezers and single-molecule Forster resonance energy transfer, we discovered how cohesin can achieve this. It grabs the DNA at two sites and moves them towards each other by a conformational change that generates force. This buckles the DNA creating a small DNA loop. The process might be the first step in the mechanism used to fold DNA in the nuclei of all living organisms. The implications of this mechanism might involve understanding how human diseases such as cancers are caused by cohesin mutations.

> “Much of our understanding on intracellular and intranuclear organisation derives from experiments with isolated molecular components.”

Outlook

Much of our understanding on intracellular and intranuclear organisation derives from experiments with isolated molecular components. However, to be able to understand and interrogate the mechanisms that drive this organisation in organisms, we need to understand how they work in live cells, i.e., in much more complex environments. This is largely limited by the tools available to manipulate more complex molecular systems. We are therefore working on new techniques and approaches to study more physiologically relevant reconstituted complexes and investigate new approaches for manipulating objects and measuring forces in live cells.

Key References

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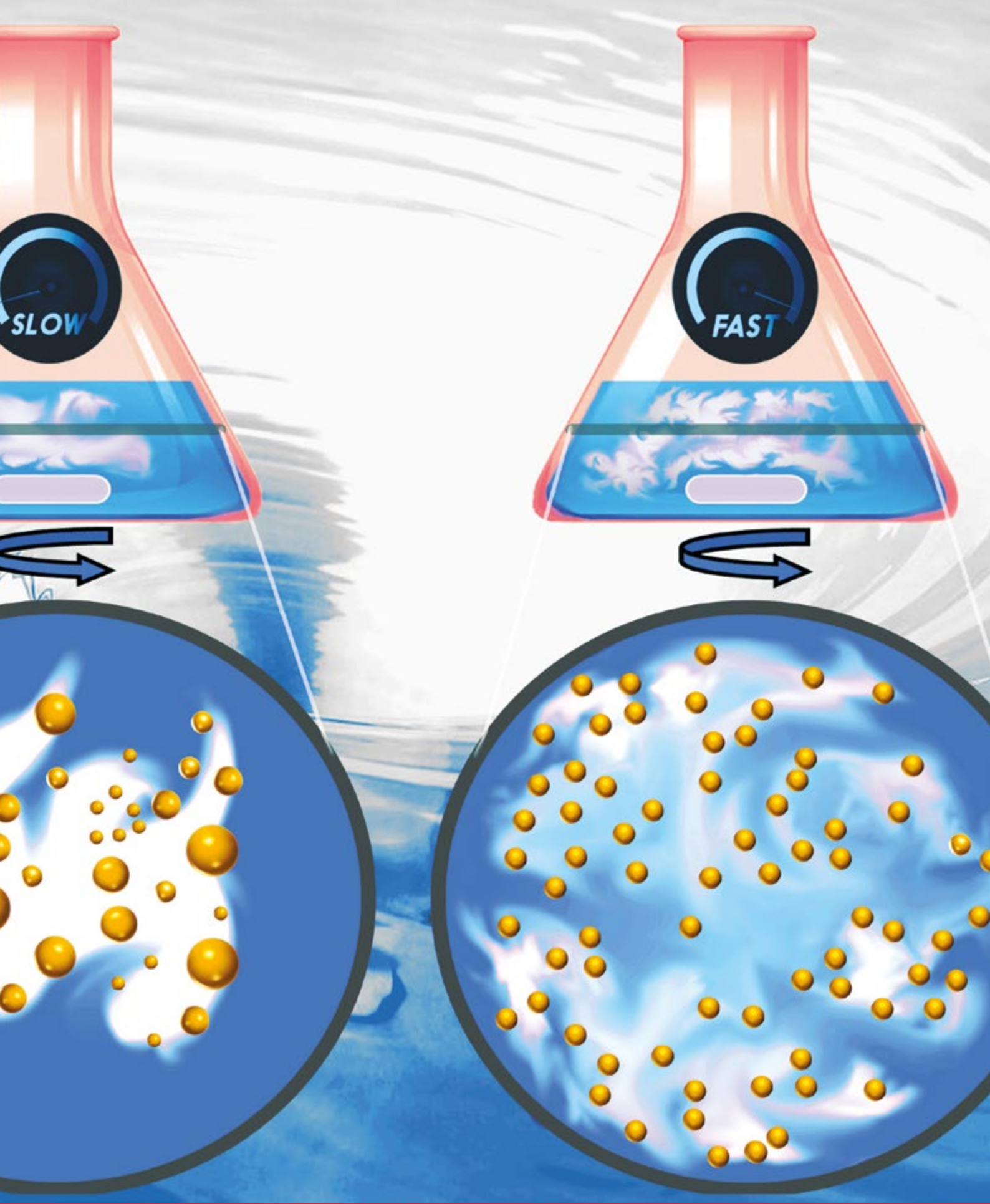
2 Davidson, I. F. *et al*. Rapid movement and transcriptional re-localization of human cohesin on DNA. *EMBO J* **35**, 2671-2685, (2016).

3 Molodtsov, M. I. *et al*. Cohesin is a molecular motor that compacts DNA. *In review*. (2019).

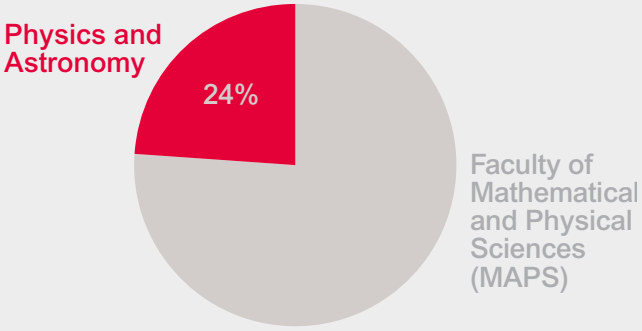


Research Statistics

Research Statistics

Active Grants and Contracts

In the last financial year (Aug 2017 – Jul 2018), the MAPS faculty as a whole yielded £54.3 million, with the Department of Physics and Astronomy contributing £13.1 million (24%) of the total research income for the MAPS faculty.



AMOPP

Quantum Cavity Optomechanics of Levitated Nanoparticles, (EPSRC), PI: Prof Peter Barker, £869,905

High-Power Unique-Stability Laser Source for Quantum Applications, (EPSRC), PI: Prof Peter Barker, £40,926

QUCLN: Quantum Control of Levitated Nanoparticles, (European Commission H2020), PI: Prof Peter Barker, £137,591

EPSRC DTP 2017, (EPSRC), PI: Prof Peter Barker, £94,623

Miniaturisation of an Optical Accelerometer, (EPSRC), PI: Prof Peter Barker, £29,993

Testing The Large-Scale Limit for Future Quantum Technologies, (European Commission H2020), PI: Prof Peter Barker, £415,197

PACOMANEDIA - Partially Coherent Many-Body Non-equilibrium Dynamics for Information Applications, (European Commission FP7), PI: Prof Sougato Bose, £947,605

Nanoelectronic Based Quantum Physics – Technology and Applications, (EPSRC), PI: Prof Sougato Bose, £441,672

SeQucom: Secure Quantum Communication and Computation, (European Commission H2020), PI: Prof Dan Browne, £137,591

Quantum Code Design and Architecture, (EPSRC), PI: Prof Dan Browne, £246,719

Production and Manipulation of Rydberg Positronium for a Matter-Anti Matter Gravitational Free Fall Measurement, (EPSRC), PI: Dr David Cassidy, £693,517

Fellowship: Spectroscopy of Positronium: Atom Control and Gravity Measurements, (European Commission FP7), PI: Dr David Cassidy, £78,900

Control and Spectroscopy of Excited States of Positronium, (EPSRC), PI: Prof David Cassidy, £802,355

Semi Classical Models for Ultra-Fast Multi Electron Phenomena in Intense Electro Magnetic Laser Fields, (EPSRC), PI: Dr Agapi Emmanouilidou, £336,665

Exotic Forms of Matter in Molecules Driven by Free-Electron Lasers, (Leverhulme Trust), PI: Dr Agapi Emmanouilidou, £108,353

Hybrid Cavity-QED with Rydberg Atoms and Microwave Circuits, (EPSRC), PI: Prof Stephen Hogan, £524,578

CATMOLCHIP: Cold Atmospheric Molecules on a Chip, (European Commission H2020), PI: Prof Stephen Hogan, £1,557,183

Interference and Resonant Phenomena Involving Antimatter, (EPSRC), PI: Prof Gaetana Laricchia, £560,729

EPSRC DTP 2016: Doc Prize, (EPSRC), PI: Dr Ying Lia Li, £103,486

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

Scrambling of Quantum Information in Many-Body Systems, (EPSRC), PI: Dr Lluis Masanes, £809,237

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

Fellowship: Quantum Information Science: Tools and Applications for Fundamental Physics, (EPSRC), PI: Prof Jonathan Oppenheim, £984,329

IT from QUBIT: Quantum Fields, Gravity nd Information, (Simons Foundation), PI: Prof Jonathan Oppenheim, £251,429

EPSRC DTP 2017, (EPSRC), PI: Prof Jonathan Oppenheim, £94,623

Studentship: Impact, Janelle Rajroop: Atomic Magnetometers for Medical Applications, (NPL Management Ltd), PI: Prof Ferruccio Renzoni, £32,583

Studentship: Sarah Yasmin Hussain: Research PhD - Application of Quantum Magnetomers to Security and Defence Screening, (Defence Science and Technology Laboratory), PI: Prof Ferruccio Renzoni, £124,662

Studentship: Cylindrical Magnetic Imaging Tomography, (Atomic Weapons Establishment), PI: Prof Ferruccio Renzoni, £61,500

Fellowship: Luca Marmugi: Gammalas Towards Gamma-Ray Lasers via Super-Radiance in a Bose-Einstein Condensate of 135Mcs Isomers, (European Commission H2020), PI: Prof Ferruccio Renzoni, £128,418

Localization of Arrythmogenic Foci with a Radio-Frequency Atomic Magnetometer, (Wellcome Trust), PI: Prof Ferruccio Renzoni, £44,688

EPSRC Industrial Case 2015, (EPSRC), PI: Prof Ferruccio Renzoni, £80,670

Magnetic Induction Imaging with Cold Atoms - MAGICA, (Royal Society), PI: Prof Ferruccio Renzoni, £12,000

Quantum Sensors for Magnetic Induction Tomography of the Heart, (EPSRC), PI: Prof Ferruccio Renzoni, £454,182

Radio-Frequency Atomic Magnetometers for Medical Applications, (EPSRC), PI: Prof Ferruccio Renzoni, £132,898

Electromagnetic Imaging for Aviation Security, (Defence Science and Technology Laboratory), PI: Prof Ferruccio Renzoni, £65,692

Corrosion Under Insulation Imaging with Atomic Magnetometers, (Innovate UK), PI: Prof Ferruccio Renzoni, £25,419

EPSRC NPIF 2017-21, (EPSRC), PI: Prof Ferruccio Renzoni, £101,280

Electromagnetic Induction Imaging with Atomic Magnetometers, (EPSRC), PI: Prof Ferruccio Renzoni, £7,093

Research and Development into Machine Learning Aided Electromagnetic Imaging with Atomic Magnetometers, (Defence Science and Technology Laboratory), PI: Prof Ferruccio Renzoni, £45,437

Electromagnetic Imaging for Aviation Security – Phase 2, (Defence Science and Technology Laboratory), PI: Prof Ferruccio Renzoni, £149,123

Coherent Gamma Rays from BEC of 135Mcs Isomer, (Atomic Weapons Establishment), PI: Prof Ferruccio Renzoni, £29,612

Magnetic Induction Tomography with Optical Sensors, (EPSRC), PI: Prof Ferruccio Renzoni, £55,997

Fellowship: Coherent Quantum Matter out of Equilibrium from Fundamental Physics Towards Applications, (EPSRC), PI: Prof Marzena Szymanska, £1,222,168

The UK Theory of Condensed Matter Summer School, (EPSRC), PI: Marzena Szymanska, £170,029

Correlations and Entanglement with Photons in Cavities, (British Council (Canada)), PI: Prof Marzena Szymanska, £8,500

Polariton Lattices: A Solid-State Platform for Quantum Simulations of Correlated and Topological States, (EPSRC), PI: Prof Marzena Szymanska, £116,174

STFC IND CASE 2013-17, (STFC), PI: Prof Jonathan Tennyson, £82,836

EPSRC DTG (CASE) 2013-17, (EPSRC), PI: Prof Jonathan Tennyson, £64,494

Studentship: James Hamilton: Electronic Impact Vibrational Excitation of Water Molecules, (Quantemol Ltd), PI: Prof Jonathan Tennyson, £12,900

Studentship: Phillip Coles: Modelling of Spectra of Hot Molecules, (Servomex Ltd), PI: Prof Jonathan Tennyson, £18,150

EPSRC DTA 2015-19, (EPSRC), PI: Prof Jonathan Tennyson, £90,319

EPSRC CASE 2015-2019, (EPSRC), PI: Prof Jonathan Tennyson, £85,713

High Accuracy Transition Intensities for Ozone, (NERC), PI: Prof Jonathan Tennyson, £347,048

EPSRC DTP CASE 2016, (EPSRC), PI: Prof Jonathan Tennyson, £68,567

Fellowship: Laura McKemmish 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 H2020), PI: Prof Jonathan Tennyson, £127,046

ECSE08-7: Distributed Hamiltonian Build and Diagonalisation in UKRMOL+, (EPSRC), PI: Prof Jonathan Tennyson, £86,612

Studentship: Daniel Darby: R-Matrix Calculation of Electron Collisional Excitation Rates of Jet and Iter Relevant Molecules, (UK Atomic Energy Authority), PI: Prof Jonathan Tennyson, £23,000

EPSRC DTP Case 2017, (EPSRC), PI: Prof Jonathan Tennyson, £69,960

Science as a Service: Twinkle, (EPSRC), PI: Prof Jonathan Tennyson, £12,380

Integrated Software for Electron-Molecule Collisions, (STFC), PI: Prof Jonathan Tennyson, £322,353

UK Atomic, Molecular and Optical Physics R-Matrix Consortium (UK AMOR), (EPSRC), PI: Prof Jonathan Tennyson, £368,071

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

UCL Astrophysics Consolidated Grant 2018-2021, (STFC), PI: Dr Sergey Yurchenko, £371,077

Astrophysics

Fellowship: Abdalla Design and Exploitation of Current and Future Cosmological Surveys, (Royal Society), PI: Dr Filipe Abdalla, £318,537

Fellowship: Dr Maria Marcha – Daphne Jackson Fellowship, (Daphne Jackson Memorial Fellowships Trust), PI: Dr Filipe Abdalla, £77,401

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, £387,195

SKA Preconstruction Phase Continuation at UCL, (STFC), PI: Dr Filipe Abadalla, £274,814

Europlanet 2020 Research Infrastructure — EPN2020-RI, (European Commission H2020), PI: Prof Nick Achilleos, £247,980

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

Observations of Thermospheric Winds in the Presence of Traveling Ionospheric, (Royal Society), PI: Dr Anasuya Aruliah, £70,240

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

Time-Variability of the Ionospheric Electric Field: Solar Wind Driving and Atmospheric, (NERC), PI: Dr Anasuya Aruliah, £88,611

Auroral Thermosphere Density Study, (Office of Naval Research), PI: Dr Anasuya Aruliah, £64,909

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

Fellowship: Eberhardt: Nature Versus Nurture: The Effect of Stellar Irradiation on Atmospheric Evolution, (Royal Astronomical Society), PI: Dr Jo Barstow Eberhardt, £165,219

Additive Manufacturing of Space-Based Optics, (UK Space Agency), 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

Early Star-Forming Galaxies and Cosmic Reionisation, (European Commission H2020), PI: Prof Richard Ellis, £1,843,804

Archaeology of Exo-Terrestrial Planetary Systems and a Search for Water, (STFC), PI: Dr Jay Farihi, £318,087

UCL Astrophysics Consolidated Grant 2018-2021, (STFC), PI: Dr Jay Farihi, £332,067

Fellowship: Dr Andreu Font-Ribera: Precision Cosmology at High Redshift with the Lyman-Alpha Forest, (STFC), PI: Dr Andreu Font Ribera, £491,529

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

STFC DTG 2012-2017, (STFC), PI: Prof Ian Howarth, £590,561

STFC DTG 2015-2020, (STFC), PI: Prof Ian Howarth, £590,831

A Multi-Probe Strategy to Pin Down the Nature of Gravity and Dark Energy, (STFC), PI: Dr Benjamin Joachimi, £218,171

Fellowship: Benjamin Joachimi: Advancing Weak Lensing and Intrinsic Galaxy Alignment Studies into the Era of Precision Cosmology, (STFC), PI: Dr Benjamin Joachimi, £351,642

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

TESDE: Testing the Dark Energy Paradigm and Measuring Neutrino Mass with the Dark Energy Survey, (European Commission FP7), PI: Prof Ofer Lahav, £1,983,326

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

UCL Astrophysics Consolidated Grant 2018-2021, (STFC), PI: Prof Ofer Lahav, £460,325

Studentship: Palmese: Weighing the Stellar Content of Galaxies as a Tool of Precision Dark Energy Measurements, (Universities Research Association Inc), PI: Prof Ofer Lahav, £9,677

Cosmic Dawn - Understanding the Origins of Cosmic Structure, (European Commission FP7), PI: Prof Hiranya Peiris, £1,183,573

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

Fellowship: Andrew Pontzen: Connecting Physics and Galaxy Formation, (Royal Society), PI: Dr Andrew Pontzen, £454,692

Leadership in Analysis of Massive Cosmological Simulations, (Royal Society), PI: Dr Andrew Pontzen, £9,952

Experimenting with Reality, (Royal Society), PI: Dr Andrew Pontzen, £4,825

UCL Astrophysics Consolidated Grant 2018-2021, (STFC), PI: Dr Andrew Pontzen, £129,713

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

Fellowship: Dr Amelie Saintonge, (Royal Society), PI: Dr Amelie Saintonge, £460,270

Cold Gas and the Chemical Evolution of Galaxies, (Royal Society), PI: Dr Amelie Saintonge, £69,577

Cold Gas as a Probe of Galaxy Evolution: Multi-Phase Outflows at High Resolution, (Royal Society), PI: Dr Amelie Saintonge, £95,992

Critical Technology Advancement of the Locus Mission: Towards Future Space Light, (UK Space Agency), PI: Prof Giorgio Savini, £702,991

EXOLIGHTS - Decoding Lights from Exotic Worlds, (European Commission FP7), PI: Prof Giovanna Tinetti, £1,463,966

Studentship: Damiano: Exoplanet Spectroscopic Observations from Space and Ground-Telescopes and Data Reduction, (Istituto Nazionale Di Astrofiscia), PI: Prof Giovanna Tinetti, £24,358

Studentship: Tiziano Zingales the Science of Ariel, (Istituto Nazionale Di Astrofiscia), PI: Prof Giovanna Tinetti, £24,358

Exoplanet Atmosphere New Emission Transmission Spectra Analysis, (European Commission H2020), PI: Prof Giovanna Tinetti, £181,700

Ariel Space Mission Phase B, (UK Space Agency), PI: Prof Giovanna Tinetti, £214,993

UCL Astrophysics Consolidated Grant 2018-2021, (STFC), PI: Prof Serena Viti, £15,632

The Interstellar Medium and Star Formation in Extreme Galactic Environments, (Royal Society), PI: Prof Serena Viti, £12,000

ExoAI: Deciphering Super-Earths Using Artificial Intelligence, (European Commission H2020), PI: Dr Ingo Waldmann, £1,200,000

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

EPSRC iCASE 2016, (EPSRC), PI: Dr Jeremy Yates, £81,430

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

Studentship: De Ceuster: Accelerated 3D General Purpose Radiative Transfer Codes, (Intel Corporation UK Ltd), PI: Dr Jeremy Yates, £27,144

DiRAC2.5 Operations: The DiRAC Project Office 2017-2020, (STFC), PI: Dr Jeremy Yates, £216,428

DiRAC Benchmarking of Public and Private Cloud Systems, (STFC), PI: Dr Jeremy Yates, £27,000

Computer Vision and Machine Learning for Pattern Recognition in LHC Data, (Lenovo Technology (UTD Kingdom)), PI: Dr Jeremy Yates, £48,500

Biophysics

Some Biophysics grants are held at the London Centre for Nanotechnology and therefore not listed here.

New Approaches to Studying Redox Metabolism Using Time-Resolved NAD(P)H Fluorescence and Anisotropy, (BBSRC), PI: Prof Angus Bain, £296,382

Physics of Bacterial Growth Control and Antibiotic Resistance, (EPSRC), PI: Dr Shiladitya Banerjee, £216,297

Characterisation of Electron Transport in Bacterial Nano-Wire Proteins through High Performance Computing and Experimentation, (EPSRC), PI: Dr Jochen Blumberger, £321,327

Manipulation and Destruction of Cancer Cells Using Cavitation Bubbles Generated by Optical and Acoustic Tweezers, (British Council), PI: Prof Philip Jones, £99,415

New Microscopy Developments Fund 2014: A Fast Fluorescence and Photonic Force Microscope with Nanometre and Femtonewton Resolution, (MRC), PI: Dr Isabel Llorente Garcia, £50,000

EPSRC DTP 2016, (EPSRC), PI: Dr Isabel Llorente Garcia, £72,025

Nanoscale Magnetism in Next Generation Magnetic Nanoparticles, (Air Force Office of Scientific Research), PI: Prof Thanh Nguyen, £156,444

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 Fluorescence Imaging for Non-invasive Detection of In-Vivo Biomaterial, (Royal Society), PI: Prof Thanh Nguyen, £12,000

Engineering Hydrogel Nanoparticles to Enhance Transdermal Local Anesthetic Delivery, (Royal Academy of Engineering), PI: Prof Thanh Nguyen, £24,000

Nanoscale Magnetism of Novel Structures, (Air Force Office of Scientific Research), PI: Prof Thanh Nguyen, £110,345

Amyloid Aggregation: Inhibition of Self-Replication and Membrane-Mediated Control, (Academy of Medical Sciences), PI: Dr Andela Saric, £99,304

Physics of Protein Organisation Beyond the Cell's Edge, (Royal Society), PI: Dr Andela Saric, £526,770

Collagen Assembly: From Molecules to Fibrils, (EPSRC), PI: Dr Andela Saric, £100,772

Rational Design of Cell-Reshaping Elements, (Royal Society), PI: Dr Andela Saric, £88,992

Physical Mechanisms of Membrane Remodelling by Active Elastic Filaments, (Royal Society), PI: Dr Andela Saric, £97,048

CMMP

Studentship: Impact: Exploration of the Performance of a CDFT for the Calculation of Parameters that govern the Thermodynamics and Kinetics of Interfacial ET Reactions, (Pacific Northwest National Laboratory), PI: Dr Jochen Blumberger, £40,961

SOFTCHARGE: Charge Carrier Transport in Soft Matter: From Fundamentals to High-Performance Materials, (European Commission H2020), PI: Dr Jochen Blumberger, £1,492,491

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

Synchronics Supramolecularly Engineered Architectures for Optoelectronics and Photonics: A Multi-Site Initial Training Action, (European Commission H2020), PI: Prof Franco Cacialli, £802,338

Multifunctional Polymer Light-Emitting Diodes with Visible Light Communications (Marvel), (EPSRC), PI: Prof Franco Cacialli, £372,355

Centre for Advanced Materials for Integrated Energy Systems (CAM-IES), (EPSRC), PI: Prof Franco Cacialli, £83,733

TOMCAT: Theory of Mantle, Core and Technological Materials, (European Commission FP7), PI: Prof Ronald Cohen, £826,477

EPSRC DTP 2018-20: Fisher - Quantum Systems Engineering: Applications, Technology and Engineering (inQuBATE), (EPSRC), PI: Prof Andrew Fisher, £103,766

Consequence Analysis Post-Doctoral Research Assistant, (Ministry of Defence), PI: Prof Ian Ford, £227,288

GRAPHENECORE1 - Graphene-Based Disruptive Technologies, (European Commission H2020), PI: Dr Chris Howard, £68,933

Towards the Commercialisation of a Novel Platinum/Graphene Catalyst, (EPSRC), PI: Dr Chris Howard, £29,960

Graphene Flagship Core Project 2, (European Commission), PI: Dr Chris Howard, £15,330

HETEROICE - Towards a Molecular-Level Understanding of Heterogeneous Ice Nucleation, (European Commission FP7), PI: Prof Angelos Michaelides, £1,535,272

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

EPSRC DTP 2017, (EPSRC), PI: Prof Angelos Michaelides, £94,623

EPSRC DTP 2017: Doc Prize, (EPSRC), PI: Dr Cip Pruteanu, £109,169

ENGD: Advanced Gate Stack and Dielectric in Resistive Memory Material, (International Sematech), PI: Prof Alexander Shluger, £48,047

Impact Studentship: Laser-Materials Interactions: Theory and Experiment, (Pacific Northwest National Laboratory), 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

Understanding and Controlling Dynamic Functional Oxides, (Leverhulme Trust), PI: Prof Alexander Shluger, £147,817

Studentship: Jakobsen: Adsorption Self-Assembly, (University of Hamburg), PI: Prof Alexander Shluger, £32,000

Structural Dynamics of Amorphous Functional Oxides, (EPSRC), PI: Prof Alexander Shluger, £338,952

Surface and Interface Toolkit for the Materials Chemistry Community, (EPSRC), PI: Prof Alexander Shluger, £91,390

Defect Functionalized Sustainable Energy Materials: From Design to Devices Application, (EPSRC), PI: Prof Alexander Shluger, £470,811

EPSRC DTP (CASE) 2013-17, (EPSRC), PI: Prof Neal Skipper, £85,857

Studentship: David Ingram: Regeneration of H2 Storage Materials, (Cella Energy Limited), PI: Prof Neal Skipper, £36,000

Uncovering Hidden Phases of Metal-Amine Solutions: Glasses to Superconductors, (Leverhulme Trust), PI: Prof Neal Skipper, £191,579

Studentship: Edoardo Maria Zatterin: Probing the Static and Dynamic Properties of Nanoscale Ferroelectric Domains, (European Synchrotron Radiation Facility), PI: Dr Pavlo Zubko, £45,475

Epitaxial Hyperferroelectrics, (Royal Society), PI: Dr Pavlo Zubko, £15,000

HEP

Unlocking Neutrino Mysteries with the Nova and Dune Experiments, (Royal Society), PI: Dr Christopher Backhouse, £508,256

Maximizing Nova Physics Potential with Test Beam Measurements, (Royal Society), PI: Dr Christopher Backhouse, £99,209

Towards Leptonic CP Violation with Nova and T2K, (Royal Society), PI: Dr Christopher Backhouse, £110,231

EPSRC DTG 2014-18, (EPSRC), PI: Prof Jonathan Butterworth, £398,014

Fellowship: Izakun Jimenez Serra: Massive Star Formation with New Generation Interferometers, (STFC), PI: Prof Jonathan Butterworth, £451,297

STFC DTG 2014-2018, (STFC), PI: Prof Jonathan Butterworth, £309,322

STFC DTG 2014-2018, (STFC), PI: Prof Jonathan Butterworth, £254,023

Fellowship: Rikkert Hendrik Frederix: Event Simulation for the Large Hadron Collider at High Precision, (STFC), PI: Prof Jonathan Butterworth, £428,325

EPSRC DTA 2015-19, (EPSRC), PI: Prof Jonathan Butterworth, £342,928

EPSRC DTP 2016-2020, (EPSRC), PI: Prof Jonathan Butterworth, £191,585

EPSRC DTP 2016, (EPSRC), PI: Prof Jonathan Butterworth, £143,140

MCnetITN3: Innovative Network for Monte Carlo Event Generators for LHC Physics, (European Commission H2020), PI: Prof Jonathan Butterworth, £290,252

STFC DTP 2017-21 HEP, (STFC), PI: Prof Jonathan Butterworth, £251,014

STFC DTP 2017-21 Astronomy, (STFC), PI: Prof Jonathan Butterworth, £201,681

Development of the Dune Neutrino Observatory, (Royal Society), PI: Prof Mario Campanelli, £5,000

South-Eastern Particle Theory Alliance Sussex - RHUL- UCL 2017-2020, UCL Node, (STFC), PI: Dr Frank Deppisch, £119,786

Exotic Contributions to Double Beta Decay, (Royal Society), PI: Dr Frank Deppisch, £12,000

Fellowship: Facini: Searches for Beyond the Standard Model Physics with Hadronic Topologies, (STFC), PI: Dr Gabriel Facini, £489,070

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

STFC DTG 2015-2020, (STFC), PI: Dr Gavin Hesketh, £621,138

Mu3e: A Proposal to Extend the Sensitivity to Charged Lepton Flavour Violation by 4 Orders of Magnitude, (STFC), PI: Dr Gavin Hesketh, £4,536

Extending the Sensitivity to Charged Lepton Flavour Violation by 4 Orders of Magnitude with the Mu3e Experiment, (Royal Society), PI: Dr Gavin Hesketh, £37,698

Fellowship: Anna Holin: Investigating the Neutrino with Minos and Liquid Argon Detector Technology, (Royal Society), PI: Dr Anna Holin, £477,430

Chemical Pathways to Life: Amino Acids and their Precursors in the ISM, (STFC), PI: Dr Izakun Jimenez Serra, £241,742

Impact Studentship Hui Wong: A Calorimeter for Proton Therapy, (NPL Management Ltd), PI: Dr Simon Jolly, £34,107

OMA: Optimization of Medical Accelerators, (European Commission H2020), PI: Dr Simon Jolly, £177,637

Water Equivalent Calorimeter for Quality Assurance in Proton Beam Therapy, (STFC), PI: Dr Simon Jolly, £119,149

Developing Quality Assurance Tools for Proton Beam Therapy, (STFC), PI: Dr Simon Jolly, £304,453

STFC DTG 2012-2017, (STFC), PI: Prof Nikos Konstantinidis, £424,033

ATLAS Upgrade 2012 (Phase 1), (STFC), PI: Prof Nikos Konstantinidis, £245,246

ATLAS Upgrade R&D 2016, (STFC), PI: Prof Nikos Konstantinidis, £164,003

STFC iCASE 2017-2023, (STFC), PI: Prof Nikos Konstantinidis, £2,261,707

ATLAS Phase-2 Upgrades – Construction Project, (STFC), PI: Prof Nikos Konstantinidis, £970,302

Fellowship: Korn Andreas Heavy Quarks a Window into New Physics at ATLAS, (STFC), PI: Dr Andreas Korn, £363,285

MUSE: Muon Campus in US and Europe Contribution, (European Commission 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

Probing The Ultra-High Energy Universe with Anita and Ara, (Leverhulme Trust), PI: Prof Ryan Nichol, £220,205

LNBE and the Fermilab Liquid Argon Detector Programme, (STFC), PI: Prof Ryan Nichol, £4,058

UCL Experimental Particle Physics Consolidated Grant (2015-2019), (STFC), PI: Prof Ryan Nichol, £4,427,251

UCL Experimental Particle Physics Consolidated Grant (2015-2019), (STFC), PI: Prof Ryan Nichol, £267,349

UCL Experimental Particle Physics Consolidated Grant (2015-2019), (STFC), PI: Prof Ryan Nichol, £168,981

DUNE: Pre-Construction Phase, (STFC), PI: Prof Ryan Nichol, £85,677

Fellowship: Emily Nurse - Search for a Vector Boson Fusion Produced Higgs Boson at ATLAS, (Royal Society), PI: Dr Emily Nurse, £406,633

Fellowship: Emily Nurse Higgs Studies and a Search for Dark Matter at the ATLAS Experiment, (Royal Society), PI: 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

Searching for Dark Matter at the LHC, (Royal Society), PI: Dr Emily Nurse, £84,444

Fellowship: Tim Scanlon Determining the True Nature of the Higgs-Like Particle, (Royal Society), PI: Dr Tim Scanlon, £483,706

Determining True Nature of 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, £383,431

CHROMIUM, (European Commission H2020), PI: Prof Jennifer Thomas, £2,146,848

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

Particle Phenomenology, QCD and the Standard Model, (STFC), PI: Prof Robert Thorne, £435,388

Supernemo Commissioning and Sensitivity Demonstration, (STFC), PI: Prof David Waters, £420,768

AIDA 2020 Advanced European Structure for Detectors and Accelerators, (European Commission H2020), PI: Prof Matthew Wing, £290,848

AWAKE: A Proton-Driven Plasma Wakefield Acceleration Experiment at CERN, (STFC), PI: Prof Matthew Wing, £179,279

Search for Dark Protons and Investigation of QCD Using Novel Accelerator Scheme, (Leverhulme Trust), PI: Prof Matthew Wing, £318,272

AWAKE: A Proton-Driven Plasma Wakefield Acceleration Experiment at CERN, (STFC), PI: Prof Matthew Wing, £378,915

Staff Snapshot

Head of Department
Professor R. K. Prinja

Deputy Head of Department
Professor F. Renzoni

Astrophysics
Head of Group: Professor S. Viti

Professors:
G. Savini, 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

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

Atomic, Molecular, Optical and Positron Physics
Head of Group: Professor P. Barker

Professors:
A. Bain, P. Barker, S. Bose, D. Browne, D. Cassidy, C. Figueira de Morisson Faria, S. Hogan, G. Laricchia, T. Monteiro, A. Olaya-Castro, J. Oppenheim, F. Renzoni, A. Serafini, M. Szymanska, J. Tennyson

Reader and Senior Lecturers :
A. Emmanouilidou, S. Yurchenko

Lecturer:
I. Llorente Garcia

Research Fellowships:
N. Breuckmann, J. Lang, Y.L. Li, L. Masanes, A. Pontin

Research Associates/Fellows:
A. Alonso, T. Babij, H. Banks, A. Bayat, T. Blacker, S. Brawley, S. Burton, J. Camps, G. Dagvadorj, Gentil Dias de Moraes Neto, C. Deans, O. Duarte, A. Loreti, B. Mant, L. Marmugi, A. Rahman, R. Sarkar, E. Spinlove, D. Toniolo, M. Toros, C. Zagoya Montiel, A. Zamora, P. Zucconi Galli Fonseca

Support Staff:
K. Bouzgan/J. Levin, B. Buck, F. Garza, F. R. Jawad, S. Khan

Biological Physics
Heads of Group: Professor B. Hoogenboom

Professors:
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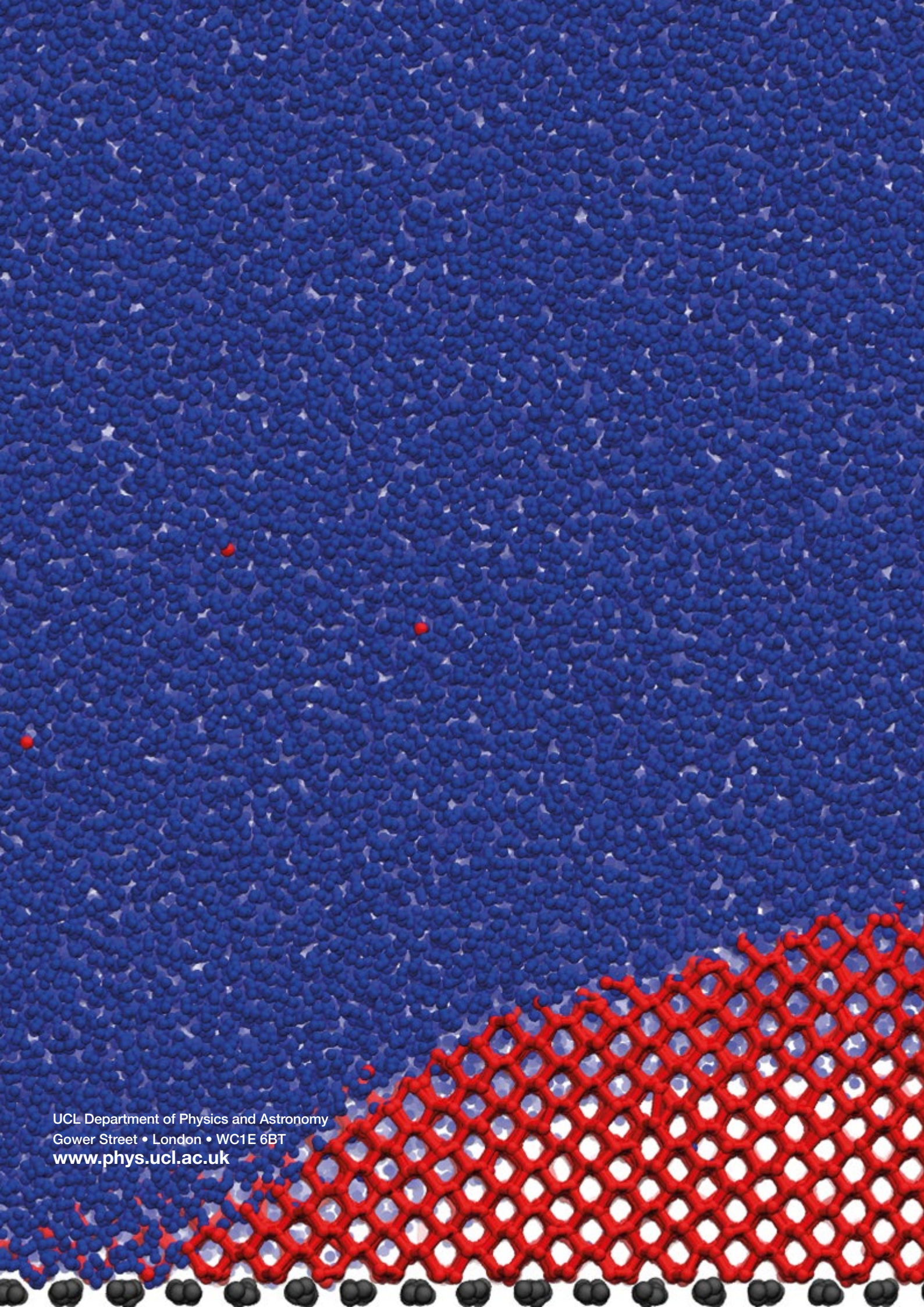

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