IOP Institute of Physics
Astroparticle Physics Group

NEWSLETTER **2021**

Issue no. 11

Image credits: E. Meehan (STFC Boulby Laboratory), S. Spencer (HESS telescope), X. R. Liu (Remote^3 project)

Follow us!

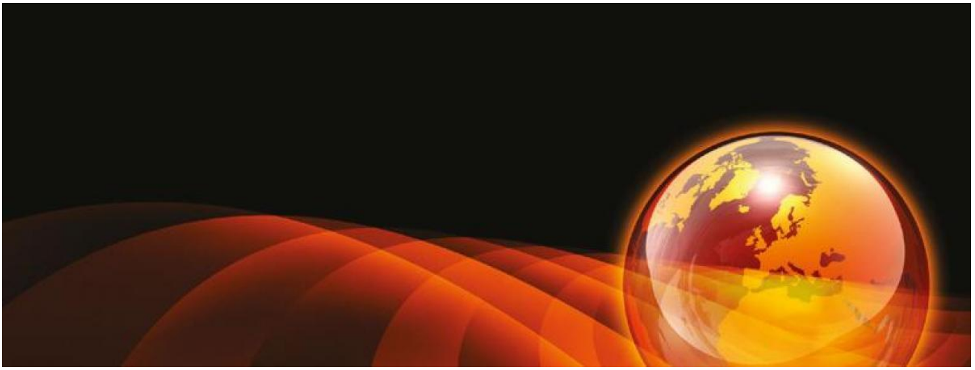
Facebook: @IOPAPP, www.facebook.com/IOPAPP

Twitter: @IOP_APP, https://twitter.com/IOP_APP

Website: https://www.iop.org/physics-community/special-interest-groups/astroparticle-physics-group

Content

HEPP and APP Annual Conference 2022



3-6 April 2022,

Rutherford Appleton Laboratory, Didcot, UK, OX11 0DE

https://events.iop.org/iop-hepp-app-annual-conference-2022

Abstract Submission Deadline

14 February 2022

From 03-06 April 2022, the Institute of Physics will be bringing together the UK High Energy Particle Physics and Astroparticle Physics communities for a joint annual conference, marking the 65th anniversary of this IOP conference. The meeting will feature keynote and invited talks from major national and international speakers, as well as extensive opportunities for contributed talks. A poster session will also take place to showcase work and discoveries. and updates and discussions with senior members of the Science and Technology Facilities Council will be provided at a Town Meeting.

Words from the Chair

In this second year of pandemic, we hosted several events, including the 2021 annual conference, online. But now, we are also resuming in-person activities. We hosted the very first in-person event on Nov. 10 at the IOP building, and plan for the 2022 annual meeting to be in-person. We are continuously monitoring the situation of the pandemic, but the momentum of the APP working group is unstoppable!

APP is one of the fastest-growing IOP working groups. Currently, it has around 2000 members and is the 6th largest group out of 51 IoP special interest groups. The growth of our community is supported by young members, and over 60% of the group members are under 30 years old. This reflects our strategy and we have a dedicated sub-group for outreach activities. This year, we are pleased that the APP committee member, Dr. XinRan Liu (Edinburgh) won the IOP Somerville medal for the promotion of science. We engage in further activities to satisfy all spectra of APP members from supporting APP research activities to the public.

Chair, Teppei Katori (King's College London)

Editorial

It hasn't been the year we'd have wished for. The winter lockdown meant that our annual conference, scheduled for beautiful Edinburgh, was held online. Master's students graduated without ever attending campus, or meeting their supervisors face-to-face. We've learned to adapt to new ways of working, and once again, travel restrictions and the need to protect ourselves, our colleagues, and our loved ones, have stretched our resourcefulness to its limits. That's why I hope this newsletter will be a celebration – of scientific achievement, of resilience, and of the connections we've found both inside and outside of the APP community. I hope you enjoy it.

Newsletter editor, Cheryl Patrick (University of Edinburgh)

Meet your committee

Teppei Katori *(KCL)*
Chair
Neutrino physics

Anthony Brown *(Durham)*
Secretary
Gamma-ray astronomy

XinRan Liu *(Edinburgh)*
Treasurer
Dark matter

Garret Cotter *(Oxford)*
Gamma-ray astronomy

Theresa Fruth *(UCL)*
Dark matter

Ian Harry *(Portsmouth)*
Gravitational waves

Chris McCabe *(KCL)*
Astroparticle physics theory

Emma Meehan *(Boulby)*
Underground lab specialist

Cheryl Patrick *(Edinburgh*)
Neutrino physics

Matt Roth *(ANU)*
Diffuse astrophysical backgrounds

Sam Spencer *(Oxford)*
Cherenkov telescopes

Upcoming IOP APP Prizes

IOP APP Early-Career Prize 2021

Nominations are now open for the APP Early Career Prize, awarded in alternating years, which includes a £250 prize and certificate.

Eligible researchers should work in the area of astroparticle physics, either experiment or theory, in any institution in the UK or Ireland. Broadly, 'astroparticle physics' includes cosmic ray physics, neutrino and gamma ray astronomy, dark matter, gravitational waves, neutrinoless double-beta decay and nuclear astrophysics. Winners from previous years can be found on the **Group webpage.**

To be eligible:

- The nominee should have five years or less postdoctoral experience (allowing for career breaks).
- Two nominators are required, of whom one should be from an institution that is not the nominee's current employer.
- At least one nominator should be a member of the IOP Astroparticle Physics Group.
- In cases where eligibility is unclear, the prize awarding committee will adjudicate.

Nominations should include three papers that the nominee has worked on in the preceding two years (as pdf copies or the DOI of the paper) and a nomination letter highlighting the nominee's contributions to the field. The papers must have been published or accepted for publication in a peer-reviewed or refereed journal. The winner will be selected by a committee of the IOP Astroparticle Physics Group committee (excluding the nominators, if any).

The deadline for submissions is 31 January 2022. Should you have any questions regarding the prize, or wish to submit a nomination, please email the APP prize committee chair **Dr. Theresa Fruth.**

Dr Theresa Fruth, of UCL, won the 2019 IOP APP Early-Career Prize for her work on the LUX-ZEPLIN dark matter experiment. She is pictured here heading underground to the LZ detector in the Sanford Laboratory, South Dakota, USA.

IOP APP Thesis Prize 2022

Next call will be in late 2022

Eligible nominees have submitted an outstanding thesis in astroparticle physics (either experiment or theory), in any institution in the UK and Ireland. Broadly, “astroparticle physics” includes cosmic-ray physics, neutrino and gamma-ray astronomy, dark matter, double-beta decay and nuclear astrophysics. In cases where eligibility is unclear, the prize-awarding committee will adjudicate. **Two nominators** are required; one of them should be the thesis supervisor or external examiner. Nominations should include an electronic copy of the thesis.

IOP APP Prize Winners

IOP APP Thesis Prize 2020

Dr. Jost Migenda (University of Sheffield) for the thesis, *Supernova Model Discrimination with Hyper-Kamiokande*.
Interviewed by Theresa Fruth, UCL

TF: *Jost, congratulations on your well-deserved award! Your thesis work was on supernova detection with Hyper-Kamiokande. Can you tell us a bit about how Hyper-Kamiokande works?*
JM: Thank you, Theresa! Hyper-Kamiokande is a cylindrical detector that's 68 m in diameter and 72 m high and currently under construction deep underground inside a mountain in Japan, 250 km north-west of Tokyo. It will be filled with ultra-pure water and surrounded by over 20,000 high-sensitivity photomultiplier tubes (PMTs). Every second, quintillions of neutrinos from various sources—our Sun, distant supernovae, a neutrino beam from a particle accelerator, and more—go through the detector. However, because neutrinos only interact through the weak nuclear force, just a few hundred per day will interact in the detector and produce a flash of flight that's bright enough to be detected by the PMTs. We can then use the detected light to reconstruct the energy of the neutrino and its approximate direction of origin. We use this to study both neutrinos themselves and their sources.

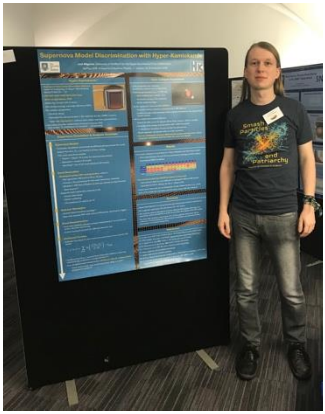
***TF:** What are supernovae and why are they so interesting to study?*

JM: Core-collapse supernovae[1] occur when massive stars of at least eight solar masses explode at the end of their lives. These are some of the most magnificent events in the universe, with one single star shining about as bright as a whole galaxy of billions of stars. What fascinates me most about supernovae is how multi-faceted they are. They are incredibly large explosions, yes; but they also leave behind neutron stars and black holes, which are themselves fascinating astrophysical objects; they produce many chemical elements like oxygen, calcium or silicon, which are necessary for life as we know it; they expel those elements into their cosmic surroundings, enriching and disturbing nearby gas clouds and causing a burst of new star formation; and they are laboratories for fundamental physics, allowing us to study nuclear and particle physics under extreme conditions that are impossible to reproduce on Earth.
Neutrinos play a key role in facilitating the explosion and since they interact only weakly, they can also escape from the centre of the star during that explosion, allowing us to study—millisecond by millisecond !—how the explosion happens. So my research combines the tiniest known objects in the universe (neutrinos), with some of the most energetic ones (supernovae). Even after more than six years of working on this topic, that contrast still blows my mind whenever I stop to think about it!

TF: *You are also an active advocate of diversity in Physics. In your opinion, what are some of the key things to make research careers more accessible and enjoyable for everyone?*
JM: On a systemic level, uncertain working conditions for early-career researchers—short-term contracts, having to move between different countries or even continents, etc.—can be a major problem. These factors affect everyone in the field, but they often are particular hurdles for researchers who are already disadvantaged, e.g. if they have caring responsibilities (that can make international moves challenging) or mental health problems

[1] There’s another type of supernova, called type Ia, which works in a different way. They’re important standard candles for cosmology, but they produce few neutrinos, so I’ll ignore them here

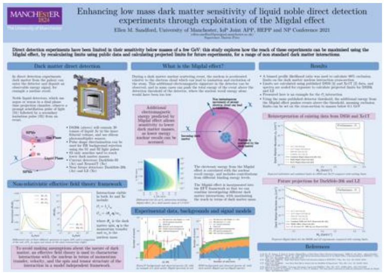
(that can flare up in a new environment), or if they come from non-western countries and suffer from travel or visa restrictions. For an individual researcher, these systemic issues are almost impossible to fix; the best ways to affect change are to join a union and to vote. On an individual level, having a network of people like you can be so important! For example, I first attended the LGBTQ+ STEMinar in 2017 and discovered a community that has been an incredible source of both practical and emotional support through the ups and downs of my PhD. Depending on your background and career stage, you might find similar networks through events like the Conference for Undergraduate Women in Physics (CUWiP) or Twitter communities like @DisabledStem, @BlackInAstro and many others.



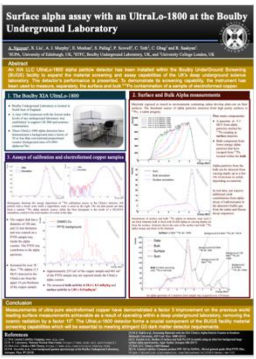
TF: *One of the great things about working in our field is that we get to travel a lot, try new things, and meet interesting people. Do you have any funny stories from your time on Hyper-Kamiokande?*
JM: Traveling to Japan for collaboration meetings and conferences (and a bit of sightseeing afterwards) has definitely been a highlight of my PhD! There are so many beautiful memories, but one experience that I will always remember happened on the first day: I had just arrived after a long flight, was terribly jetlagged due to the 9 hour time difference and went to a supermarket to get something to eat. In there, the culture shock really hit me—I couldn't read a word of Japanese and barely recognized half the foods. Being too exhausted to be adventurous, I picked a "safe option" and bought what looked like rice dumplings with caramel. Only as I took the first bite did I learn that the "caramel" was actually a soy sauce-flavoured syrup!
TF: *Thank you, Jost! Congratulations again, and best wishes for the future. I'm sure we will all see much more of you!*

IOP APP poster contest 2021

The IOP's joint high-energy particle, astroparticle and nuclear physics meeting in 2020 was hosted by the University of Edinburgh – but due to Covid-19 restrictions, the event was held online. Thanks to the creativity and resourcefulness of our hosts, we still got the full conference experience – including a fantastic poster session held in the virtual meeting-space app, Gather.Town. PhD students showed off great work done in challenging conditions. Two students' posters particularly impressed the judges, and they were awarded the APP poster prize. Congratulations, Anh and Ellen!



Ellen Sandford, from the University of Manchester, explained how it was possible to enhance the low-mass dark-matter sensitivity of liquid-noble direct-detection experiments by exploiting the Migdal effect (see separate article). She showed how detectors like Darkside-50 and Xenon-1T could benefit from using the additional electromagnetic energy predicted by the Migdal effect to detect ultra-low-energy nuclear recoils.



The University of Edinburgh's **Anh Nguyen** works on direct dark matter detection with the LUX-ZEPLIN (LZ) experiment. Her [winning poster] described a surface alpha assay with an UltraLo-1800 at the Boulby UnderGround Screening (BUGS) facility. The detector expands the material screening and assay capabilities of Boulby, the UK's deep underground science laboratory. Anh and her colleagues demonstrated its performance and world-leading sensitivity by measuring the ^{210}Po contamination of a sample of ultra-pure copper.

Physics highlights of 2021

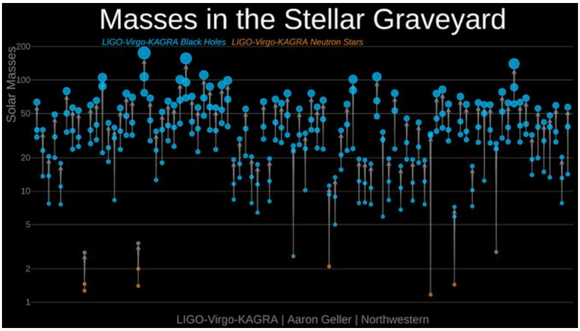
Gravitational Waves

***Ian Harry**, University of Portsmouth*

On September 14, 2015 the Advanced LIGO Gravitational Wave observatory made a Nobel Prize winning observation. It made the first direct detection of gravitational waves, and observed for the first time the collision of two black holes. Gravitational-wave astronomy has advanced significantly in the 6 years since that discovery with another 35 gravitational wave observations recently having been announced, bringing the total number of observed events to almost 100.

Gravitational waves are one of the key predictions of Albert Einstein's general theory of relativity. These can be thought of as "ripples" in space time produced by some of the most extreme events in the Universe, such as two black holes colliding with each other. However, the effect of these waves on matter is extremely small and it has taken many decades of instrumental development to be able to design and build gravitational-wave observatories that are sensitive enough to observe even the strongest sources of gravitational waves.

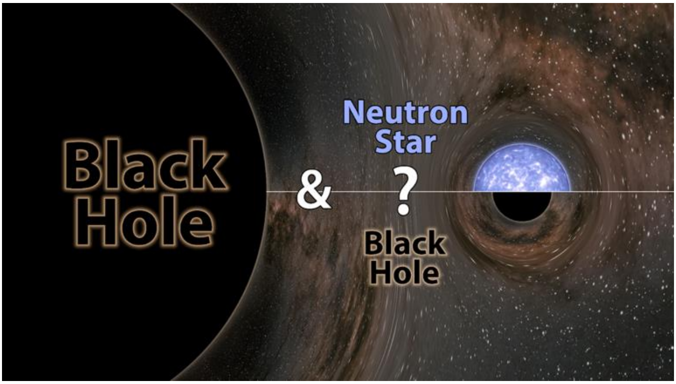
In the past 6 years, the LIGO, Virgo and KAGRA collaborations have collectively observed around 90 black hole collisions, two double neutron star collisions and at least two instances of a neutron star colliding with a black hole. The complete set of objects observed can be seen in [the first image]. Arguably the most important of these observations was the colliding pair of neutron stars observed on the 17th August 2017. This event was noteworthy because, as well as being the first observation of two colliding neutron stars, it was observed simultaneously as a gamma-ray burst by the Fermi satellite and later observed over a range of electromagnetic frequencies with many different observatories. This observation allowed scientists to make an independent measurement of the expansion rate of the Universe, probe the unknown composition of neutron stars and begin to understand the connection between neutron star collisions and gamma-ray bursts.



Compact object masses. Each circle represents a different compact object and the vertical scale indicates the mass as a multiple of the mass of our Sun. Blue circles represent black holes and orange circles represent neutron stars. Half-blue / half-orange mixed circles are compact objects whose classification is uncertain.

Each merger involves three compact objects: two merging objects and the final resulting object. The arrows indicate which compact object merged and the remnant they produced. Credits: LIGO-Virgo-KAGRA Collaborations/Frank Elavsky, Aaron Geller/Northwestern.

Recently, LIGO and Virgo conducted their third observing run, which ran from April 2019 to March 2020. One of the highlights of this observing run was the observation of two systems consisting of a neutron star colliding with a black hole. Previous to these observations it was expected that systems consisting of one neutron star and one black hole would exist from the evolution of a massive pair of stars, but no such system has been observed with conventional telescopes. Now we know for sure that they exist! We can also predict that within a distance of one billion light years from the Earth there will be 5 to 15 collisions between a neutron star and a black hole every year. Another highlight was the signal observed on the 14th August 2019. Just like all the other signals observed to date this involved the merger of two highly compact objects. However, while we know that the heavier of the two objects was a black hole, the identity of the lighter object remains a mystery. The mass of this object was determined to be close to 2.6 times the mass of our Sun. This means that this object is *either* the heaviest neutron star to ever be observed, which has significant implications for the internal composition of such objects. *Or* it is the lightest black hole we have ever observed. The general consensus supports the black hole hypothesis, as theoretical neutron star modelling as well as electromagnetic observations provide estimates of the maximum neutron star mass that is significantly less than 2.6 times the mass of our Sun. It is even possible that this object was the remnant from a *previous* collision of two neutron stars, which is now colliding with a heavier black hole.



Artist's impression of the curious observation from 17th August 2019. Credit: Robert Hurt (Caltech)

The fourth observing run, involving LIGO, Virgo and KAGRA is due to begin at the end of 2022. With the sensitivity of these observatories continuing to increase, it is expected that hundreds of gravitational wave sources will be observed. Will it also be the first time when we observe a gravitational wave signal that is not coming from colliding neutron stars and/or black holes? Other potential sources of gravitational waves include galactic supernovae, rapidly spinning asymmetric neutron stars in the Milky Way, stochastic gravitational wave emission from the early Universe and, perhaps most interestingly, some new source that has not been theorised at all to date.

For more details about recent gravitational wave results, please see the summary pages at **ligo.org/science/outreach.php**, which are available in a number of languages.

Experiment Spotlights

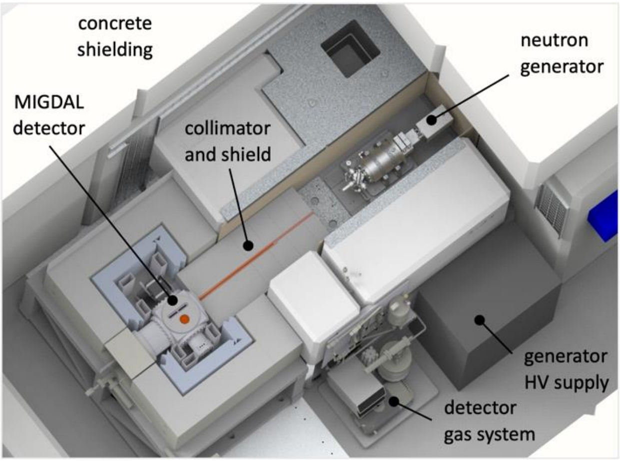
The MIGDAL Experiment

***Christopher McCabe**, King's College London*

The MIGDAL experiment aims to unambiguously detect the 'Migdal effect' under the most favourable conditions. The prediction of this effect dates to the work in 1939 by Russian physicist Arkady Migdal. He noticed that quantum mechanics predicts that if a particle gives a sudden jolt to the nucleus of an atom, there is a small probability (of approximately 1 in a million) that the atom will emit a high-energy electron.

This effect was largely ignored by the particle physics community but in the last decade or so, various theoretical physicists realised that it could have significance in the search for dark matter. For over 30 years, physicists have been running laboratory experiments to search for dark matter particles, which current theories say are constantly streaming through the Earth. Usually, these experiments search for dark matter particles that scatter elastically with an atomic nucleus. This scattering collision gives the nucleus some energy, which can be detected with these exquisitely sensitive detectors operating deep underground. The theoretical physicists realised that the sudden collision of the dark matter particle with the nucleus can also be followed by the emission of an electron, exactly through the mechanism predicted by Arkady Migdal. Although this happens only rarely, many of the most sensitive dark matter detectors find it easier to detect electrons rather than a recoiling atomic nucleus, so the Migdal effect helps in the search for dark matter particles with a mass between the electron and proton masses, which are predicted by many particle-physics theories of dark matter.

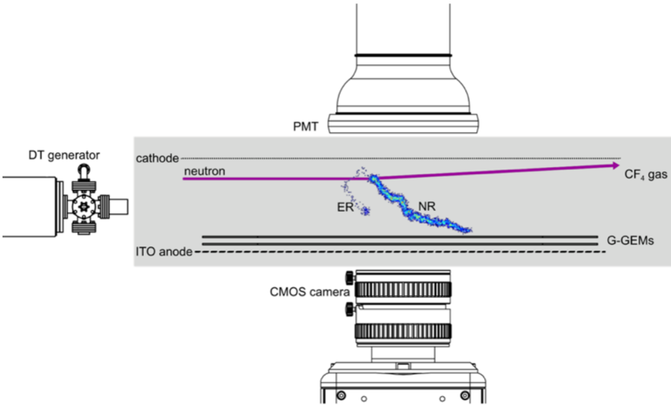
We know the Migdal effect is promising for dark matter searches, but it has never been observed in the context of nuclear scattering. The MIGDAL experiment aims to detect the tell-tale emission of the low-energy electrons ejected from atoms and molecules upon the scattering of fast neutrons providing a unique and unambiguous signal of the Migdal effect. A beam of fast neutrons will be used as a proxy for the dark matter particles as both dark matter and neutrons are electrically neutral and the way they interact with the atomic nucleus shares many similarities. It is also relatively straightforward to buy equipment that produces a neutron beam while no-one has yet been able to produce a dark matter beam in the laboratory!



The MIGDAL experiment at the NILE facility at RAL

The MIGDAL experiment will employ an Optical Time Projection Chamber (OTPC) to detect neutron interactions in a gaseous medium at pressure far below the normal atmospheric pressure. Our detector allows three-dimensional tracks to be reconstructed through the following detector sub-systems: i) track ionisation is drifted to a double Gas Electron Multiplier (GEM) and converted to an optical signal which is imaged by a fast CMOS camera; ii) the amplifier charge is collected at an anode plane segmented into readout strips to obtain the perpendicular coordinate; iii) a photomultiplier tube detects both the primary and secondary scintillation light to provide the absolute depth coordinate. All of this to say that we have designed a system to capture and measure the tracks from the recoiling nucleus and the emitted electron that originate at a common vertex, as they must if the electron is emitted from the atomic nucleus that has been hit by a neutron. Operating the experiment at a small fraction of atmospheric pressure will allow the electron tracks to go further, giving us a better chance of ‘photographing’ them in the detector.

The experiment will be installed at the Neutron Irradiation Lab for Electronics (NILE) facility at ISIS facility at the Rutherford Appleton Laboratory in the UK and be exposed to intense D-D and D-T neutron generators in a series of runs beginning in early 2022. The MIGDAL Collaboration benefits from the expertise of scientists working in six countries. The project started in October 2019 with funding by the UK’s Science & Technology Facilities Council.



Credit: Tim Marley. A schematic representation of the MIGDAL experiment showing the OTPC exposed to neutrons from a DT generator, with interactions in the low-pressure CF4 gas. The active volume of the OTPC is approximately 7cm x 7cm x 3cm. Optical signal are recorded by an external camera and a VUV PMT, while track ionisation is detected by an ITO-strip anode. An example 2D-projected Migdal event (scaled up by a factor 3 for clarity) is shown.

The experiment will be installed at the Neutron Irradiation Lab for Electronics (NILE) facility at ISIS facility at the Rutherford Appleton Laboratory in the UK and be exposed to intense D-D and D-T neutron generators in a series of runs beginning in early 2022. The MIGDAL Collaboration benefits from the expertise of scientists working in six countries. The project started in October 2019 with funding by the UK’s Science & Technology Facilities Council.

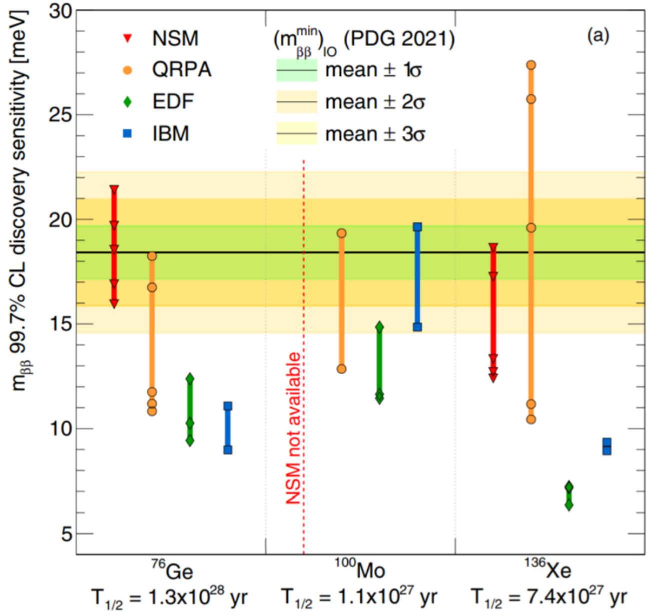
Hunting matter creation with double-beta decays - LEGEND’s quest is about to start

Matteo Agostini, *UCL*

What a year 2021 has been for the community hunting for neutrinoless double-beta decay. The interest in this hypothetical matter-creating nuclear transition has never been higher. Its discovery could soon be within reach, bringing us a step closer to explaining the origin of neutrino mass and why the universe contains more matter than antimatter, a fact to which we owe our very existence.

The discovery of neutrino mass at the turn of the century raised the pressing question of whether that mass could be of the particular type proposed by Majorana. It also fixed a goal for experiments, setting an upper limit on the half-life of the decay when mediated by inverted-ordered neutrinos. Having a concrete goal and new theory motivations triggered a worldwide experimental endeavour, with many R&D projects exploring different candidate nuclei and detection techniques. These efforts set the stage for selecting the most promising detection concepts and designing ultimate experiments ensuring a discovery in the inverted-ordering scenario. The community is currently proposing several next-generation quasi-background-free ton-scale experiments as part of a global enterprise, with the goal for the next decade of extending the half-life sensitivity in multiple nuclei by two orders of magnitude, up to 10^{28} years - a million billion times the age of the universe.

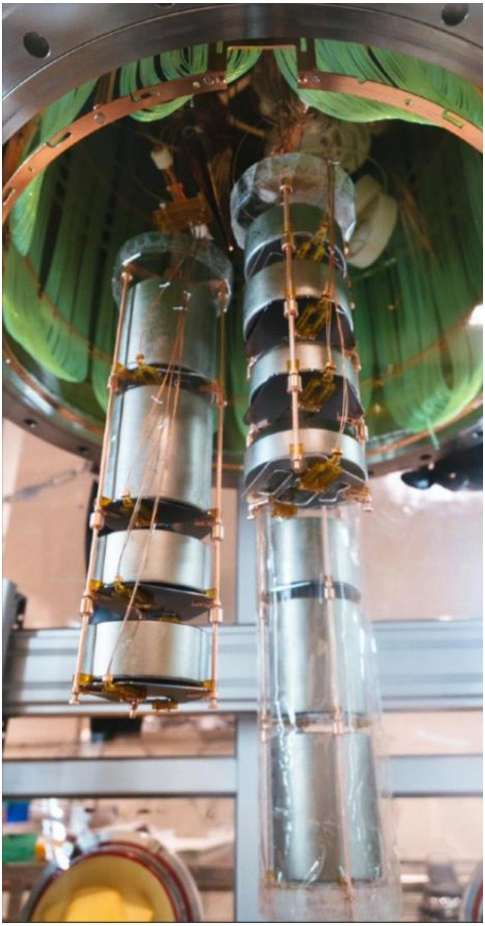
In 2013, the US Department of Energy started a "down selection" process to choose one or more of these next-generation experiments to support, culminating in a "US portfolio review" this summer, with international collaborations defending their designs. This was followed by the first "North America-Europe Workshop on Future of Double Beta Decay", organised by INFN, the Astroparticle Physics European Consortium (APPEC), and the US DOE. Representatives from European funding agencies, including STFC, gathered to define an international strategy. Four experiments were discussed: CUPID (^{100}Mo), LEGEND (^{76}Ge), nEXO (^{136}Xe), and NEXT (^{136}Xe). The agencies will soon select one or more of these for funding.



Discovery power of future double-beta decay experiments. The discovery power is expressed through the effective Majorana mass $m_{\beta\beta}$, which is the parameter of interest for these searches. Planned half-life sensitivities in several isotopes are converted in $m_{\beta\beta}$ values using nuclear physics many-body calculations (i.e., NSM, QRPA, EDF, IBM), leading to the uncertainties illustrated by the vertical bars. The horizontal bands show the lowest value of the Majorana mass, assuming inverted-ordered neutrinos. Experiments like LEGEND-1000 (see ^{76}Ge) will be able to discover a signal even at the bottom of the inverted ordering parameter space. Taken from "Agostini et al., PRC 104 (2021) 4".

The UK continues to lead neutrinoless double-beta decay searches, with the SNO+ and SuperNEMO experiments currently undergoing commissioning and planning to start data taking next year. A newcomer on the UK scene is LEGEND, one of the experiments competing in the recent international reviews. LEGEND is proceeding in two phases. LEGEND-200 is fully funded, currently undergoing commissioning at the Gran Sasso underground laboratory in Italy, and plans to start data taking early in 2022. LEGEND-1000 is the ultimate ton-scale experiment, whose scientific merit and technical maturity have been strongly recognised during the US portfolio review. The LEGEND community in the UK is growing rapidly, with UCL as one of the founder members of the project and Lancaster University, University of Liverpool and University of Warwick joining shortly after. A LEGEND showcase workshop will take place early next year to further broaden the UK participation in the project.

2022 promises to be an even more exciting year for the double-beta decay community. With three UK-led experiments coming online, along with many others around the world, we will increase the experimental sensitivity by one order of magnitude, exploring uncharted energy scales, where new physics can show up at any time.



Test strings of the germanium semiconductor detectors used in LEGEND-200. More than a hundred detectors will be mounted in strings, surrounded by the green optical fibres, and immersed in a 64 cubic meter cryostat filled with liquid argon. These detectors can reconstruct the event's size and location with the accuracy of a few millimetres and measure its energy with a per-mill resolution. In addition, the fibres detect the scintillation light of the liquid argon, enhancing the signal-background discrimination

Outreach

The Remote³ Project

A vital part of our work is sharing our excitement about astroparticle physics with the community, and nobody does it better **than Dr XinRan Liu**, physicist on the LUX-ZEPLIN dark matter experiment, and winner of the **IOP's 2021 Mary Somerville medal and prize** for his exceptional contributions to public engagement.

Young people in Scotland enjoy programming their Remote³ robots, helped by IOP APP scientists.

Among XinRan's vast array of outreach activities, the flagship is his remarkable Remote³ project. This enables groups of pupils from schools in remote Scottish locations to build and program remote-controlled robots, which are sent to one of the most remote locations in Britain – the STFC Mars Yard in Boulby Underground Lab. The teams compete to see whose robot can complete the most tasks in this challenging environment. The project gives young people the opportunity to work in teams, learn coding and problem-solving skills, plan and prioritise their projects, and interact with physicists from across Scotland – and experience the strange world of the Mars Yard. A condensed version of the project has also been a success at science fairs like the IOP's Big Bounce in Glasgow.

Projects like Remote³ help bring science to life for children in underserved communities – plus they're great fun. Congratulations, XinRan; your prize is well deserved.

Events

The 12th International Conference on Position-Sensitive Detectors (PSD12)

Phil Allport, *University of Birmingham*

The conference was hosted for the first time in Birmingham from 12th to 17th September 2021 having been delayed from September 2020. As is the tradition of the conference, all sessions were run as plenary but due to continuing restrictions this is the first time also with virtual participation. The conference series itself started as the London Conference and is the sister conference to the Vienna Conference on Instrumentation (21st-25th February 2022 https://vci2022.hephy.at/) with which it would normally be 18 months out of phase. Previous PSD venues have been: UCL London (1987); IC London (1990); Brunel University, London (1993); University of Manchester (1996); UCL London (1999); Leicester University (2002); University of Liverpool (2005); Glasgow University (2008); Aberystwyth University (2011); Surrey University (2014) and Open University (2017).

Virtual and In-Person Attendees in the University of Birmingham Teaching and Learning Building

For PSD12 we had 223 registrants (62 in-person and 171 online) which is more than typical because of the large numbers joining online. However, as a key aspect of the conference is to facilitate informal contacts between younger researchers and the international leaders in a very wide range of disciplines, we hope that when PSD13 runs in Oxford during 2023 this can return to a fully in-person format. Nevertheless, the conference had 16 keynote presentations by international experts on a very wide range of topics along with 77 further oral presentations and 99 poster presentations, and was attended and supported by 7 industrial exhibitors. More information on the conference can be found at www.psd12.co.uk and the proceedings will be published in JINST. The conference was hosted by the Birmingham School of Physics and Astronomy and the University of Birmingham Conferences and Events Management team, using the Teaching and Learning Building and the Edgbaston Park Hotel (both on the main campus) for accommodation.

Dark Matter Day

***XinRan Liu**, the University of Edinburgh*

The UK played a vital part in organising International Dark Matter Day this year, led by XinRan Liu from the University of Edinburgh, Emma Meehan and the outreach team at the Boulby Underground Laboratory, and Sophy Palmer and Lauren Mowberry from the Rutherford Appleton Laboratory's Public Engagement team.

Dark Matter Day (DMD) proceedings were kicked off by a joint event between the SNOLAB in Canada and the STFC Boulby Underground Laboratory in the UK. Speakers discussed evidence for dark matter and detection techniques, and included Nobel Laureate, Art McDonald; Caterina Doglioni, professor of particle physics at The University of Manchester; Alberto Oliva, a astroparticle physicist at INFN; and Jeter Hall, director of research at SNOLAB. This was followed by travelling deep underground to visit two of the most fascinating – and unusual – laboratories in the world! Then there was the launch of a virtual Dark Matter Expo showcasing the incredible variety of Dark Matter Experiments around the world, and the laboratories which host them.

The finale for DMD was the *Ask Me Anything* event which invited the public to ask any and all questions they had ever wanted to know about Dark Matter to the assembled scientists. The panellists included; Catherine Heymans, the Astronomer Royal for Scotland; Alex Murphy, professor of nuclear and particle astrophysicist at the University of Edinburgh; Tracy Slatyer, professor at MIT; and Nigel Smith, the Director and CEO of TRIUMF (and the first Briton to successfully winter at the South Pole).

Dark Matter UK Meeting

Christopher McCabe*, King's College London*

On 16th November 2021, the UK community of researchers working on searches for dark matter was able to meet again in-person at the Rutherford Appleton Laboratory (RAL) in Oxfordshire for the first DMUK meeting since the start of the pandemic. The RAL visitor centre proved to be the ideal location, with a large open space that allowed for plenty of social distancing, while also having an excellent infrastructure that allowed the meeting to be live streamed for those that preferred to watch online. The 65 people in attendance meant that this was the largest meeting yet, highlighting that this is a growing, vibrant research area within the UK physics programme. Our diverse list of speakers covered topics ranging from updates on the AION, DarkSide, DarkSphere, DEAP-3600, MIGDAL and LZ experiments; updates from the Boulby and NILE facilities; as well as theoretical updates on black holes as dark matter and modifications to the early history of the universe. We ended the meeting with a thought-provoking talk by Prof Chamkaur Ghag on the changes that we can make as a community to respond to the climate emergency.

Opportunities with Atmospheric Neutrinos (OWAN21)

***Teppei Katori**, King's College London, and **Xianguo Lu**, University of Warwick*

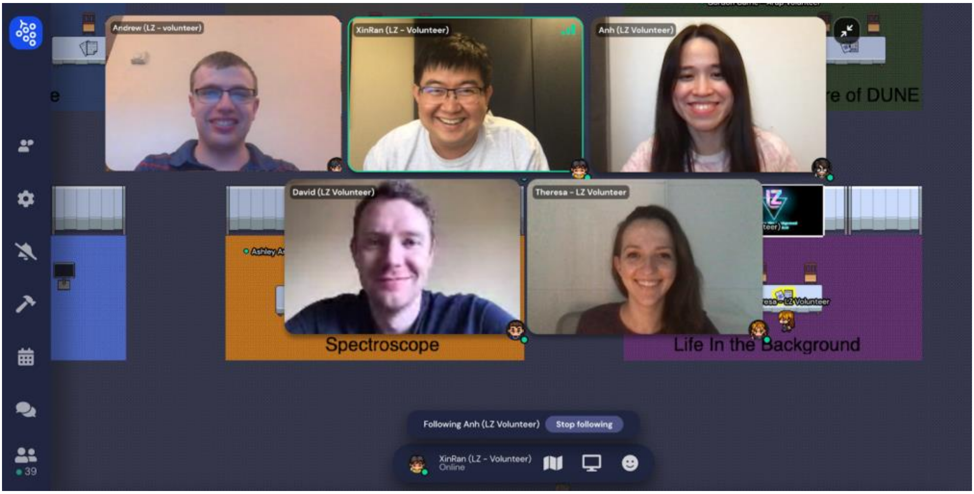
Atmospheric neutrinos offered an opportunity to the Super-Kamiokande experiment to discover neutrino oscillations (Nobel Prize 2015), but new opportunities with atmospheric neutrinos for upcoming experiments including DUNE, Hyper-Kamiokande, IceCube-Gen2, JUNO, P-ONE, PUEO, SNO+, etc may bring further ground-breaking discoveries. OWAN21, chaired by Dr Xianguo Lu (Warwick), was the first in-person event hosted by the APP at the IoP building (on November 10, 2021) with social distancing rules. Talks covered theoretical aspects to relevant experimental studies by leading scientists. The workshop also hosted several short APP student talks. Discussion sessions were dedicated to 2 topics; UK contribution to the JUNO experiment (led by Dr Xianguo Lu), and the UK high-energy neutrino consortium (led by Dr Teppei Katori).

Speakers included; Laurence Cook (Oxford), Dr. Abbey Waldron (Imperial), Dr. Andrew Chappell (Warwick), Dr. Maria Brunetti (Warwick), Dan Barrow (Oxford), Dr. Andy Blake (Lancaster), Dr. Yuber Perez-Gonzalez (Durham), Rogan Clark (King's College London), Joanna Gao (King's College London), Thomas Holvey (Oxford), Anežka Klustová (Imperial), Kang Yang (Oxford). Please find more details from the website.

Neutrino Day 2021

***XinRan Liu**, the University of Edinburgh*

This year, Neutrino Day was hosted by the Sanford Underground Research Facility (SURF) and was fully virtual, a lot of fun and a great success. The event was kicked off by a joint UK/US panel discussion on neutrinos and their properties. The recorded content has nearly 2000 views so far via the various SURF social media channels.

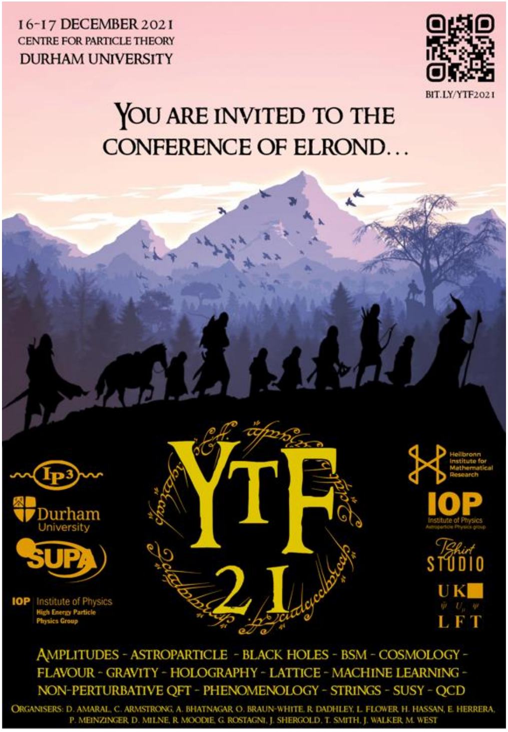


The main event was entirely on Gather Town from 9 a.m.-3:30 p.m. MT on Saturday, July 10th. LZ hosted an information booth and an activity stand, both constantly staffed by 3 volunteers on rotation thanks to help from Andrew Stevens, Anh Nguyen, David Woodward, Robert James, Theresa Fruth & XinRan Liu. The event was topped off with a keynote from Hugh Lippincott, LUX-ZEPLIN (LZ) spokesperson, talking about Dark Matter and detection with the LZ detector.

YTF 21

***Peter Meinzinger**, Durham University*

YTF is a PhD student conference organised by students for students. It aims to provide attendees with an inter-institutional and collaborative environment in which students have a unique opportunity to present their work to a friendly audience of fellow research postgraduates from across the UK and abroad. It covers a wide range of topics in mathematics and theoretical particle physics.



This year's edition will again allow for vivid discussions and socialising among fellow students. You can have a look at the timetable and the topics on the website: bit.ly/YTF2021

Also look out for next year's conference, registration will open some time in October. You will find information about it on conference.ippp.dur.ac.uk

IOP APP Funding Opportunities

IOP APP group funding for workshops & conferences

IOP APP financially supports various workshops and conferences. Please write up a one-page proposal about (1) event summary, (2) organizers details, (3) budget break down, and (4) the requested budget. If the event is organised by the IOP APP group only, the guidance for the subsidy is:

- For half-day meetings: up to £500
- For one-day meetings: up to £1000

If more than one group wishes to organise a joint meeting, the recommended maximum subsidy will increase by 50%. For details, please contact the IOP APP chair (Teppei Katori, teppei.katori@kcl.ac.uk).

IOP Research-Student Conference Fund

IOP APP provides financial support for IOP-member PhD students to attend conferences, with up to £300 awarded for a single trip. We will consider funding for international events organised by the Institute. (Meetings organised by our groups are not covered by this funding as these are already subsidised by the Institute.)

Applications run on a quarterly basis. Please send your applications before 1st March, 1st June, 1st September, 1st December. Applications must reach us three months in advance of the conference you plan to attend; for more information see: https://www.iop.org/about/grants/travel-bursaries/research_student/page_38808.html

Please follow the link, download an application form, and return to supportandgrants@iop.org.

This newsletter is also available on the web and in larger print sizes

The Institute of Physics, 37 Caledonian Road, N1 9BU, UK.

Tel: 020 7470 4800
Fax: 020 7470 4848