



UCL

A low-angle, upward-looking photograph of a large, white, spherical structure, likely a particle detector or a large-scale experiment. The structure is composed of many white, bowl-shaped components arranged in a grid-like pattern. Each bowl contains a yellow liquid. The structure is supported by a network of white cables and a central vertical column. The background is a bright, overcast sky.

**ANNUAL
REVIEW
2022**

Cover image:

The completed LUX-ZEPLIN Time Projection Chamber installed underground and surrounded by the veto photomultipliers (yellow glass bulbs) making up the outer detector.

Credit: LZ experiment and the Sanford Underground Research Facility

Image Page 5:

The fully assembled corrector and a picture looking through the lenses.

Credit: Mark Cunningham

Image Page 38:

The 'Great Carina Nebula', NGC 3372, lies in the southern Milky Way. This false-colour image shows the more highly ionized gas in blue; at top right is η Carinae, one of the most luminous stars in the Galaxy.

Credit: Ian Howarth/Telescope Live

Image Page 53:

Magnetic Particle Imaging: Tracer Development and The Biomedical Applications of a Radiation-Free, Sensitive and Quantitative Imaging Modality. *Nanoscale*, 10: 3647-3974.

Credit: Harvell-Smith, S., Tung, L. D., Thanh, N. T. K. (2022)

Image Page 56:

This complex region of gas and dust, catalogued as LHA120-N11, lies in the Large Magellanic Cloud, a satellite galaxy of our own Milky Way. The central cavity, swept clean by the combined outflows of a cluster of massive stars, measures some 200 light-years across.

Credit: Ian Howarth/Telescope Live

Image Page 61:

The completed LUX-ZEPLIN Time Projection Chamber being installed underground.

Credit: the LZ experiment and the Sanford Underground Research Facility.

Image Page 67:

Micrograph of the solar cell device, created from an inverted perovskite solar cell device stack (left) with phosphorene nanoribbons (PNR) sandwiched between poly(triarylamine) (PTAA) and the perovskite (BC, bathocuproine; fullerene derivative, PCBM and indium tin oxide, ITO).

Credit: Thomas J Macdonald, Thomas Webb

Image Page 72:

NGC 6888, dubbed the 'Crescent Nebula' (so-called because only the brightest, crescent-shaped region is visible in small telescopes), showing emission from ions of hydrogen and oxygen (in red and blue, respectively). At its heart lies a hot Wolf-Rayet star, but the nebula probably consists largely of material that was ejected during an earlier, red-supergiant evolutionary stage.

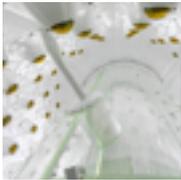
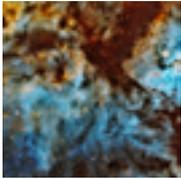
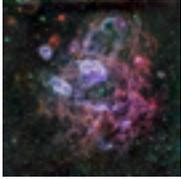
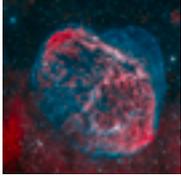
Credit: Ian Howarth/Telescope Live

Back page image:

The ionized region NGC 6357 hosts the star cluster Pismis 24, a collection of hot, bright stars that, although largely hidden behind gas and dust in this image, is responsible for much of the structure and colour in the nebula.

Credit: Ian Howarth/Telescope Live

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Welcome

A very warm welcome to our 2021/22 departmental annual review. For so many of us an undoubted highlight of the academic year has been the return to a buzzing UCL campus. With caution against the backdrop of omicron covid infections, we have welcomed a return to in-person teaching and traditional events such as the annual sessional prize evening, seminars, and social gatherings (a.k.a. parties). It was also wonderful to see the physical return this year of the Physics and Astronomy Festival (PandA day) in Logan Hall (IOE), showcasing an impressive breadth of student and staff talent that spanned sketches, music performances, parodies, and so much more.

In May 2022 the REF (Research Excellence Framework) 2021 results were announced. This is the regular national assessment exercise for both the quality of UK university research and its wider impact, and I'm pleased to say the headline is that UCL has done extremely well. REF results are important as they are used in defining the "QR funding" that universities receive from the government. Our Unit of Assessment 9 (Physics) outcome was a joint one for the Physics and Astronomy Department, Space and Climate Physics (MSSL) and London Centre for Nanotechnology (LCN). The score is based on a set of 'outputs' (largely journal publications that together contribute 60%), a set of case studies on the wider impact of the research (25%) and a written statement describing the research environment for the discipline at the institution (15%). For each of these factors (outputs, impact, environment) a 'quality profile' is produced giving the percentage of the activity assessed to be at different levels, ranging from 4* (world-leading) to 1* (nationally recognised). An overall 'quality profile' is then computed from a weighted average of the quality profiles for the individual factors.

The UCL Physics submission had the fifth highest 'Research Power' of all Physics submissions nationally (which broadly speaking measures the quantity of internationally excellent research being undertaken). Though REF rules have changed since 2014, the 2021 results have confirmed the broad excellence of our Unit at UCL. We have an excellent overall ranking in outputs with a combined 4*/3* of 96.4% that places us 6th at UCL. Our department has 5th highest overall score volume of 4*research. In the sector comparison, in terms of 4* percentage we are Q4 (top quartile) for environment. The REF2021 outcomes also give us important steers to plan how we can support further the development of very strong impact cases for the next REF. Overall, UCL had the second



Credit: Andreas Salina

highest 'Research Power' nationally behind the University of Oxford.

It was also very pleasing to note our strong National Student Survey (NSS) 2022 overall satisfaction score of 77.1 % (up from 73.4 last year), along with a sharp rise in the learning resources ratings. There are some very positive comments too – especially for the tutors and lab technicians, and it's good to see that despite the challenges of the last few years we're doing really well on the "Learning Community" questions. There are also some well-thought out comments about remote teaching which will be useful feedback in planning what we do next. The graduating students filing this NSS were heavily impacted by the pandemic and switches to online learning. A huge thanks to all our staff for their sustained hard work and expertise in educating and inspiring our students. And good luck to the graduands this year for their new exciting adventures ahead.

This year we have also seen the publication of a series of discussion papers that set out a UCL strategic plan for the next 5 years.

We have set out the department's visions and aspirations as inputs to a UCL-wide process that's founded on seven university consultation papers, including for example; Education priorities and programmes, Cross-disciplinary Grand Challenges, Opportunities for targeted investment, Enablers of our academic priorities and UCL Size and Shape.

Finally, to some extent it seems that 'challenging times' is a term we are having accept as a new norm. Following on from the pandemic, still raging war in Ukraine, an unprecedented 40°C UK heatwave, we now also face a year or more of high inflationary costs. With an internationally excellent research base, vibrant undergraduate and masters teaching programme, highly talented PhD student community, deeply valued EDI priorities, outstanding professional services staff and skilled technical staff, we remain in a strong vessel to ride out the next storm.

Professor Raman Prinja
Head of Department



Community Focus

Teaching Lowdown

It has been another incredibly challenging year for teaching and learning in the department as we navigated the next stages of the pandemic with all the surprises it could throw at us. As UCL attempted to return staff and students to campus, albeit in a limited way, we were faced with another new operating model focussing on “blended learning”, combining both face to face teaching with the online learning approach we’d first implemented at the start of the pandemic. With face-to-face teaching events largely restricted to groups of 35 students or less, many of our lectures had to take place, once again, over Zoom. It’s to the credit of our excellent academic and professional services staff that we were able to pull this off and end up with an overall very successful year.

Now, as we are preparing for the 2022/23 academic year, we are also re-shifting the balance back to on-campus, face-to-face teaching. While this is extremely welcome, we are also hoping to make good use of the new resources that were developed during the pandemic and ensure that the successes of our pandemic-era teaching are both celebrated and endure.

Teaching and Learning Highlights

MAPS Faculty 2021 Postgraduate Prize

Postgraduate Taught Prize

The 2021 Postgraduate Taught Prize was jointly awarded to Paul Anil Shah for his impressive work in his MSc Astrophysics during the last academic session. Search the ‘MAPS Faculty 2021 Postgraduate Prize Winners Announced’ webpage for the full article.

Kathleen Lonsdale Medal

Lorenzo Pica Ciamarra was nominated for the Kathleen Lonsdale Medal.

The Dean’s List Commendees

The Dean’s List, created in 1995, commends outstanding academic performance by graduating students, equivalent to the top 5% of student achievement. It is currently awarded to around 40-50 graduates per year (growing every year as student numbers increase).

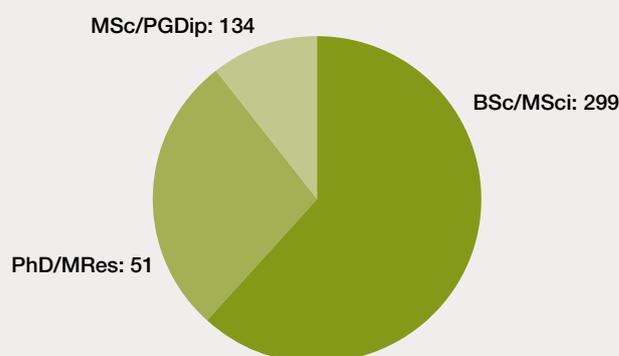
Among the teaching and learning highlights this year, ten undergraduate students from the Department were placed on the Dean’s list:

Hamza Afzal
Omar Choudhry
Leonardo Corsaro
Zory Davoyan
Samuel Fedida
Zac Hale
Augustus Le Roux
Elene Lominadze
Zheng Miao
Dávid Puskás

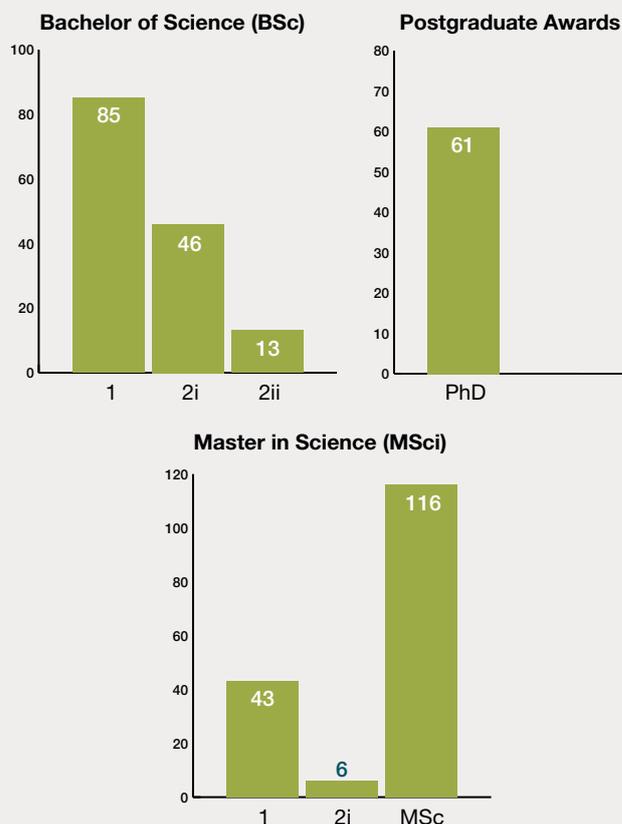
Dr Louise Dash

Director of Teaching

Intake



Awards



Student Accolades

UNDERGRADUATE PRIZES 2020/21

Oliver Lodge Prize

Best performance 1st year Physics

Pavel Viegas

Halley Prize

Best performance 1st year Astrophysics

Hypatia Tam

C.A.R. Tayler Prize

Best performance in Communication Skills,
1st/2nd year

James Henderson

Wood Prize

Best performance 2nd year Physics

Osama Alsaiari

Huggins Prize

Best performance 2nd year Astrophysics

Lorenzo Pica Ciamarra

David Ponter Prize

Most improved performance in department,
1st to 2nd year

Not awarded

Dr Sydney Corrigan Prize

Best performance in experimental 2nd year work

Surabhi Luthra

Best Performance 3rd Year Physics Prize

Zhu Sun

Best Performance 3rd Year Astrophysics Prize

Hamza Afzal

Sessional Prize for Merit

Best 4th year project achieving balance between
theoretical and practical physics

Frederick Eyles

Burhop Prize

Best performance 4th year Physics

Dominik Kufel

Herschel Prize

Best performance 4th year Astrophysics

James Marsden

Brian Duff Memorial Prize

Best 4th year project

Dominik Kufel

William Bragg Prize

Best overall undergraduate

Zhu Sun

Tessella Prize for Software (Tessella is now part of Capgemini Engineering and their team is changing its name to Hybrid Intelligence.)

Best use of software in a final year (Astro) physics project

Ryan Brady



Surabhi Luthra



Dominik Kufel



Frederick Eyles



Osama Alsaiari



James Marden



Hypatia Tam



Pavel Viegas



Hamza Afzal



Lorenzo Pica Ciamarra update with UG Prize winners



L to R: Alex Ferraro (Tessella), Ryan Brady and Raman Prinja. Tessella Prize for Software (Tessella is now part of Capgemini Engineering, and their team is changing its name to Hybrid Intelligence).

POSTGRADUATE PRIZES

Harrie Massey Prize

Best Astrophysics and Planetary Science MSc Student

Paul Shah

Harrie Massey Prize

Best Physics and Quantum Technologies MSc Student

Shushen Qin

MSc in Scientific and Data Intensive Computing Prize

Best SDCI MSc Student (Jointly awarded)

Jackson Barr and Hankang Gu

Spreadbury Prize

Outstanding postgraduate research in High Energy Physics

James Chappell

High Energy Physics Prize

Outstanding postgraduate physics research in High Energy Physics

Patrick Bolton

Biological Physics Prize

Outstanding postgraduate physics research in Biological Physics

Katharine Hammond

Marshall Stoneham Prize

Outstanding postgraduate physics research in Condensed Matter and Materials Physics (Jointly awarded)

Samuele Giannini

Marshall Stoneham Prize and Carey Foster Prize

Outstanding postgraduate physics research in Condensed Matter and Materials Physics (Jointly awarded) and Outstanding postgraduate physics research in Atomic, Molecular, Optical and Positron Physics (Jointly awarded)

Paul Brookes

Carey Foster Prize

Outstanding postgraduate physics research in Atomic, Molecular, Optical and Positron Physics (Jointly awarded)

Lokesh Gurung

Christopher Skinner Prize (Astro)

Outstanding postgraduate physics research in Astrophysics

Andrew Swan

Jon Darius Memorial Prize

Outstanding postgraduate physics research in Astrophysics

Quentin Changeat



Samuele Giannini



Paul Brookes



Quentin Changeat



Andrew Swan



Jackson Barr



Paul Shah



James Chappell



Lokesh Gurung

Alumni Matters

The Physics and Astronomy Prize Giving Ceremony 2021-22 was held in the Jeremy Bentham Room on 25 March 2022. The Annual Physics and Astronomy Lecture and the Annual Gala Dinner had not been able to go ahead as planned this year due to the Covid-19 pandemic.

Professor Raman Prinja, Head of Department, opened the award ceremony and welcomed all the staff, students and guests at the event, including UCL's President and Provost, Dr Michael Spence and Vice-President (Operations) Fiona Ryland.

We are incredibly proud of our remarkable community of over 7000 alumni, living in over 60 countries worldwide and always enjoy hearing from you. Please do reach out to share your news and connect with us at UCL.

As UCL alumni, you are a crucial part of UCL's vibrant global network and there is a huge range of useful services and exclusive benefits available to you. Please visit the UCL Alumni website to view services available to you, lifelong learning opportunities and opportunities to volunteer and support UCL students: www.ucl.ac.uk/alumni



Michael Spence



Clubs and networks

To help you stay connected with your UCL peers, our volunteers run a range of alumni clubs and community networks especially designed for UCL alumni.

Reconnect digitally by joining the UCL official alumni group on LinkedIn.

Alumni professional development series

Heidi Allen (BSc Astrophysics, 1996), Chair of CHS Group, Strategic Adviser to the RSPCA, Feeding Britain Trustee and Hughes Hall By-Fellow. Heidi was the MP for South Cambridgeshire from 2015 until 2019.

Heidi Allen spoke at UCL Connect Event 'How to Change Careers'

Search the 'UCL Connect: How to...change careers' webpage to read the full article and the YouTube channel to watch the video recording.

Bonita Carboo
Alumni Coordinator

The Gordon J Lush Laboratory

Gordon Lush, a longstanding member of the Department of Physics and Astronomy sadly passed away in 2018. Gordon had a passion for building apparatus. During his long career, he oversaw the first-year laboratory and was then director of the final year labs until his retirement. Gordon generously left a sizable legacy donation to the department, and it was decided to use this donation to upgrade one of the teaching labs, reflecting his passion for practical physics.



The third-year laser lab (C12) was selected as it has been neglected for several years prior and was in desperate need of modernising. The money enabled us to upgrade C12 into a state-of-the-art laser lab paying particular attention to laser safety as this was always a barrier to the participation of undergraduate students in laser experiments.

Upgrades included a complete redecoration, electrical work, a laser safety curtain system around the optical bench as well as a brand-new quantum cryptography experiment (BB84). A further two experiments, another BB84 and a nitrogen vacancy (NV-)in diamond experiment were acquired in collaboration with The London Centre for Nanotechnology (LCN) Centres for Doctoral Training (CDT) programme. Each one of these advanced physics experiments cost more than twice our annual teaching lab budget and so the donation was greatly appreciated.

These upgrades, along with a teaching smart board has enabled us to triple the teaching capacity of the room from two students to six, the maximum capacity of the room. The generosity of Gordon Lush and his family has therefore enabled the department to provide higher quality practical teaching to more students. As a show of gratitude for this generous donation, the lab will be renamed The Gordon J Lush Laboratory.

Kelvin Vine,
Experimental Development Officer,
Undergraduate Physics Labs at
Gower Street

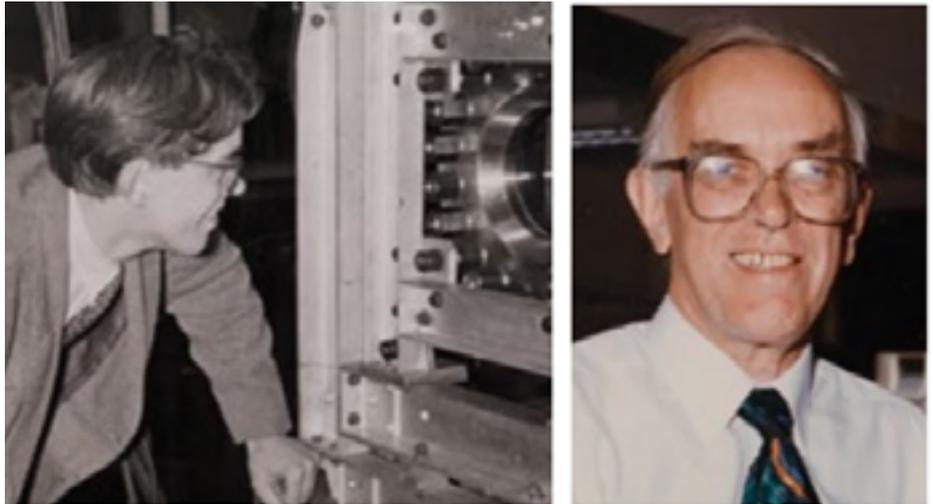


Figure 1: Dr. Gordon Lush

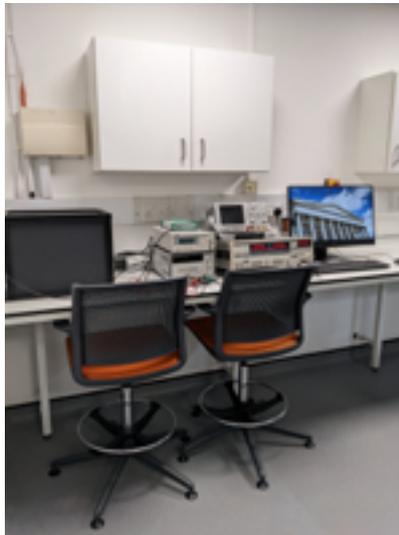


Figure 2: Nitrogen Vacancy Experiment

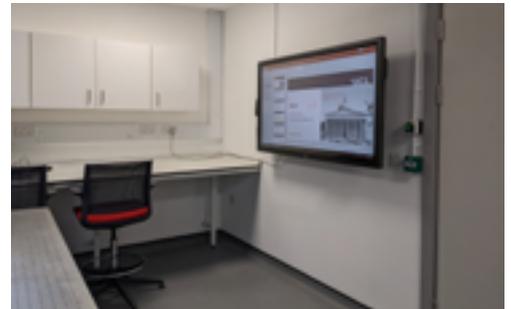


Figure 3: Teaching Smartboard



Figure 4: BB84 Experiment

Equality, Diversity and Inclusion

Equity, Diversity and Inclusion in academia: walk the walk

I am convinced that academia not only can but must do better. In line with this understanding, I approached my period as Vice-Dean (EDI) in the Faculty of Mathematical and Physical Sciences (MAPS) at UCL with one main goal in mind: helping to accelerate the much-needed cultural change that universities and academia need.

One of the books that provided an important background to the way I navigated my role as MAPS vice-Dean EDI was “An inclusive academy: Achieving Diversity and Excellence.”¹ There, Stewart and Valian argue convincingly a link between a representative and better academy and a change towards more diverse student and staff populations in environments that ensure fairness and inclusiveness. As they rightly write, for this to happen it is not enough to talk about change, to think about change, or to plan for change. We must change.

Here, I would like to highlight some key points that I think we in Physics and Astronomy must address to accelerate a change towards a modern department where our commitment to best practice in teaching and research is fully matched with a commitment to sustain safe, nurturing, inclusive and overall equitable study, work and research environments.

Understand and address the diversity-innovation paradox in science. A 2021 study² considered over a million of PhD dissertations in the USA to analyse the rate at which different demographic groups of PhD students present scientific concepts in novel ways, the extent to which such novel contributions are adopted by colleagues, and the subsequent impact in their scientific careers. The study revealed a stratified system where underrepresented groups –particularly women and non-white scholars– innovate at higher rates than majority students, but their contributions are overlooked and less likely to result in academic positions. This is devastating news for both science and society and points once again towards the need of establishing and following processes that effectively reduce well-known biases in the academic ecosystem, from biases in recruiting procedures, research assessments, publication practices to everyday interactions with students and colleagues.

Reject performative EDI. Support and reward effective EDI practice. There is nothing more damaging to an agenda to create cultural change in academia than what is seen as “performative EDI,” that is, having individuals or institutions superficially advocating for change but not following through meaningful and accountable actions to transform power imbalances and privileges.

Well-written anti-racist statements or having individuals publicly voicing support for gender equity in science can show best intentions but do not suffice. Resources and well-thought strategies to establish and reward genuine and evidence-based efforts to consolidate inclusive and safe environments must be put in place together with reliable and unbiased assessments of the impacts of such initiatives.

In short, when it comes to embedding effective EDI in universities the most important action right now is to walk the walk and be accountable, rather than just talk the talk.

Everyone plays a role in ensuring the department is a safe environment. We must strive to be a department in which everyone feels always respected and valued –let’s be honest, that is not always the case.

A culture of inclusiveness goes hand in hand with a culture where we agree to do, individually and collectively, everything necessary to prevent and challenge unacceptable behaviours such as bullying, abuse of power, harassment, racism, sexual misconduct, among others. The impact of such behaviours can be profoundly detrimental to the well-being and careers of those directly exposed to these experiences besides brewing a toxic environment that affects us all.

Expectations of behaviours for staff and students must be set clearly and upfront. In line with this, we shall engage in a reflection on the impact of our own current behaviours on the relationships with colleagues and students. We must then learn to be active bystanders. We each must be the change we want to see.

Professor Alexandra Olaya-Castro

on behalf of the Physics and Astronomy EDI committee

¹Stewart Abigail J., and Valian, Virginia, 2018, An Inclusive Academy. Achieving Diversity and Excellence. The MIT Press, Cambridge Massachusetts, London England.

²Hofstra, Bas et al., The Diversity–Innovation Paradox in Science, Proceedings of the National Academy of Sciences, 117 (17) 9284–9291 (2020).

Students in Action

Women in Physics

The UCL Women in Physics Group is Hosting:
Julie Jebsen, Researcher on gender inequality in STEM

Women's Career Progression in STEM

6th April 2022 @ 6pm - Zoom Event

For Zoom details DM the @uclphysics Instagram
or
Email Fern Pannell: fern.pannell@ucl.ac.uk



Robyn Steward
Autism Awareness Workshop

14th October 2021 @ 4:30pm
Zoom Event

Message @AbbieBrayPhys for Zoom Credentials!



LONDON'S GLOBAL UNIVERSITY

The Women in Physics Group is hosting:

Dr Will Dunn
ORBYTS – UCL-led Physics
Research-with-Schools Projects

29th July 2021 @ 5pm on Zoom



Dr. Jost Migenda

Creating a Trans-Inclusive
Publishing Ecosystem

28th October 2021 @ 5pm
Zoom Event



The UCL Women in Physics group (WiP) has been championing and celebrating women and their achievements through a variety of events. This year, alongside the evening talks, we have increased the number of training events provided, with a recent focus on autism awareness and support.

For the last two years, WiP has been coordinated by AMOPP PhD student Abbie Bray. The group has undoubtedly gone from strength to strength under her leadership, and we congratulate Abbie on securing the position of Associate Lecturer with the London Centre for Nanotechnology. As Abbie wraps up her PhD and moves to this full-time position, the WiP Coordinator baton has been passed to HEP PhD student Fern Pannell.

Over the last year we have hosted a variety of talks and training, including:

- **Dr Mary Huff** (Dragonfly Mental Health Ambassador) with “*Dragonfly Mental Health Literacy – A Scientist’s Primer on Mental Health*”
- **Dr Will Dunn** (UCL Astrophysics Research Fellow and ORBYTS Coordinator) with “*ORBYTS – UCL-led Physics Research-with-Schools Projects*”
- **Robyn Steward** (Autism Specialist and Author) with “*Autism Awareness Workshop*”
- **Dr Jost Migenda** (KCL Experimental Particle and Astroparticle Physics Research Associate) with “*Creating a Trans-Inclusive Publishing Ecosystem*”
- **Freya Elise and Dr Mel Romualdez** (Centre for Research in Autism and Education) with “*Supporting Autistic Students and Staff in Academic Environments*”
- **Julie Jebsen** (University of Manchester, Lecturer in Organisational Psychology) with “*Women’s Career Progression in STEM*”

Research Headline

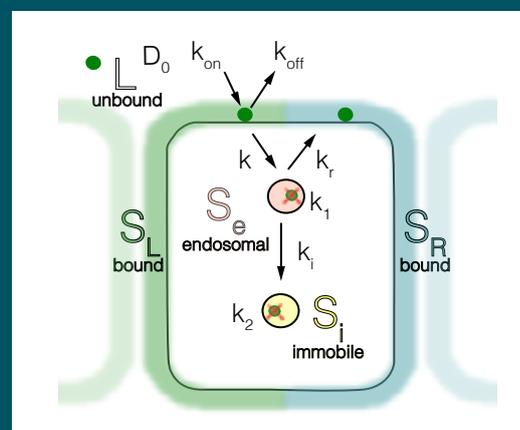
Fruit fly wing patterns: A case for physics

The origins of patterns and shapes are recurrent themes in biological physics. How can a group of cells grow into a larger, multicellular functional tissue, such as a wing? And how is that defined from over length scales of a few micrometres (a cell) to millimetres or larger (tissues). Focussing on this problem for the development of a wing in *Drosophila melanogaster* (fruit fly), Dr Zena Hadjivasiliou modelled how pattern-generating molecules diffuse through a developing wing, including binding and uptake in the cells that build the wing. These molecules – called morphogens – develop concentration gradients in the wing, which in turn result in the emergence of patterns when cells activate target genes as a function of the local morphogen concentration they sense.

By studying the various processes that dictate how morphogen gradients emerge, using both experiment and theoretical modelling, Dr Hadjivasiliou and her colleagues developed a quantitative description of how morphogens move through a wing. Her model facilitated the discovery that cellular uptake, storage and next release of these morphogens were crucial to form and maintain morphogen gradients over larger length scale, and thereby to the development of wing vein patterning.

Dr Hadjivasiliou started her appointment as research fellow and group leader at UCL Physics and Astronomy and the Francis Crick Institute in September 2022.

Romanova-Michaelides*, M., Hadjivasiliou*, Z., Aguilar-Hidalgo, D. et al. Morphogen gradient scaling by recycling of intracellular Dpp. *Nature* 602, 287–293 (2022). <https://doi.org/10.1038/s41586-021-04346-w>



Model of diffusion, binding and cellular uptake of molecules that define the shape of a wing in fruit flies.

- WiP and Institute of Physics (IOP) Careers Panel: Women in Academia with **Dr Anasuya Aruliah**, **Dr Cornelia Hofmann**, **Fern Pannell** and **Louise McCaul**. Hosted by IOP Ambassador **Maya Maciurzynska**.

Taking on recent feedback from our audience, we are hoping to move some of our Thursday evening talks to lunch times to ensure those with caring responsibilities have more opportunities to engage with our events synchronously.

This year, MAPS opened their first ever EDI Funding Call “Take bold action for inclusion”, with the aim of supporting EDI initiatives within the faculty. WiP proposed the project “Enhancing the UCL Physics and Astronomy Women in Physics Group Online Accessibility”. As we recover from the pandemic and the department experiences a rise in the demand for in-person events, the silver lining of the pandemic becomes apparent – the accessibility of online events. The proposed project requested funding for our own AV equipment to ensure we create (for lack of a better term) “hybrid” events going forward. We are delighted to share that not only were we successful in our application for funding, but our proposal meant the next funding call was open to all PhD students – where the department saw other physics PhD students receive awards.

With the recent nonsense in the media stating that girls avoid physics because they don’t like “hard maths”, it’s clear we still have a lot to do. As I begin my role as the WiP group coordinator, I will be exploring the ways in which we can increase our current involvement with undergraduates. Having come through UCL as an undergraduate myself, I know first-hand how invaluable support networks can be.



Stay well, adore maths,
Fern Pannell

If you have any suggestions for what WiP can do to best help you, then please give me a shout.

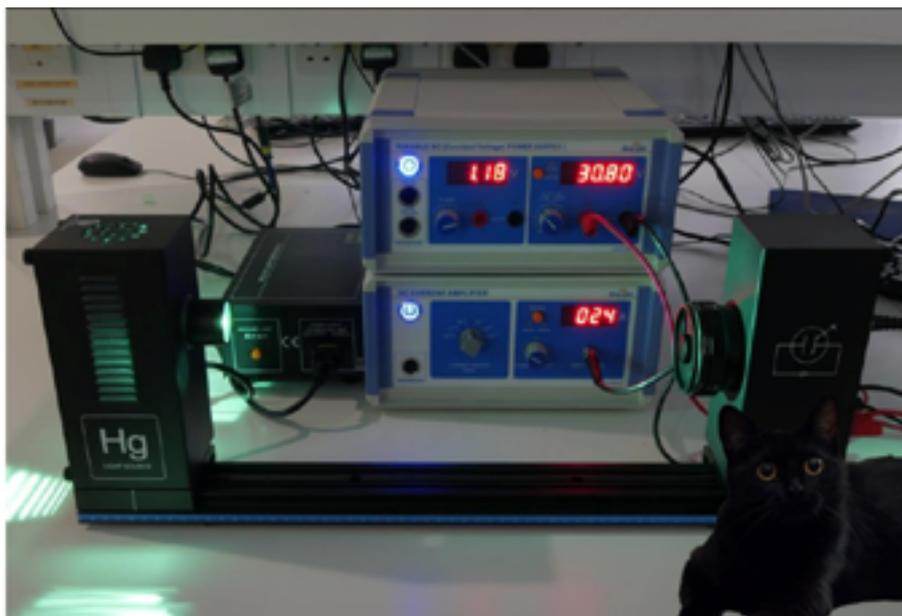
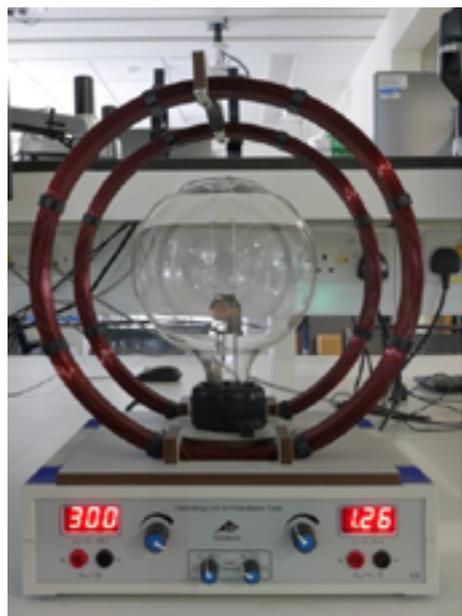
Teaching

Campus → Online → Campus

We made it back to campus: hooray! Returning to in-person activities has brought much excitement and enthusiasm for both students and staff. There were many colleagues whom I had not met in person for well over a year and it has been a delight to be working face-to-face with them again. 2021 – 2022 has seen many changes and challenges: coping with unprecedented student numbers, for example, and the resulting increased workload, overhauling modules, new staff and rapid changes to delivery.

Following much upheaval and uncertainty due to the pandemic, Autumn 2021 saw a welcome return to campus for practical (laboratory) courses and problem solving tutorials with many lectures – largely those for our largest classes - delivered online. This was particularly challenging for the year 1 practical skills course which had a cohort of over 300 students. With a new module convener and joint leads for the laboratory component, the module team worked over the summer to develop the first iteration of new

experimental elements for the module, progressively integrating with computing and data analysis components. Our aim was to support our incoming students - many of whom had faced enormous challenges - in using computing and data analysis effectively for practical work and this has already seen benefits, with increased student confidence in applying data analysis skills evident in their formal reports in addition to increased enthusiasm to use Python programming. For the coming year, the data analysis component will be rewritten and the computing component will be adapted to reflect the knowledge and skills needed for the laboratory course. Without the significant funds secured by Professor Raman Prinja and the support of our new Director of Teaching, Dr Louise Dash, we would not have had the equipment vital for the success of our students' first taste of university-level experimental physics. The funds allowed us to offer experiments investigating fundamental concepts in physics, many of which students encounter during their year 1 lecture modules.



New equipment for our first year students: measuring e/m and measuring Planck's constant using the photoelectric effect.

Following an exciting first term back on campus, rapidly rising infection rates due to the Omicron variant meant not all lab courses could be conducted safely in-person and we were dismayed to have to return to online teaching for the start of the second term. Staff and students managed well, however, returning to campus not long after.

Despite the roller coaster effect of COVID-19 on teaching, there was much good news as the department recruited two new Lecturers (Teaching) with whom we are thrilled to be working: Dr Monika Szumilo with a background in optoelectronics and Dr Joe Frost-Schenk whose research focused on nuclear astrophysics. Monika, who arrived in April 2021, has taught on several modules this year and recently organized the first meeting of the P and A Teaching Community of Practice with many interesting topics to come. We are also delighted to welcome Dr Emily Milner, already known to many of us, as our new Technician and look forward to working with her in labs.



Welcome to our new staff: Dr Monika Szumilo, Dr Joe Frost-Schenk and Dr Emily Milner

Finally, UCL hosted the first in-person Horizons in STEM Higher Education Conference since 2019 with a local organising committee comprised of staff from the departments of Physics and Astronomy, Chemistry, Mathematics, Statistical Sciences and the Faculty of Engineering. The conference was a huge success, with over 170 attendees and speakers covering topics from active learning to projects, and equality, diversity and inclusion to pedagogic research. Highlights included talks from students and the keynote speakers, Dr Richard Blackburn (University of Leicester) and Prof Louise Archer (IoE) and, of course, a lively cruise down the Thames.

Whilst COVID-19 has had a negative impact on the world, it has driven many innovations and stretched us all to develop new skills for more than two years. We are fortunate to be in an environment where we can now combine the pedagogical discoveries made with the best of traditional teaching approaches to truly benefit both students and staff. One such discovery was the result of a survey carried out in one of my own modules – I learned that the things students valued most were worked solutions, extra questions and cats. So, in case this also applies to staff, I have included a cat, Sourpuss, here for you too.



The third most requested module content was cats, behind worked solutions and additional problem sets. Sourpuss proved popular.

Dr Jasvir Bhamrah
Lecturer (Teaching)

Physics Laboratory

This has been another thrilling year for the teaching laboratories. Coming out of lock down was quite a surprising challenge as we returned to the 'new normal'. In most cases, the change was seamless, but we did have a time where we thought that Covid would burst back onto the scene. We mitigated against this by having the Spring term, first-year laboratory teaching undertaken remotely for a few weeks. However, we returned to face-to-face teaching as we got the 'all clear'. That did not mean that we still did not take precautions with masks and sanitiser in all teaching spaces for students and staff alike.

We had another bumper crop of new first-year students this year. It seems that UCL is benefitting from the confidence perspective students have in our offerings. This created challenges for the laboratories as we can only have a fixed number of students in the labs at once. Consequently, the number of lab sessions were increased accordingly with some taking place in the summer term for the first time.

The increases in numbers of students, over time, has been rippling through all years in the UCL laboratories. To deal with this, new experiments and experimental systems have been obtained to meet the needs of our students. Due to this need, the College has kindly given us enhanced funds to make this so. It means that many of these systems have been modernised or augmented.

It is not just laboratory physics that takes place in our laboratories. Computing and other modules utilise the facilities for teaching delivery. Indeed, many do not know that we hold physics courses for students that undertake the Undergraduate Preparatory Certificate for Science and Engineering. This is run by the UCL Centre for Languages and International Education and helps those whose first scientific language is not in English. It is expected that they will go on to undertake physics degrees in the English Language because of what they do in UCL.

Our technical staff have really been working very hard to deliver all the teaching in the laboratories under difficult and changing conditions. They always excel. We would not be able to do the astonishing things we do without them. We have been very lucky in that we will now be getting a fifth laboratory technician in Dr Emily Milner. She will formally start in her new role in September but is not stranger to the teaching laboratories as she has been a demonstrator on numerous modules for quite a few years now. We welcome her to our team.

Change can be hard, but it means we do not stagnate. Staff who had to re-develop their laboratory modules during lockdown have a new perspective on what can be achieved in the laboratory context. Many of the new teaching and assessment techniques are still being utilised and expanded upon. I think that creates an enriched environment for the students to flourish in.

Professor. Paul Bartlett
Director of the Teaching laboratories

Science in Action

PandA Day 2022 Review

On the 9th of June 2021 the third annual 'PandA Day' – a vibrant celebration of the people in Physics and Astronomy – saw a return to the live, in-person, stage. Held once again in Logan Hall, this year's event featured faculty staff, students, and technicians sharing the stage and auditorium, with over 100 people in attendance. The show was packed with live music, sketches and the new physics gameshow, in which staff and students went head-to-head and toe-to-toe in challenges ranging from the cerebral to the athletic.

Hosted by PhD student Saad Shaikh, the curtains rose to the sound of Eva Aw's unique rendition of pop classic "Mad World". A masterful suite of classical piano pieces were provided by first year undergraduates Leo Li and Xiaohe Ma. First year undergraduate Leyla Iskandarli impressed with her acoustic performance, including a superb rendition of "Drops of Jupiter". Lecturer (teaching) Francisco Diego's set featuring his signature Mexican fusion style had the audience cheering and clapping along. Even more musicians took the stage by storm: Noor Inès-Boudjema's and Abigail Pickering's wonderful piano duet, Live Music Society's crossover ensemble "Physics Rhapsody" performing pop and rock classics, and Ryan Brady's polemic physics parody "Burn Lecture Burn".

Undoubtedly the highlight of the event was the first ever Physics Game Show, hosted by very sharply dressed 3rd year undergraduates James Henderson and Charlie Drury. The contestants were staff members Bart Hoogenboom, Amelie Saintonge, Paul Bartlett, Chris Howard, captained by 3rd year undergraduates Maya Maciurzynska and Aidan Bartholomew. The two teams faced off in events which tested the limits of their minds, bodies, and professional reputations. Games like "Prove It!" found out just how many rolls of toilet paper it takes to completely wrap Paul Bartlett. "Hunt the Higgs" had Bart Hoogenboom – clearly unwilling to miss out on a potentially ground-breaking discovery – leaping off the stage and sprinting into the audience in search of the Higgs boson. Both teams competed fiercely in a series of quiz questions; and in the end, win or lose, brought a new kind of joy to the department.

Last, but in no way least, the theatrical troupe starring PhD students Robert James, Kyriaki Kefalà, Ryan Brady and undergraduates Max Henderson, Annie Wu, Aditya Didwania and Neil Booker seized the stage for their hilarious sketch "The Office (Hour)", depicting some of the trials and tribulations faced by teaching members of staff. Sergey Yurchenko's impersonation of Jeremy Bentham was an added treat.

PandA Day 2022 serves as the latest in the annual parade of talent and creativity (outside of physics) that surrounds our department. Future events are already being planned, so if you've a creative outlet you'd like to share with people, an idea for a short film, sketch, or talk, a burning administrative desire to orchestrate risk assessments and venue access, or just want to learn more about getting involved: get in touch and PandA will help make it happen! If you missed the event, all of the acts from PandA Day 2022 were filmed by King's Physics undergraduate Callum Swan and can be found on PandA's YouTube channel (search UCL PandA).

PandA Day will return to the stage 31st January 2023.

PandA Committee



Robert James starring role as Nick Nicolou, as he faces off with a student on Zoom, played by Kyriaki Kefalà.



Bart Hoogenboom, Paul Bartlett and team captain Aidan Bartholomew presenting their physics experiment as part of the Physics Game Show.



First year undergraduate Leyla Iskandarli musical performance.

Original Research By Young Twinkle Scientists (ORBYTS)

2021-2022 was another year of impact for UCL's ground-breaking ORBYTS programme. Teachers D. Fleming and W. Whyatt respectively said:

"this project has surpassed anything I could have possibly imagined - not only have our students been consistently blown away by the science of other planets, it has helped them better understand the value of their own one. ORBYTS is definitely one of the coolest things I've been exposed to in my 15 year career."

"It's clear to me that the ORBYTS project has been the most successful project we have been fortunate to work with and its importance cannot be overstated."

ORBYTS creates partnerships between scientists and schools, providing students with relatable science role models while empowering them to conduct their own original research projects. This structure of regular engagements that last several terms, inspirational role models and active ownership of scientific research is proving to be transformative; dispelling harmful stereotypes and profoundly shifting perceptions of science and scientists. To ensure that these opportunities go to groups who have historically been excluded from science, we ensure that all school groups are 50% pupil premium (a measure including deprivation) and 50% girls. Since 2018, the programme has enabled more than 200 school students to author publications in scientific journals - world-leading for a school outreach programme - and has supported significant increases in the uptake of physics by students from under-represented groups. This includes several new publications this year that included research produced by school students.

This year, supported by funding from UCL Widening Participation and a UK Space Agency 'Space for All' grant, ORBYTS partnered with more than 20 schools, each hosting a bespoke research project. These projects spanned P & A's research interests including projects on: Attosecond science projects at Newham Collegiate sixth form with Abbie Bray and Dr Comelia Hofmann; Protein phase separation and Parkinson's disease at King Henry School with Dr Lidice Cruz Rodriguez; galaxy exploration at Park Academy School, Rickard's Lodge and Wimbledon High School with Professor Amelie Saintonge, Lucy Hogarth, Andreea Varasteanu, Dirk Scholte and Pascal Foerster; Cube-sat exploration of Earth's atmosphere at Southfields Academy

Students from St Richard Reynolds Catholic College deliver a talk on their observations of Earth's aurorae and space weather at the second 2022 UCL ORBYTS Conference.



Students from King Henry School present their fluorescence studies of protein phase separation in Parkinson's disease at the second 2022 UCL ORBYTS Conference.

Credit: photos taken by Alejandro Salinas Lopez

with Sachin Reddy; Star formation observations at Highams Park with Luke Keyte; Exploration of Jupiter and Saturn's magnetospheres through modeling, Cassini data and auroral observations at King's College School, St Gilgen's School and Malaysia Stellar Academy through Professor Nick Achilleos, Dr Dimitrios Millas, Dr William Dunn and Matthew Cheng; ExoMol projects at Parmiters School through Professor Jonathan Tennyson and Ryan Brady; exploration of galactic spectra at Banbridge Academy with Mark Cunningham. While ORBYTS was founded by researchers at Physics and Astronomy, the programme has expanded to partner with other departments and institutions. Researchers from the Mullard Space Science Laboratory and Northumbria University supported hundreds of ORBYTS schools students with research projects on solar physics, space physics and cometary and planetary science. The scale that ORBYTS now operates at meant that we had to run multiple end-of-year conferences to ensure all schools had the opportunity to present their research; these included two in-person conferences at UCL (photos below) and an online conference.

In recognition of the programme's impact, ORBYTS rated extremely highly in the Research Excellence Framework Impact assessment and won this year's ERC 'Inspire' award, which will enable us to support a further 15 schools next year.

Dr William Dunn (coordinator of the programme) very much welcomes contact from any researchers or schools interested in taking part.

Dr William Dunn
ORBYTS Programme Co-ordinator



Students from King Henry School present their fluorescence studies of protein phase separation in Parkinson's disease at the second 2022 UCL ORBYTS Conference.

Students from Newham Collegiate Sixth form, who had delivered their talk on attosecond electron science, explore 3D images of the surface of Mars at the second 2022 UCL ORBYTS Conference.



Credit: photos taken by Alejandro Salinas Lopez

Research Headline

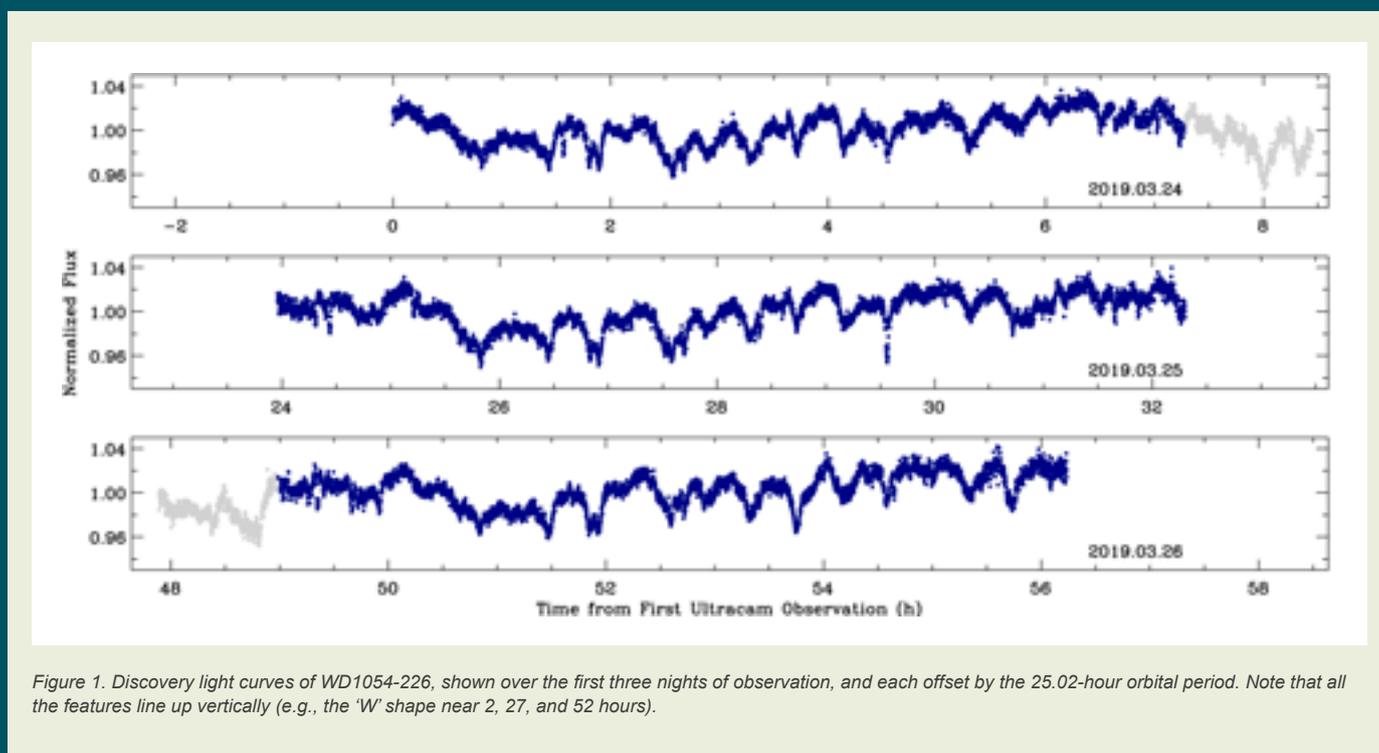
Planetary bodies discovered in the habitable zone of a white dwarf star

In February 2022, UCL scientists announced the unexpected discovery of planetary transits in the habitable zone of a white dwarf star. The team, led by Professor Jay Farihi of the Astrophysics group, was not looking for objects in the habitable zone, and thus the discovery was a huge surprise, challenging notions about the persistence or re-emergence of life across cosmic time. The study was published in *Monthly Notices of the Royal Astronomical Society*.

The discovery was made in real time in 2019, using the ULTRACAM high-speed camera fixed on to the ESO 3.5m New Technology Telescope La Silla Observatory in Chile. The

instrument has custom software that produces a light curve – a plot of stellar brightness over time – immediately after each set of measurements. Professor Farihi recalls, “Over the first three nights of observations, the team could see many distinct transits repeated exactly every 25.02 hours, which we deduced is the orbital period of these planetary bodies” (Figure 1).

“When a colleague informed me by email that a 25-hour orbit was right in the middle of the habitable zone, I thought they were making a joke, and replied with many colourful words. But he was right, and it seems we won the white dwarf transit lottery.”



White dwarfs are glowing embers of stars that have burned through all their hydrogen fuel. Nearly all stars, including the Sun, will eventually become white dwarfs, but little is known about their planetary systems. Together with other members of the scientific community, Professor Farihi’s work has overturned the view that white dwarfs are ‘dead stars’, and shown they commonly host planetary systems.

To the team’s surprise, they found pronounced dips in light corresponding to 65 evenly spaced clouds of planetary debris orbiting the star every 25 hours. The researchers concluded that the precise regularity of the transiting structures – dimming the starlight every 23 minutes – suggests they are kept in such a precise arrangement by a nearby planet.

“This is the first time astronomers have detected any kind of planetary body in the habitable zone of a white dwarf. The moon-sized structures we have observed are irregular and dusty (e.g.,

comet-like) rather than solid, spherical bodies. Their absolute regularity, one passing in front of the star every 23 minutes, is a mystery we cannot currently explain”, said Farihi.

“An exciting possibility is that these bodies are kept in such an evenly spaced orbital pattern because of the gravitational influence of a nearby planet. Without this influence, friction and collisions would cause the structures to disperse, losing the precise regularity that is observed. A precedent for this ‘shepherding’ is the way the gravitational pull of moons around Neptune and Saturn help to create stable ring structures orbiting these planets.”

It is important to keep in mind that more evidence is necessary to confirm the presence of a planet. The planet cannot be observed directly, so confirmation may come by comparing computer models with further observations of the star and orbiting debris.

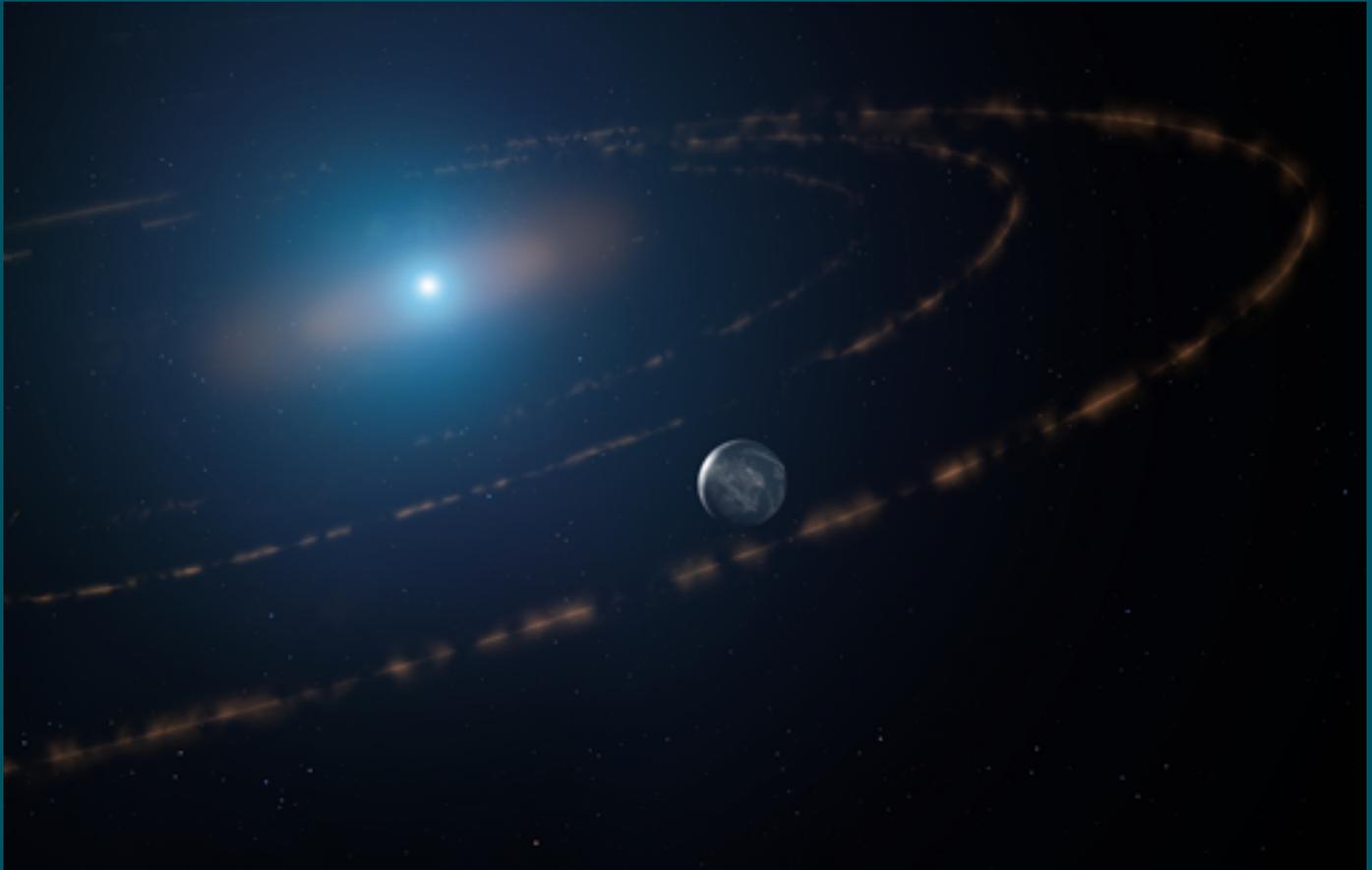


Figure 2. Illustration of the possible architecture of the WD1054-226 planetary system, with a pictured, habitable world together with the transiting planetary debris features.
Credit: Mark. A Garlick / markgarlick.com

It is expected that this orbit around the white dwarf was swept clear during the giant star phase of its life, and thus any planet that can potentially host water and thus life would be a recent development. The area would be habitable for at least two billion years, including at least one billion years into the future. Professor Farihi added: “More than 95% of all stars will eventually become white dwarfs, including our Sun in a few billion years. Our study thus provides a glimpse into the future of our own solar system.”

Planets orbiting white dwarfs are challenging for astronomers to detect because the stars are much fainter than main-sequence stars (like the Sun). So far, astronomers have only found tentative evidence of a gas giant (like Jupiter) orbiting a white dwarf. To better interpret the changes in light, the researchers also looked at data from the NASA Transiting Exoplanet Survey Satellite (TESS), which allowed the researchers to confirm the planetary structures had a 25-hour orbit. They found that the light from WD1054-226 was always somewhat obscured by enormous clouds of orbiting material passing in front of it, suggesting a ring of planetary debris orbiting the star.

The habitable zone, sometimes called the Goldilocks zone, is the area where the temperature would theoretically allow liquid water to exist on the surface of a planet. Compared to a star like the Sun, the habitable zone of a white dwarf will be smaller and closer to the star as white dwarfs give off less light and thus heat. The structures observed in the study orbit in an area that would have been enveloped by the star while it was a red giant, so are likely to have formed or arrived relatively recently, rather than survived from the birth of the star and its planetary system.

The study received funding from the UK’s Science and Technology Facilities Council (STFC) and involved a team of researchers from six countries, including Boston University, the University of Warwick, Lund University, the University of Cambridge, the University of St Andrews, Wesleyan University, the University of La Laguna, Naresuan University, the University of Sheffield, and the Instituto de Astrofísica de Canarias.

Outreach

ORBYTS wins prestigious European Research Council (ERC)

ORBYTS is a UCL led program to engage students with research via partnerships between researchers and schools, focussed particularly on engaging pupils from under-represented groups.

This acclaimed program has won a highly prestigious ERC Public Engagement with Research Award 2022.

On the 14th July, at a glittering awards ceremony in Leiden, the European City of Science 2022, ORBYTS won the prestigious Inspire category at the ERC Public Engagement with Research Awards. Nominations from 17 countries with a total of 67 applications were considered by a panel of experts from around Europe. Winners in each of the three categories: Involve with citizen science, Inspire through public outreach, and Influence media and policy were selected.

The panel who selected Professor Jonathan Tennyson (UCL Department of Physics and Astronomy), a founding member of ORBYTS whose ERC funded ExoMol project made the nomination possible, cited ORBYTS for being an “excellent example of targeting and engaging school students from underrepresented groups with real research”

The current committee of William Dunn (UCL), Hannah Osborne (MSSL) and Mark Fuller (UCL) who was present to collect the award in Leiden, ensured ORBYTS has enhanced its outstanding impact and expanded the number of school partnerships targeting those young people underrepresented in physics. The panel felt “the relationships that were built up with repeat visits from PhD mentors” was key to the success of ORBYTS impact “increasing diversity of those coming into Physics education” at all levels.

Dr Mark Fuller
Outreach Co-ordinator and Ogden Science Officer

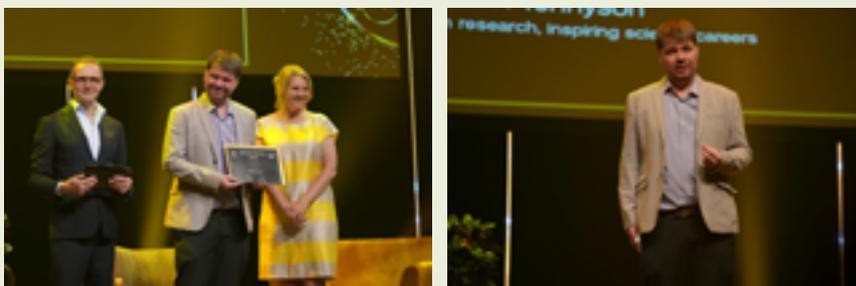
STOP PRESS:

ORBYTS WINS ANOTHER NATIONAL AWARD

ORBYTS has been selected as the project to receive a three-year funding package through the Ogden Collaborative Project Funding award. Announced during the inaugural Ogden Outreach Awards on Thursday 28th July held at The Royal Society, this small award is designed to help expand and evaluate the impact that ORBYTS has on the young people, researchers and teachers who take part. The funding is designed to help administration costs and to widen the reach through collaborations with other institutions so that more young people outside of London can get the benefit of the multi-award winning ORBYTS Programme.



Receiving the Ogden Collaborative Project Funding award (from left to right) Teacher Declan Fleming, ORBYTS organising committee members Mark Fuller and William Dunn and ORBYTS Fellow Abbie Bray. Image courtesy of The Ogden Trust



Mark Fuller receiving the ERC Public Engagement with Research Award 2022, and discussing ORBYTS in Leiden, the European City of Science 2022. Images courtesy of the ERC

TV News interviews by Francisco Diego

In the last few months, I was called several times by different news channels to comment on relevant astronomy and space topics. What follows is a small selection.

Both Euronews and Aljazeera News covered the grazing approach to the Sun by the Parker solar probe by mid December 2021. There were also interviews on space debris, deliberate destruction of satellites and uncontrolled re-entries of discarded rockets.

The most important topics were the Event Horizon Telescope successful imaging of SgrA* at the centre of the Milky Way and of course the launch, deployment, calibrations and first science results of the James Webb Space Telescope, as illustrated on the pictures, captions and links included.

I take the opportunity to report that for the historical NASA release of the first JWST 'science quality' images, we booked a large UCL lecture theatre where more than 100 UCL staff/alumni and general public watched and commented the live NASA broadcast on a large screen. A unique communal experience.

Just before finishing this report, Aljazeera and TRT World called me to comment on the possible withdrawal of Russia from the ISS and Euronews about a few large asteroids about to come relatively close to the Earth. I explained that both US and Russia are the main ISS partners and any withdrawal would endanger the survival of the ISS. I dealt with the possible consequences of the (still unregulated!) space exploration by a growing number of actors with all kinds of interests, including the military. The interviews can be found in the links:

TRT World: <https://www.youtube.com/watch?app=desktop&v=f2z2WYD9HZY>
Aljazeera: <https://www.youtube.com/watch?v=L30CNzN1GGQ>

Dr Francisco Diego Quintana
Lecturer (Teaching)



The Parker Solar probe made its first close approach to the solar surface in mid December, 2021. It was necessary to clarify that the approach was far from 'touching' the surface of the Sun, as the media originally reported.



Description of the first image of Sgr A, the super massive black hole at the centre of the Milky Way. The image was synthesised with the observations by the world-wide array that forms the Event Horizon Telescope, one of the largest international scientific collaborations.*



The technology behind the JWST was explained in some detail. For example, here I am displaying a small sample of raw beryllium, the very light metal used as a substrate for the JWST 18 golden-coated mirrors.

The video recording can be found here:

Euronews: bit.ly/3zZFWFd



Aljazeera's Inside Story covered the first Nasa JWST image release in great detail. I was sharing the analysis with Amaya Moro-Martín (Astronomer at the Space Telescope Science Institute) and Abraham Loeb (Theoretical physicist and professor of science at Harvard University).

The video recording can be found here: **Aljazeera:** <https://www.youtube.com/watch?v=qK42PEp04o4>

Diploma Club on-line Lectures during the pandemic

After 20 years of existence, the Diploma (now Certificate) of Higher Education in Astronomy has now about 400 alumni, most of them Fellows of the Royal Astronomical Society, and automatic members of the 'Diploma Club'.

Created by our late Bill Somerville, the Diploma Club has become a major tradition with monthly lectures (on a Thursday at 18:30) and also visits to relevant places (including MSSL, CERN, expeditions to solar eclipses and so forth).

Before the COVID emergency, we used the Harrie Massey Theatre for the lectures and Physics and Astronomy room E3/7 for social gathering afterwards.

Since the start of COVID restrictions in March 2020, we continued the lectures by ZOOM and this has been very successful, doubling to about 80 the usual attendance. Discussions at the end are very lively.

Lecturers include UCL/MSSL staff and students, Diploma/Certificate alumni and also lecturers from abroad, all in real time.

Here is a selection of lecturers, affiliations and talk titles for the last 2 years.

Susan Pyne, UCL (16th Apr 2020)
"Astrophysics and inference: a historical journey"

Dr Lorne Whiteway, UCL (21st May 2020)
"How to see invisible matter"

Dr Chiara Circosta, UCL (18th Jun 2020)
"The old friendship between super massive black holes and galaxies"

Stewart Coulter, UCL Certificate Alumnus (16th Jul 2021)
"Cook, the Transit of Venus, Aftermath and Legacy"

Dr Francisco Diego, UCL (26th Aug 2021)
"Cosmic Fire on Earth The amazing energy of star death"

Professor Benjamin Joachimi, UCL (17th Jul 2020)
"How Clumpy is the Universe? (KiDS)"

Dr Simon Steel, SETI, California (ex-certificate teacher) (15th Oct 2020)
"The SETI Institute and the Search for Life in the Universe"

Professor Steve Miller, UCL (19th Nov 2020)
"Thirty years of (planetary) astronomy with H3+"

Dr Mihkel Kama, UCL (17th Dec 2020)
"The symmetry of planets and life in the Universe"

Dr Alessio Spurio Mancini, UCL/MSSL (21st Jan 2021)
"Dark energy: Unveiling the true nature of cosmic acceleration with gravitational lensing"

Professor Richard Ellis, UCL / Prof Mat Page, MSSL, UCL (4th Mar 2021)
"Bill Somerville legacy / BBC-OU programme on Active Galactic Nuclei"

Professor Nick Achilleos (25th Mar 2021)
"Exploring Saturn and Jupiter's Space Environments"

Dr Umut Yildiz, JPL, California (UCL Certificate alumnus, 22nd Apr 2021)
"Molecules (H₂O, O₂) in Star Formation and Long Wavelength Astronomy"

Professor Andrew Coates, MSSL, UCL (20th May 2021)
"Present and planned Mars missions"

Dr Niall Jeffrey, UCL-Ecole Normale Supérieure de Paris (24th Jun 2021)
"Mapping dark matter using gravitational lensing with the Dark Energy Survey"

Dr Aayush Saxena, UCL (28th Oct 2021)
"James Webb Space Telescope: Revolutionising our view of the early Universe"

Dr Francisco Diego, UCL (9th Dec 2021)
"The environmental crisis, a cosmological context"

Professor Lucie Green, UCL, MSSL (27th Jan 2022)
"The Sun's Twisted Magnetic Mysteries"

Karen Devoil, UCL, CPS (Certificate alumna, 24th Feb 2022)
"Frozen: Icy Wonders of the Solar System"

Dr Corentin Cadiou, UCL (5th May 2022)
"The Universe in a box — understanding the emergence of galaxy properties through numerical simulations"

Dr Kate Pattle, UCL (9th June 2022)
"Star and Planet Formation in the Milky Way"

We plan to be back to the Harrie Massey Lecture Theatre in the new academic year and will try to keep the live streaming too in a hybrid scheme.

Dr Francisco Diego Quintana
Lecturer (Teaching)

The recordings of the Lectures can be viewed on the webpage: <https://www.ucl.ac.uk/physics-astronomy/certificate-in-astronomy>

Physics Postgraduate society

The key to a successful PhD is balancing work and play. For many students, however, the latter is often overshadowed by constant meetings, deadlines, and broken code. Normally, most students would not have the opportunity to meet people from other research groups. The goal of the student-run Physics Postgraduate society (PPG) is to provide opportunities for students across all subdepartments in physics to meet, share ideas, and have fun over pizza and refreshments.

Throughout the academic year, the PPG hosts monthly 'PhD Talks', where UCL students are invited to give a short 20-minute presentation about their research topic. These events provide a relaxed setting where a student working on planet formation can learn about particle physics detectors, exoplanets, hypervolumes and vice versa.

In the Physics Postgraduate Society we're continuously maintaining and improving the wonderful community that's been built in Physics and Astronomy, and looking forward to continuing this next year! We hope to get some new faces, so join us in running the society!

Catarina Alves and Pascal Foerster
on behalf of the Physics Postgraduate society

Your Universe Festival 2022

The 17th edition of the festival ran from 22nd to 25th June 2022. We were delighted to be back on campus after the restrictions imposed by the COVID emergency last year, when the festival was delivered on-line to record audiences.

This time we booked the North and South Cloisters, the Jeremy Bentham Room, the Front Quad and the Gustave Tuck Lecture Theatre.

The format was the usual one with pre-booked school groups on the weekdays and families and general public on the Saturday afternoon, with a panel discussion in the evening.

There were about 10 different stations with the usual themes, to include stellar evolution, interactive HR diagram, cosmology, space-time continuum simulation, telescope optics, galaxy classification, solar observing on H alpha light (we even had good weather!) and more.

A major addition this time was a virtual reality visualisation using stereoscopic headsets for interactive virtual tours of the facilities at the UCL observatory. There was also a practical demonstration (orrery based) of exo-planet transmission spectroscopy to illustrate the chemical analysis of alien planet atmospheres. These two activities were conceived, implemented and presented by Shana Sullivan, Observatory Technician.

Another new activity was a mobile planetarium with a capacity of 25 people. This was installed in the Jeremy Bentham room, running performances every 30 minutes to a total audience above 250.



Stewart Coulter setting up his valuable H-alpha solar telescope in the front Quad. Stewart has been volunteering for many years.



Shana Sullivan demonstrates the technique of transmission spectroscopy to analyse the atmospheres of extra solar planets. Copyright: Alejandro Salinas Lopez



North Cloisters during primary school group visits



After their short presentations, the panelists engaged in a productive discussion with the audience for nearly two hours. From left to right: Quentin Changeat, Emma Curtis-Lake, Aayush Saxena and Jay Farihi. Copyright: Alejandro Salinas Lopez

Unfortunately the festival happened at the time of major disruptions due to public transport strikes. Several large school groups (and some of our demonstrators) had to cancel at the last minute. Despite that, we still had around 150 primary and 50 secondary students and their teachers on weekdays, plus around 150 members of the public and families on the Saturday, when we had a major panel discussion on the JWST in the Gustave Tuck Lecture Theatre.

As demonstrators, we had around 20 undergraduate and postgraduate students, plus a few enthusiastic volunteers from our certificate alumni. They were allocated to diverse slots on each of the four days (morning and afternoon), according to requirements and their availabilities. All of them did a fantastic job, some for the first time.

As always, Mark Fuller did an excellent job in organising the complex task force of demonstrators and the logistics of school groups. Mark also organised the loan of the mobile planetarium from Dr Kevin Walsh at the Westminster School.

The Saturday panel discussion was on the James Webb Space Telescope and took place in a nearly packed Gustave Tuck Lecture Theatre. Our panelists were Richard Ellis (UCL) Emma Curtis-Lake (Hertfordshire), Aayush Saxena (UCL), Jay Farihi (UCL) and Quentin Changeat (UCL). The moderator was Francisco Diego. This session lasted nearly three hours due to a lively audience discussion.



Primary children use simple optical benches to understand the principle of the refracting telescope (demonstration by Stewart Coulter)
Copyright: Alejandro Salinas Lopez

Your Universe Annual Festival is now the most demanding on-site public outreach effort at UCL, covering a substantial space of the campus with around 10 to 15 simultaneous exhibits, lectures and panel discussions for several days. Under normal conditions, audiences come in their hundreds.

However, the infrastructure supporting this effort is very precarious and depends on the intense work of only a couple of us, dealing with venue bookings, school promotions, Eventbrite publicity, website updates, finding lecturers and panelists both from UCL and elsewhere, demonstrator task force, extra AV equipment, budget, all of which involves dozens of phone calls and hundreds of email messages for several months ahead of the event.



Andrei-Catalin Popa, outreach intern in the department, at the entrance of the mobile planetarium installed in the Jeremy Bentham Room.

Clearly this is not sustainable, so an improvement is imperative if this unique festival is to continue. A dedicated outreach team with some administrative support will be essential in the longer term.

The festival received a small grant from Group A, relieving a lot of pressure associated with the recruitment and payment of our team of demonstrators.

Once again, we are grateful to the efficient team at UCL room bookings and also at the UCL ISD service desk and AV unit for their loan of large visual displays.

Dr Francisco Diego
Founder and Director of Your Universe Festival



Primary school children on a virtual tour of the UCL Observatory
Copyright: Alejandro Salinas Lopez



After their short presentations, the panelists engaged in a productive discussion with the audience for nearly two hours.
From left to right: Quentin Changeat, Emma Curtis-Lake, Aayush Saxena and Jay Farihi.



Stewart Coulter shows how to produce an image by reflection on a concave mirror
Copyright: Alejandro Salinas Lopez



Clear demonstration of the distortion of the space-time continuum by the presence of massive objects. Copyright: Alejandro Salinas Lopez



Stewart Coulter explains a reflecting telescope on an led screen
Copyright: Alejandro Salinas Lopez



The stars station with the interactive HR diagram during the visit of a primary school group. Tim Parsons appears demonstrating.



Solar observing from the front Quad



North Cloisters during the visit of secondary school groups



Francisco explains the JWST launch and the critical moment of separation from the Ariane rocket, leaving the JWST on its own, in the right direction and at the right speed.



Prof Richard Ellis summarises the long history of the JWST, since he was on the original international 'HST and Beyond' 1996 committee that started the project.

Astronomy and environment education in Cuba, an international collaboration

This project was triggered by the International Year of Astronomy 2009, offering a good networking opportunity that has been growing since, but interrupted by the COVID pandemic.

I have been liaising with Dr Oscar Alvarez, the Cuban 'public astronomer' member of the IAU and fellow of the RAS. A very dynamic organiser of events and a popular personality on Cuban TV. Dr Alvarez is prominent in the Academia de Ciencias de Cuba, the Ministerio de Educacion (MINED) and the Ministerio de Ciencia, Tecnología y Medio Ambiente (CITMA).

I had the pleasure of visiting Cuba several times before the pandemic, leaving there a few simple refracting telescopes and binoculars to be used in schools and public events.

I lectured in primary and secondary schools in la Habana and in the countryside. I also had the privilege of being the first lecturer in what became a very popular series of lunch our lectures given at the magnificent Paraninfo of the Academia de Ciencias de Cuba.

More recently, I was invited as a speaker to the X and XI editions of the Congreso Internacional Didactica de las Ciencias in April 2018 (in-person, with around 200 delegates from 18 countries) and in April 2022 (on-line due to the pandemic).

In both events, I presented workshops on the history of the Universe, origin of chemical elements, formation of solar systems and origin of life, aimed mainly at primary and secondary teachers. I offered a few sample lectures at several schools and also at the Universidad de Ciencias Pedagógicas "Enrique José Varona".

The project emphasises the unique sequence of events that produced this unique and delicate paradise in great need of protection and preservation, something that is now crucial for general education and modern culture.

Plans for further development are under way. The working title of the project is 'La Tierra: planeta paraíso' (Paradise Planet Earth).

Dr Francisco Diego Quintana
Lecturer (Teaching)



The Paraninfo at the Academia de Ciencias de Cuba in la Habana, is the main venue for science events. The linear time line of the Universe fitted well in the wide stage. There were many interesting questions at the end.



Francisco Diego and Oscar Alvarez with two of the organisers at the Palacio de Convenciones, at the end of the X Congreso Internacional Didactica de las Ciencias that took place in April 2018.



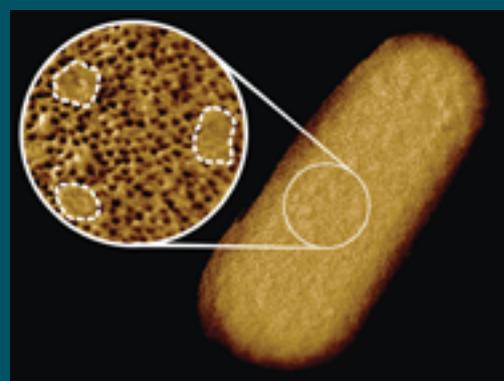
Lecturing about the relevance of Copernicus in the discovery of the Universe. The main hall at the Casa Alejandro von Humboldt was packed with very disciplined yr5 children.

Research Headline

Bacteria show their spots

The sharpest images ever of entire living bacteria have been recorded by Dr Georgina Benn in Professor Bart Hoogenboom's lab at the London Centre for Nanotechnology, revealing the complex architecture of the protective layer that surrounds many bacteria and that makes them harder to be killed by antibiotics.

Using atomic force microscopy, Dr Benn revealed that the protective outer membrane of the bacteria contains dense networks of protein building blocks, alternated by patches or domains that do not appear to contain proteins but instead are enriched in glycolipids. The textbook picture of the bacterial outer membrane shows proteins distributed over the membrane in a disordered manner, well-mixed with other building blocks of the membrane. The new images demonstrate that that is not the case, but that lipid patches are segregated from protein-rich networks just like oil separating from water, in some cases forming chinks in the armour of the bacteria. This new way of looking at the outer membrane means that we can now start exploring if and how such order matters for membrane function, integrity and resistance to antibiotics.



High-resolution atomic force microscopy image of a living bacterium, showing dense protein networks alternated by glycolipid-enriched nanodomains.

These images are part of a study published as Benn, G., et al. Phase separation in the outer membrane of *Escherichia coli*. Proc. Natl. Acad. Sci. USA 118(44), e2112237118 (2021). <https://doi.org/10.1073/pnas.2112237118>

Centre for Doctoral Training in Data Intensive Science (CDT DIS) and Centre for Data-Intensive Science and Industry (DISI)

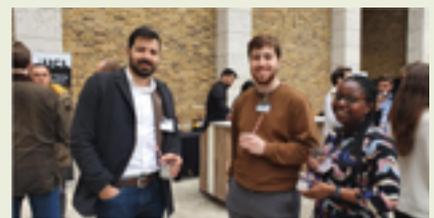
UCL's Centre for Doctoral Training (CDT) in Data-Intensive Science (DIS) has been awarded a £1.3M grant from STFC to extend its activities for the next 6 years. The grant, awarded in a highly competitive bidding process, will allow us to continue the comprehensive doctoral training in data-intensive science for at least an additional 24 PhD students (12 of them supported by STFC and 12 by UCL and industry partners) over three cohorts until 2028.

Five cohorts with 53 students in total have already been part of the first phase of the CDT (2017-2022). 10 of our CDT students who have successfully defended and completed their PhD theses and moved on to careers in academia and industry. In addition, more than 50 research articles led by the CDT PhD students have already been published. The CDT DIS together with over 30 partners from a broad range of activities in the private, public, government and academic sectors, have continued to successfully deliver a multitude of training and research activities including seminars, career events, industry group projects and 6-month industry placements.

The CDT DIS is now part of a larger structure at UCL, the Centre for Data-Intensive Science and Industry (DISI), launched in December 2021. The DISI Centre, supported by the Provost's Strategic Development Fund, also incorporates an MSc programme (of over 70 students per year) and various research activities. With the launch of the new DISI Centre, we appointed two new lecturers, Dr. Gabriel Facini and Dr. Nikos Nikolaou, and a Centre Manager, Dr. Elizabeth De-Ben Rockson. In addition, Ms. Minh Cao has also joined the DIS CDT in February 2022 as the CDT Manager.

The vision of the new DISI Centre is to build on the success and expand the scope of the DIS CDT along three directions: (a) research – to enhance research outcomes through the application of advanced DIS tools and expertise, both in the STFC domain and beyond; (b) training – to develop a comprehensive curriculum for DIS training from undergraduate level through to PhD students, researchers and academics; and (c) knowledge exchange – to foster interdisciplinary collaborations and cross-fertilisation of ideas between industry and academia, and, as a result, enhance societal and economic impact.

The CDT/DISI is led by co-directors Professor Nikos Konstantinidis and Professor Ofer Lahav (both from Physics and Astronomy Department), supported by a team of academics from 6 Departments, all leading researchers in their respective DIS fields, to train diverse and outstanding cohorts of students to be future leaders in Data-Intensive Science. Building on the successful cross-training and collaboration with industry partners, the CDT/DISI will embark on a new phase and continue building on this path of success.



CDT DIS returning to normality post pandemic with a successful CDT DIS and DISI Centre event held on campus on 29th April 2022.

Career profile

graduate destinations

Total number of graduates: 222

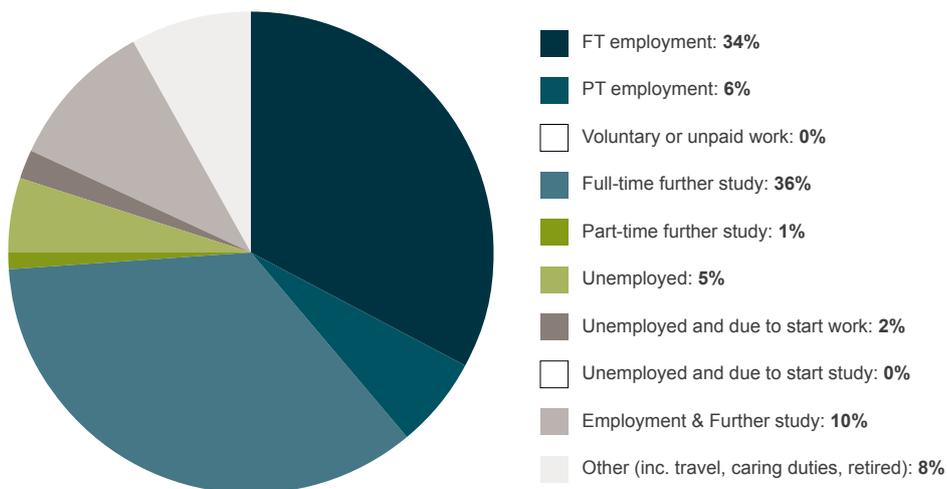
Response rate: 66%

Average salary:

UG £34,181 (employment)

PGT £40,650 (employment)

PGR £30,000 (employment)



The data is for the 2020/21 graduating cohort, for all students

The journey is more important than the destination....Rafid Jawad

I could say that my journey into electronics started since childhood as I ruined several of the family perfectly working radios and cassette tape players/recorders trying to "improve" them.



When I grew up I passed the national baccalaureate examination in Iraq, I did well enough to be offered a place at the University of Technology in Baghdad, there I started studying electrical engineering until my study was interrupted by the Gulf War in 1990.

In 1991 I left Baghdad to come and live in London where I continued my study at the University of Westminster, I graduated in 1994 with BEng (Hons) degree in electronics engineering. After graduation, I started my first job in electronics at a lighting systems

company in Brentford in west London, my job as an electronics engineer involved designing printed circuit boards (PCBs) and building prototype electronic circuits for lighting systems based on Microchip Technology PIC microcontrollers.

I moved on to my second job as an electronics engineer for an industrial electronics repair company in Aylesbury, Buckinghamshire, it was different from the first job as it was solely repairs, I was repairing all sorts of industrial electronics ranging from controllers for giant chocolate mixing machines for a chocolate factory to controllers for bank cards production machines. To add more excitement to that job, all the work was done to component level and without using schematic diagrams.

In the beginning of 2004, I joined the Physics and Astronomy department at UCL, working as an electronics technician for the AMOPP research group. I was inspired and amazed by the experiments running behind the doors of the AMOPP research laboratories, that made me decide to study physics in the evening at Birkbeck College, I graduated in 2009 with BSc (Hons) degree in physics.

My work here involves both of development and repair of electronic equipment for experimental physics applications, few examples of the equipment include photo-diode amplifiers, diode laser drivers, high-voltage amplifiers, vacuum controllers and high power laser controllers. Currently I'm involved in building and testing high voltage amplifiers with digital to analogue converters used as part of charged particle trap in Professor Peter Barker's laboratory, it is part of large European project that is testing the macroscopic limits of quantum mechanics.

In addition to my work for the AMOPP group, I will be running practical electronics course for PhD students in the summer, I am very excited to be doing this and I hope that it will be a positive experience for the participants and myself, let's wait and see.

Rafid Jawad
Electronics Technician

Adventures in Engineering and Big Physics experiments over 48 years.... Derek Attree

On a sunny July day in 1974 I walked through the front quad to start my 5-year apprenticeship in engineering in the departmental workshops, first with Tony Walker in the student workshop and then under mainly Bill Marsh and Keith Smith in the main workshop that occupied the entire basement and mezzanine floors with about 27 staff. Sir Harry Massey was Head of Department.



I was familiar with UCL as my father Harry had worked as a research grant accountant in central accounts for the previous 25 years, and it was through him I heard about the opportunity in Physics.

After completing my training, I had a brief time in the stores and purchasing with John Mitchel.

I then went into the first-year teaching lab before handing over to Derek Thomas and then a move to the 3rd year lab following Gordon Lush and that was when I started work in my spare time for the Counter Group which I joined full time in 1982 and found the job I was looking for.

I was thrown in at the deep end and sent to CERN to modify some equipment on WA75 a fixed target experiment with Derek Imrie and Harry Watson. This would turn out to be the first many trips over the next 40 years.

Towards 1986 the groups B and C merged to become the HEP group run by David Miller and Tegid Jones and we were told were going to be in OPAL at LEP CERN and Zeus in DESY.

I did end up doing work for both, the gas monitoring for Zeus central tracker and the main task for myself and Brian Anderson the Forward detector on OPAL.

In 1994 with my new wife Jo (UCL PHD in Psychology) I was given the chance to spend the best part of a year at CERN working on the micro vertex detector with the teams from Cambridge and Birmingham universities. This was a small silicon wafer detector round the beam pipe in the heart of OPAL and a prototype for Atlas on the LHC.

We returned to UCL in 1995 and my son Peter was born in March that year.

In the year 2000 Opal was decommissioned and I was involved in the strip down and removal from point 6.

By this time, we were working towards the SCT on Atlas, I built a full-size space model in room C23 and visitors and engineers from all over came to check fits of components and cable and pipe runs on this model.

I was involved in a considerable proportion of the Atlas build at CERN up to 2008.

The Minos calibration detector at CERN came next and then and still currently Super Nemo with Ruben Saakyan and David Waters and many others.

I have built the radon detector and rebuilt the gas system for this and many Scintillator Blocks with PMT assemblies.

I also served as Department safety officer for about 10 years.

In 2019 I was awarded the first Technician of the Year prize which was a pleasant surprise.

UCL has been the major influence in my life and the story is coming to an end as after 48 years I am slowly trying to wind down to retirement so I can get on with my large stock of model engineering projects in my home workshop.

So, the HEP has continued engineering support I have been training Connor to step into the role within the group.

A long way round... Monika Szumilo

My career path has been rather unusual for a Lecturer in Teaching. Traditionally, after completing their PhD one would stay in academia, usually as a postdoc and teach more and more until a purely teaching position opens up. That is not what I did. But I don't regret any of my choices.



It started quite uneventfully: I completed the subsequent levels of Physics education: BSc, MPhil and finally PhD at Cavendish Laboratory in Cambridge. My research projects spanned across various applications of organic semiconductors: OFETs, thermoelectrics and photovoltaics. I still vividly remember the excitement when after weeks of measurements in a dark room, I saw the 'blip' on the spectrum. That was the discovery of photon recycling in hybrid perovskites. Moments like these make research enjoyable but I've always known that was not what I wanted to do for the rest of my life.

Even before joining university, I had been drawn to teaching. Leading an afterschool club here, volunteering at a Saturday school there, it has always been somewhere in my schedule. During my studies I also took every opportunity to teach and educate myself about how to do it well. And when I submitted my PhD thesis, this is what I decided to focus on.

What did I do instead of the traditional postdoc? First, I worked as a Director of Curriculum for a summer school provider in Cambridge. It gave me a chance to explore teaching that is purely curiosity-driven and delivered by passionate high achievers. Some of my many responsibilities were recruitment, training and supervision of teachers on the programs. They were usually researchers from top world institutions, and they always had plenty of fantastic ideas for engaging their students! I learned a lot from observing classes in all kinds of subjects: from Criminology to English Literature, to Medicine.

After 3 years of this exploration, it was time to increase my teaching load. I accepted a position as a Lecturer at INTO City, University of London. It is a joint venture providing undergraduate and postgraduate foundation courses and I was responsible for Physics, Maths and Engineering courses. I had a real chance to practice, practice, practice. Teaching over 20 hours of classes each week gave me plenty of opportunities to experiment with my approach and polish my teaching skills.

In 2020 I accepted a teaching position at Imperial College, London. There, I designed and taught my own MSc course (Artificial Intelligence for Aerospace Engineering). It was a great and enjoyable experience but when my current role was advertised, I jumped at the opportunity to go back to Physics. And here I am now.

A lot of people ask me why I love teaching, why I have chosen this career path. The answer is simple: I love to learn. Working in all of these roles gave me new and unique perspectives. Each of them taught me something different and influenced how I teach and work today. I highly value every step of my journey and hope to use what I have learnt in years of teaching to come.

Unravelling the physics of the extreme... Carla Figueira de Morisson Faria

I am originally from the Amazon Delta, where I started my physics studies. I was lucky enough to be exposed to science since early childhood, as dad is a STEM professor as well. He used to fill our home with science and music, so we have learned to appreciate both. Since I always felt like travelling the world, I have transferred to the University of Sao Paulo, where I finished my undergraduate studies in 1992, and my MSci in 1994.



At that time, I fell in love with a German scientist who has become my significant other and moved to Berlin for a PhD in 1995. I got really interested in the work done at the Max Born Institute, on Strong-Field and Attosecond Physics. The extreme conditions awakened my interest: typically, in optics lasers were used to excite/de-excite systems, and established theoretical methods did a good job. However, in our field perturbation theory just broke down and the times were so short that nothing used in the stationary regime seemed to work anymore. Attoseconds (10^{-18} s) are among the shortest time scales in nature, which in principle allows tracing electron dynamics in real time. Electrons play a huge role in chemical bonds, carry energy in biomolecules, nanostructures, etc. To control their dynamics can revolutionize many areas, and this dream is becoming a reality.

I finished my PhD in 1999, and after that several postdocs followed, at the Max Planck Institute for Physics of Complex Systems, Dresden (1999-2001), the MBI-Berlin again (2002-2003), the Technical University Vienna (2002) and the University of Hanover (2003-2004). Eventually, I moved to London, where I held longer-term positions. They included a University Research Fellowship at City, University of London in 2004, an EPSRC Advanced Fellowship in 2006 at University College London. In 2007 I took up lectureship at UCL, in 2013 I was promoted to Reader in Physics and in 2018 I was made full professor. My group and I have been studying quantum effects in a wide range of strong-field phenomena. Our research includes high-order harmonic generation, above-threshold ionization, correlated multielectron processes in strong fields, attosecond pulses, tailored fields, photoelectron holography, and novel approaches such as the Coulomb Quantum Orbit Strong-Field Approximation (CQSFA), which is one of the most advanced in our field. Beyond attoscience, I have worked on non-Hermitian Hamiltonian systems and helped develop a formalism for explicitly time-dependent systems. We also run the Atto Fridays Seminar Series, which aim to bring science to all everywhere in the world free of charge. Since 2007, I have been the primary supervisor of research students at all levels and from a wide range of backgrounds and have hosted several post-doctoral fellows, some of them self-funded. From 2016 to 2019 I was the Departmental Undergraduate Admissions Tutor, which taught me powerful lessons on setting boundaries, politics and interacting with the public, and I enjoy teaching theory-oriented modules.

I have broken many barriers, such as being the first South American to win the Institute of Physics Thomson Medal and Prize in 2021, or possibly the first physics female professor in the UK of mixed Black heritage. The support of countless people, in particular my dear husband, my family and my allies, was instrumental for all this glass-ceiling smashing, and I will be eternally grateful. Certain South American characteristics, such as stubbornness and a healthy disregard for authority also helped, although I am aware there is still a long way to go, for me and for all of us.

Welcome Back to Campus - Astro Afternoon Tea

On the 5 April 2022, the Astrophysics group hosted a “Welcome Back to Campus - Astro Afternoon Tea” in the Jeremy Bentham Room. It was after a couple of very tough years and a long time that many members of the group got together socially; to celebrate our return to campus, to reunite and to catch-up, over some glorious treats, including “Zalmon” sandwiches and a delectable assortment of mouth-watering macarons, creamy cheesecakes, and exquisite eclairs! Catering was provided by UCL Hospitality: Gather and Gather - an exceptional range of vegetarian treats.

Photographs courtesy of PhD student Pascal Förster



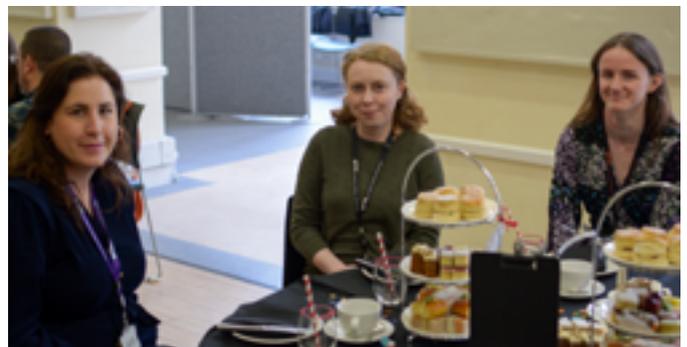
Pascal Förster



Tim Parsons, Kate Pattle and Jason Sanders



Gandhali Joshi, Corentin Cadiou, Chiara Circosta, Aayush Saxena and Niall Jeffrey



Raphaële Raupp, Lucy Keeping and Katherine Irwin



Jay Fairhi



Mario Morvan



Mark Cunningham



Luke Ketye and Gordon Yip



Maria Niculescu-Duvaz and Davide Piras



Vinooja Thurairathnam



Sushuang Ma and Samuel Wright

A few quotes from colleagues who were present at the event:

"It was super refreshing, approaching intoxicating even, to be back in person and be able to see and interact with so many valued colleagues after so long. The treats were also excellent, and very much eye candy as well!"

Prof Jay Farihi

"The Astro Welcome Back to Campus event was a much-needed chance for many of us to meet other friends and colleagues in person, in many cases after not having properly seen each other for long periods of time. The Covid-19 pandemic has had a huge impact on all of us; further valuable events like this one will serve as welcome opportunities for further face-to-face social interactions that support our sense of community."

Prof. Nick Achilleos



Matt Scourfield

"The tea and treats were real, not virtual – and delicious, I might add. The participants were 3D people, not images on a screen."

This event reminded all of us how important human connection is, especially in academia. And sharing food was symbolic and profound, I think we all felt we were living a special moment together."

Prof Giovanna Tinetti

"I thoroughly enjoyed the afternoon tea last month. It was really nice to see so many people from our group; it gave me a sense of community that I miss, especially since I started remotely and there were not many in person social events with the whole Astro group. The catering was amazing, and I loved the detail that the glitter decorations were astro-themed too! Everything together made the whole event feel very special."

Lillian Guo, PhD student:

"After the disappointing but necessary cancellation of the Astro Christmas party back in December due to Covid-19, having the afternoon tea to look forward to in the Spring was an excellent way to lift everyone's spirits. The tea was the perfect mix of elegant and refined with towering stands of beautifully crafted assorted cakes and sandwiches yet also casual enough to encourage lots of conversation between everyone in the department with lots of people mixing between the many tables later on for lively discussions (both astrophysical and non-astrophysical). A long awaited department wide social event that definitely did not disappoint!"

Alexandra Thompson, PhD student

Observatory News

The UCL Observatory: where teaching meets research

This year has seen a return to face-to-face activities as we come to terms with the new reality of pandemic life. Regardless, our robotic telescopes at UCLO, the safety distancing measures in place and our collaborating network of telescopes abroad have allowed our students to observe the sky and its wonders throughout autumn and winter in a range of modules from year 1 to year 4 as well as research projects.

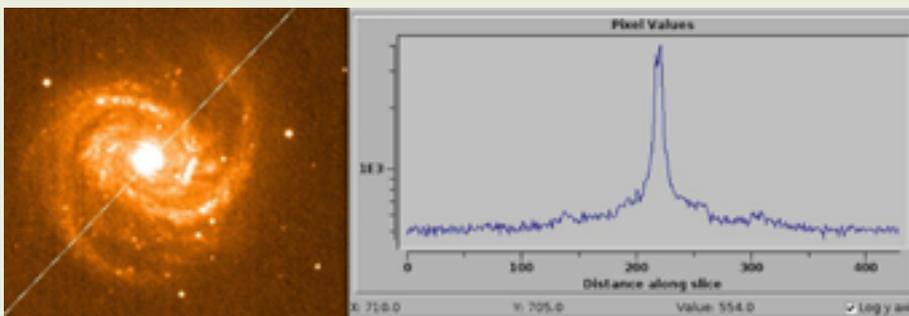
Our collection of state-of-the-art telescopes (up to 80cm diameter aperture) as well as our older fully-mechanical units, allow students to learn all aspects of observing, from basic manual observing to scheduled time-critical observations in remote locations. Observations are performed with CCD and CMOS cameras and spectrographs allowing students to become familiar with the most advanced techniques in observation and data-analysis.

In the third year, students pool together in small groups to perform a research exercise supervised by an expert academic in a given field. Here is a selection of the resulting posters for three astro-physically different targets.

Colour gradient in Spiral Galaxies

Colour gradients are an important observational feature seen in spiral galaxies, a subclass of galaxies characterised by a bright central bulge and flat disc with spiral arms.

In Hubble's classification scheme, spirals are labelled as barred (SB) or unbarred (S), followed by a letter denoting their bulge/disc ratio (a,b,c in descending order).

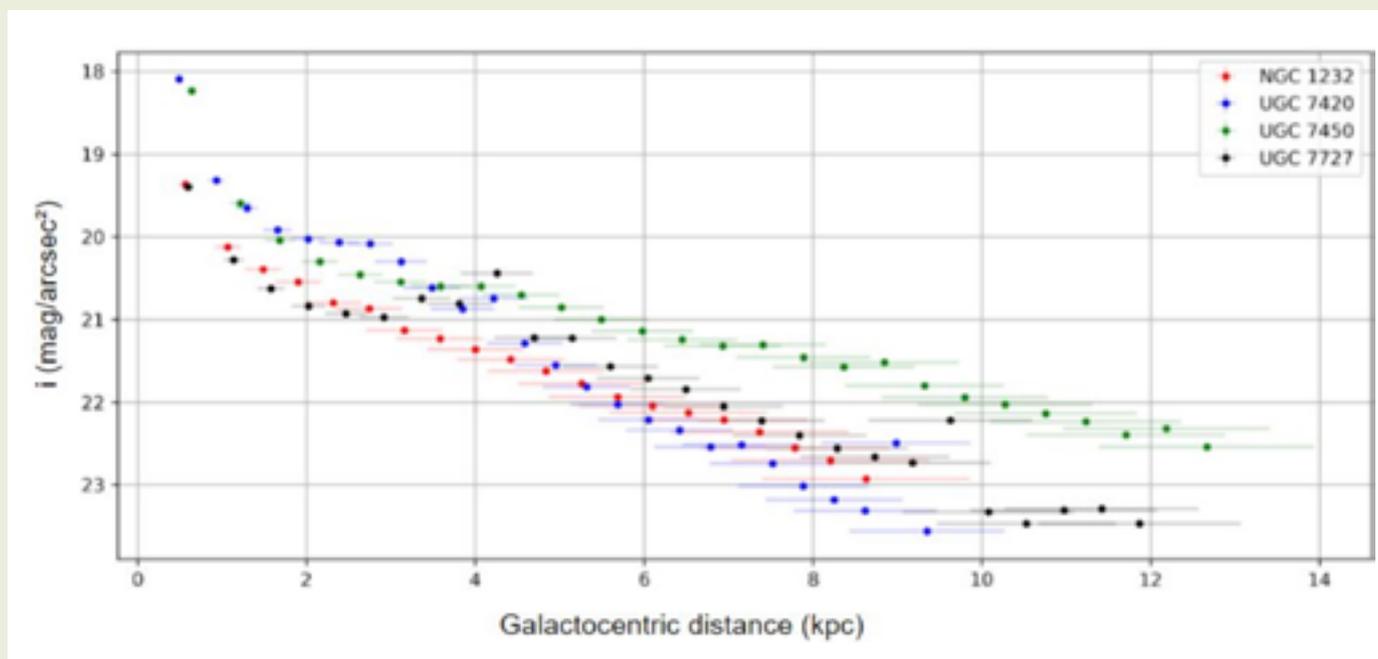


Example slice through UGC 7450

As colours are a valuable indicator of stellar ages, these gradients can prove a useful indicator of the assembly history of galaxies. The data shown below indicate that spiral discs grow outward with time, most likely by accreting gas which forms younger, bluer stars.

Project Students: Elliot Denis, Wenzhao Qi, Nasko Stefanov, Nancy Yang

Project Supervisor: Professor Richard Ellis



i-magnitude as function of galacto-centric distance in kpc.

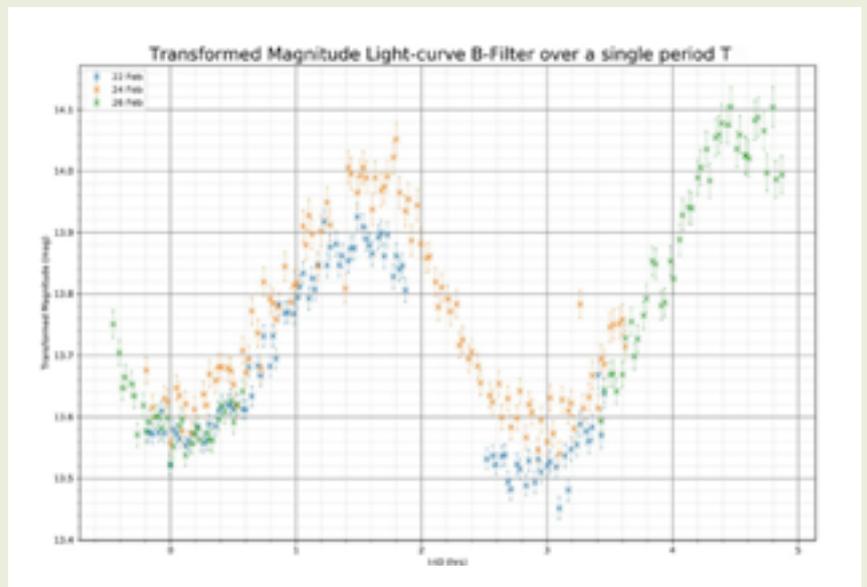


Photometry of Asteroid 762 Pulcova

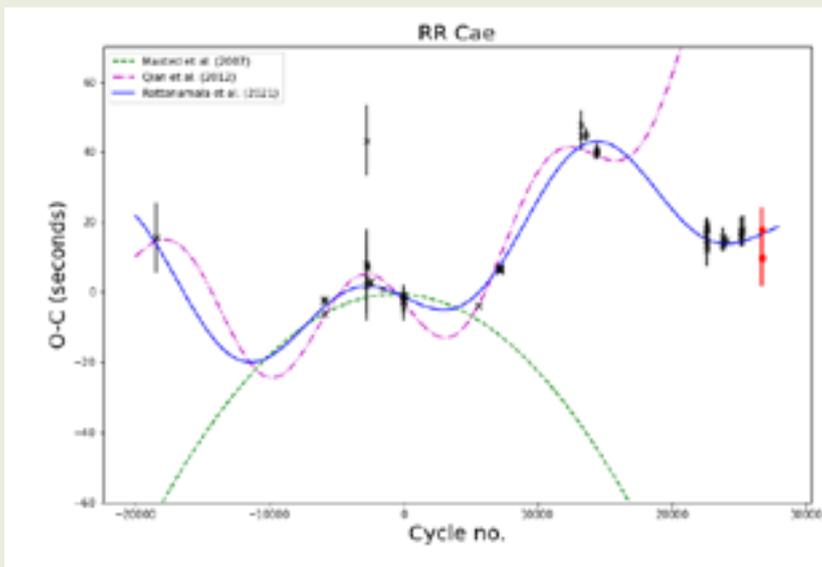
Asteroids can provide great insight into the formation of our solar system. The asteroids we observe today are remnants from the formation of the terrestrial planets, and allow us to understand the processes and environments from which the terrestrial planets formed. Light reflected from the surface towards us can be collected in a time series to assemble a light curve tracking a fluctuation in brightness over time. Lightcurves present a great deal of physical information such as; rotational period, colour index, albedo, absolute magnitude, composition and classification.

Project Students: Niamh Flood, Nikita Patel, Oliver Pearce, Eoin Samuels.

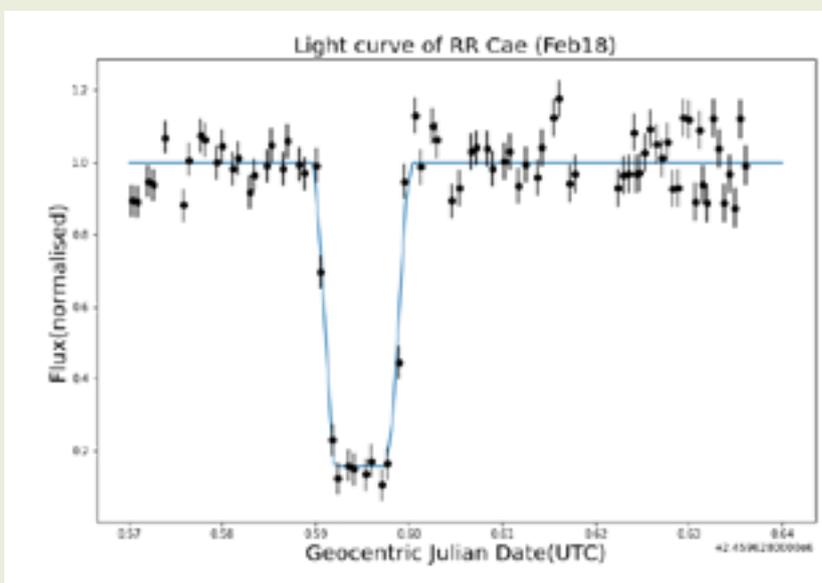
Project Supervisor: Dr. Gianrico Filacchione



RR Cae comparison with past data/ models



Normalised light curve of RR Cae with a fitted line.



Eclipse timing variations in evolved binaries

Eclipsing binary stars are crucial benchmarks in astrophysics, providing mass and radius directly, where eclipse timing variations can be sensitive to orbiting third bodies as well as changes in the angular momentum of the system.

Time-series photometry of two short-period, eclipsing binaries containing a white dwarf and a main-sequence star were obtained to construct light curves and measure mid-eclipse times. Eclipse time variations were then calculated by comparing measurements with reported ephemerides in order to distinguish between possible explanations for this as-yet unexplained phenomenon.

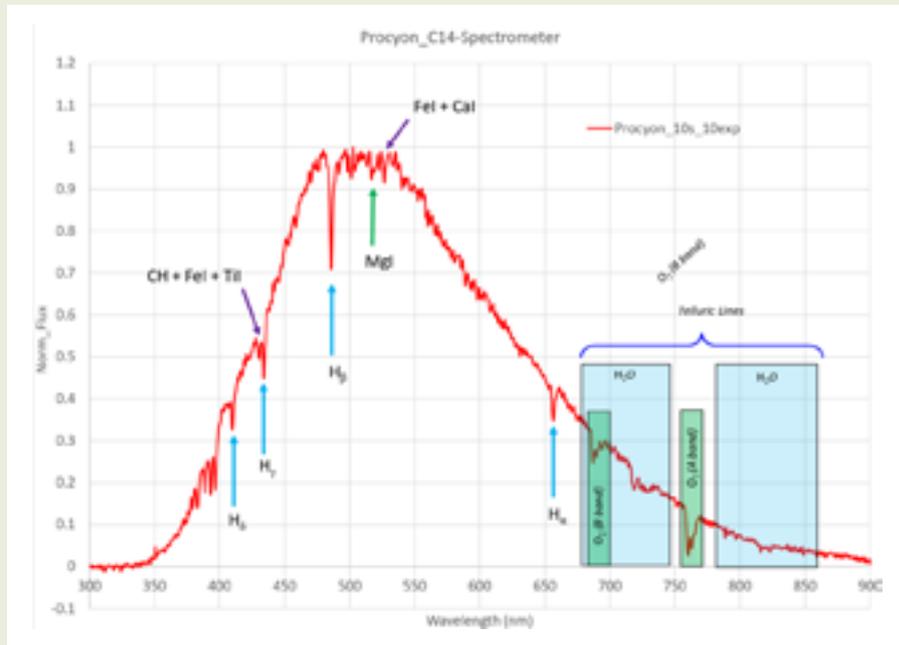
Project Students: Neal Bai, Xing Li, Yuhan Yang, Emma Yang.

Project Supervisor: Professor Jay Farihi

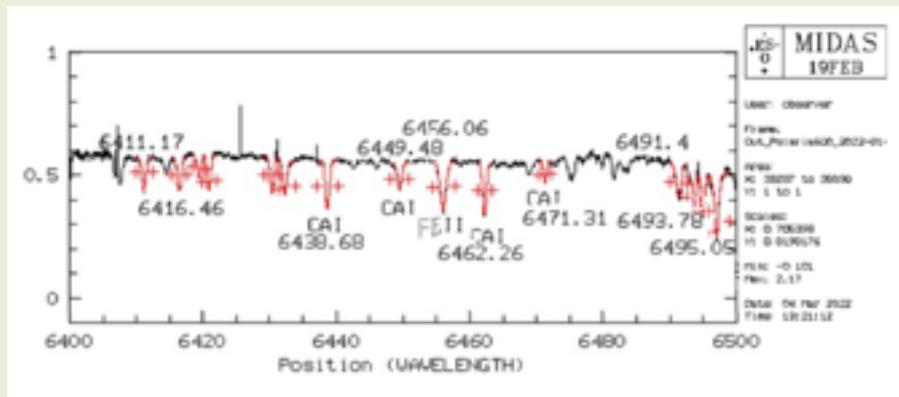
The new upcoming facilities

The new echelle high-resolution spectrograph has had an initial testing campaign on a few bright stars and is ready to be used by students for their projects at UCLO. Below are a few examples of high-resolution spectrograph frames and recovered spectra.

Spectroscopy is also being implemented on the smaller telescopes via commercial spectrometers. Example of spectra on known targets are shown.



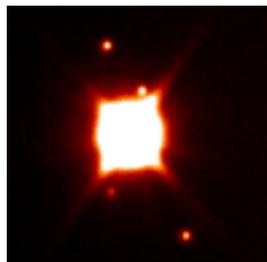
10-average spectrum (each 10s integration) of Procyon (α CMi) taken with a commercial Czerny-Turner. Visible are the Hydrogen Balmer series, a few other lines as well as the telluric set of atmospheric absorption bands in the near infrared.



Portion of the spectrum of Polaris taken with the Perren Echelle at UCLO and analysed with the MIDAS software used at ESO. The spectral resolution was measured between 12000 and 13000.

With the recently acquired fast readout CMOS camera we have been testing sensitivity and speed of response. This has allowed us to replicate CCD performance without issues, but also allowed us to plan for moving targets (fast and slow).

Here below are a couple of examples.



A saturated frame taken on Uranus and its largest and closest satellites. The negligible read out time of the CMOS camera allows for precise timing projects as well as deep photometry ones.

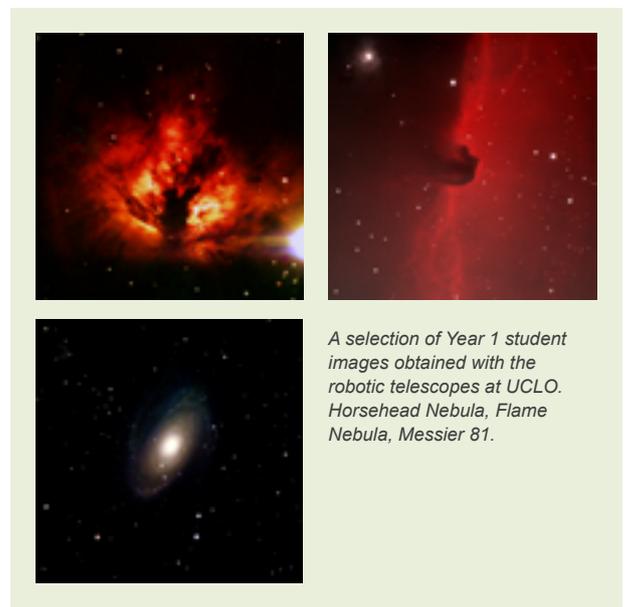


Keeping an eye on JWST (the flatish line centre-left) in March... the NASA observatory can be seen here on superimposed 4 minute frames.



"Size" map of all telescopes accessible by UCLO students.

Professor Giorgio Savini,
Director of UCLO



A selection of Year 1 student images obtained with the robotic telescopes at UCLO. Horsehead Nebula, Flame Nebula, Messier 81.

Centre for Space Exochemistry Data (CSED)

Despite the many challenges, it has been a very exciting year for CSED!

The UK Government has confirmed the investment of £30+ million for the European Space Agency's exoplanet mission Ariel¹. Due to launch in 2029, the Ariel's mission is to understand the links between a planet's chemistry and its environment by characterising the atmospheres of 1,000 known planets outside our solar system. Another important milestone for the mission was the selection of Aerospace giant Airbus as prime contractor to build the spacecraft².



In February, the Provost and Chief of Staff, visited our offices at Harwell and the RAL facilities where Ariel will be integrated



Engineering drawing of Ariel spacecraft. Credit Airbus²

UCL CSED has launched the third Ariel Machine Learning Data Challenge. After two very successful challenges in 2019 and 2021, we are pleased to be running this year's challenge at the prestigious NeurIPS 2022 conference³. This year's challenge will focus on improving the interpretation of exoplanet spectroscopic data through the development of inverse Bayesian modelling using machine learning. Dr Ingo Waldmann, CSED Deputy Director and Alan Turing fellow explained: "Bayesian neural networks are at the cutting edge of modern artificial intelligence (AI) research and results from this challenge are expected to not only inform exoplanet science but be equally important for physical and medical sciences." Kai Hou (Gordon) Yip, Research Fellow at CSED and Ariel Data Challenge Lead added: "The NeurIPS data challenge 2022 provides an excellent platform to facilitate cross-disciplinary solutions with AI experts." For the first time, this year the competition is also offering 20 participants access to High Powered Computing resource through DiRAC.

Five long-standing questions about planets outside our solar system known as "hot Jupiters" have been answered in a major new study led by Dr Quentin Changeat and other CSED researchers. The study, published in *The Astrophysical Journal Supplement Series*, is one of the largest ever surveys of exoplanet atmospheres ever undertaken. Dr Ahmed Al-Refaie, Head of Numerical Methods at UCL CSED and co-author of the study, has commented: "The need for state-of-the-art tools and supercomputing resources are paramount in making these types of large-scale analysis possible, especially as the field of exo-atmospheres is moving to the era of the James Webb Space Telescope and ESA's Ariel space telescope". This work was made possible by the collaborative use of large supercomputing facilities: the UK's DiRAC High Performance Computing (HPC) facility, and the OzSTAR facility at Swinburne, Australia.

With the philosophy that everyone can contribute to real research and become part of a bigger project, such as a space mission, the ExoClock⁴ team have created special tools and educational guides for any observatory and school around the world that would like to support the future of exoplanets. Started as a citizen-science program led by Anastasia Kokori and Dr. Angelos Tsiaras, ExoClock has obtained transformational results throughout the years (two papers in the *The Astrophysical Journal Supplement Series* in 2022), well beyond the original scope of the project, while maintaining its highly inclusive and educational nature. As such, ExoClock is an inspirational program, showcasing in an exemplary way, how one can do great science in the 21st century on a limited budget, while inspiring hundreds of citizens around the world!

¹<https://www.gov.uk/government/news/uk-takes-the-lead-in-exoplanet-mission-with-30-million-investment>

²<https://www.bbc.com/news/science-environment-59556684>

³<https://www.ariel-datachallenge.space>

⁴<https://www.exoclock.space/>

Academic Showcase

A Sample of Staff Accolades

Department Teaching Prize

This year's Departmental Teaching Prize is awarded to **Dr Jasvir Bhamrah** for sustained excellence in teaching. In particular, at the start of the pandemic and our pivot to online delivery, she proactively developed innovative approaches to remote lab work and, in collaboration with students, novel experiments for home-based learning. This came on the back of the successful leadership of the teaching of our first year computational module for theoretical physics students, and more recently the optics component of PHAS0005. Dr Bhamrah has represented the physics streams of the Natural Sciences programme for a number of years and has consistently supported Natural Sciences students and ensured that they are integrated within our department. Beyond this, Dr Bhamrah has been taking the lead in promoting academic integrity, and, most recently, in the current academic year she has shown excellence in leadership in convening and bringing together the separate components of our introductory practical physics module PHAS0007. In short, she has demonstrated outstanding success in all aspects of teaching and learning, as well as sustained dedication to ensuring student success.



Technician of the Year Award

The Physics and Astronomy Departmental Technician of the Year Award for 2021-22 has been awarded to **Shana Sullivan**.

Despite starting shortly before the COVID19 pandemic, Shana engaged immediately in all activities at the Observatory. Taking on the routing maintenance duties, but also proposing and carrying out more complex instrumentation related activities. As the pandemic hit, the Observatory needed to shift our presence from physical to online, for our students, but especially for all of the outreach and public engagement activities.

Shana created from scratch a virtual interactive environment (learning in a very short time both CAD programs and the unity engine) accessible through browser which allowed our tours to go online. This virtual observatory was further developed in a learning tool that is now used to teach basic astronomical concepts to school children (as well as to maintain some virtual tours as a possible option for non face-to-face visits). Shana has taken the lead in commissioning the new echelle spectrometer on the large telescope providing the necessary software bridge, through her own coding, between hardware as delivered and practical usage by students, without which, supervision of the project students working on it would have not resulted in a successful and practical outcome. Providing regular teaching support on telescopes at all necessary hours on site for students, Shana has made herself available for all allowed events we held during and after the pandemic.

Professional Services Staff Prize

The Physics and Astronomy Departmental Professional Services Staff Prize for 2021-22 has been awarded to **Sarah McGrath** and the runner Up Prize has been awarded to **Rebecca Martin**.

This is the first year that we have nominated and awarded a prize to a Professional Services staff member within the department. We decided to include this in recognition of the fantastic work that our PS staff do as they are often the unsung heroes helping to facilitate the extremely important work of a busy and successful academic department. As expected we received a number of nominations and the field was exceptionally strong. Each individual who was nominated has demonstrated all the qualities we would expect from our exemplary colleagues. Because of the strength of the nominations in the field, we decided to award a prize winner and a runner up prize. Both recipients of the award have proved themselves to be exceptional citizens of the department providing excellent service, professionalism and displaying resilience and tenacity, in what is often a challenging situation.

Congratulations goes to Sarah McGrath as the recipient of the 2022 Professional Services Award for her work on timetabling and managing the complexities of the PGT portfolio. Sarah started in the Education support team only 3 days prior to lockdown in March 2020, and has become a central part of the team despite working remotely for the first year.

Congratulations also goes to Rebecca Martin, who has recently been appointed to the Senior Research Officer role. This role absolutely pivotal to the success of the department, and Rebecca's work reviewing our research portfolio has been much needed and well overdue. Rebecca is no stranger to the department, having previously worked with some senior academic colleagues. Their loss (sorry!!) is definitely the department's gain.

A heartfelt thank you from the management of the Physics and Astronomy Department to all the nominees and especially to the prize winners in this category. Keep up the good work.



UCL Leadership Award for Outstanding Contribution

Professor Raman Prinja has been awarded one of the Leadership Award for Outstanding Contribution. The nominees for the Leadership Award for Outstanding contribution were nominated by their teams and individuals with the winners selected by Fiona Ryland, Vice-President (Operations).

Raman has gone above and beyond the call of duty in leading the Physics and Astronomy department through a very challenging period with fairness and compassion, always looking out for the well-being of students and staff first.

He works tirelessly to deliver programmes at a level that both students and staff can be proud of and demonstrates a strong commitment to inclusion and diversity, actively seeking funding opportunities to improve access and participation.

By setting a positive and emotionally intelligent example that motivates others to follow, he has allowed the department to thrive in a very challenging time.

UCL Council

Professor Jonathan Butterworth has been elected a member of UCL Council.

Professor Butterworth, who is scientific advisor to the UK delegation to CERN Council, a member of the Science Technology Facilities Council and chair of its Technology and Accelerator Advisory Board is looking forward to joining the Council:

"UCL can be an enormous power for good, giving talented people the confidence and resources to excel. From my work with big international science organisations, I know the importance of good governance in achieving this. I am really looking forward to being able to contribute as a member of the Council."

See UCL's press release **New members of UCL Council announced**

IOP 2021 Medal and Prizes

2021 Clifford Paterson Medal and Prize awarded to **Ying Lia Li**.

Dr Ying Lia Li has been awarded the 2021 Clifford Paterson Medal and Prize for developing her pioneering quantum sensing research into an inertial sensor startup to commercialise breakthrough optomechanical accelerometers, and for her drive to build a better and more supportive research community.

2021 Joseph Thomson Medal and Prize awarded to **Carla Figueira De Morisson Faria**

Professor Carla Figueira De Morisson Faria has been awarded the 2021 Joseph Thomson Medal and Prize for distinguished contributions to the theory of strong-field laser-matter interactions, particularly the development of semi-analytical models bringing together attoscience and mathematical physics that provide vital tools to the physics community. She is the first South American and the first woman of colour to win this award. She was also appointed as an IoP fellow in 2021.

2021 Lise Meitner Medal and Prize awarded to **Raman Prinja**

Professor Raman Prinja was awarded the 2021 Lise Meitner Medal and Prize for distinguished long-term contributions to engage and inspire children in physics, including his highly motivating range of books, public lectures and interactive science events for young people.

CIUK 2021 Jacky Pallas Memorial Award

CIUK 2021 Jacky Pallas Memorial Award awarded to **Niall Jeffrey**

Dr Niall Jeffrey has been awarded the CIUK 2021 Jacky Pallas Memorial Award. In the Dark Energy Survey (DES), we have created the largest ever map of dark matter – invisible matter thought to account for 80% of the total matter of the Universe – using gravitational lensing of galaxies. I will share the exciting developments used for this cosmic cartography over a quarter of the Southern Hemisphere. Exploiting this map to understand the unknown physics of the Universe, in the DiRAC project “Likelihood-free inference with the Dark Energy Survey”, we combine GPU-accelerated cosmological simulations with novel artificial intelligence techniques. By using deep learning in a Bayesian framework, I will demonstrate how we can now quantify our belief in different cosmological models using information encoded in the new DES map.

Estonian Young Academy of Sciences

Dr Mihkel Kama was elected to the Estonian Young Academy of Sciences (EYAS), a branch of the Estonian National Academy of Sciences. EYAS members can serve until age 40. Activities include advising government agencies and engaging with researchers, public servants, and the wider public on matters relevant to higher academia.

Royal Swedish Academy of Sciences

Professor Hiranya Peiris has been elected as a foreign member (Physics class) of the Royal Swedish Academy of Sciences in recognition of her outstanding research achievements.

Founded in 1739, the body is one of the oldest scientific academies in the world. It is responsible for awarding the Nobel prizes in Physics, Chemistry and Economic Sciences.

The academy noted that Professor Peiris had made “significant contributions to cosmology by combining observations with theoretical physics research and advanced data analysis”.

Royal Society of Chemistry 2022

2022 Interdisciplinary Prize

Professor Nguyen T. K. Thanh has received the award for 2022 Interdisciplinary Prize for outstanding contributions to interdisciplinary research on fundamental understanding of chemical syntheses, physical studies of plasmonic and magnetic nanomaterials for biomedical applications.

ERC Public Engagement Award

Professor Jonathan Tennyson received the award in the category “Inspire - public outreach.” with his project **ORBYTS**. He successfully involved school students with real research led by PhD mentors. The teamwork in schools with low STEM take-up, which afterwards reported widening access to education in physics, boosting pupils’ confidence in these fields and broadening the uptake of science in the curriculum, particularly in underrepresented groups and girls.

The **ERC Public Engagement with Research Awards 2022** was announced in a ceremony held in Leiden on 14 July and attended by the Department’s outreach officer Dr Mark Fuller.

Fellowship of the Institute of Physics (IOP)

Awarded to Professor Jochen Blumberger

Fellows of the Higher Education Authority

Dr Roger Johnson and Dr Mark Fuller have been elected as Fellows of the Higher Education Authority.

Mathematical and Physical Sciences Faculty

Vice Dean (Equality, Diversity and Inclusion)

Professor Nick Achilleos has been appointed Vice-Dean (Equality, Diversity and Inclusion)

Professor Nick Achilleos writes:

I have been in my current ‘incarnation’ at UCL since being appointed as a new Lecturer in 2007. Equality, diversity and inclusion work has been more of a focus for me in the last few years, and I have met many dedicated and wonderful people at UCL who are continually striving for a better and more equitable working environment for all. I aim to continue the important work done by Professor Alexandra Olaya-Castro, and to also focus on the EDI-related benefits of establishing partnerships between UCL and initiatives, based on compassion, which exist beyond our walls.

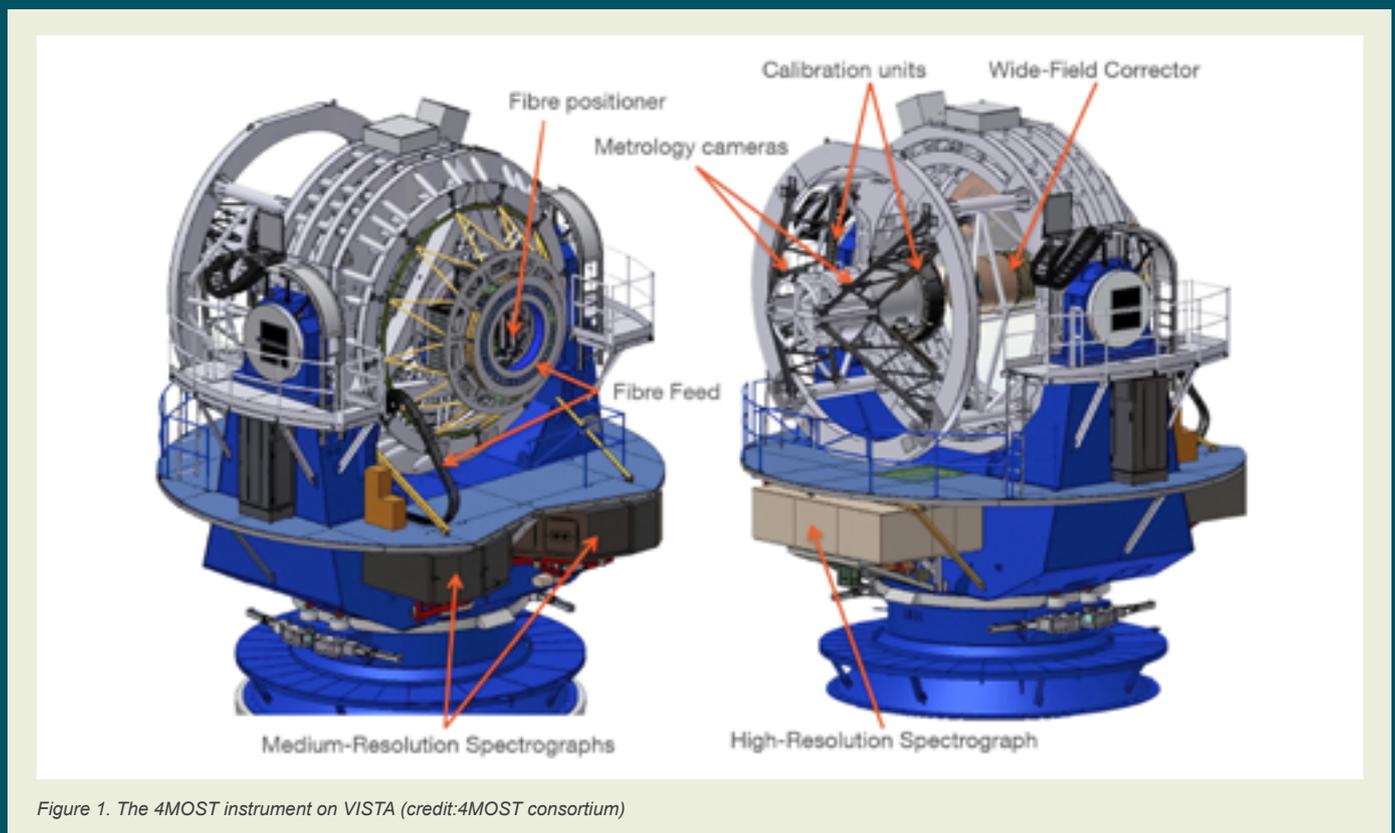
Visiting Professor at Oxford

Professor Ofer Lahav has been elected Visiting Professor at Oxford for a period of 3 years. Ofer plans to use this honorary position to enhance UCL-Oxford links.

Research Headline

4-metre Multi-Object Spectrograph Telescope (4MOST) is a project to build a new multi-object astronomical spectroscopic survey facility that will provide the highest target multiplex on the largest field-of-view in the Southern Hemisphere. This involves building a new instrument that will be installed on the 4.1-m VISTA telescope which is situated at an altitude of 2518m at the ESO Paranal Observatory in northern Chile.

The instrument itself will record 2436 simultaneous spectra over a 4.2 square degree field of view and consists of an optical wide-field corrector (WFC), a tilting spine fibre positioner (AESOP), and three spectrographs giving both high and low spectral resolution.



The goal of 4MOST project is to create a general-purpose and highly efficient spectroscopic survey facility for use of astronomers in the 4MOST consortium and the ESO community. In its first five years of operation 70% of 4MOST time will be dedicated to ten key astronomical surveys. Five of the surveys will focus on galactic and Magellanic Cloud studies, in particular follow up of the GAIA satellite mission. There will also be five Extragalactic surveys that will focus on Active Galactic Nuclei, galaxy clusters, the evolution of galaxies, large scale structure and the spectroscopic follow-up of extragalactic optical transients and variable sources. The remaining 30% of 4MOST time will be open to ESO community led surveys.

The 4MOST data will complement data from several present and future space based and ground based facilities, such the Gaia, eROSITA, EUCLID, and PLATO satellite missions and the Rubin Observatory and Square Kilometre Array (SKA), many of which UCL has direct involvement in.

UCL joined the 4MOST consortium in 2018 and its role in the construction of the 4MOST instrument has been in contributing to the design of the wide field corrector and in the assembly and testing of the corrector in the astronomical instrumentation lab at UCL. The corrector consists of an assembly of four lenses, two of which are doublets (two lenses glued together). The largest lens is 90cm in diameter and the two doublet lenses are mounted in rotary system and act as an atmospheric dispersion corrector (ADC). The lenses are mounted in individual mounts (cells) and these are in turn are mounted in the barrel.

To achieve the optimum performance the lenses have to be mounted in the assembly with an accuracy of ~50 micrometres. This was mainly achieved using contact dial gauges and the use of a precision rotary table. Laser pencil beam systems were also used to check the position of the lenses in the barrel after installation.

The components for the corrector were made in a variety of countries. The glass for the lenses were procured from Corning in the USA and Schott in Germany. The lenses were ground and polished in New Zealand and California, USA. Finally the lenses were coated with a multi-layer anti-reflection coating by Coherent in the USA and shipped to UCL. The lens cells and barrel components were manufactured in Germany and the UK.

The corrector components arrived at UCL through 2020 and 2021- only slightly delayed by the pandemic. The first three lenses arrived at UCL in November 2020 and the last in August 2021.



Figure 2. Dial gauges used to align the L1 lens and cell

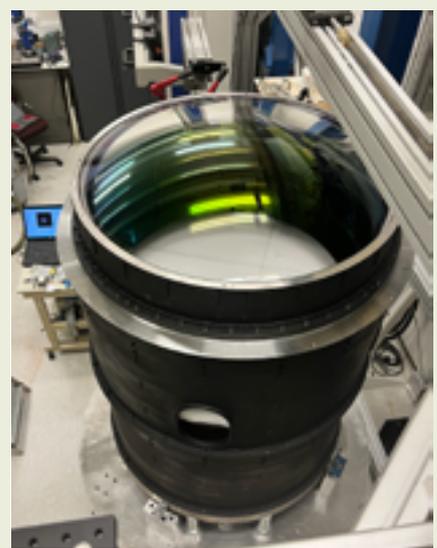


Figure 3. The corrector under pencil beam laser test

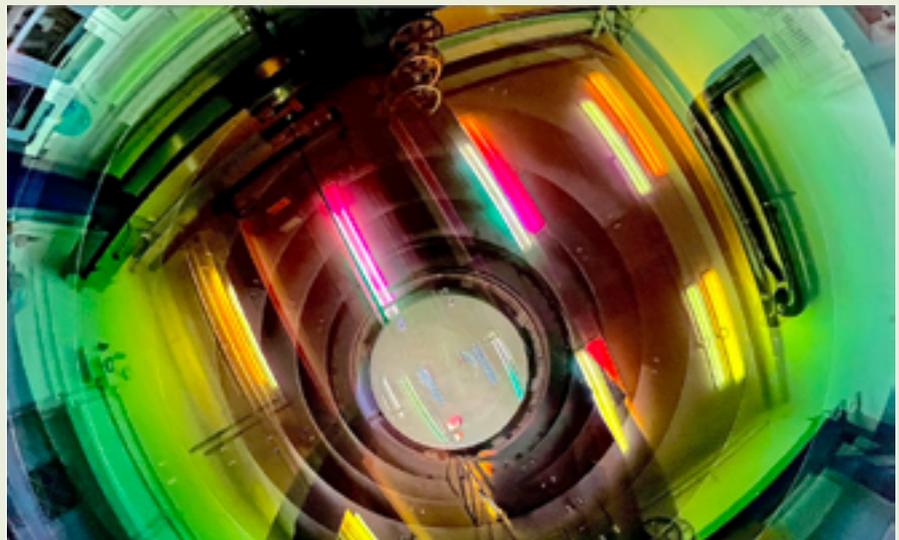


Figure 4. The fully assembled corrector (left) and a picture looking through the lenses (right)

The assembly and test of the corrector was completed in May this year. Getting the 1.5 tonne, 2 metre tall corrector out of the basement in the Physics building was a slightly fraught task with the corrector being hand-winchd out of the Physics yard "pit" and then moved by forklift to the Gower Place entrance where it was carefully loaded into a lorry and transported to the AIP, Potsdam. At the AIP the corrector will be integrated and tested with the AESOP fibre system. The whole instrument is planned to be shipped to VISTA for commissioning in 2023 with the first release of data in 2024.

Peter Doel, David Brooks and Mark Cunningham

Research Degrees

December 2020 – December 2021

Tecla Arcidiacono

Fabrication and characterization of direct and inverse opals for the manipulation of spontaneous emission in conjugated polymers
(Prof F. Cacialli)

Jack S. Baker

Long range order in ferroelectric and antiferroelectric perovskites meets large scale density functional theory
(Prof D. R. Bowler)

Luciana Barros Henaut

Non-classicality as a source of computational power
(Prof D. E Browne)

Sebastian J. Bending

Measurement of 3-flavour neutrino oscillation parameters in the Nova experiment
(Dr A. Holin)

Paul S. Brookes

Protected states and metastable dynamics in superconducting circuits
(Prof S. Bose)

Nathanael P. J. Bullier

Optomechanics with an electrodynamically levitated oscillator
(Prof P. Barker)

Quentin Changeat

Next generation techniques to characterise exoplanetary atmospheres
(Prof G. Tinetti)

Dario V. Conca

Development of novel Optical techniques for the study of cell-surface proteins in living cells at the single molecule level
(Dr I. Llorente Garcia)

Procopios C. Constantinou

Fabrication and characterization of metallic, two-dimensional dopant delta-layers in silicon
(Dr S. Schofield)

Eamon K. Conway

Investigation of high overtone rotational vibrational spectra of small molecules using theoretical methods with primary focus on the water molecule
(Prof J. Tennyson)

Luke K. Davis

Towards a minimal physical model of the nuclear pore complex
(Prof B. W. Hoogenboom)

James A. Farr

Towards precision measurements of large-scale structure with next-generation spectroscopic surveys
(Prof A. Pontzen)

Thomas J. Fletcher

The Ionising Output and Gas Content of Galaxies
(Prof A. Saintonge)

Samuele Giannini

Electronic Transport in Nano-scale Organic Semiconductors from Non-Adiabatic Molecular Dynamics
(Prof J. Blumberger)

Lokesh Gurung

Precision Microwave Spectroscopy of the Positronium $n=2$ Fine Structure
(Prof D. B. Cassidy)

Katherine A. Hammond

Elucidating membrane disruption mechanisms of peptide antibiotics
(Prof B. W Hoogenboom)

Flavien Hardy

Morphology and Dynamics of Saturn's Magnetopause
(Prof N. A Achilleos)

Georgios Kasparis

Pre-Clinical Development of Best-in-Class $Zn_{0.4}Fe_{2.6}O_4$ Magnetic Nanoparticles for Thermal Treatment of Brain Glioblastoma
(Prof N. T. K. Nguyen)

Laurent Kelleter

A Scintillator-Based Range Telescope for Particle Beam Radiotherapy
(Dr S. Jolly)

Vasilis Konstantinidies

Detector corrected cross-sections in topologies sensitive to dark matter production with the ATLAS experiment
(Prof E. L. Nurse)

Isabella Lamperti

Probing galaxy evolution through interstellar dust and gas properties
(Prof A. Saintonge)

Thao P. Le

The emergence of objectivity and the quantum-to-classical transition
(Prof A. Olaya-Castro)

Gleb Lukicov

Alignment of the straw tracking detectors for the Fermilab Muon $g - 2$ experiment and systematic studies for a muon electric dipole moment measurement
(Prof A. M. Lancaster)

Constance R. C. Mahony

Cosmoparticle constraints with large-scale structure
(Prof B. Joachimi)

Thomas D. Meltzer

The Calculation of Electron Collisions with Atoms and Molecules
(Prof J. Tennyson)

Romain A. Meyer

The Role of Galaxies and Quasars in Reionising the High Redshift Intergalactic Medium

(Prof R. Ellis)

Marco Montella

Search for single production of a Vector-Like partner of the bottom quark in the $bH(bb)$ final state in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

(Dr G. G. Hesketh)

Joel Morley

Towards a Weak Measurement of Transverse Momentum in a Matter-Wave Interferometer

(Prof P. Barker)

Alice P. Morris

Search for exotic long-lived particles decaying into hadronic states in the calorimeter of the ATLAS detector at the Large Hadron Collider

(Dr G. G. Hesketh)

Alexandru Paraschiv

Influence of mechanical forces on the self-organisation of biomolecular systems

(Dr A. Saric)

Benjamin J. Parrett

Synthesis and Characterisation of single-crystal transparent conducting oxide: Gallium doped Zinc Antimonate

(Dr R. Perry)

Ravi-Kamal Patel

Electrical Stress Induced Structural Dynamics in Silicon Oxide Resistive Memories

(Prof A. Shluger)

Francesco Rossi

Development of polymer films embedded with anisotropic metal nanoparticles and a photosensitizer dye for antimicrobial purposes

(Prof N. T. K. Nguyen)

Patrick W. Rowe

Accuracy and Transferability in Machine Learned Potentials for Carbon

(Prof A. Michaelides)

Richard Smith

A DFT investigation of Al-based atomically precise epitaxy

(Prof D. R. Bowler)

Michael F. Staddon

Physics of tissue fluidity and collective cell motion in epithelia

(Dr S. Banerjee)

Josh C. Tingey

Convolutional neural networks for the CHIPS neutrino detector R&D project

(Prof J. A. Thomas)

Umit Uktu

Background and sensitivity studies for the LUX-ZEPLIN dark matter experiment

(Dr G. G. Hesketh)

Fang Xie

Radon background studies for the SuperNEMO experiment

(Prof R. Saakyan)

Claudio Arena

Design of a Fine Guidance System for a Low-Earth Orbit Exoplanet Spectroscopy Mission

(Prof G. Savini)

Patrick D. J. Bolton

Exotic Neutrino Interactions as a Probe of Physics Beyond the Standard Model

(Prof F. F. Deppisch)

James A. Chappell

Experimental study of long timescale plasma wakefield evolution

(Dr G. G. Hesketh)

Victoria H. J. Clark

Development of Computational Spectroscopic Methods for the Analysis of Molecular Reactions

(Prof S. Yurchenko)

Yuval Cohen

Radio-frequency atomic magnetometry with a rubidium Bose-Einstein condensate

(Prof F. Renzoni)

Matthew L. Elilis

Development and Application of Mixed Quantum-Classical Non-adiabatic Molecular Dynamics Techniques for Charge Transport in Organic Semiconductors

(Prof F.B. Abdalla)

Alexander J. M. Ferrier

Stochastic phase space methods for non-equilibrium systems

(Prof M. H. Szymanska)

Tomas A. James

Astrophysical shocks and their astrochemical consequences in star forming regions

(Prof S. Viti/Prof J. M. Rawlings)

Rina Kadokura

Electron, positron and positronium cross sections

(Prof G. Laricchia)

Georgios P. Katsoulis

Attosecond phenomena in atoms and molecules driven by intense and ultra-fast laser pulses

(Prof A. Emmanouilidou)

Cristobal Lledo Veloso

Dissipative phase transitions in light-matter lattice systems

(Prof M. H. Szymanska)

Oliver H. Lunt

Phases and phase transitions in non-equilibrium quantum matter

(Dr A. Pal)

Christian T. Pedersen

Neutrino mass and cosmology from the Lyman-alpha forest

(Prof O. Lahav/Prof T. Kitching)

Tanapoom Poomaradee

Towards ultracold Caesium isomers

(Prof F. Renzoni)

Thomas R. Sruby

Logical Gates by Code Deformation in Topological Quantum Codes

(Prof D. E. Browne)

Portrait of...

Ian Ford

The path Ian took to become a physicist is quite convoluted, and the backstory to his current position in the Condensed Matter and Materials Physics group even more so. At school, in Plymouth, chemistry was his favourite subject, and why not? There, he came across atomic orbitals and quantum numbers while physics seemed to revolve around connecting batteries across incandescent bulbs. Furthermore, his brother, the first in the family to go to university, had chosen physics, so it seemed sensible not to establish a pattern. But the Natural Sciences degree at Cambridge allowed Ian to realise that, in actual fact, they went rather more deeply into quantum mechanics (and light bulbs) in the Physics Department, so he switched his allegiance, and not for the last time.

Ian's chemistry teacher Roy Axell had, however, instilled an interest that was not so easy to shake off. He introduced him, one afternoon, to the off-syllabus mysteries of entropy and the second law of thermodynamics, topics which he works on to this day.

Ian's DPhil at Oxford was where he really got to grips with statistical physics, though not in the typical condensed matter areas of application. He calculated spin-dependent interactions between quarks using quantum chromodynamics in its lattice gauge theory representation. He worked under the supervision of Dick Dalitz, an illustrious particle physicist to whom he feels indebted in many ways. One of these, he discovered recently at a conference dinner, was in providing him with a blue-chip academic ancestry: Dick's supervisor was none other than Wolfgang Pauli. Ian enjoys the warmth of bathing in reflected glory!

After Ian had finished with quarks, for all their strangeness and charm, he joined the Harwell Laboratory of the UK Atomic Energy Authority (UKAEA) where he was involved in research in a great variety of topics. He was particularly taken by the phenomenon of nanoparticle nucleation from the gas phase, where the statistical physics of molecular interactions was the main theoretical tool and entropy change a key ingredient. It introduced him to the, then niche, area of aerosol science, which in recent years has become more widely appreciated for the central roles it plays in atmospheric pollution, global climate change and human respiratory health. Ian also worked on aspects of materials science, solid and fluid mechanics and laser-atom interactions. But after eight years at Harwell, including a period of attachment to the Department of Materials at Oxford funded by a Royal Society Industrial Fellowship, and with key support from Marshall Stoneham, Ian joined the Condensed Matter and Materials Physics group at UCL, where he has been ever since.

Ian feels that his path in science could be described as a stochastic or random process! But also that this is not necessarily a bad thing. He has found there are many interesting problems in transdisciplinary science, where a variety of approaches and a broad perspective are key. And working with different groups of people has been stimulating. His publications have consequently



appeared in a wide range of journals, including numerous parts of Physical Review and Journal of Physics, and also Biophysical Journal, Crystal Growth and Design, Journal of Geophysical Research, Nuclear Engineering and Design, even Monthly Notices of the Royal Astronomical Society! And, in making peace with his earlier abandonment of the discipline, Ian has contributed to Journal of Physical Chemistry.

Ian currently works on the theory of the nucleation and growth of new phases, both liquid and crystalline, as well as soft matter problems in biology, particularly molecular transport through polymer tangles. These are all nonequilibrium thermodynamic processes, often described using stochastic mathematics. He has also been active in an area of statistical physics called stochastic thermodynamics. This is thermodynamics for the 21st century, where fluctuations are incorporated and through which many

peculiarities of the discipline can be demystified. In particular, he has studied the irreversibility of processes in classical and quantum systems using the concept of stochastic entropy production. He is part way towards convincing himself that characterising irreversibility in quantum mechanics is not so very different from doing so in classical mechanics; that the collapse of the wavefunction, normally considered absolutely irreversible in contrast to anything in classical physics, is potentially reversible and therefore associated with finite amounts of entropy production. He likes to think that the world is evolving as Newton had it: in a fundamentally deterministic fashion in spite of quantum uncertainty, such that the future is entirely encoded in the present state of the world. He is interested in the issues that this raises, though the premise could be entirely wrong!

Ian has taught statistical physics at various levels, as well as solid state physics and stochastic mathematics, and published a textbook entitled 'Statistical Physics: an Entropic Approach' based on his second year module. His research directs his teaching efforts, and vice versa. He has served as Physics Programme Tutor and Chair of the Departmental Exam Board. Ian is currently involved in the UCL Natural Sciences undergraduate degree programme, that encourages students to acquire the broad viewpoint that is so important in solving real scientific problems. He has been President of the Aerosol Society of the UK and Ireland.

Time's arrow takes a central position in his research, and the growth of entropy that it represents is often characterised as a gloomy business of degeneration and decay. On the other hand, Ian prefers to teach a more cheerful interpretation; that the second law is just as much responsible for construction as destruction. In this connection, he looks after a large mature garden at home. Entropy is constantly being produced and yet amazingly complex living structures are maintained, at least in a cyclic fashion, all driven by whatever caused the Big Bang. Talking of which, he notes that Amy Farrah Fowler, in *The Big Bang Theory*, is asked 'How's your life?' She replies, perhaps not as positively as he would like: 'Just like everyone else's.' Subject to entropy, decay, and eventual death. Thank you for asking.'

Tony Harker writes:

Tony Harker (Deputy Head of Department 2004-2013) was at Harwell when Ian joined the Theoretical Physics Division there, and always respected Ian's ability to work with precision and insight across a variety of fields. At that time there were ever-increasing pressures within UKAEA for work on applied topics, and Ian made valuable contributions in areas ranging from nuclear reactor safety to laser isotope separation. Whenever Ian entered a new field you could be sure that he would not be content with just making an incremental change based on the latest few papers: he would track back through the literature to be sure that anything he did was based on sound underlying principles and rigid derivations. When he moved to UCL Ian applied his attention to detail to providing carefully crafted lectures, and later to overseeing the Department's examinations with an eye for clarity and fairness. It is good to see the Natural Sciences programme benefitting from his breadth of experience in the same way as the Department did during his time as Physics Programme Tutor. Keep enjoying the entropy, Ian.

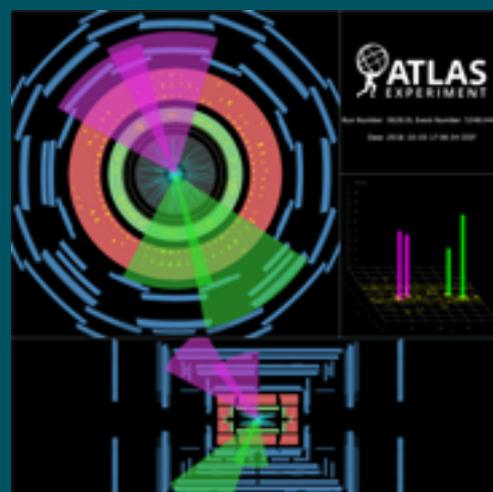
Research Headline

Searching for Higgs Pair Production at the LHC

This summer marks the 10th anniversary of the discovery of the Higgs boson by the ATLAS and CMS collaborations at the LHC. Since then, a large number of studies have produced impressive results on the Higgs boson properties, with the UCL ATLAS team playing a leading role in the first-ever observation of the dominant Higgs decay mode $H \rightarrow b\bar{b}$. So far, all such measurements agree with the theoretical predictions of the Standard Model (SM) of Particle Physics, but the uncertainties are dominated by limited statistics, despite the vast amounts of data delivered by the LHC, because the processes leading to Higgs boson production are extremely rare compared to other "background" processes.

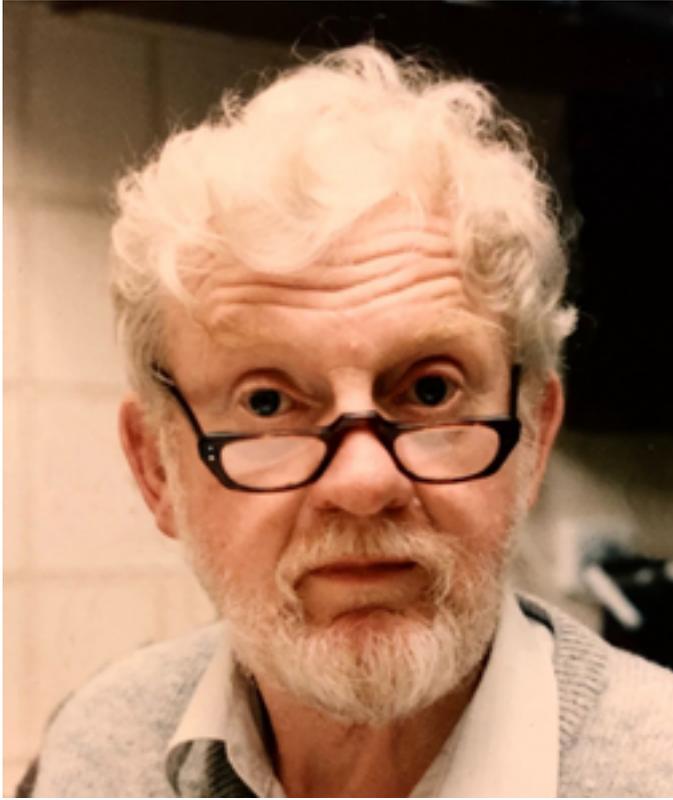
The UCL ATLAS team led by Professor Nikos Konstantinidis has also pioneered and been playing a leading role in the search for an even rarer, yet unobserved, process - the pair-production of Higgs bosons. This is the only process in the SM involving the interaction of three identical particles (three Higgs bosons meet in the same vertex of a Feynman diagram), provides a unique probe of the shape of the Higgs field potential (the famous "Mexican hat") and promises to shed light on the nature of the Electroweak Phase Transition, which could connect the Higgs boson field to cosmological inflation. The latest ATLAS result (<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2022-035/>)

in the final state $HH \rightarrow b\bar{b}b\bar{b}$, presented in June 2022, shows that the Higgs-pair production cross section is smaller than 5.4 times the SM expectation, adding to the excitement for the prospect of observing this extremely rare process after combining all possible final states and analysing the data from Run-3 of the LHC, which is starting in July 2022 and will continue until late 2025, at a new record centre-of-mass energy of 13.6 TeV.



An LHC collision event recorded by the ATLAS detector. The event has a topology consistent with Higgs pair production and decay via $HH \rightarrow b\bar{b}b\bar{b}$.

In Memoriam



David Aitken

We are sorry to report the death on August 10th of Dr David Aitken, a former member of staff of the Department. Dave obtained his PhD in 1957 working with Franz Heymann in the Nuclear Physics Group.

One of his first papers, published with Dick Jennings, describes the design and operation of a 29 MeV Microtron. Following his appointment in the early 1960's as a Lecturer in the Department, Dave worked on nuclear physics instrumentation until deciding in 1970 to set up a team in the nascent field of mid-infrared astronomy. In 1971 he published a paper describing the first flux measurement of the Crab Nebula at a wavelength of 10 microns, obtained with a bolometer mounted on the 24-inch telescope at the College's Mill Hill Observatory. Subsequent papers, obtained with a 1.5m telescope on Tenerife, reported the first 8-13 micron spectrum of Jupiter and the first detection of an ionized gas infrared fine structure line from the Galactic Centre. The subsequent commissioning of the 3.9m Anglo-Australian Telescope and the 3.8m UKIRT on Mauna Kea provided Dave and his group with the opportunity to establish a world-leading position in mid-infrared astronomy using spectrometers that they had built in the Department. In 1981 David left the UK for a position at ADFA in Canberra, Australia, where with his team he continued his innovative work in infrared astronomy, developing novel polarimeters and imagers until his retirement and return to the UK in 1998, where he continued to work, with his most recent paper being published in 2008. He trained and mentored several generations of infrared astronomers and leaves a lasting impact on the field. We extend our condolences to David's family.

Mike Barlow and Pat Roche



Michael Duff

I have sadly been informed that Professor Michael Duff passed away on 29 December 2021, aged 88.

He headed the UCL Image Processing Group who developed a series of Cellular Logic Image Processors (CLIP). It was for the CLIP programme that he received the British Society Award for technical innovation in 1985. He was also made a fellow of the International Association for Pattern Recognition (IAPR) in 1994 for "contributions to architecture for parallel processing and outstanding leadership". The IAPR dedicated their Jan 2022 newsletter from page 12 onwards to him - <https://iapr.org/docs/newsletter-2022-01.pdf>

In the 1990s Professor Duff was also head of postgraduate admissions in the department.

Raman Prinja

John Bartley

We are sad to announce the death in May 2022 of Dr John Bartley, a retired member of the Department of Physics and Astronomy who made important contributions to teaching in the undergraduate laboratories and had been chair of the undergraduate teaching committee.

He grew up in the dockyards area of Liverpool, where he was a teenage contemporary of John Lennon and other members of the Beatles.

He did his PhD work at Liverpool University, using their Synchrocyclotron. His thesis, on A Search for Neutrinoless Decay Modes of the Muon, was presented in 1966 after that, he spent some years working at the CERN laboratory in Geneva, using heavy -liquid bubble chambers for studies of neutrino interactions and of hyperon decay. From there he moved to teach, and to join Professor Jack Schneps' research group, at Tufts University in Medford Massachusetts. UCL then recruited him to a lectureship a, filling a gap in the heavy -liquid bubble chamber team, and

advising several Ph D students, including Tofiqh Azemooon. The Bubble Chamber Group eventually amalgamated with other groups in Physics and Astronomy to form the current HEP Group, to which John belonged until he retired in 2008.

As a colleague in Physics, he was hard-working and a good team player. That was also true when he played in Departmental staff-student soccer matches and, in the, continuing, UK-wide Inter-Bubble-Chamber Groups soccer tournament., where he once scored the winning goal for UCL against Imperial College on their home pitch in Hyde Park.

David Miller



Members of the Bubble Chamber and Emulsion Groups, taken some time between 1969 and 1971.

Back row L-R:[unknown]; Rüdiger Schäffer; John Wybourn; Gerry Busby; Tofiq Azemooon; Martin Palmer

Middle row L-R:Ted Wragg; John Bartley; Linda Brum; Jackie Gordon; Doris Chapman; Nina Azemooon; Elaine Stafford; Roger Worthington; Eric Strachan

Front row L-R:[unknown]; Denise Brown; David Miller; Mike Esten; Fred Bullock; Sue Clarke; Lyn Larson; [unknown; later married Brian Letchford]

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Russell Stannard OBE: 1931-2022

Russell Stannard died on 4 July 2022, after a period of Long Covid. He grew up in Lambeth, in London, just South of the Thames, not far from the Houses of Parliament. He attended Archbishop Tenison's School, which overlooks the Kennington Oval cricket ground closely enough that one could watch Test Matches or Surrey County games from the classroom or laboratory windows. He once said that he chose to study science because he could watch cricket from the Physics laboratory. Alec Bedser was one of his idols.



He came to UCL as an undergraduate in 1950 and gained his BSc in 1953. After graduating he took his PhD with the cloud chamber group under Eric Burhop, working on "Susie", a high-pressure cloud chamber (at that time the standard method for studying sub-atomic particles) in 1956-7. The chamber was on Mount Marmolada in the Dolomites in north-eastern Italy; access to the lab involved a 3 hour climb up the mountain, and the equipment itself was extremely dangerous; on one occasion he received an electric shock that was "eight times more powerful than what you would get from sticking your fingers in a 240-volt light socket. His body jack-knifed and he was involuntarily flung across the laboratory. There was the smell of burning flesh. He believed that he had been literally within an inch of being killed".

After the completion of his cloud chamber work, Stannard moved to Eric Burhop's nuclear emulsion group, investigating the interactions and decays of particles including K mesons and sigma hyperons. This work was a collaboration with groups at Bristol, Brussels, Dublin, Milan and Padua.

In the late 1950s it became clear that the bubble chamber, invented by Donald Glaser would become the dominant particle detector. Sir Harrie Massey, head of the UCL Physics Department wished to join in with the development of this new device for research in Particle Physics. He seconded Cyril Dodd from UCL to work with Glaser's group in Michigan, where Cyril did tests which he convinced Glaser and colleagues that clear tracks of bubbles could be seen in a heavy liquid like propane.

Wilson Powell, at the University of California, Berkeley, exploited this idea by building a specialised "Heavy Liquid Bubble Chamber," which could be filled with either propane or a Freon to observe the interactions and decays of particles from the secondary beams produce by the Bevatron proton accelerator.

Russell Stannard was seconded by Massey in 1959 to visit Powell's group in Berkeley to find out how serious Particle Physics was being done with the photographs of tracks in the heavy-liquid chamber.

Before Russell returned to London, UCL was invited to join a collaboration, led by Powell's Berkeley group, with participation from other US laboratories, to complete the analysis of the film from a Bevatron run with the heavy-liquid chamber in a secondary beam of K minus mesons.

In order to scan and measure the UCL share of the film, a special scanning laboratory was set up in a set of connected rooms in an obscure corner of Foster Court, close to the Science Library. Some of the nearby rooms were occupied by a team of physicists, engineers and technicians, led by Harry Tomlinson, Cyril Henderson and Cyril Dodd, together with postdocs George Kalmus and Fred Bullock. Based on information from Wilson Powell's group, they began to design what was to become the "British National Heavy Liquid Bubble Chamber," which was intended to be used in secondary beams from the NIMROD proton accelerator at the newly founded Rutherford Laboratory (now called RAL) near Harwell.

The scanning group and the design group were soon amalgamated under the leadership of Cyril Henderson.

Russell gave many lecture courses to Physics undergraduates, including a new "Introduction to Modern Physics," which continued for many years after he left UCL, and was, since then, extended to include "Astronomy," after all the UCL Physicists and Astronomers were amalgamated into one department. He also supervised some final year laboratory projects, including my own, in which I constructed a diffusion cloud chamber which gave clear particle tracks from a radioactive source and from cosmic rays. I then discovered what a keen and supportive person he was.

Russell took charge of organising the team of scanners in Foster Court, many of them school leavers, together with PhD students, Physic staff and postdocs.

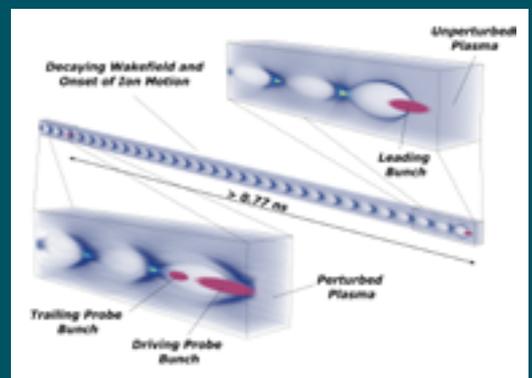
As down-to earth experimenters, neither Cyril nor Russell were involved in the deeper mathematical mysteries of Elementary Particle theory but they thought it was worth sending us PhD students to theory lectures and to theory summer schools.

Russell left UCL in 1969 to help set up the physics department at the newly founded Open University (OU), and became a prominent member of the department there, becoming a professor in 1971, head of physics from 1971-92, and pro-vice chancellor from 1974-76. He was President of the Institute of Physics from 1987-91.

Headline Research

Recovery Time of a Plasma Wakefield Accelerator

The UCL HEP group have been collaborating with DESY, Hamburg on the FLASHForward experiment that aims to demonstrate plasma wakefield acceleration with electron bunches as a useable technology. Much like with lasers or bunches of protons, bunches of electrons can excite electric fields in plasma that can be harnessed to accelerate particles to high energies over distances much shorter than conventional radio-frequency accelerators. This could yield shorter and cheaper accelerators in high energy particle physics, for free-electron lasers and for use in medicine. In particle physics, as well as high energy, one of the key properties of the accelerators is the luminosity, which depends on various aspects of the bunches, including the frequency of accelerating bunches which is required to be above the kHz scale. We addressed this in a recent paper published in *Nature* (603 (2022) 58) as well as being the main subject of PhD student James Chappell's thesis. In this experiment, we injected a leading bunch of electrons to drive a strong wakefield and used two probe bunches to sample the perturbed plasma (see associated Figure). The spacing between the leading and probe bunches was varied in increments of 0.77 ns and the properties of the two probe bunches were measured. It was found that after about 63 ns, there was no effect of the initial leading bunch on the two probed bunches, i.e. the plasma had returned to its unperturbed state. This means that for this configuration, particles could be reproducibly accelerated to high energy with a 63 ns spacing which provides a frequency limit of about 15 MHz as the repetition rate for particle acceleration. Hence plasma accelerators of the future can in principle attain the high luminosities and brilliances needed for particle physics and photon science.



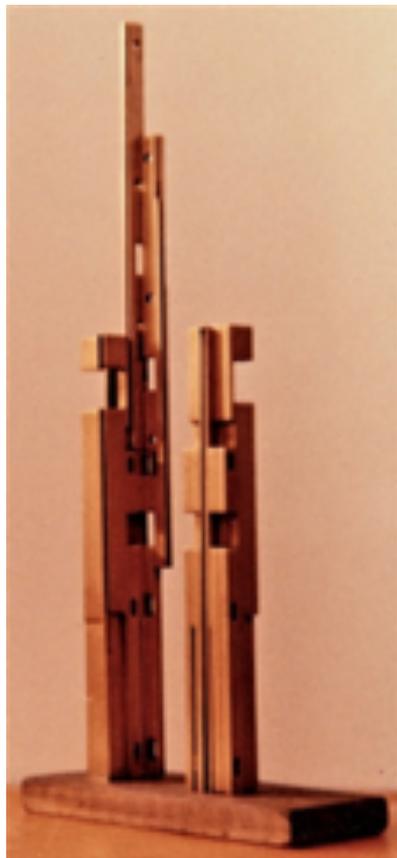
A schematic of the setup used by the FLASHForward experiment to determine how plasma perturbation by the leading electron bunch affects a subsequently injected bunch.

At the OU, he brokered a collaboration with the UCL physics department to teach a joint course in quantum mechanics, which was widely acclaimed. His OU colleague David Broadhurst describes him as “an innovative teacher, always seeking to render what others considered as abstruse to be comprehensible to dedicated adult learners”. Another OU colleague, John Bolton, found the OU department to be “happier and more collegiate than others around us” under his leadership, while Bob Lambourne remembers his practice of giving copies of “Complete Plain Words”, Sir Ernest Gower’s essential guide to clear English, to all new academics. He continued his particle physics research at the OU, setting up an emulsion group there, and discovered one of the first three tracks from a charmed particle in nuclear emulsion while working at the OU.

He became interested in the interface between science and religion, and was for 12 years a trustee of the John Templeton Foundation, whose vision is “to advance our understanding of the deepest and most perplexing questions facing humankind”. His son Adrian notes that this work “brought together two naturally opposing views in the church and science, [and] found a way to marry them and bring people together.”

In the 1990s, he was commissioned by Cambridge University Press to write an updated version of George Gamow’s “Mr Tompkins” popular-science books. He also published his own series of physics-related children’s books, the “Uncle Albert” series., including “The Time and Space of Uncle Albert,” in which a cartoon character looking like Einstein gives a simplified intuitive explanation of some of the paradoxes of Special Relativity.

He was a keen self-taught amateur sculptor, strongly influenced by the work of Henry Moore, and had some of his works on display at the OU. Some of his creations were inspired by pieces of physics equipment, such as a piece (shown above) entitled “City Structures” which is based on part of a machine used for scanning nuclear emulsions.



City Structures Credit: Jim Grozier

In 1998 Russell Stannard was awarded the OBE for “contributions to physics, the Open University and the popularisation of science”.

He is survived by his wife Maggi and his four children.

David Miller

Contributors: Jim Grozier, George Kalmus, Bob Lambourne, David Broadhurst, John Bolton, Bill Knight. and Stephen Lewis.

Staff News



Attendees at Mike Barlow's retirement event.

Retirement



Mike Barlow

May 2022 saw the retirement of Mike Barlow, Professor of Astrophysics in the Department of Physics and Astronomy.

Mike did his thesis studies at the University of Sussex, advised by Roger Tayler. He subsequently worked at the University of California, Berkeley; at JILA, University of Colorado; and at the Anglo-Australian Observatory. Returning from the AAO to the UK in 1979, he held an Advanced Fellowship at UCL before being appointed to a 'New Blood' Lectureship in 1983 – the first new departmental appointment for 11 years! He was promoted to Reader in 1989, becoming a Professor of Astrophysics in 1994. From 2004-2007, Mike served as Head of Teaching, introducing the Workload Management Scheme (WMS), as a tool to help equalise, as far as possible, the teaching and admin loads of staff. From 2011-2016, he served as Head of the Astrophysics Group.

During his time at UCL, he was involved in the production and commissioning of the CGS3 mid-infrared spectrometer for UKIRT and the Ultra-High Resolution Facility (UHRF) for the Anglo-Australian Telescope. He was a Co-I of the Long Wave Spectrometer (LWS) instrument for ESA's Infrared Space Observatory and a member of the SPIRE Science Team for ESA's Herschel Space Observatory. He is currently a member of the European Science Team for the JWST-MIRI instrument. His current research interests include dust physics, observational and theoretical studies aimed at elucidating whether supernovae are

significant dust contributors to galaxies, as well as observational and numerical modelling studies of nebulae and evolved stars in our own and other galaxies.

Mike aims to maintain his research profile during retirement, with several Cycle 1 JWST programmes to be carried out from July keeping him busy.

To celebrate Mike's many achievements and contributions as a scientist, mentor and colleague, a retirement event was held on Thursday 26th of May. Attendees and speakers joined in person at UCL and online for a series of scientific talks from close collaborators/friends, followed by an evening reception in the Jeremy Bentham Room. Of the many former colleagues and students who were able to attend, two had travelled from as far afield as Canada and Chile to be there. Mike commented, "I was overwhelmed by the event, attended by so many friends from UCL, as well as from far away!"

Joanna Fabbri

Project Manager for Mike Barlow and Ingo Waldmann; Scientific Officer, The Centre for Planetary Sciences at UCL/ Birkbeck

Promotions 2021-22

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 Anasuya Aruliah (Astro)

Professor of Auroral Physics

Professor Gavin Hesketh (HEP)

Professor of Physics

Professor Andreas Korn (HEP)

Professor of Physics

Professor Edina Rosta (CMMP)

Professor of Molecular Modelling

Promotion to Associate Professor

Dr Rebecca Chislett (HEP)

Associate Professor

Dr Roger Johnson (CMMP)

Associate Professor

Promotion to Associate Professor (Teaching)

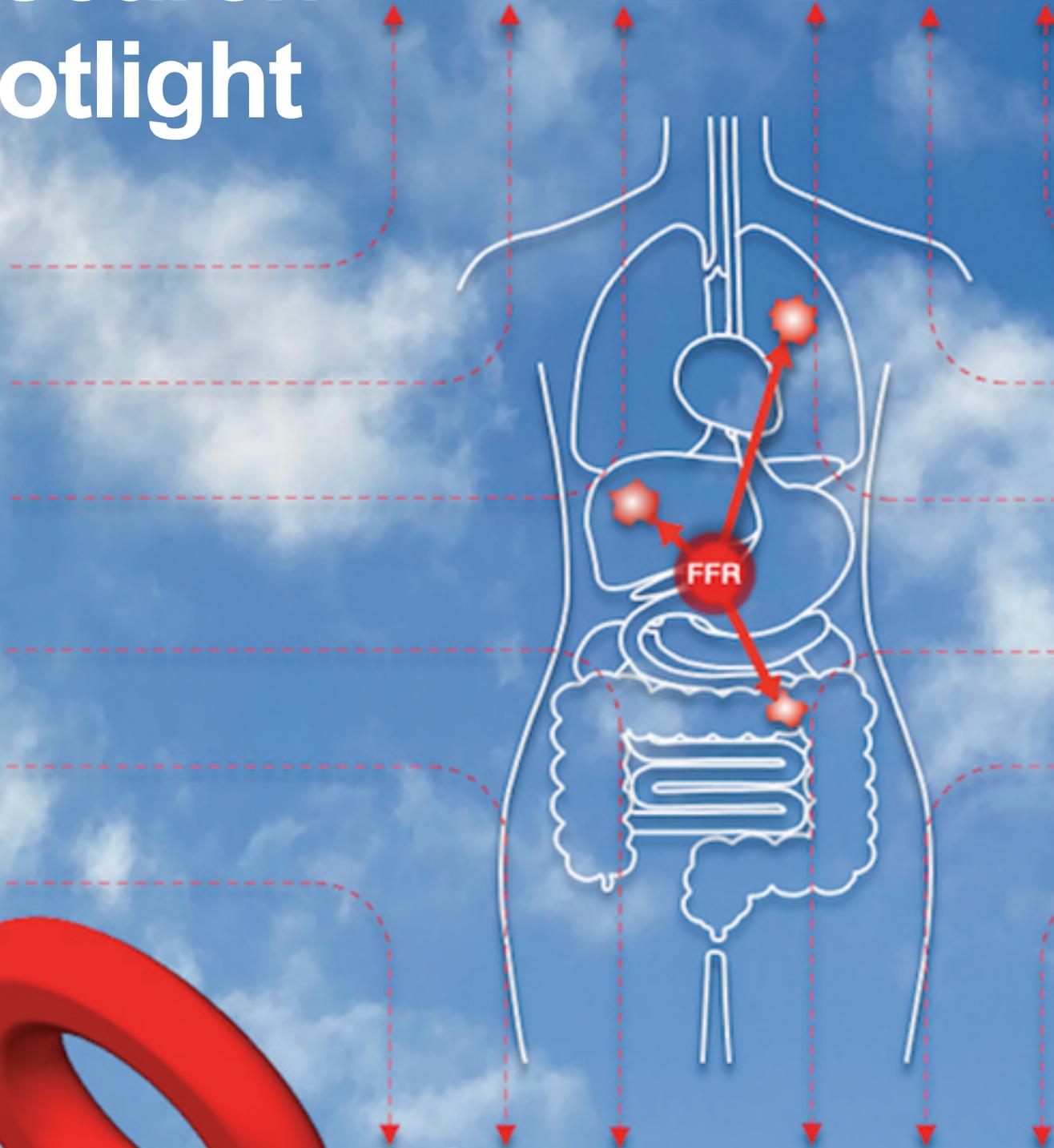
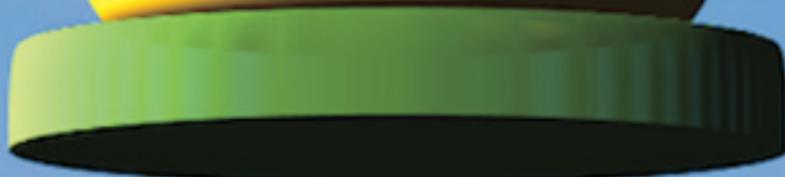
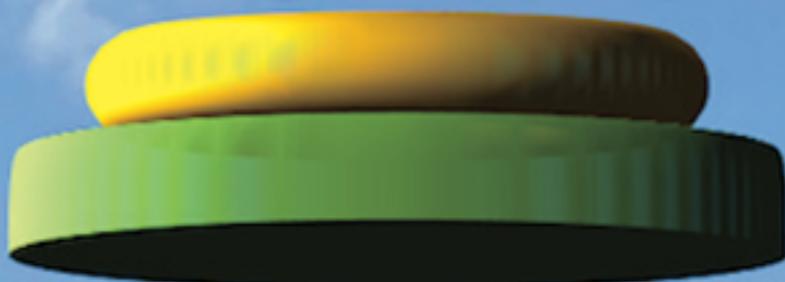
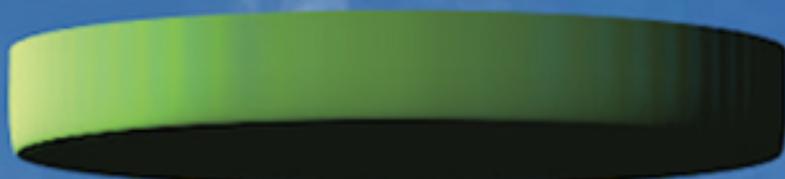
Dr Jasvir Bhamrah

Associate Professor (Teaching)



Mike with his former PhD students at the retirement event. From left to right: Felix Priestley; Roger Sylvester; Maria Niculescu-Duvaz; Oskar Karczewski; Antonia Bevan; Dave Stock; Mike Barlow; John Deacon; Patrick Owen; Nick Wright; Jo Fabbri; Antonio Hales; Barbara Ercolano

Research Spotlight



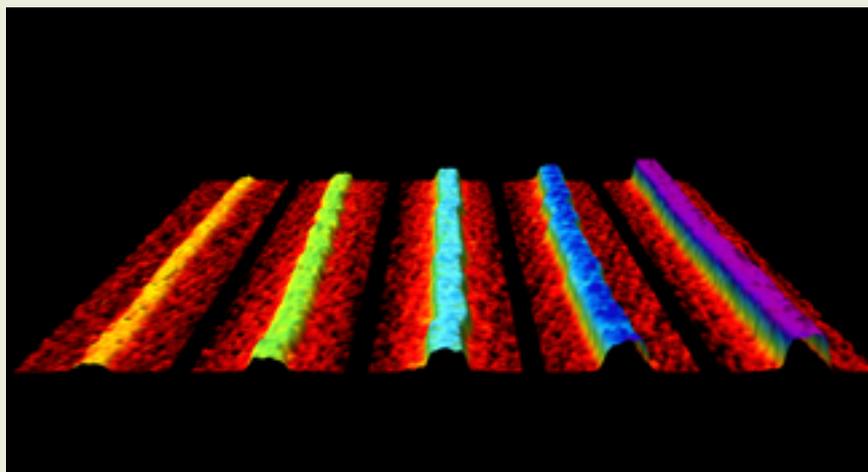
Condensed Matter And Material Physics (CMMP)

The CMMP group comprises has 24 academics (including partial appointments) and their groups, who research a diverse range of subjects in condensed matter physics. Broadly, the research activities in the group may be divided into theory, materials modelling, central facilities experimentation (X-ray and neutron scattering) and in-house experimentation. Several academic staff have been promoted this year: Drs. Pavlo Zubko and Stan Zochowski to Professor and Dr. Arijet Pal to Associate Professor

This year, the CMMP group has welcomed the arrival of Dr. Jon Breeze, who has come from Imperial College. Dr. Breeze is an expert in cavity quantum electrodynamics and its experimental applications, and is notably the co-inventor of the room temperature maser, the microwave equivalent of a laser, that has previously only been available at low temperatures. In particular, with colleagues from Imperial College, Dr. Breeze first demonstrated room-temperature maser action based on nitrogen–vacancy defect centres in diamond. Later, with colleagues from the London Centre for Nanotechnology at UCL, he extended this work to show how use of an organic molecular crystal allows a room temperature maser to be operated in air and in the earth's magnetic field. Dr. Breeze will continue and develop this work in his laboratory at UCL and brings an exciting new dimension to experimental activity in the CMMP group.

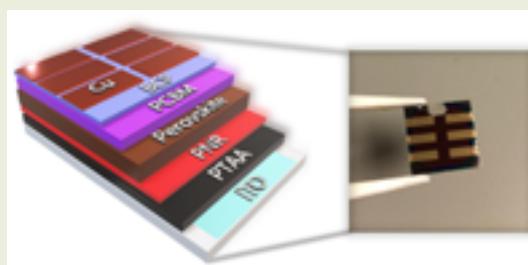
Professor Chris Howard and his group have continued their pioneering studies of phosphorene nanoribbons and their applications, having discovered these in 2019. These are ribbon-like strands of the 2D material phosphorous, which, similar to graphene, are made of single-atom-thick layers of atoms. This year, in a study led by UCL and Imperial College London researchers, the nanoribbons have been incorporated into new types of solar cells, dramatically improving the cells' efficiency,

The solar cells work has, in fact realised some transformative properties of phosphorene nanoribbons, that were theoretically predicted but not yet realised. Indeed there have been hundreds of theoretical studies predicting exciting and applicable properties of phosphorene nanoribbons, but the latest work is the first time that such properties have been demonstrated experimentally. The team incorporated the nanoribbons into solar cells made from perovskites – a new class



Phosphorene nanoribbons (PNRs) are ribbon-like strands of the 2D material phosphorous, which, similar to graphene, are made of single-atom-thick layers of atoms.

of materials that hold promise as scientists can easily change how they interact with light to suit a range of applications. Contrary to traditional inflexible silicon-based solar cells, perovskite solar cells can be made from liquid solutions, facilitating low-cost printing into thin, flexible films. The nanoribbons can be simply printed as an extra layer to improve device functionality and efficiency. By including the nanoribbons, the team were able to produce perovskite solar cells with an efficiency above 21 per cent, and on a par with traditional silicon solar cells.



Micrograph of the solar cell device (right), created from an inverted perovskite solar cell device stack (left) with phosphorene nanoribbons (PNR) sandwiched between poly(triarylamine) (PTAA) and the perovskite (BC, bathocuproine; fullerene derivative, PCBM and indium tin oxide, ITO). (credit Thomas J Macdonald, Thomas Webb).

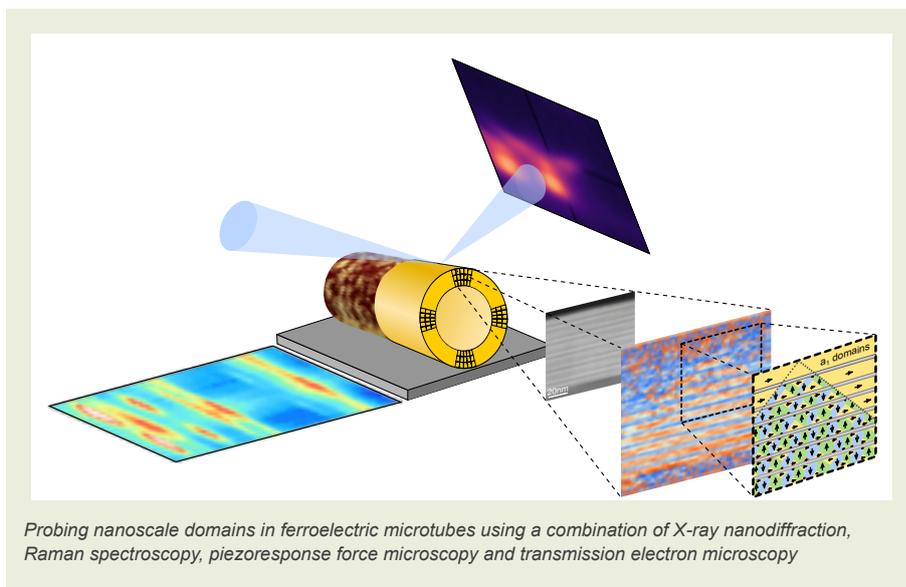
They also showed how the nanoribbons improve the mobility of “holes” (the opposite partner of electrons in electrical transport), so improving their mobility and assisting electrical current flow between layers of the device.

This year there has also been progress in understanding and manipulating ferroelectric materials: that is, materials with a spontaneous and electrically switchable polarization, of particular interest with respect to computer memory. Devices are getting smaller and smaller and at the nanoscale, ferroelectrics are strongly influenced by the mechanical and electrical boundary conditions, which give rise to intricate polarization patterns and unusual phenomena such as negative capacitance that could be applied to more power

efficient transistors. At the same time, there is a strong interest in ferroelectricity in non-planar structures, motivated by the drive to integrate ferroelectrics into 3-dimensional device architectures that would increase the storage density of non-volatile memories.

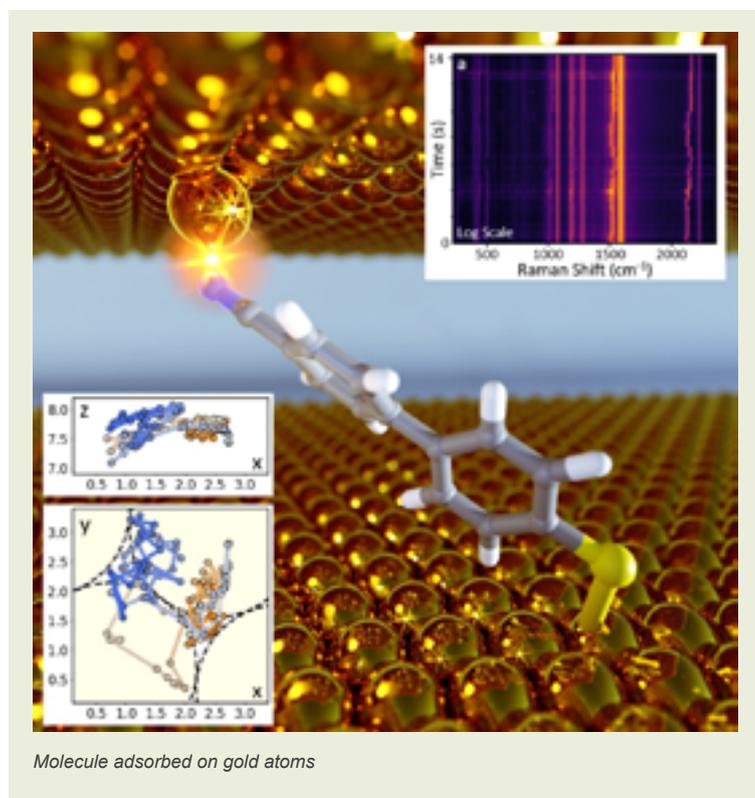
Writing in the journal *Advanced Materials*, CMMP's Professor Pavlo Zubko with other UCL colleagues and an international team of researchers from UK, France, Sweden, Switzerland, Ireland and the Netherlands, have investigated how the competing effects of electrostatic and mechanical forces in nanoscale ferroelectric membranes lead to the appearance of complex nanoscale polarization patterns (or domain structures) and a spontaneous bending of the material, allowing the team to study the behaviour of ferroelectric domains in curved geometries.

The team sequentially deposited alternating layers of ferroelectric and non-ferroelectric oxides, each only a few nanometers thick, to create an ultrathin, artificially layered crystal or superlattice. By releasing the superlattice from its underlying support, the researchers then altered the balance between the electrostatic and mechanical interactions



between the constituent layers, causing the released membrane to roll up into a microscopic tube. Using an arsenal of advanced characterization techniques such as X-ray nano-diffraction imaging, Raman scattering and atomic-force and transmission-electron microscopies, the team was able to image the complex nanoscale domain patterns in these curved nanoscale crystals, observe how they change throughout the thickness of the tube, and reveal how they evolve when the tube was mechanically deformed.

Such superlattices, where the electrostatic and elastic interactions can be tuned through careful choice of constituent materials and their thicknesses offer exciting possibilities for designing flexible, adaptive materials with enhanced electromechanical properties.



The CMMP group has a strong presence in materials modelling. This year, Dr. Edina Rosta and her group have linked with the NanoPhotonics group of Cavendish Laboratory in Cambridge to apply computer modelling alongside experiment to reveal the motion of molecules at sub-angstrom resolution. Surface-enhanced Raman spectroscopy is a technique that can in principle be used to determine the vibrations of single molecules but the complex spectra need to be interpreted theoretically. In the experimental setup, monolayers of organic molecules were confined within gaps in gold surfaces. The molecules were situated within the confined optical fields of the plasmonic metals giving an enhancement in scattering and absorption; these allowed the researchers to obtain high-intensity, time-resolved Raman spectra of optically generated surface gold adatoms anchored to single molecules. The Density functional theory (DFT) models of the CMMP group demonstrated the sensitivity of the vibrational peak positions on the adatom location relative to the organic molecule. The chemical perturbation of the coordination is transferred to more than ten bonds away and distorts the vibrational modes. By matching the computational and experimental spectra, the researchers propose a reconstruction of the adatom trajectories that are comprised of sub-angstrom steps restricted close to a flat plane.

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Astrophysics (Astro)

A new view of the Universe from James Webb Space Telescope

The James Webb Space Telescope (JWST), the \$10 billion successor of the highly successful Hubble Space Telescope, was launched on Christmas Day on Ariane 5 from French Guyana.

The mission – a partnership between NASA, the European Space Agency (ESA) and the Canadian Space Agency (CSA) – is expected to make breakthrough discoveries in all fields of astronomy by investigating the light of the Universe at (invisible) infrared wavelengths.

After 1 month on a transfer trajectory, the observatory operates at approximately 1.5 million kilometres from Earth, in an orbit around the second Lagrange point of the Sun-Earth system, L2.

It has a large 6.5-metre segmented mirror that will collect almost six times more light than Hubble. A giant, five layered shield protects the telescope and the instruments from the light and heat of the Sun. At 22 × 12 metres, this is about the size of a tennis court (Fig. 1). JWST carries four state-of-the-art science instruments: the MIRI mid-infrared camera and spectrograph, the NIRSpec near-infrared spectrograph, the NIRCам near-infrared camera, and the FGS-NIRISS combined fine guidance sensor and near-infrared imager and slitless spectrograph.

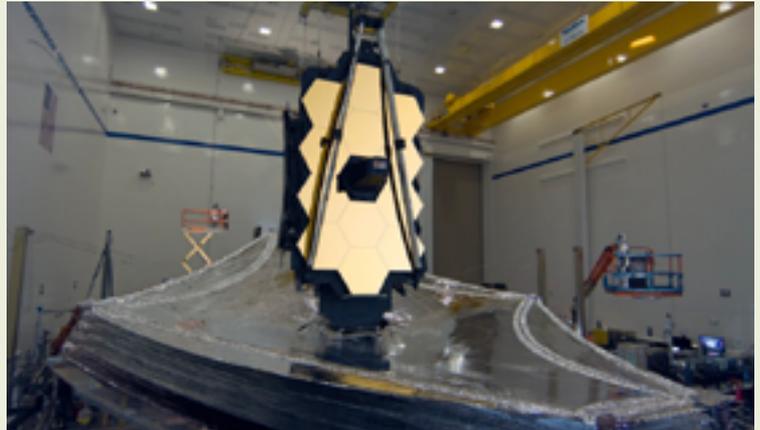


Figure 1. James Webb Space Telescope with its Sunshield fully deployed inside the cleanroom at Northrop Grumman in Redondo Beach, CA. Credit: Northrop Grumman in Redondo Beach and NASA.

JWST's commissioning process culminated on July 12th, with the release of the telescope's first full-colour images and spectroscopic data (Fig. 2, 3, 4), and the official beginning of its science mission.

Professor. Mike Barlow is a member of the European Science Team for James Webb's mid-infrared imager (MIRI), which involves advising the instrument team and planning how to use 450 hours of MIRI's observation time. He is co-leading a programme of observations of the remnant of Supernova 1987A, one of the brightest exploding stars astronomers have ever seen.

Professor. Richard Ellis and Dr Aayush Saxena will be analysing the first cycles of observations from James Webb to probe the evolution of the first stars, galaxies and black holes.

Dr Andrew Swan and Professor Jay Farihi have secured time on James Webb for studying a rare example of white dwarf hosting a planetary debris disk. Professor Mike Barlow said:

"The combination of JWST's larger mirror plus the sensitivity of its infrared science instruments represent a considerable advance in performance over both the Hubble and Spitzer Space Telescopes that have so far pioneered the exploration of the early universe. I'm now really excited as this dramatic progress augurs well for reaching the ultimate prize for many astronomers like myself: pinpointing 'Cosmic Dawn' - the moment when the universe was first bathed in starlight."

Professor Richard Ellis



Figure 2. JWST has produced the deepest and sharpest infrared image of the distant universe to date. Known as Webb's First Deep Field, this image shows the galaxy cluster SMACS 0723 as it appeared 4.6 billion years ago. The combined mass of this galaxy cluster acts as a gravitational lens, magnifying more distant galaxies behind it. Thousands of galaxies – including the faintest objects ever observed in the infrared – have appeared in Webb's view for the first time. Credit: NASA, ESA, CSA, and STScI.



Figure 3. Star birth: NGC 3324 In Carina Nebula. Young, star-forming region captured in infrared light by JWST, this image reveals for the first time previously invisible areas of star birth. The tallest 'peaks' in this image are about 7 light-years high.
Credit: NASA, ESA, CSA, and STScI.

"To be able to achieve such sensitivity and resolution at infrared wavelengths is truly paradigm shifting, opening up a whole range of possibilities. These capabilities will be revolutionary to detect some of the first galaxies to have formed in the Universe, since the ultraviolet or optical light from extremely distant objects is 'redshifted' into the infrared regime. Thanks to the lensing effects of galaxy clusters as we saw in the image, it is further possible to detect even fainter objects in the distant Universe that are being magnified by the cluster. Overall, this was an amazing teaser of JWST's revolutionary capabilities."

Dr Aayush Saxena



Figure 4. Stellar Death: Planetary Nebula NGC 3132. Clouds of gas and dust expelled by a dying star, approximately 2,500 light-years away, are revealed by JWST.
Credit: NASA, ESA, CSA, and STScI.

"JWST's extended infrared wavelength coverage encompasses key emission bands from many different molecules and dust particles, which are ultimately the building blocks of planets and of life itself as new stars are formed. I'm particularly excited by the prospect of JWST studying with unprecedented sensitivity the formation of molecules and dust by stars during the final stages of their lives. We plan to study with JWST the archetypal Supernova 1987A in the nearby Large Magellanic Cloud galaxy in order to study the molecules and dust formed in its rapidly outflowing ejected material and to perhaps detect for the first time a remnant neutron star buried deep inside it."

Professor Mike Barlow

High Energy Physics (HEP)

High energy physics (HEP) is about looking at extremely small sizes, or equivalently, at extremely high energies. Its aim is to explore the underlying nature and foundations of the entire physical universe, as well as the forces and laws that govern its development.

As one of the largest particle physics groups in the country our research at UCL HEP covers a wide range of areas, from theoretical physics and exploring the world's highest energy proton-proton collisions at the Large Hadron Collider (LHC), to unlocking the mysteries of neutrinos, searching for elusive dark matter, exploring new physics with precision muon studies and many more. In addition to fundamental physics research, we are involved in several interdisciplinary and knowledge exchange projects and are active in promoting particle physics in schools and among the general public.

The last year has, again, been very exciting for our group. The LHC has re-started collisions, and several experiments (SuperNEMO, LEGEND and LUX-ZEPLIN) have started taking data. A recent ultra-precise measurement of the mass of the W boson by the CDF experiment, work that UCL has historically played a strong role in, does not agree with the precise prediction of the Standard Model. Perhaps this anomaly is related to others recently reported in the heavy-flavour sector of the Standard Model, but this remains to be seen. Further measurements by the LHC experiments, the g-2 experiment at Fermilab, and others are eagerly awaited.

As a group we are enjoying being back in the department following the pandemic. We are pleased to welcome Dr. Gabriel Facini to the HEP group. Dr. Facini works on ATLAS and will be a member of the HEP group alongside his role in the Centre for Data Intensive Science and Industry. Dr. Stefano Vergani joins us as a new detector physicist (with an emphasis on the DUNE experiment) and we are also looking forward to welcoming Dr. Nicola McConkey into the group later this year; Nicola has been awarded a prestigious Ernest Rutherford Fellowship to work on Quantum Technologies for Neutrino Mass (QTNM) amongst other projects.

Here we provide a few highlights from 2021-22. More information on the UCL HEP group activities can be found at: <http://www.hep.ucl.ac.uk/research.shtml>

ATLAS

ATLAS and the Large Hadron Collider (LHC) have concluded a 3-year shutdown and are now taking data again. The existing dataset will be more than doubled over the next few years, which opens up substantial new discovery possibilities. Analysis of the existing dataset is itself yielding exciting new results (see research highlight "Searching for Higgs Pair Production at the LHC"). A lot of technical work continues to take place preparing for the high-luminosity phase of the LHC, scheduled to start towards the end of this decade, and its associated detector upgrades.

Neutrinos and Dark Matter

The group has a long-standing tradition of initiating and leading international experiments exploring new physics with neutrinos and searching for dark matter. In the past year we have made significant contributions to neutrino oscillation experiments (NOvA, DUNE, CHIPS) and neutrinoless double beta decay experiments

(SuperNEMO, LEGEND). Both SuperNEMO and LEGEND (see Figure) are now collecting data, promising a very exciting few years ahead.

Direct dark-matter search experiment LUX-ZEPLIN is conducting its first science run having been successfully commissioned at the SURF underground laboratory in the US (with UCL leadership of the Time-Projection Chamber (TPC) commissioning activity throughout this period) and thoroughly calibrated. Calibrations show we have particle discrimination as projected in our sensitivity paper and early background data shows remarkable consistency with predictions based on >1,200 radio-activity assays and comprehensive cleanliness controls, much of which was UCL-led. First science results from LUX-ZEPLIN will be published later this year.

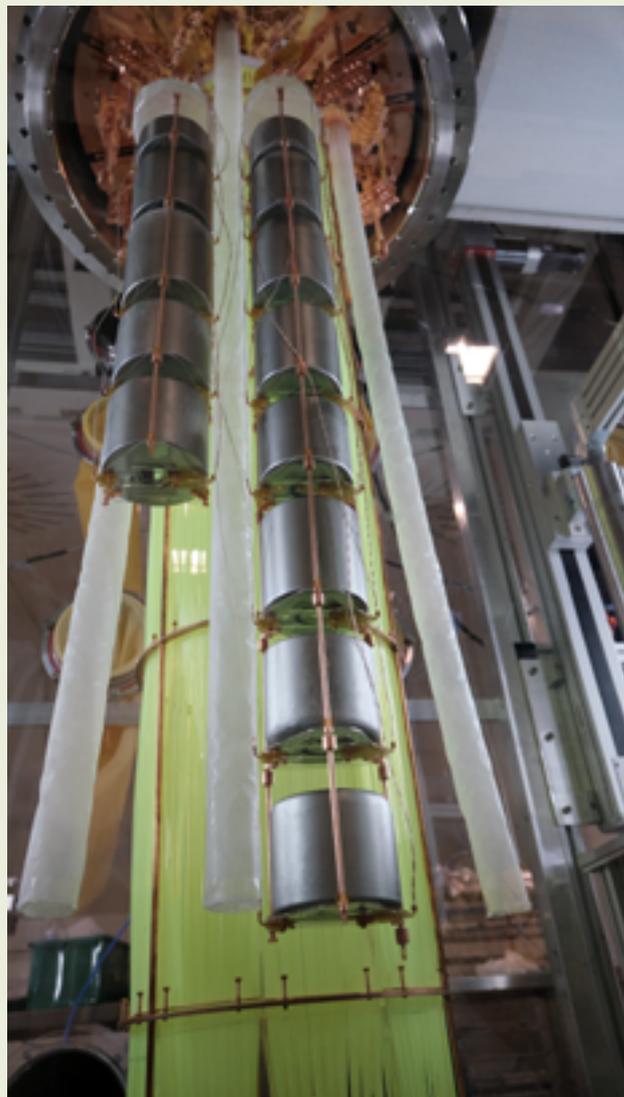
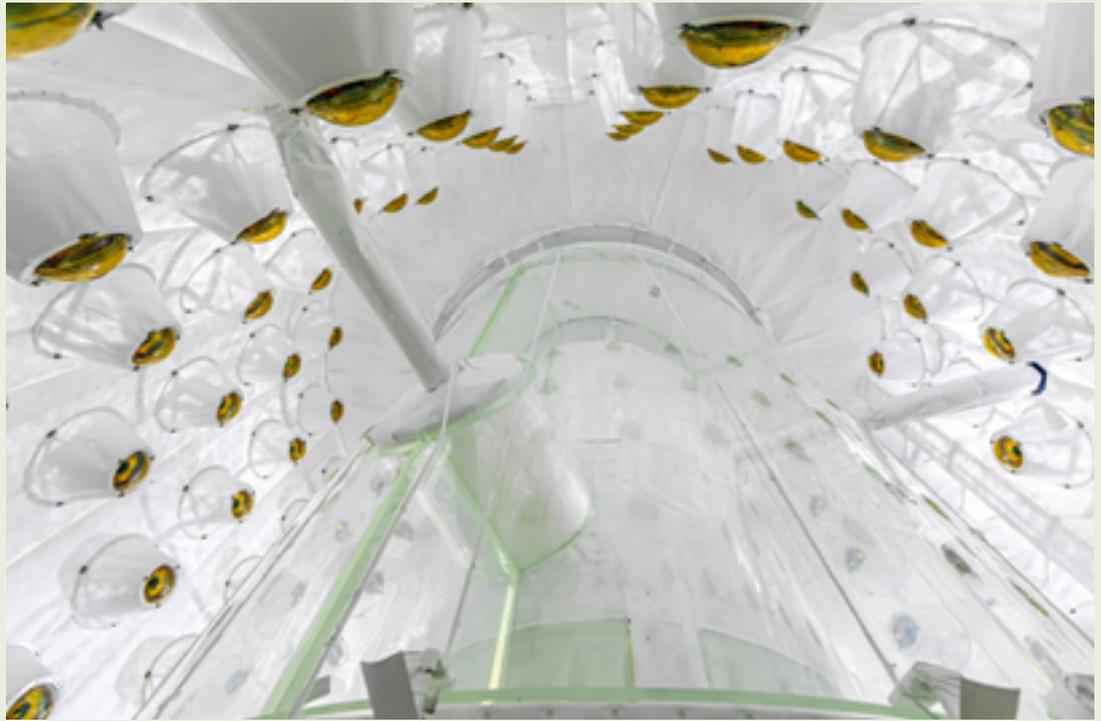


Figure 1. Strings of high-purity germanium (HPGe) detectors for the neutrinoless double-beta decay experiment LEGEND being prepared for lowering into the liquid argon cryostat at the LNGS underground laboratory in Italy.

Figure 2. The completed LUX-ZEPLIN Time Projection Chamber installed underground and surrounded by the veto photomultipliers (yellow glass bulbs) making up the outer detector.



Theory

UCL is leading in several efforts exploring the properties of neutrinos, and using them as a gateway to look for new physics beyond the Standard Model. This includes theoretical and phenomenological studies interpreting experimental results and proposing novel processes and mechanisms as signatures of new physics in the neutrino sector. A crucial process in this regard is the so-called nuclear double beta decay. In its neutrinoless variant, it probes the possible Majorana nature of neutrinos and is sensitive to new physics that can explain how neutrinos get their tiny but non-zero masses. We have proposed several new models and mechanisms that can be searched for in double beta decay, such as a novel Majoron scenario (Phys.Rev.Lett. 122 (2019) 18, 181801), right-handed currents (Phys.Rev.Lett. 125 (2020) 17, 171801) and sterile neutrinos (Phys. Rev.D 103 (2021) 5, 055019). They result in minute variations of the double beta decay signature (see Figure below for the example of the Majoron model) that can nevertheless be detected experimentally. If observed, it would lead to a profound shift in our understanding of neutrinos.

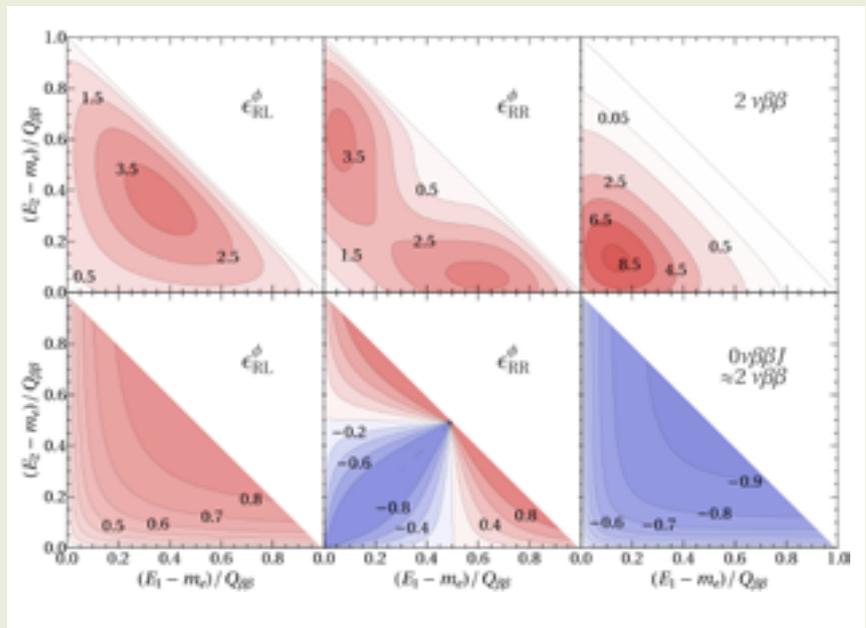
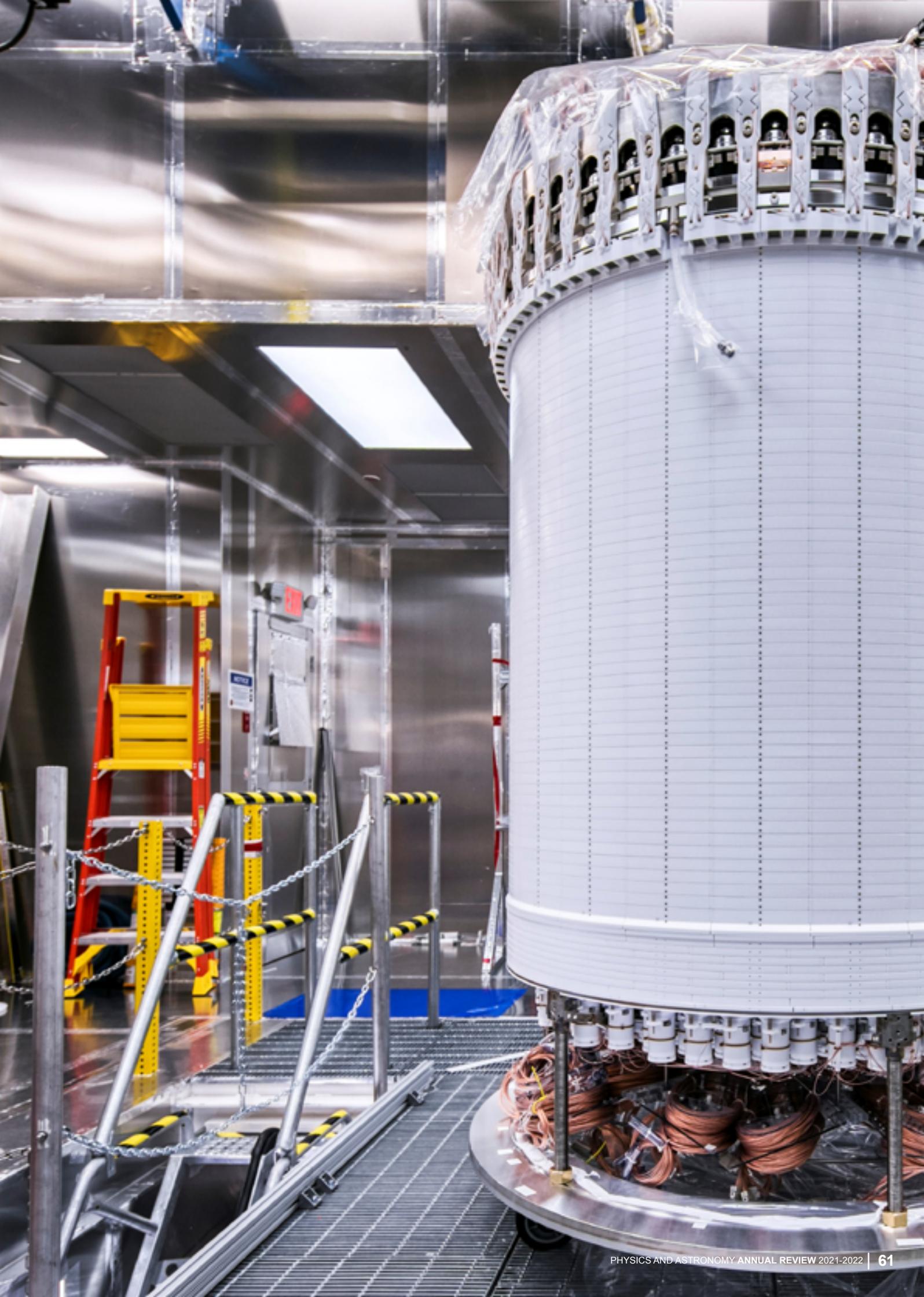


Figure 3. Signature of double beta decay in two variants of the novel Majoron model (left and middle column) compared to standard two-neutrino double beta decay (right column). The top row shows the energy distribution with respect to the kinetic energies of the emitted electrons: the darker the colour, the more likely the emission occurs with given energies. The bottom row shows the angular correlation between the electrons of given energies: red indicates that electrons are predominantly back-to-back whereas blue means they are more likely emitted in the same direction.



Atomic, Molecular, Optical and Positron Physics (AMOPP)

Over the last year, research activities in the Atomic Molecular Optical and Positron Physics (AMOPP) group have continued to expand. In addition to the core AMO physics research areas covered by the group, a broad range of work now takes place at the boundaries with the other research groups in the department.

Work on theoretical molecular physics and spectroscopy, and on quantum gravity connects to the **Astro** group. Experimental and theoretical studies involving superconducting circuits, polaritons and spintronics have strong overlaps with condensed matter physics – the **CMMP group and the London Centre for Nanotechnology**. Studies of resonant energy transfer in biomolecules, including light harvesting complexes, are associated with core activities in the **BioP** group. And new experimental work on measurements of the neutrino mass and Dark Matter detection are directly connected with the **HEP** group.

Now, in summer 2022, operations in the group, and the department, are returning toward normal after the Covid-19 pandemic. However, the last year has been challenging for everyone, with the need to adapt to changes in teaching delivery, and changes in the guidelines for working on site or from home and for in-person and remote meetings and seminars.

Throughout the Covid-19 pandemic the group size has remained constant with >110 personnel, including 17 members of academic staff and now 5 permanent support staff. Sadly, over the last year Dr Isabel Llorente Garcia, and our group administrator, Shanice Thomas, left us to move to other positions. However, we are delighted to welcome a new mechanical technician, Finn Noyes, who together with John Dumper, Rafid Jawad and Fabian Garza Trevino provide us with excellent technical support, without which we could not carry out our research.

With regard to the major research outputs from the group over the last year, there has been significant further growth in the area of **precision tests of fundamental physics using AMO techniques**. Professor Stephen Hogan leads the UCL experimental components of a project held in collaboration with researchers in

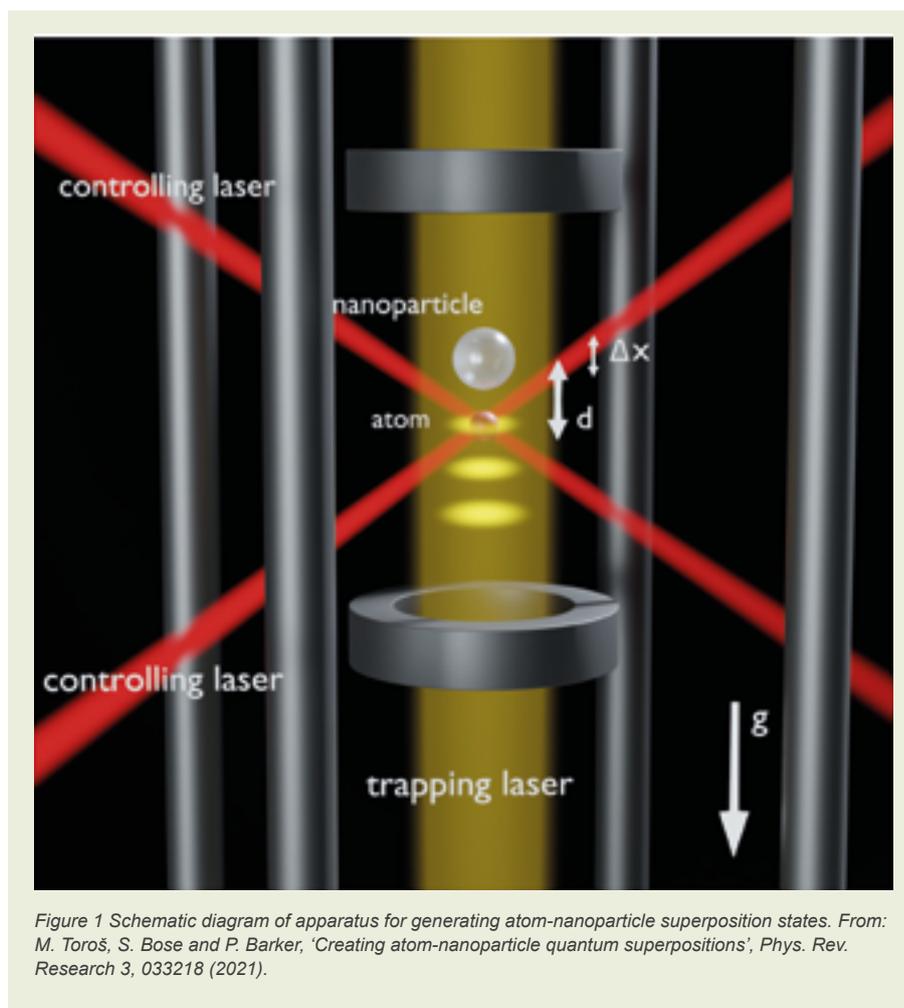
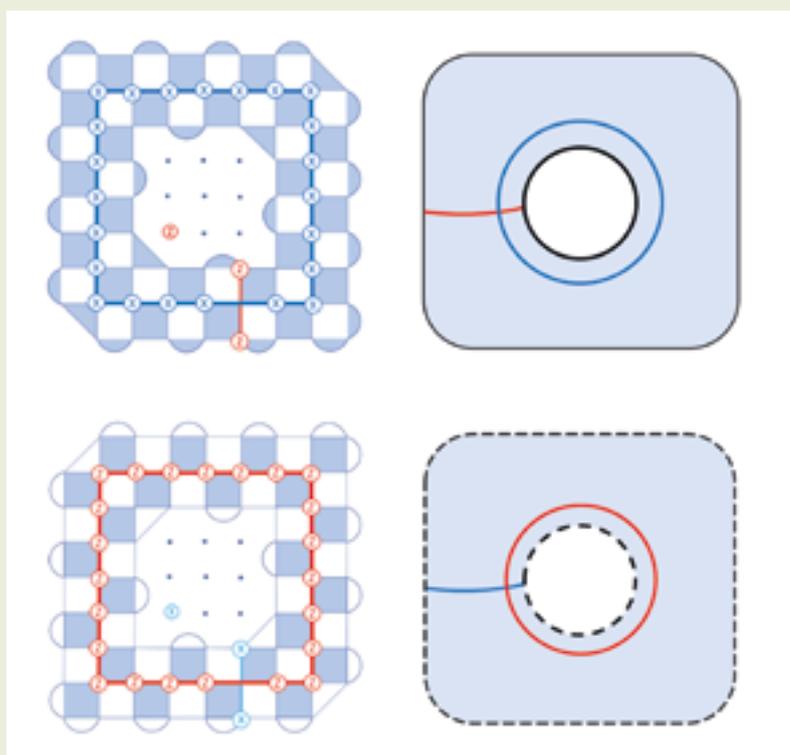


Figure 1 Schematic diagram of apparatus for generating atom-nanoparticle superposition states. From: M. Toroš, S. Bose and P. Barker, 'Creating atom-nanoparticle quantum superpositions', *Phys. Rev. Research* 3, 033218 (2021).

the HEP group and at Cambridge, Swansea, Warwick and NPL to measure the absolute neutrino mass using quantum technologies. Professor David Cassidy and his group have continued work on tests of bound-state quantum electrodynamics through high-precision microwave spectroscopy measurements of excited-state fine-structure in positronium. Cassidy and Hogan are also now working together on a new project to test antimatter gravity by performing matter-wave interferometry with Rydberg positronium atoms using a technique recently invented for this purpose in the group. Professor Peter Barker leads the experimental component of a new project with collaborators in the HEP group to develop levitated quantum optomechanical sensors for Dark Matter detection. Theoretical activities in this general area include work in Professor Sougato Bose's group on testing the quantum nature of gravity through the entanglement of nanoparticles in a matter-wave interferometer, and work in collaboration with Barker on the generation of superposition states of atoms and nanoparticles (Figure 1). Studies have also been performed by Prof Jonathan Oppenheim's group of constraints on post-classical quantum gravity in classes of theories in which space-time is treated classically, while interacting with quantum fields.

Figure 2 Diagrams of puncture defects on the toric code. From: A Benhemou, J. K. Pachos, and D. E. Browne, 'Non-Abelian statistics with mixed-boundary punctures on the toric code', *Phys. Rev. A* 105, 042417 (2022).



In areas of **quantum optics, attosecond physics and quantum technologies – including information processing, sensing, interfaces and computing** – Professor Dan Browne and his group have worked on optimal encoding circuits for the surface code – a leading candidate quantum error correcting code because of its compatibility with existing experimental quantum computing architectures. They have also investigated how lattice defects – punctures – can be employed for quantum information tasks (Figure 2), developed a compiler – 2QAN – to optimise quantum circuits for applications in quantum simulation, and realised software approaches to mitigate against gate errors that degrade performance in quantum computation.

Professor Sougato Bose's group have studied information flow in quantum networks and how it can be used to quantify causality. They have also worked on the development of ways to control the flow of quantum information between distant qubits, e.g., in arrays of quantum dots, by implementing voltage-controlled spin transistors.

Professor Marzena Szymanska and her group have studied how quantum information stored in chains of qubits, e.g., Josephson junctions, can be protected from relaxation and decoherence by carefully engineering the symmetries of the Hamiltonian describing the system. They have also investigated phase transitions in exciton-polariton condensates, studied condensation in a hybrid quantum system composed of a superconducting resonator coupled to microscopic spin systems, and worked on polariton condensation into vortex states in the synthetic magnetic fields of a strained honeycomb lattice. Prof Tania Monteiro and her group have investigated the use of nuclear spins that surround electron spin qubits as quantum registers and long-lived quantum memories for applications in quantum information processing and biological sensing.

Professor Peter Barker's group have carried out theoretical studies directed toward the realisation of 'Einstein's mirror' – a situation in which an object's motion is damped by the recoil of photons when placed inside a blackbody cavity – by using high intensity light from an amplified thermal light source and a small optomechanical system.

Professor Carla Faria and her group have worked on a range of new studies of electron dynamics following ionisation in strong laser fields. This has included studies of angular momentum conservation for twisted electrons ionised in strong linearly and circularly polarised fields, and effects of laser polarisation in strong-field ionisation of helium. They have also investigated symmetries and sub-cycle interference in photoelectron holography (Figure 3), an understanding of which is essential for imaging sub-angstrom attosecond dynamics in atoms and molecules. Professor Agapi Emmanouilidou's group have developed a general three-dimensional semiclassical model to treat double- and triple-ionisation of three-electron atoms in strong laser fields including effects of the Coulomb potentials experienced by each of the particles, contributions from the magnetic field of the laser pulse and the motion of the atomic nucleus. They have also calculated new potential energy surfaces for singly- and doubly-charged molecular nitrogen cations. These are essential to the understanding of ionisation and dissociation dynamics in intense short-wavelength laser fields generated by free-electron lasers.

From an experimental perspective, Professor Ferruccio Renzoni's group have used atomic gases as quantum magnetic-field sensors. In this area they have implemented a new way to precisely identify pilot-holes that act as anchor points located under the surfaces of metal structures using a mechanically translatable atomic magnetometer. They have also realised

a radio-frequency magnetometer based on a Bose-Einstein condensate. This has potential applications in electromagnetic induction microscopy for nanotechnology. Professor Peter Barker's group have realised velocity-tuneable spin-polarized beams of metastable argon atoms for matter-wave interferometry. They have also worked on cooling the centre-of-mass motion of nanoparticles using purely quadratic coupling between their motion and the optical fields in which they are trapped in high finesse cavities. The advantage of this type of passive parametric cooling, over conventional electronic feedback methods, is that the cavity automatically applies the feedback required to achieve the cooling. Professor Stephen Hogan's group continue to develop hybrid interfaces between gas-phase Rydberg atoms and superconducting microwave circuits for applications in quantum sensing and information processing. Recently this has led to the use of Rydberg atoms as microscopic quantum sensors to precisely measured dc and microwave electric field strengths in close proximity to chip-based superconducting resonators operated at temperatures below 4 K.

In the area of **molecular physics and spectroscopy** Professor Jonathan Tennyson and Professor Sergey Yurchenko have continued to work on the development of theoretical methods for the calculation of a wide range of high-precision spectral line lists for small molecules of interest in studies of Exoplanet atmospheres. The molecules treated in this work include, e.g., H_2O , CaH , MgH , ... Detailed studies of electron scattering

cross-sections, high-order multipole transition moments, and hyperfine structure of molecules such as I_2 , N_2 and CO have also been reported. In this general area, Professor Stephen Hogan's group perform experiments to decelerate and trap cold samples of NO molecules in high Rydberg states. This work has allowed studies of lifetimes of the Rydberg states in NO over previously inaccessible timescales, and provided new insights into effects of rotational and vibrational couplings on their decay dynamics.

In the last year, Professor Carla Faria was awarded the **2021 Joseph Thomson Medal and Prize of the Institute of Physics** for her distinguished contributions to the theory of strong-field laser-matter interactions. Professor Jonathan Tennyson was awarded an **ERC Public Engagement with Research Award** for his project ORBYTS in which he involved school students, particularly those in schools with low STEM uptake, with research led by PhD mentors. Members of the group have also led the organisation of major international conferences and workshops at UCL, including, e.g., Atto-FEL 2022, and an international Workshop on Cold Rydberg Chemistry.

This year's Carey Foster Prize 'for outstanding postgraduate physics research in AMOPP' was awarded jointly to Dr Paul Brookes (Theory) and Dr Lokesh Gurung (Experiment) for their theses on 'Protected states and metastable dynamics in superconducting circuits', and 'Precision microwave spectroscopy of the positronium $n=2$ fine structure', respectively.

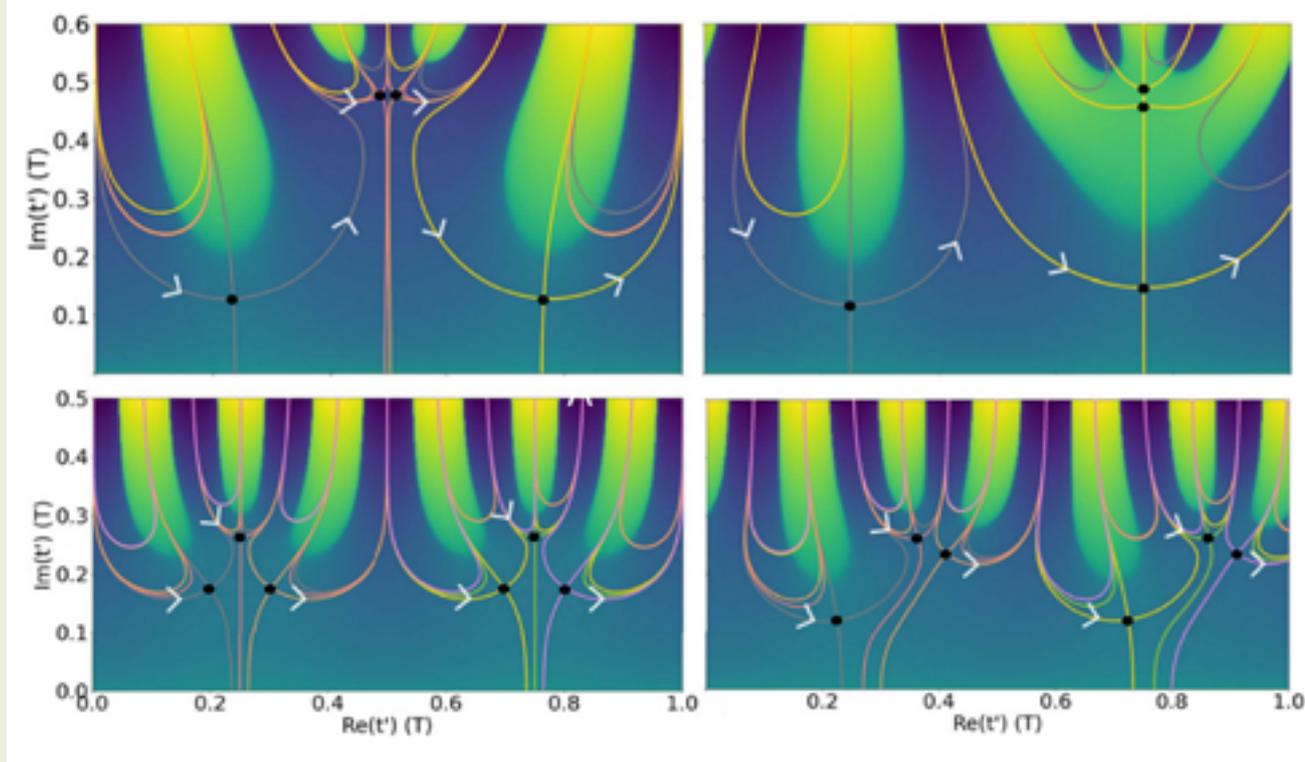


Figure 3 Semiclassical action at a range of ionisation time delays for atoms in bichromatic laser fields. From: T. Rook and C. Figueira de Morisson Faria, 'Exploring symmetries in photoelectron holography with two-color linearly polarized fields', *J. Phys. B* 55, 165601 (2022).

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. Several of its activities focus on the broad question of morphogenesis (literally the origin of shape in biology) across multiple scales, ranging from single cells to tissues and whole organisms. These activities are aimed at understanding how we may describe these complex processes, how we can predict them and ultimately control them. However, questions of form and geometry also arise in many everyday phenomena that we often take for granted, but which, on closer inspection, can reveal quite extraordinary behaviours. One fascinating example is offered by the humble apple, which featured in a Nature Physics study by the Michaels lab.

The cusp of an apple

The next time you're about to bite into an apple, cut it in half through the stalk and observe its shape (Fig. 1). The most interesting thing is not that it's almost spherical. If you look more closely at where the stalk meets the fruit, you'll notice something fascinating: the cusp of the apple. Now ask the following question: which mathematical function $y = y(x)$ describes the shape of the apple cusp? You may want to try out a few known functions to see which mimic the cusp shape. After a few tries you may conclude that any function of the type $y(x) = x^\alpha$ with $0 < \alpha < 1$ would do the job.

This raises the next question: what exponent α describes the cusp of the apple? To answer this question, one must turn to singularity theory, a mathematical framework used to describe numerous natural phenomena from the propagation of cracks to black holes. The exciting thing about singularities is that they are common to many different systems and give rise to universal structures which are largely independent of the specific details that separate the different systems. The concept of universality goes very deep and can be very useful because it connects singular phenomena observed in very different physical systems. Singularity theory knows a particular type of singularity that is relevant to the apple problem: the cusp singularity. Cusp singularities exhibit the universal shape $y(x) = x^{2/3}$ (the universal exponent $\alpha = 2/3$ emerges because of the mirror symmetry) and appear in many everyday phenomena, including the caustics in a coffee mug or a wedding ring, when a droplet breaks or when you empty your hot tub (Fig. 2). These systems appear to have almost nothing in common, yet they all make the same universal cusp shape. This raises the natural question of whether the apple exhibits the same universal shape. To answer this question, we collected

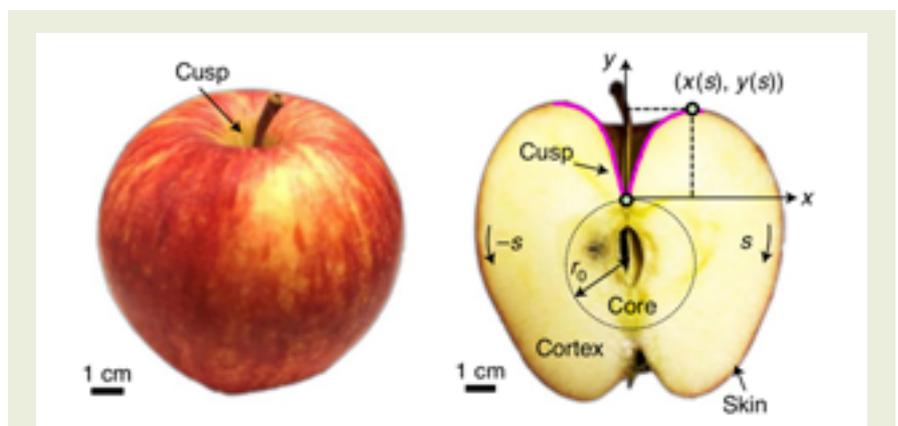


Figure 1. A study by the Michaels lab analysed the shape of an apple, showing how the cusp that forms near the stem is a singularity.

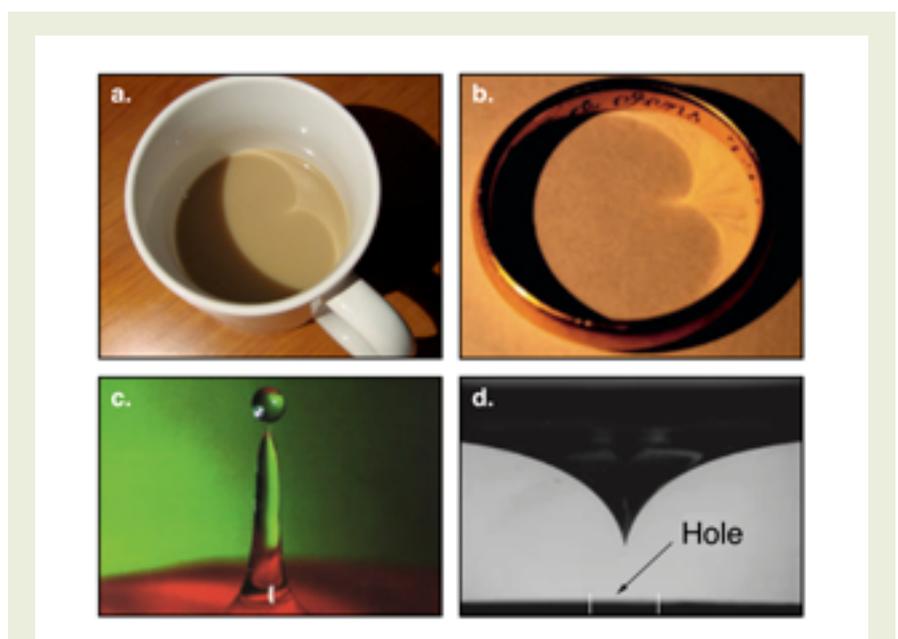


Figure 2. Cusp singularities in nature. (a) Caustics in a coffee mug, (b) in a wedding ring, (c) the breaking of a droplet and (d) the emptying of a tank filled with a viscous fluid all give rise to cusp singularities featuring the same universal shape.

>100 apples at various growth stages from an orchard at Peterhouse College at University of Cambridge (the alma mater of another famous apple lover, Sir Isaac Newton). The apples were cut in half giving rise to a pseudo-time course for the growth of the cusp (Figs. 3a,b). Singularity theory predicts that if the x and y axes are appropriately rescaled, the data should collapse onto the same universal curve $y(x) = x^{2/3}$. And the data does indeed show that, as can be seen in Fig 3c.

Simulations and experiments describe cusp formation

Our argument based on singularity theory relies only on geometry and symmetry but has no information about the details of the system or the mechanism by which the cusp forms. We therefore used numerical simulation to understand how differential growth between the fruit cortex and the core drives formation of the cusp. We then corroborated the simulations with experiments which mimicked the growth of apples using gel that swelled over time. The experiments showed that different rates of growth between the bulk of the apple and the stalk region resulted in the dimple-like cusp.

How about multiple cusps?

Although we have focused on axisymmetric cusps so far, casual observations show that apples can have non-axisymmetric cusps, as seen in some apples and other drupes, such as peaches, apricots, cherries and plums. Interestingly, our experiments showed that axisymmetric cusps can lose stability and become lobed as the size of the stalk is increased (Fig. 4). In particular, we found that the number of cusps that developed was dependent on the ratio of the plant's stalk to the apple's diameter — a trend that persisted across other fruits.

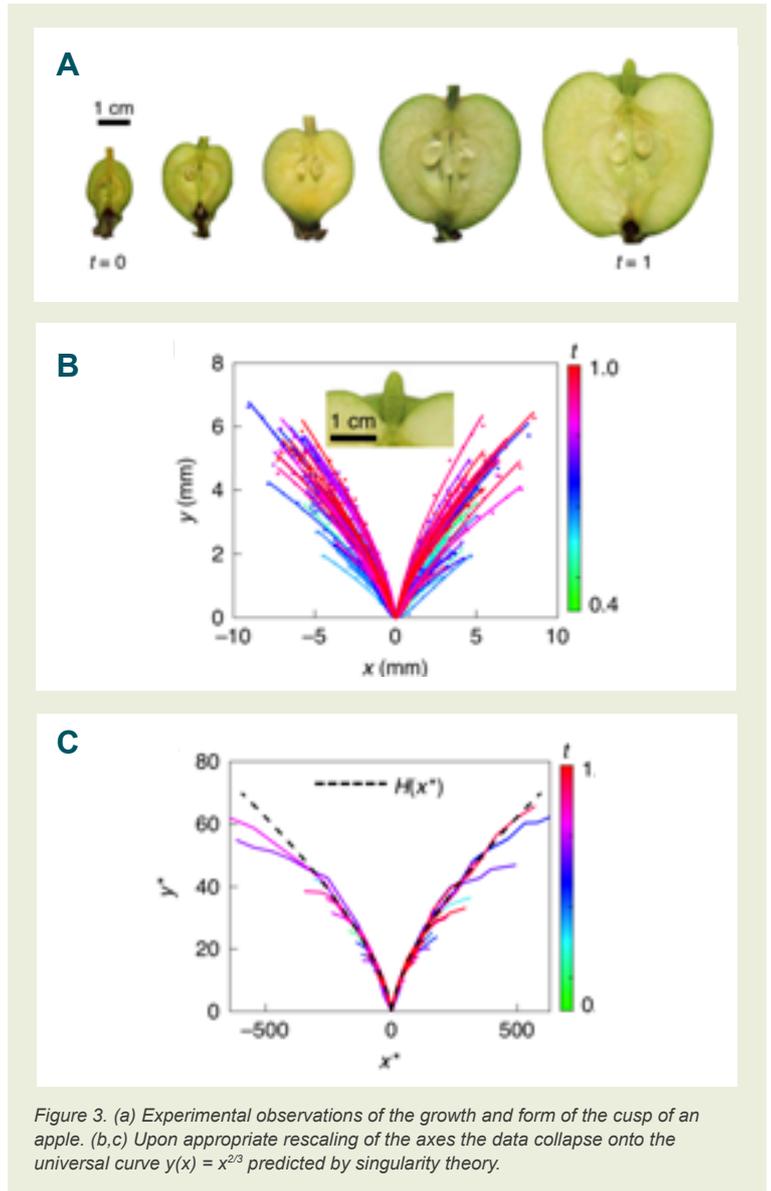


Figure 3. (a) Experimental observations of the growth and form of the cusp of an apple. (b,c) Upon appropriate rescaling of the axes the data collapse onto the universal curve $y(x) = x^{2/3}$ predicted by singularity theory.

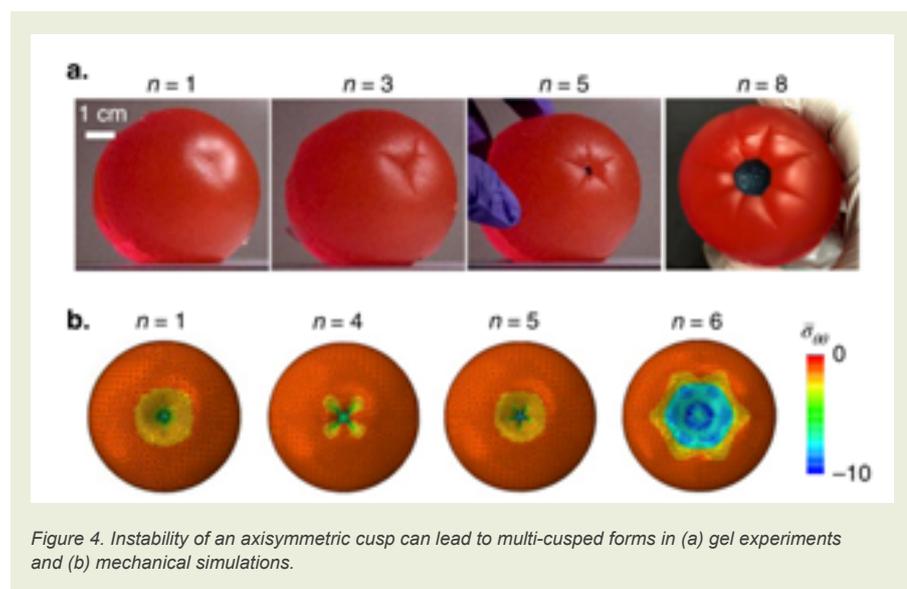


Figure 4. Instability of an axisymmetric cusp can lead to multi-cusped forms in (a) gel experiments and (b) mechanical simulations.

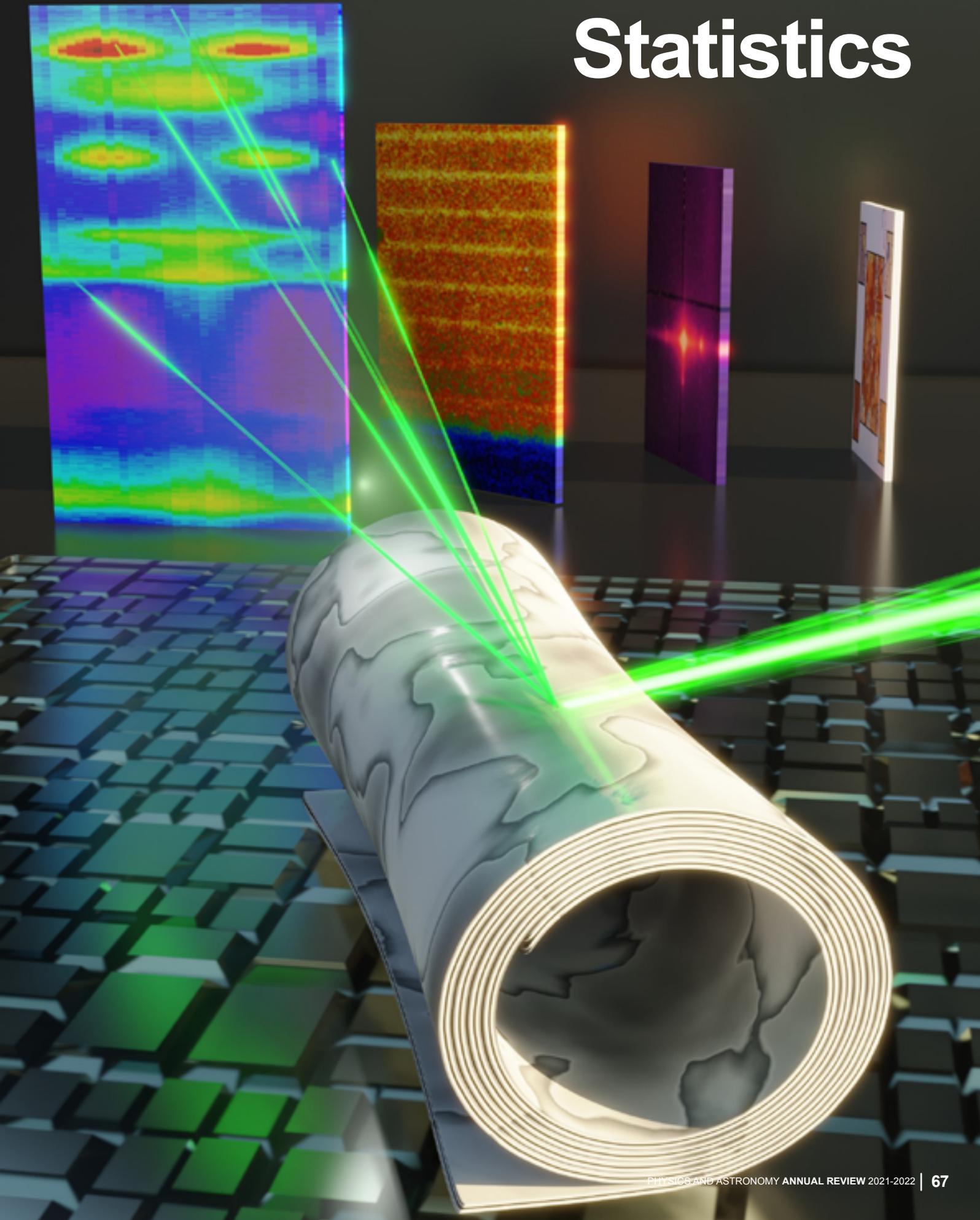
How does the apple fit in the bigger picture?

Why should we care about the apple cusp? Morphogenesis is one of the grand questions in biology. The shape of the humble apple has allowed us to probe some physical aspects of a biological singularity. Biological shapes are often organised by the presence of structures that serve as focal points. These focal points form singularities where deformations are localized. Of course, we now need to understand the molecular and cellular mechanisms behind the formation of the apple cusp, as we move slowly towards a broader theory of biological shape.

Further reading

A. Chakrabarti, T.C.T. Michaels, E. Sun, S. Yin and L. Mahadevan, *Nature Physics*, 17, 1125-29, 2021.

Research Statistics

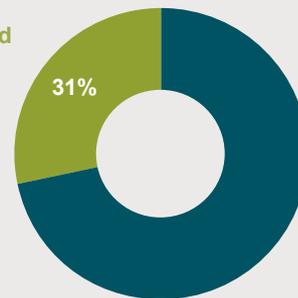


Research statistics

Active Grants and Contracts

In the last financial year (Aug 2021 – Jul 2022), the MAPS faculty as a whole yielded £40.2 million with the Department of Physics and Astronomy contributing £12.5 million (31%) of the total research income for the MAPS faculty.

Physics and Astronomy



Faculty of Mathematical and Physical Sciences (MAPS)

Astrophysics (Astro)

Europlanet - Research Infrastructure 2020-2024; European Commission H2020; PI: Achilleos, N; £51,091.73

Solar System Consolidated Grant 2019-22; STFC Science and Technology Facilities Council; PI: Achilleos, N; £457,240.00

DRivers and Impacts of Ionospheric Variability with EISCAT-3D; NERC Natural Environment Research Council; PI: Aurliah, A; £95,222.20

Predicting the upper atmospheric response to extremes of space weather forcing; NERC Natural Environment Research Council; PI: Aurliah, A; £49,225.00

SNDust - : Supernova Dust: Production and Survival Rates; European Commission H2020; PI: Barlow, M; £2,133,028.25

X-raying the Gas and Ice Giants; STFC Science and Technology Facilities Council; PI: Dunn, W; £560,420.16

First Light - Early star-forming galaxies and cosmic reionisation; European Commission H2020; PI: Ellis, R; £2,068,100.29

UCL Astrophysics Consolidated Grant 2018-2021; STFC Science and Technology Facilities Council; PI: Farihi, J; £332,066.67

UCL Astrophysics PATT Travel Grant 2020-22; STFC Science and Technology Facilities Council; PI: Farihi, J; £37,279.12

Towards new physics from next-generation cosmological data; Royal Society; PI: Feeney, S; £572,894.19

DiRAC-3 Operations – 2022-23 extension - UCL; STFC Science and Technology Facilities Council; PI: Jenner, C; £267,605.82

DiRAC-3 Operations 2019-2022 - UCL; STFC Science and Technology Facilities Council; PI: Jenner, C; £912,851.46

Euclid UK Ground Segment Bridging Grant Phase 2 - UCL Physics and Astronomy contribution; UK Space Agency; PI: Joachimi, B; £306,437.85

Photometric redshift estimation and DESC-related software development; STFC Science and Technology Facilities Council; PI: Joachimi, B; £313,767.64

Benchmarks for AI for Science at Exascale; EPSRC Engineering and Physical Sciences Research Council; PI: Lahav, O; £26,312.00

Newton Fund for capacity building in data intensive science in the Middle-East; STFC Science and Technology Facilities Council; PI: Lahav, O; £271,358.05

Small-scale clustering from eBOSS Ly-alpha forests; Universities Research Association Inc; PI: Lahav, O; £6,298.70

UCL Astrophysics Consolidated Grant 2018-2021; STFC Science and Technology Facilities Council; PI: Lahav, O; £460,325.12

New cosmology measurements with voids in next-generation galaxy surveys; STFC Science and Technology Facilities Council; PI: Nadathur, S; £527,836.60

The Role of Magnetic Fields in ISM Evolution and Star Formation; Royal Society; PI: Pattle, K; £607,130.75

Quantum Simulators for Fundamental Physics Version A; STFC Science and Technology Facilities Council; PI: Peiris, H; £602,975.64

Consolidating leadership in a new approach to galaxy formation; Royal Society; PI: Pontzen, A; £215,701.40

GMGalaxies - Understanding the diversity of galaxy morphology in the era of large spectroscopic surveys; European Commission H2020; PI: Pontzen, A; £1,392,984.00

UCL Astrophysics Consolidated Grant 2018-2021; STFC Science and Technology Facilities Council; PI: Pontzen, A; £129,712.76

Understanding the Hubble sequence; Royal Society; PI: Pontzen, A; £356,433.96

Cold gas as a probe of galaxy evolution; Royal Society; PI: Saintonge, A; £352,852.69

Cold gas as a probe of galaxy evolution: multi-phase outflows at high resolution; Royal Society; PI: Saintonge, A; £106,838.00

Cold gas as a probe of galaxy evolution: the dust connection; Royal Society; PI: Saintonge, A; £220,670.98

UCL Astrophysics Consolidated Grant 2021-2024; STFC Science and Technology Facilities Council; PI: Saintonge, A; £780,046.90

Dynamics of the Milky Way with Gaia; Royal Society; PI: Sanders, J; £487,645.92

Development of Large Anti-Reflection Coated Lenses for Passive (Sub)Millimeter-Wave Science Instruments; European Space Agency; PI: Savini, G; £44,422.64

PRISTINE design : a space mission to measure high accuracy deviations from the uniform black-body spectrum.; Royal Society; PI: Savini, G; £11,700.00

Distributed Pipelines for Networks of Robotic Telescopes; Konica Minolta Business Solutions Europe GmbH; PI: Savini, G; £36,000.00

Ultra-lightweight metamaterial telescopes and optics for Earth Observation applications; UK Space Agency; PI: Savini, G; £28,878.40

ARIEL Science Advisory Team UK Activities 2019-21; STFC Science and Technology Facilities Council; PI: Tinetti, G; £87,309.00

Ariel Science Advisory Team UK Activities 2021-22; STFC Science and Technology Facilities Council; PI: Tinetti, G; £34,913.92

ESA M4 mission Ariel Implementation Phase; UK Space Agency; PI: Tinetti, G; £162,259.57

AstroChemical Origins; European Commission H2020; PI: Viti, S; £450,516.10

The Interstellar Medium And Star Formation In Extreme Galactic Environments; Royal Society; PI: Viti, S; £12,000.00

UCL Astrophysics Consolidated Grant 2018-2021; STFC Science and Technology Facilities Council; PI: Viti, S; £27,781.76

Co-Sponsored PhD: "Enabling data-driven searches in ESA Astronomical images for the first time with deep learning"; ESA European Space Agency; PI: Waldmann, I; £40,769.23

Deciphering super-Earths using Artificial Intelligence; European Commission H2020; PI: Waldmann, I; £1,258,528.04

Computer vision and machine learning for pattern recognition in LHC data; Lenovo Global Technology UK Ltd; PI: Yates, J; £48,500.00

Using switches to control clusters and data flows; Mellanox technologies Ltd; PI: Yates, J; £48,136.08

UCL Astrophysics Consolidated Grant 2018-2021; STFC Science and Technology Facilities Council; PI: Yurchenko, S; £367,327.27

Atomic, Molecular, Optical and Positron Physics (AMOPP)

Laser refrigeration on the nanoscale: From nanocryostats to quantum optomechanics; EPSRC Engineering and Physical Sciences Research Council; PI: Barker, P; £729,666.70

Testing the Large-Scale Limit for Future Quantum Technologies; European Commission H2020; PI: Barker, P; £415,197.00

Measurement-based entanglement of single-dopant As spin qubits; EPSRC Engineering and Physical Sciences Research Council; PI: Bose, S; £70,981.09

Non-Ergodic Quantum Manipulation; EPSRC Engineering and Physical Sciences Research Council; PI: Bose, S; £570,712.68

Uncovering the Nonclassicality of Macroscopic Systems; Royal Society; PI: Bose, S; £111,825.00

Making quantum processors robust: from theory to practice; Innovate UK; PI: Browne, D; £25,732.86

Quantum Computing and Simulation Hub; EPSRC Engineering and Physical Sciences Research Council; PI: Browne, D; £252,643.08

Prosperity Partnership in Quantum Software for Modeling and Simulation; EPSRC Engineering and Physical Sciences Research Council; PI: Browne, D; £308,579.31

Reliable and Robust Quantum Computing; EPSRC Engineering and Physical Sciences Research Council; PI: Browne, D; £57,062.92

Control and Spectroscopy of Excited States of Positronium; EPSRC Engineering and Physical Sciences Research Council; PI: Cassidy, D; £802,355.26

Precision Microwave Spectroscopy of Positronium; EPSRC Engineering and Physical Sciences Research Council; PI: Cassidy, D; £933,501.02

Production of positronium atoms, ions, and molecules; EPSRC Engineering and Physical Sciences Research Council; PI: Cassidy, D; £853,721.00

Exotic forms of matter in molecules driven by Free-Electron Lasers; Leverhulme Trust; PI: Emmanouilidou, A; £180,939.00

Ultra-fast three and four-electron dynamics in intense electro-magnetic laser fields; EPSRC Engineering and Physical Sciences Research Council; PI: Emmanouilidou, A; £430,851.06

AQuA DIP: Advanced Quantum Approaches to Double Ionisation Processes; EPSRC Engineering and Physical Sciences Research Council; PI: Figueira De Morisson Faria, C; £388,202.00

CATMOLCHIP: cold atmospheric molecules on a chip; European Commission H2020; PI: Hogan, S; £1,720,982.65

Optomechanical sensors: rapid prototyping for navigation and quantum technologies; Royal Academy of Engineering; PI: Li, L; £198,855.00

Revealing unambiguous signatures of quantum coherence in photosynthetic complexes on a photonic chip; Gordon and Betty Moore Foundation; PI: Olaya-Castro, A; £1,480,212.59

IT from Qubit - Quantum Fields, Gravity and Information; Simons Foundation; PI: Oppenheim, J; £473,650.81

Quantum information applied to fundamental physics; EPSRC Engineering and Physical Sciences Research Council; PI: Oppenheim, J; £623,081.00

Coherent Gamma Rays from BEC of 135mCs isomer; Atomic Weapons Establishment; PI: Renzoni, F; £29,612.00

Electromagnetic Induction Imaging for the Aviation Industry; EPSRC Engineering and Physical Sciences Research Council; PI: Renzoni, F; £49,445

Electromagnetic Induction Imaging for the Aviation Industry / add on; EPSRC Engineering and Physical Sciences Research Council; PI: Renzoni, F; £15,000.00

Gamma-ray coherent emission in a Bose-Einstein condensate of 135mCs isomers; Air Force Office of Scientific Research; PI: Renzoni, F; £75,015.00

Far From Equilibrium Quantum Simulators; EPSRC Engineering and Physical Sciences Research Council; PI: Szymanska, M; £850,350.00

Quantum and many body physics enabled by advanced semiconductor nanotechnology; EPSRC Engineering and Physical Sciences Research Council; PI: Szymanska, M; £353,750.92

Electron initiated chemistry: dissociative attachment of small molecules; Royal Society; PI: Tennyson, J; £2,500.00

ExoMolHD: Precision spectroscopic data for studies of exoplanets and other hot atmospheres; European Commission H2020; PI: Tennyson, J; £1,989,072.00

Exploring complexity and scalability of Near-term Quantum Computing algorithms for Quantum Chemistry; Rahko Ltd; PI: Tennyson, J; £33,000.00

Quantum Simulations for Real Problems; Rahko Ltd; PI: Tennyson, J; £24,575.00

Radiative transport modeling in technological plasmas and combustion; STFC Science and Technology Facilities Council; PI: Tennyson, J; £360,511.22

Short wavelength absorption by water vapour; NERC; PI: Tennyson, J; £272,984.00

Towards quantum-based realisations of the pascal; European Commission H2020; PI: Tennyson, J; £56,000.00

UK Atomic, Molecular and Optical physics R-matrix consortium (UK AMOR); EPSRC Engineering and Physical Sciences Research Council; PI: Tennyson, J; £368,071.34

Liquid density-functional modelling of rovibrational molecular spectroscopy and dynamics in quantum solvents; Royal Society; PI: Yurchenko, S; £6,000.00

Quantum processes assisted with machine learning: application and development; Moscow Witte University; PI: Yurchenko, S; £132,277.00

Biophysics (BioP)

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

Physical determinants of cellular fitness for survival and proliferation; Royal Society; PI: Banerjee, S; £89,022.75

Autofluorescence across scales: an integrated understanding of redox cofactors as intrinsic probes of metabolic state; BBSRC Biotechnology and Biological Sciences Research Council; PI: Blacker, T; £405,382.56

Advancing first principles computational modelling of electron transfer processes at molecule/electrode interfaces; Pacific Northwest National Laboratory; PI: Blumberger, J; £36,548.34

SoftCharge - charge carrier transport in soft matter: from fundamentals to high-performance materials; European Commission H2020; PI: Blumberger, J; £1,703,779.00

Advanced flow technology for healthcare materials manufacturing; EPSRC Engineering and Physical Sciences Research Council; PI: Nguyen, T; £324,222.96

Development of Biocompatibility and Colloidal Stability of Ultrasmall Iron Oxide Nanoparticles as alternative T1 MRI contrast agents from routinely used Gadolinium complexes; Royal Society of Chemistry; PI: Nguyen, T; £10,000.00

Devices and Diagnostics TIN Pilot Data Scheme Call 2; Wellcome Trust; PI: Nguyen, T; £10,000.00

Facilitating Translation of Super Heating Iron Oxide Nanoflowers Production to Clinical Magnetic Hyperthermia Cancer Treatment; EPSRC Engineering and Physical Sciences Research Council; PI: Nguyen, T; £45,207.00

Market mapping and prototyping development of T1 MRI contrast agent; EPSRC Engineering and Physical Sciences Research Council; PI: Nguyen, T; £31,663.00

Nanoscale Magnetism of Novel Structures; Air Force Office of Scientific Research; PI: Nguyen, T; £110,344.83

Real-time tracking stem cells in vivo using dual mode NIR-II fluorescence and magnetic resonance imaging; Royal Society; PI: Nguyen, T; £12,000.00

Revealing unambiguous signatures of quantum coherence in photosynthetic complexes on a photonic chip; Gordon and Betty Moore Foundation; PI: Olaya-Castro, A; £1,480,212.59

Non-Equilibrium Protein Assembly: from Building Blocks to Biological Machines; European Commission H2020; PI: Saric, A; £1,139,659.20

Physical mechanisms of membrane remodelling by active elastic filaments; Royal Society; PI: Saric, A; £107,894.00

Physics of protein organisation beyond the cell's edge; Royal Society; PI: Saric, A; £526,769.82

Rational design of cell-reshaping elements; Royal Society; PI: Saric, A; £88,992.00

The Evolution Of Trafficking: From Archaea To Eukaryotes; Volkswagen Stiftung; PI: Saric, A; £158,560.00

Condensed Matter and Materials Physics (CMMP)

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

Advancing first principles computational modelling of electron transfer processes at molecule/electrode interfaces; Pacific Northwest National Laboratory; PI: Blumberger, J; £36,548.34

SoftCharge - charge carrier transport in soft matter: from fundamentals to high-performance materials; European Commission H2020; PI: Blumberger, J; £1,703,779.00

Diamond masers – a new quantum technology platform; Royal Society; PI: Breeze, J; £374,658.84

CAM-IES - Centre for Advanced Materials for Integrated Energy Systems; EPSRC Engineering and Physical Sciences Research Council; PI: Cacialli, F; £83,733.10

MARVEL - Multifunctional Polymer Light-Emitting Diodes with Visible Light Communications ; EPSRC Engineering and Physical Sciences Research Council; PI: Cacialli, F; £372,355.18

Graphene Flagship Core Project 3; European Commission H2020; PI: Howard, C; £29,709.12

Spin physics in Two-Dimensional Layered Ferromagnets; EPSRC Engineering and Physical Sciences Research Council; PI: Howard, C; £36,754.85

Domain Switching in Multifunctional Materials: Towards a Multiferroic Memory; Royal Society; PI: Johnson, R; £155,255.55

Strain-tuning of Magnetic Frustration in Quantum Materials; Diamond Light Source; PI: Johnson, R; £27,280.00

Materials and Molecular Modelling Exascale Design and Development Working Group; EPSRC Engineering and Physical Sciences Research Council; PI: Michaelides, A; £3,701.24

Materials and Molecular Modelling High Performance (HPC) Hub; OCF PLC; PI: Michaelides, A; £140,000.00

The Materials and Molecular Modelling Hub; EPSRC Engineering and Physical Sciences Research Council; PI: Michaelides, A; £4,510,208.00

TIER 2 Hub in Materials and Molecular Modelling; EPSRC Engineering and Physical Sciences Research Council; PI: Michaelides, A; £4,000,000.00

Correlated Non-Equilibrium Quantum Matter: Fundamentals and Applications to Nanoscale Systems; European Commission H2020; PI: Pal, A; £1,213,497.01

Bionet - Dynamical Redesign of Biomolecular Networks; European Commission H2020; PI: Rosta, E; £775,054.00

Novel Enhanced Sampling Methods in Multiscale Modeling; EPSRC Engineering and Physical Sciences Research Council; PI: Rosta, E; £541,660.34

THOR - TeraHertz Detection Enabled by Molecular Optomechanics; European Commission H2020; PI: Rosta, E; £185,901.96

Atomistic calculations of relevant point defects near the SiC/SiO₂ interface; Infineon Technologies Austria AG; PI: Shluger, A; £45,000.00

Defect Functionalized Sustainable Energy Materials: From Design to Devices Application; EPSRC Engineering and Physical Sciences Research Council; PI: Shluger, A; £470,810.80

Degradation and dielectric breakdown in modern HfON based devices; Synopsis Inc; PI: Shluger, A; £36,000.00

Molecular dynamics simulation of interface structure of interface structure and interface diffusion phenomena for the Cu/TiW system; Infineon Technologies Austria AG; PI: Shluger, A; £40,000.00

Uncovering hidden phases of metal-amine solutions: glasses to superconductors; Leverhulme Trust; PI: Skipper, N; £210,857.11

New paradigms of quantum many-body dynamics; EPSRC Engineering and Physical Sciences Research Council; PI: Turner, C; £463,724.32

FNR - Fundamentals of Negative Capacitance: Towards New Low Power Electronics; EPSRC Engineering and Physical Sciences Research Council; PI: Zubko, P; £464,861.00

High Energy Physics (HEP)

Uncovering the Origin of Neutrino Masses through Direct Searches and Global Fits; STFC Science and Technology Facilities Council; PI: Agostini, M; £529,519.28

Maximizing NOvA physics potential with test beam measurements; Royal Society; PI: Backhouse, C; £110,055.00

Towards leptonic CP violation with NOvA and T2K; Royal Society; PI: Backhouse, C; £121,077.20

Unlocking neutrino mysteries with the nova and dune experiments; Royal Society; PI: Backhouse, C; £508,255.81

Innovative Network for Monte Carlo Event Generators for LHC Physics; European Commission H2020; PI: Butterworth, J; £267,214.82

SoftWare InFrastructure and Technology for High Energy Physics experiments; STFC Science and Technology Facilities Council; PI: Butterworth, J; £106,373.63

A proposal to extend the sensitivity to charged lepton flavour violation by 4 orders of magnitude; STFC Science and Technology Facilities Council; PI: Chislett, R; £64,887.00

NEw WindowS on the universe and technological advancements from trilateral EU-US-Japan collaboration; European Commission H2020; PI: Chislett, R; £72,000.00

South-Eastern Particle Theory Alliance Sussex - RHUL - UCL 2017-2020; STFC Science and Technology Facilities Council; PI: Deppisch, F; £131,100.16

South-Eastern Particle Theory Alliance Sussex - RHUL - UCL 2020-2023 - UCL Node; STFC Science and Technology Facilities Council; PI: Deppisch, F; £124,155.00

Widening the search for Dark Matter and Physics beyond the Standard Model with direct detection experiments; STFC Science and Technology Facilities Council; PI: Dobson, J; £511,341.00

XENON FUTURES: R&D for a Global Rare Event Observatory; STFC Science and Technology Facilities Council; PI: Dobson, J; £61,887.16

Searches For Beyond The Standard Model Physics With Hadronic Topologies; STFC Science and Technology Facilities Council; PI: Facini, G; £64,863.10

UCL Experimental Particle Physics Consolidated Grant (2019-2022); STFC Science and Technology Facilities Council; PI: Ghag, C; £3,785,064

XENON FUTURES: R&D for a Global Rare Event Observatory - Phase 1; STFC Science and Technology Facilities Council; PI: Ghag, C; £117,773.00

Spanning multi-TeV to GeV scales for collider discoveries and measurements; European Commission H2020; PI: Hamilton, K; £291,630.34

Developing Quality Assurance Tools for Proton Beam Therapy; STFC Science and Technology Facilities Council; PI: Jolly, S; £304,452.99

Quality Assurance Range Calorimeter for Proton Beam Therapy; STFC Science and Technology Facilities Council; PI: Jolly, S; £364,766.58

ATLAS Phase-2 Upgrades – Construction project; STFC Science and Technology Facilities Council; PI: Konstantinidis, N; £970,302.00

Exotic search for dark sector physics using lepton jets; Royal Society; PI: Malik, S; £2,179.00

Search for dark matter with quantum sensors; Royal Society; PI: Malik, S; £450,231.89

DUNE Construction Grant; STFC Science and Technology Facilities Council; PI: Nichol, R; £350,947.00

Higgs studies and a search for dark matter at the ATLAS experiment; Royal Society; PI: Nurse, E; £272,868.66

Searching for Dark Matter at the LHC; Royal Society; PI: Nurse, E; £102,290.00

Support for Machine Learning Based Surrogate Models for Emulating the Extreme Scale Simulation of Tokamak plasma; UK Atomic Energy Authority; PI: Nurse, E; £32,000.00

Determination of Absolute Neutrino Mass Using Quantum Technologies; STFC Science and Technology Facilities Council; PI: Saakyan, R; £1,897,333.34

Deep Learning in the CHIPS water Cherenkov detector; Czech Technical University in Prague (CTU); PI: Scanlon, T; £48,000.00

Enhancing H-bb: Exploring the Higgs Sector and Discovering New Physics; Royal Society; PI: Scanlon, T; £199,796.22

Exploring the Higgs Sector and Probing for New Physics using H->bb; Royal Society; PI: Scanlon, T; £365,348.57

CHROMIUM; European Commission H2020; PI: Thomas, J; £2,287,002.17

Peering at Neutrino Oscillations with a Magnifier; Royal Society; PI: Thomas, J; £1,114,497.07

Standard Model Phenomenology; STFC Science and Technology Facilities Council; PI: Thorne, R; £366,312.00

LEGEND: Neutrinoless Double-Beta Decay and Germanium Detector Technology; STFC Science and Technology Facilities Council; PI: Waters, D; £23,840.00

Advancement and Innovation for Detectors at Accelerators; European Commission H2020; PI: Wing, M; £104,000.00

Production of high quality electron bunches in AWAKE Run 2; STFC Science and Technology Facilities Council; PI: Wing, M; £286,284.04

Search for dark photons and investigation of QCD using novel accelerator scheme; Leverhulme Trust; PI: Wing, M; £321,339.48

Staff Snapshot

A large, intricate nebula dominates the center of the page. It features a complex network of filaments and clouds in shades of red, orange, and white, set against a deep blue and teal background. The entire scene is peppered with numerous stars of varying brightness, some showing prominent diffraction spikes. The overall effect is that of a dynamic and colorful cosmic environment.

Staff snapshot

Head of Department Professor R. K. Prinja

Deputy Head of Department Professor F. Renzoni

Astrophysics

Head of Group:

Professor G. Tinetti

Professors:

G. Savini, N. Achilleos, M. J. Barlow, A. P. Doel, R. Ellis, J. Farihi, B. Joachimi, O. Lahav, H. Peiris, A. Pontzen, R. K. Prinja, J. M. C. Rawlings, G. Tinetti, A. Saintonge, S. Viti, S. Yurchenko

Associate Professors

F. Abdalla, A. L. Aruliah, S. Fossey, I. Waldmann

Lecturers:

M. Kama, J. Sanders

Professorial Research Fellow:

D. Brooks

Senior Research Fellows:

A. Al-Refai, F. Diego, S. Nadathur, K. Pattle, M. Tessenyi, A. Tsiaras, R. Wesson

Research Fellows:

C. Cadiou, Q. Changeat, C. Circosta, J. Davies, W. Dunn, E. Hang, N. Jeffrey, A. Jenkins, G. Joshi, F. Kirchschrager, A. Loureiro, M. Marcha, D. Millas, M. Niculescu-Duvaz, N. Nikolaos, D. Piras, S. Pyne, M. Rocchetto, A. Saxena, F. Schmidt, A. Shitvov, M. Tang, A. Tenneti, N. Tessore, L. Whiteway, G. Yip

Marie Curie Early Stage Researcher

R. O'Donoghue, M. Keil

Professional Services:

E. Dunford, J. Fabbri, C. Jenner, K. Nakum, M. Rangrej, R. Raupp, A. Williams

Computing, Engineering and Technical Staff:

S. Boyle, J. Deacon, E. Edmondson, M. Pearson, T. Schlichter, S. Sullivan

Atomic, Molecular, Optical and Positron Physics

Head of Group:

Professor S. Hogan

Professors:

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

Research Fellowships:

T. Blacker, L. Masanes

Research Fellows:

B. Augstein, T. Babij, A. Callison, P. Comaron, B. Cooper, L. Cruz Rodriguez, A. Ferrier, R. Ghosh, H. Gomes, G. Katsoulis, B. Maddox, C. Nation, M. Pezzella, O. Polyansky, A. Pontin, D. Rose, A. Sokolov, A. Svesko, D. Toniolo, J. Zou

Professional Services:

Currently recruiting

Computing, Engineering and Technical Staff:

J. Dumper, F. Garza, C. Godden, F. R. Jawad, F. Noyes

Biological Physics

Head of Group:

Professor B. Hoogenboom

Professors:

A. Bain (also AMOPP), J. Blumberger (also CMMP), G. Charras (Cell and Developmental Biology), B. Hoogenboom, P. Jones, T. Nguyen, A. Olaya-Castro (also AMOPP), I. Robinson (also CMMP)

Associate Professor:

A. Saric

Lecturer:

T. Michaels

Senior Research Fellows:

Z Hadjivasiliou (Crick), M. Molodtsov (Crick)

Senior Research Associates:

T. Le

Research Fellows:

T. Blacker, C. Bortolini, L. Chu (Crick), D. Khoromskaia (Crick), L. Mosby (Crick), G. Pobegalov (Crick), Q. Wu

Professional Services:

J. Gill-Thind

Condensed Matter and Materials Physics

Head of Group:

Professor S. T. Bramwell

Professors:

J. Blumberger, D. Bowler, S. Bramwell, F. Cacialli, A. Fisher, I. Ford, A. Green, C. Howard, D. McMorrow, I. Robinson, A. Shluger, N. Skipper, M. Szymanska, S. Zochowski, P. Zubko

Associate Professors:

M. Buitelaar, F. Kruger, A. Pal, E. Rosta, R. Perry, S. Schofield

Lecturers:

J. Breeze, R. Johnson, C Perez Martinez

Research Fellows:

R. Darkins, T. Foldes, S. Gehrke, S. Ghosh, T. Greenland, R. Hafizi, L. Ishibe Veiga, A. James, Z. Koczor-Benda, K. Kwakwa, B. Mukherjee, E. Parsons, J. Richter, D. Rose, M. Szyniszewski, B. Willis, C. Yin

Marie Curie Trainee:

E. Stylianidis

Most Research staff are employed through the LCN

Professional Services:

J. Levin, D. Ottley

Computing, Engineering and Technical Staff:

A. Gormanly, S. Patel, F. Sidoli

High Energy Physics**Head of Group:**

Professor D. Waters

Professors:

J. M. Butterworth, M. Campanelli, F. Deppisch, C. Ghag, K. Hamilton, N. Konstantinidis, R. Nichol, E. Nurse, R. Saakyan, J. A. Thomas, R. S. Thorne, D. Waters, M. Wing

Associate Professors:

G. Hesketh, S. Jolly, A. Korn, T. Scanlon

Lecturer:

R. Chislett, G. Facini, N. Nikolaou

Principal and Senior Research Associates:

A. Basharina-Freshville, R. Flack, P. Sherwood, B. Waugh

Ernst Rutherford Fellows:

M. Agostini, J. Dobson, N. McConkey

Royal Society University Research Fellows:

S. Malik

Research Fellows:

S. Bash, F. Cicala, J. M. Carceller, D. Cooke, T. Cridge, S. Escribano Rodriguez, T. Fruth, S. Grant, C. Gutschow, S. Jones, N. Kimura, Y. Ma, A. Martyrwood, V. Monachello, G. Oliviero, S. Rettie, L. Shi, A. Stevens, A. Sztuc, R. Verheyen, S. Vergani

Professional Services:

Currently recruiting

Computing, Engineering and Technical Staff:

D. Attree, P. Bizouard, G. Crone, E. Edmondson, C. Godden, T. Hoare, E. Motuk, M. Warren

Teaching**Director of Undergraduate Teaching:**

L. Dash

Director of Postgraduate Studies:

S. Zochowski

Undergraduate Careers Officer:

J. Farihi

Professor (Teaching):

P. Barlett

Associate Professors (Teaching):

D. Armoogum, E. Ashgrove, S. Boyle, S. Fossey, L. Dash, N. Nicolaou

Lecturer (Teaching):

J. Bhamrah, F. Diego Quintana, J. Frost-Schenk, G. Giannopoulos, M. Szumilo

Laboratories**Director of Laboratories:**

P. Bartlett

Superintendent of U/G Physics Laboratories:

D. Thomas

Senior Teaching Laboratory Technician:

B. T. Bristoll

Laboratory Technician:

E. Milner, M. A. Sterling

Experimental Development Officer

K. Vine

The Workshop: High Precision Design and Fabrication Facility (HPDFF)**Physics, Chemical and Biochemical Engineering Facility**

R. Saakyan

Admissions Tutors:

A. Aruliah (MSc), F. Diego (Astronomy Certificate), J. Blumberger (Postgraduate Research), P. Jones (Undergraduate)

Schools Liaison Officer:

C. Howard

Programme Tutors:

D. Armoogum (Undergraduate), S. Fossey (MSc), N. Nicolaou (Undergraduate), J. C. Rawlings (Astronomy Certificate), S. Zochowski (PhD)

UCL Observatory**Director:**

G. Savini

Senior Observatory Technicians:

M. Pearson (Mechanical and site officer)
T. Schlichter (Computing and Instrumentation Officer)

Observatory Technician:

S. Sullivan

Professional Services**Departmental Manager:**

L. Coletti Campbell

Deputy Departmental Manager:

L. Keepking

Senior Staffing and Communications Officer:

B. Carboo

Senior Research Officer:

R. Martin

Senior Finance Officer:

A. Balcuinas

Research Administrator:

Currently recruiting

Education Support Team

Senior Postgraduate and Student Finance

Administrator:

N. Waller

Teaching and Learning Manager:

S. Lovell

Senior Teaching Administrator:

H. Copeland

Postgraduate Taught Teaching and Learning

Administrators:

S. Begum, S. McGrath

UG Teaching and Learning Administrators:

T. Crorie, L. Medici

Postgraduate Research Teaching Administrator:

J. Bristow

Student Advisor:

R. Edmonds

Research Groups

Astrophysics Group Manager

K. Nakum

AMOPP/HEP Research Group and Operations

Administrator

Currently recruiting

Biological Physics (BioP) Research Administration

Officer:

J. Gill-Thind

Finance Officer and CMMP Research Group

Administrator:

J. Levin

Centre Manager (Centre for Space Exoplanet Data):

E. Dunford

Thomas Young Centre (TYC) and Materials and

Molecular Modelling (MMM) Hub Coordinator:

K. Stoneham

Project Manager and Scientific Officer (The Centre for Planetary Sciences):

J. Fabbri

Project Manager (Cosmoparticle Physics (CPP) Initiative) and Executive Assistant:

R. Raupp

Project Manager (Euclid):

M. Rangrej

Safety Officer and Estates Manager:

L. Bebbington

Outreach and Public Engagement

Outreach Coordinator and Ogdén Science Officer:

M. Fuller

Science Centre Organiser:

S. Kadifachi

Doctoral Training Centre

CDT Manager, CDT in Data Intensive Science (DIS):

M. Cao

CDT Manager, CDT in Data Intensive Science (DIS) and Industry:

E. De Ben Rockson

Computing and IT:

Computing Manager and IT Coordinator:

B. Waugh

Computing Administrator (HEP):

T. Hoare

IT Systems Managers:

F. Garza (AMOPP and BioP), F. Ihsan (Teaching and Learning)

Visiting Professors, Honorary Professors and Emeritus Staff:

A. Aylward, P. Beltrame, S. Bridle, A. Charalambous, R. Cohen, M. Coupland, I. Crawford, D. H. Davis, J. Drew, M. M. Dworetzky, D. Duffy, M. Ellerby, J. Ellis, M. Esten, I. Ferreras, J. L. Finney, F. Fernandez-Alonso, J. Fordham, I. Furniss, M. J. Gillan, A. H. Harker, C. Hirjibehedin, B. Hiley, C. Hilsun, P. Hobson, I. D. Howarth, J. W. Humberston, T. W. Jones, N. Kaiser, A. Kravtsov, M. Lancaster, B. R. Martin, G. Materlik, K. A. McEwen, J. McKenzie, A. Michaelides, D. J. Miller, S. Miller, D. Moores, R. Maiolino, W. Newell, G. Peach, R. Radogna, A. Slosar, A. C. Smith, A. Stevens, P. J. Storey, D. N. Tovee, C. Wilkin, D. A. Williams

UCL Department of Physics and Astronomy
Gower Street • London • WC1E 6BT
www.ucl.ac.uk/physics-astronomy

