# IOP Institute of Physics
## Astroparticle Physics Group

**NEWSLETTER** **2020**

**Issue no. 10**

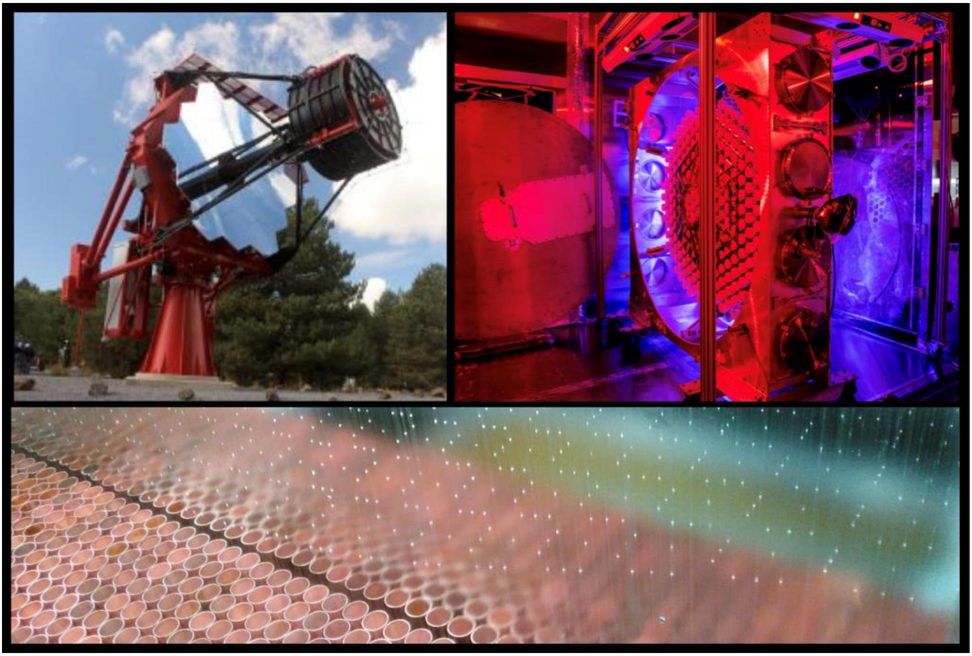

*Image credits: ASTRI consortium; M. Kapust (Sandford Lab); SuperNEMO collaboration*

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# Content

IOP Institute of Physics

# Joint APP, HEPP and NP Conference

**12–15 April 2021, University of Edinburgh, UK**

## Abstract Submission Deadline

**26th February 2021**

## Early Registration Deadline

**17th February 2021**

## Registration Deadline

**31st March 2021**

https://www.iopconferences.org/iop/frontend/reg/thome.csp?pageID=965026&eventID=1520

# Words from the Chair

2020 is an extremely challenging year for many people, including our APP community. We did not have the annual meeting, and all in-person workshops and conferences after March 2020 were cancelled. Nevertheless, there is so much progress in many projects which you can find in this newsletter. Bright news in the community was that the 2020 Nobel Prize in Physics was granted to the discovery of a supermassive black hole at the centre of our galaxy. Supermassive black holes are closely related to observations covered by APP, for example, high-energy jets from supermassive black holes are responsible for high-energy neutrinos observed by neutrino telescopes. I wish 2021 is a brighter year for many people, not only brighter by photons, but brighter in neutrinos and dark matter, or louder in gravitational waves.

**Chair, Teppei Katori (King's College London)**

# Editorial

2020 was a hard year for everyone, as we dealt with isolation, family challenges, online teaching and learning, and worries for ourselves and loved ones. That's why I've been so heartened to read the stories in this newsletter – stories not just of scientific excellence in these most difficult circumstances, but of resourcefulness and pulling together as a community. I hope you'll also be inspired to learn of our students' great analyses, our collaborations' successes, and the virtual events APP scientists have created and enjoyed. Everyone's showed great strength, creativity and perseverance; I am so proud of our community, and wish you all a better 2021.

**Newsletter editor, Cheryl Patrick (UCL)**

# Upcoming IOP APP Prizes

## IOP APP Thesis Prize 2020

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

Eligible theses must have resulted in the award of a PhD in 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, double-beta decay and nuclear astrophysics. Winners from previous years can be found on the group webpage. To be eligible:

- The PhD must have satisfied the requirements of the examiners between **1st October 2018 and 31st December 2020**.
- **Two nominators** are required, of whom one should be either the student’s supervisor or external examiner. At least one 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 a **copy of the thesis** in electronic form. 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 **31st January 2021**. Should you have any questions regarding the prize, or wish to submit a nomination, please contact the APP committee chair, **Dr. Teppei Katori**.

https://www.iop.org/get-involved/special-interest-groups/astroparticle-physics-group/app-thesis-prize

# IOP APP Early-Career Prize 2021

***Next call will be in early 2022*** *(as the 2021 IOP APP early career prize*)

Eligible nominees are early-career researchers working astroparticle physics (either experiment or theory), in any institution in the UK and Ireland, who have **5 years or less of postdoctoral experience** (allowing for career breaks). 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, at least one of whom should be from an institution other than the researcher’s current employer. Nominations should include copies of (or URL links to) **three papers** on which the nominee has worked in the **preceding two years**. The papers should have been published, or accepted for publication, in a refereed journal.


*Dr XinRan Liu, of University College London, celebrates his 2018 APP thesis prize, flanked by advisor Professor Ruben Saakyan, and Professor Chamkaur Ghag. XinRan is now at the University of Edinburgh.*

# IOP APP Prize Winners

## IOP APP Early Career Prize 2019

### Dr. Theresa Fruth (University College London), for her work on the LZ dark-matter search.

*Interviewed by Cheryl Patrick, UCL*

**CP***: Theresa, congratulations on your well-deserved award! You were nominated because of your broad range of work on the LZ experiment. Can you tell us a bit about how LZ works, and how you've contributed?*

**TF:** Thank you, Cheryl. LZ (LUX-ZEPLIN in full) is a dark matter direct detection experiment, based at the Sanford Underground Research Facility in South Dakota. The UK has an active community, with experiments like ADMX, DarkSide, NEWS-G and SuperCDMS using a variety of techniques to search for dark matter. At LZ, we use a two-phase liquid xenon time projection chamber to look for WIMPs. When a particle interacts in the detector, photomultiplier tubes detect scintillation and electroluminescence light. I've been part of the LZ collaboration since 2015, first as a PhD student at Oxford and now as a postdoc at UCL. My time on the experiment has coincided with much of the design, construction and commissioning phase. I've been involved in developing a detector monitoring sensor, PMT simulations, and analysis using simulated data. Since October 2019, I've been involved in the onsite construction and commissioning work as TPC coordinator.

***CP:** What does this role involve? What's a typical day like onsite?*

**TF:** The job of a subsystem coordinator is to keep an overview and coordinate the work related to their subsystem, raise any issues early on, and talk to other subsystem coordinators. I am responsible for the TPC – the time projection chamber. This TPC was built at the surface laboratory, inserted into the cryostat, then transported underground last autumn. Since then we have been working on integrating it with the remaining systems and infrastructure underground. Last autumn and winter (before the pandemic hit) I spent a large fraction of my time onsite. Usually, we would go underground around 7 am and come back up in the late afternoon between 4.30pm and 5.30pm. The first few times it was very exciting to go underground with all the PPE and stand in the dark cage for 15 minutes! Underground, the work is very varied – there were many connections to be made, tests and quality checks to be conducted. It's never boring!

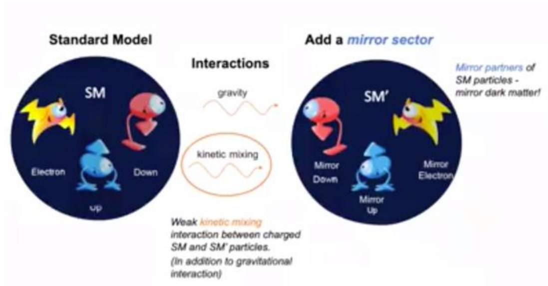
***CP:*** *2020's been challenging for everyone – and it's meant you can't travel to South Dakota. How is LZ dealing with the COVID-19 crisis?*
**TF:** When the pandemic started to spread in the US, we had to stop the onsite work for a little while. Now we have people back underground with safety measures such as masks and social distancing measures. We usually rely on collaborators being able to travel to site to help with work there. This is now much more restricted than usual, especially for European collaborators like me. But we still have a great crew onsite and are making a lot of progress. As an international collaboration, we were already used to holding meetings via Zoom, so that part has not changed that much.

***CP:*** *You are the early-career researcher of the year. How has your working life changed since transitioning from PhD student to early-career researcher?*
**TF:** While I am still working on the same experiment, the type of work I do has changed a lot. As a student, you always need to have your thesis in mind when signing up for tasks. Now I have more freedom to also do more hardware and organisational tasks. I enjoy getting a more varied exposure and getting to know different aspects of the experiment.

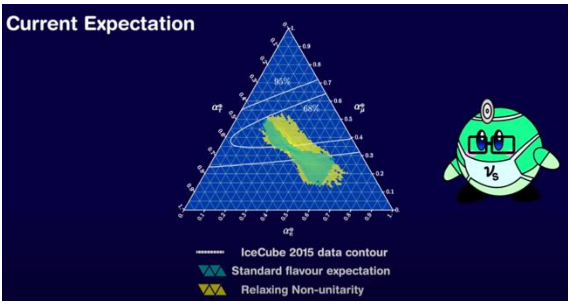
***CP:*** *Thank you, Theresa! Congratulations again, and best wishes for the future. I'm sure we will all see much more of you!*

# IOP APP of the Day - Winners

Our APP of the Day online contest invited PhD students to describe their analyses via short articles or videos. Our fantastic winners each won £50 for their innovative research and engaging videos.




**Elizabeth Leason** studies dark matter at the University of Edinburgh. Several candidates may explain this mysterious 85% of matter in the universe. Elizabeth focuses on the "mirror dark matter" theory, where each Standard Model particle has a partner in a "mirror sector", and the sectors interact via gravity and weak kinetic mixing. Elizabeth and her collaborators used statistical analysis to set first constraints on mirror dark matter from a direct detection experiment, using simulation and data from LUX. Find out how in her video and paper, on the APP Facebook page.

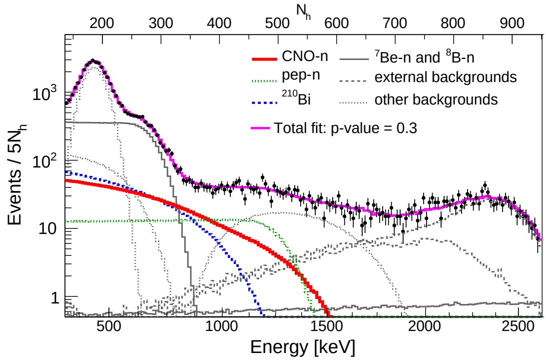



**Kareem Farrag**, of Queen Mary University of London and the University of Southampton, looks for ultra-high energy astrophysical neutrinos at IceCube. While three neutrino flavours are confirmed, anomalies found by neutrino telescopes could be explained by a fourth "sterile" neutrino. Kareem and his collaborators investigated the impact these might have on astrophysical neutrinos crossing the cosmos. If a fourth neutrino is involved in neutrino mixing, the ratio of each flavour reaching Earth could change drastically from expectations. The team's new techniques like the "flavour tetrahedron" can help visualise this ratio. Find Kareem's video and publication on our Facebook page.

# Physics highlights of 2020

## Neutrino astrophysics

***Dr Jost Migenda***
*Kings College, London*




*Energy distribution of Borexino events and spectral fit. The contribution from CNO neutrinos is shown in red. (Figure from arXiv:2006.15115.)*

The biggest astrophysical achievement of the year was the discovery of solar neutrinos from the CNO cycle, which Borexino announced in June at the Neutrino 2020 conference. This subdominant energy production mechanism in the Sun, wherein a heavier nucleus acts as a catalyst for free protons fusing to form helium, was first predicted by Weizsäcker and Bethe in the 1930s and is currently responsible for 1% of the Sun's energy production.

In the long term, this discovery opens the door to a direct measurement of the metallicity of the solar core and may help solve the "solar metallicity problem"—an almost 20-year-old discrepancy between spectroscopic measurements (which prefer low abundance of heavier elements such as C, N and O) and helioseismological probes (which are consistent with models assuming a higher abundance).

Another highlight of Neutrino 2020 was the multi-messenger searches presented during the online poster sessions: from Borexino and Super-Kamiokande to ANTARES and IceCube, neutrino detectors of different sizes and energy thresholds have searched for neutrinos coincident with gravitational-wave events observed by LIGO and Virgo, or with gamma-ray sources observed by MAGIC, H.E.S.S. or HAWC. While these searches have only produced upper limits thus far, the sheer number and breadth of searches make this an area worth watching.

In the meantime, one of the first multi-messenger collaborations is working on a major update: more than 20 years after the first test runs for the SuperNova Early Warning System (SNEWS), an upgrade is now in the works. SNEWS 2.0 will combine data from multiple neutrino detectors to provide a better advanced warning using pre-supernova neutrinos, perform triangulation to get a first estimate of the supernova direction before all events are even reconstructed, and develop follow-up strategies in close collaboration with astronomers.

Current and next-generation neutrino detectors are also making excellent progress. In July and August, Super-Kamiokande (SK) was loaded with gadolinium, a rare-earth element with a very high neutron-capture cross section. This lets SK identify antineutrino events (which frequently produce neutrons) with high accuracy, which could enable the discovery of supernova relic neutrinos (also known as the diffuse supernova neutrino background) and improve signal/background discrimination for other physics studies.
Its successor, Hyper-Kamiokande (HK), was approved by the Japanese government in early 2020, and is already gearing up for construction. (See the separate spotlight article in this newsletter for details.) In the US, construction on DUNE (see experiment spotlight in the 2019 newsletter) is progressing well and the UK announced a £65-million contribution in January 2020. In China, JUNO is preparing for detector installation and will start data taking in 2022, while HK and DUNE will start a few years later.

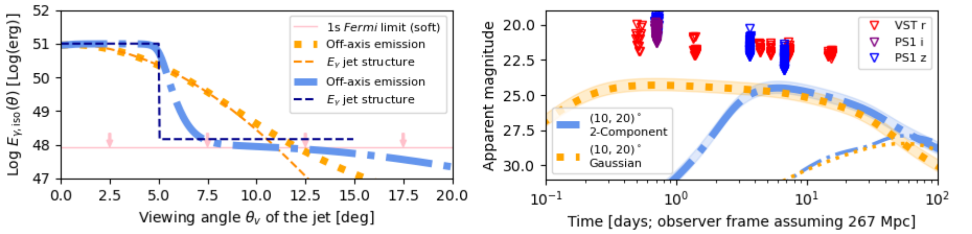
In hindsight, 2020 was not a stellar year—but it offers glimmers of hope that will bear fruit over the coming years.

# Gravitational Waves and Gamma-ray Bursts:
## What's new in the "era of multi-messenger astronomy"?

***Dr Gavin Lamb***, *University of Leicester*

Following the ground-breaking observations of a binary neutron star merger in August 2017, detected via gravitational waves (GW) and its electromagnetic (EM) counterparts, the search has been on for a second such event. LIGO/Virgo upgrades have led to improved GW detection prospects, and in the O3 cycle (21 April 2019 – 27 March 2020) a further 4 candidate binary neutron-star (BNS) mergers and 6 candidate black-hole – neutron-star mergers have been detected. However, as the typical distance for these mergers is now > 5 – 6 times further than the first and only joint GW-EM event, GW170817 at 40 Mpc, the search for an EM counterpart associated with these new events has become more challenging. The uncertain sky and distance localisation for GW sources results in large volumes within which any potential EM counterparts may be hiding and these counterparts are, due to the larger distances, intrinsically much fainter. Combining fainter sources with incomplete galaxy surveys makes finding a counterpart an increasingly difficult game of 'Where's Wally' - a cruel version where Wally might not even be in the picture!

Nonetheless, GW detections are being followed by searches at multiple facilities, from the highest gamma-ray energies to radio frequencies and neutrinos. In many cases, the searches result in the discovery of unrelated transient events. One the most promising GW candidates in the O3 cycle was GW190814, a potential neutron star - black hole binary, with one component < 3 $M_\odot$ and the other > 5 $M_\odot$. If the lighter object were a neutron star and the heavier were close to 5 solar masses, or a black hole with high spin ($a \geq 0.7$), the neutron star would be disrupted prior to plunging through the event horizon; the tidally-disrupted material would result in a kilonova (a thermal transient powered by the radioactive decay of very heavy elements synthesized due to rapid neutron capture during the ejection process), and a gamma-ray burst and afterglow-producing jet. Despite a thorough search for EM counterparts following this event, no candidate transients were found (see figure highlighting the challenges faced by astronomers in their search to these more distant O3 events).




*Searches of the GW error region for GW190814 with Fermi LAT and several ground-based optical telescopes (the VLT Survey Telescope (VST), Pan STARRS (PS)). Left: theoretical prediction for the expected gamma-ray energy with system inclination given one of two jet structures that can y explain the afterglow to GW170817), and observed limit on gamma-rays from Fermi LAT. Right: model predictions for the optical afterglow from the two structured jet models when viewed at 10° or 20° from the jet's central axis along with the upper limits from several ground-based telescopes.*

EM counterparts to a GW detection post-GW170817 have so far been elusive, but developments in theory and instrumentation, plus encouraging results from the observation of cosmological short GRBs, make us optimistic for future discoveries. Short GRB 160821B showed a clear kilonova component in the afterglow, and complex “late time energy injection“ behaviour which could also explain features in the off-axis GW170817 event. The origin of high-energy photons in short GRBs is not yet clear, but in an exciting development, GeV-TeV photons from long GRBs have now been detected from the ground by the Cherenkov telescopes MAGIC and H.E.S.S. (the latter of which has UK participation via Leicester and Oxford Universities, and is supported by STFC). The leading explanation is synchrotron self-Compton during the external shocks (afterglow); but in the central engines, relativistic electrons, high magnetic fields, thermal and non-thermal photon sources provide ideal conditions for particle acceleration and emission via the inverse Compton process. With the recent advances in Cherenkov telescope facilities, high-energy photons may frequently accompany

GW-detected neutron-star mergers, leading to further multi-messenger potential.

# Experiment Spotlights

## Cherenkov Telescope Array

***Samuel Spencer**, University of Oxford*

The Cherenkov Telescope Array (CTA) is an ambitious project to build the next generation of ground-based gamma-ray telescopes, which aims to improve on the energy sensitivity of current generation instruments (such as H.E.S.S., MAGIC and VERITAS) by an order of magnitude. To achieve this, it will consist of over 100 gamma-ray telescopes of 3 telescope classes (Small, Medium and Large-sized) situated on two sites (the Spanish island of La Palma in the northern hemisphere, and Cerro Paranal in Chile in the southern hemisphere).

*The ASTRI-Horn prototype telescope structure. Image credit: ASTRI consortium.*

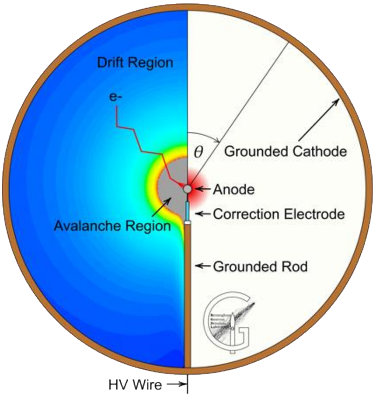
The CTA-UK national group consists of the Armagh Observatory and four universities: the University of Durham, the University of Leicester, the University of Liverpool and the University of Oxford. PhD students, postdocs and both academic and technical staff across the four universities contribute work that aids CTA development. This includes (but is not limited to) extensive Monte Carlo simulation of the array, exploring the potential for drone-based array calibration, studying the potential for deep-learning based methods of background rejection, studying CTA prospects for observations of sources (particularly Flat-Spectrum-Radio-Quasars) and studying the limits on fundamental particle physics CTA will be able to constrain. Over the last two years, CTA-UK groups have contributed towards the development of CHEC-S, one of the prototype cameras for the Small-Size Telescopes (SSTs), working both on creating software and testing hardware needed for the camera.

*The CHEC-S camera prototype. Image credit: Christian Foehr (MPIK).*

One of the most significant recent milestones achieved by the CTA-UK consortium was that in April 2019, the CHEC-S camera prototype was installed on the ASTRI-Horn prototype in Sicily. ASTRI-Horn is one of the prototype structures for the CTA SSTs, and the campaign was conducted by an international team including UK representatives. This campaign was a complete success, with integration of the two systems proving straightforward and multiple astrophysical gamma-ray sources being briefly observed. The performance of the camera's calibration and pointing monitoring systems were also verified. Partly due to the success of this campaign, it was decided by the CTA Observatory last summer that the final CTA SST design will be based primarily on this CHEC-S and ASTRI combination of instruments, taking into account lessons learned from other prototype designs. Despite the Covid-19 pandemic, work towards the construction of these new final SST cameras (now known as SSTCAMs) continues in the UK, with the goal of completed array construction by 2025. For more information visit https://www.cta-observatory.org/.

# Searching for light Dark Matter with Spherical Proportional Counters

***Prof. Kostas Nikolopoulos***,
*University of Birmingham*

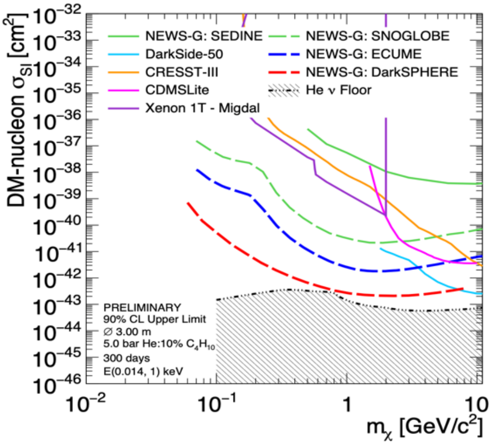



The operating principle of a spherical proportional counter. (Figure from arXiv:2002.02718)

The NEWS-G (New Experiments With Spheres – Gas) collaboration is searching for light dark matter using spherical proportional counters. The detector exhibits several features making it ideal for dark matter searches. These include low energy threshold down to single ionisation electron, thanks to the high gas gain and small detector capacitance, which is independent of the detector volume. Light gaseous targets, e.g. helium, neon, and hydrogen-rich molecules, are used, enabling sensitivity to dark matter candidates with masses in the range 100 MeV to 10 GeV.

The collaboration consists of 10 institutes in 5 countries, and has presented first results with SEDINE, a 60 cm in diameter detector operated in the Underground Laboratory of Modane (France), that extended for the first time the sensitivity to DM to 500 MeV. The University of Birmingham plays a key role in instrumentation development enabling the operation of large-scale high-pressure spherical proportional counters. Recent examples include the development of novel readout sensors: the single anode with resistive correction electrode and the resistive multi-anode structure ACHINOS (Greek for sea urchin). The group also maintains a simulation framework for gaseous detectors combining the strengths of Geant4 and Garfield++. The University of Birmingham has been recognised within NEWS-G for these significant contributions and holds two key leadership roles: spokesperson (from April 2021) and run coordinator.

A new, 140 cm in diameter, detector has been constructed from 99.99% pure copper. To further suppress backgrounds arising from contamination in the copper, a 500 μm thick layer of extremely radiopure copper has been electroplated to the inner surface of the vessel, with strong Birmingham involvement. The detector was constructed in Modane, and subsequently transferred to Canada, where it is now installed in SNOLAB. Commissioning is currently on-going with data-taking scheduled for this summer. The larger detector, lower background, and instrumentation improvements achieved, point towards a two order of magnitude improvement in sensitivity over the earlier results.



NEWS-G sensitivity to light dark matter.

The underground construction of the next generation detector ECUME, a fully electroformed SPC of 140cm in diameter, will begin in SNOLAB in fall 2021, aiming to collect data in late 2022. Further into the future, the collaboration is investigating the physics potential of DarkSPHERE, a 3 m in diameter fully electroformed underground spherical proportional counter with improved shielding. The sensitivity of DarkSPHERE is projected to reach the neutrino floor in the sub-GeV mass range. The Boulby Underground Laboratory is a strong candidate for the installation of DarkSPHERE. NEWS-G has already developed close contacts with Boulby: The Birmingham group is operating a spherical proportional counter underground, performing R&D on instrumentation, and detector physics studies, as well as developing novel techniques for neutron spectroscopy.

# Hyper-Kamiokande

***Dr Jost Migenda***
*Kings College, London*

*An adit excavated as part of the geological survey. At the ceiling near the dead end, the location of the centre of the Hyper-Kamiokande dome is marked (inset photo).*

Neutrino astrophysics received an important boost in early 2020, when Hyper-Kamiokande (HK) was approved by the Japanese government and received funds to start construction. Over the following months, detailed geological surveys took place to measure the rock quality and determine the optimal position for the detector cavern. Excavation and detector construction are expected to take six years, with data taking scheduled to start in 2027.

HK is a next-generation water Cherenkov detector that will be built near the town of Kamioka, approximately 8 km south of Super-Kamiokande (SK). Located beneath the peak of Mount Nijugo, it will have an overburden of 650 m of rock (1750 metres water-equivalent). Like its predecessor, HK is a large, cylindrical detector filled with ultra-pure water and optically separated into an outer detector, which acts as both shielding and active veto, and an inner detector viewed by an array of photosensors.

With a height of 71 m and diameter of 68 m, HK's fiducial volume is more than eight times larger than that of SK. It will also use newly developed 50 cm photosensors that offer twice the detection efficiency and twice the timing accuracy of the photosensors used in SK while keeping the dark noise rate approximately constant. Additionally, the use of multi-PMT modules, consisting of smaller 7.5 cm PMTs that offer finer granularity, is currently under investigation.

HK has a wide-ranging physics program, which includes precision measurements of neutrino oscillation parameters, proton decay searches, and astrophysical neutrinos from a wide range of sources.

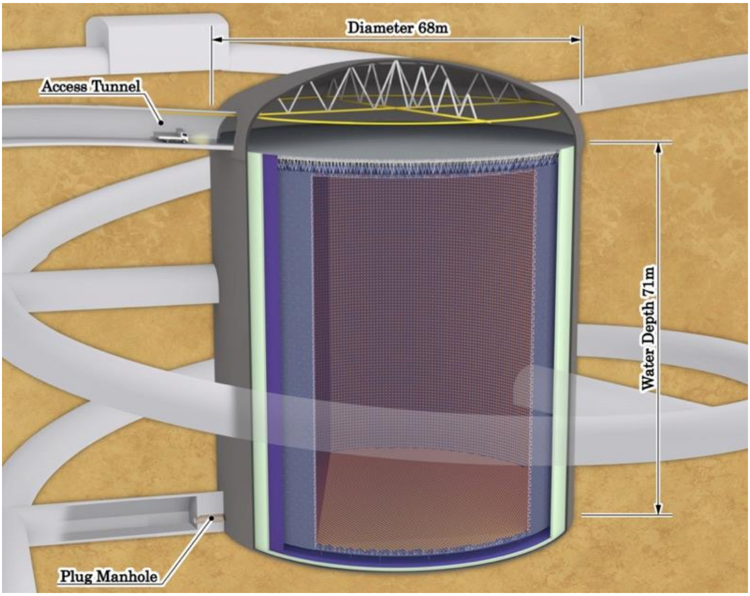



*Illustration showing the Hyper-Kamiokande detector, a dome, which will house DAQ, electronics and calibration systems, and access tunnels.*

In addition to measuring oscillation parameters from atmospheric neutrinos, HK will be the far detector for a long-baseline neutrino experiment using a neutrino beam produced 295 km away at J–PARC. With the larger detector volume and increased beam power, the experiment will go from the current, statistics-limited regime of T2K to a high-precision, systematics-limited one.

In proton decay searches, HK will go an order of magnitude beyond the current best limits, testing theories that predict a proton lifetime of $10^{35}$ years.

HK will make precision measurements of solar neutrinos. Additionally, better rejection of spallation backgrounds enabled by improved photosensors may lead to the first observation of hep neutrinos, from $^3He + p$ fusion. These are the highest-energy neutrinos produced by nuclear fusion inside the Sun, and are produced at larger radii than other solar neutrinos, making them a new probe of the solar interior.

If a galactic supernova occurs while HK takes data, tens of thousands of events are expected, which would give an unprecedented insight into the explosion mechanism of core-collapse supernovae. Information provided by one of the subdominant interaction channels—neutrino-electron scattering—will also let HK determine the direction of the supernova to approximately 1° accuracy, which will let astronomers prepare for observations of the shock breakout phase that is expected to happen within hours after the neutrino burst.

Supernova relic neutrinos (SRN) coming from the numerous, more distant supernovae that occurred throughout the universe, are likely to be detected by SK-Gd before the start of HK. However, HK's higher statistics would allow it to measure the SRN spectrum, gaining more insight into the average properties of supernovae and into the history of star formation.

Finally, HK will search for neutrinos from binary mergers of black holes or neutron stars, annihilating dark matter and other potential astrophysical sources. After all, in astrophysics it never hurts to expect the unexpected.

# Events

## IOP APP group student meeting

***Samuel Spencer**, University of Oxford*


*Photo: Teppei Katori*

A one-day astroparticle-physics group student meeting was held at King's College London on 9th March 2020. Despite a last-minute venue change, PhD and master's students from across the UK came to present talks on their work and meet fellow astroparticle-physics researchers. Topics discussed ranged from the experimental end of our field to the highly theoretical, with talks about IceCube, LZ, axion-like particle searches, and the Cherenkov Telescope Array all on the agenda. Further photos and details can be found on the IOP astroparticle group Facebook page. There are plans to hold a similar student meeting (likely virtually) in early 2021; details will be announced soon.

## Dark Matter Day

***Erin Broberg***, *Sanford Underground Research Facility*


On Dark Matter Day, nearly 300 people joined live to learn more about dark matter during the virtual “Deep Talks: An International Journey to Dark Matter Detection” event, which featured members of the LUX-ZEPLIN (LZ) collaboration.

Speakers joined from their homes in the United States and the United Kingdom, from underground at Boulby Lab and from the 4850 Level of Sanford Lab, where the LZ dark matter detector was being constructed behind event speakers. Talks with Jaret Heise, Alex Murphy, Sally Shaw, and Ed Banks focused on the journey from Zeplin to LUX to LZ—from early attempts at direct detection to the future of the search for dark matter.

This event had a truly international reach. Although Deep Talks events are usually hosted in the evenings, organizers shifted the event to 10 a.m. Mountain Time, allowing viewers from a spectrum of time zones to join the event live. Attendees from three continents included community members, educators and scientists. At midday in the United States, several educators even joined the event with their classrooms of middle and high school students.

Attendees listened, answered polls, explored underground lab spaces through virtual tours and submitted more questions than could be answered in the two-hour webinar. Because of the event’s virtual format, it has continued to impact audiences long after our speakers signed off. To date, the event has been shared 32 times and has been viewed more than 1,600 times.

Here’s what some of our attendees had to say:

> *“Choreography of speakers was great! Excellent presentations.”*
>
> *“Excellent talks! Thank you!”*
>
> *“I enjoyed learning about Boulby and seeing the facility. It’s a great reminder that experiments at SURF collaborate with researchers and institutions all around the world...”*
>
> *“Having a presenter talking from the underground lab gave the whole event a feeling of a live event from a science area that was being conducted in ‘the real world,’ rather than just a classroom environment.”*
>
> *“Please have more sessions like this!”*

This virtual Dark Matter Day event was a partnership between Sanford Underground Research Facility, Boulby Underground Laboratory, the University of Edinburgh, the Science and Technology Facilities Council and the LUX-ZEPLIN dark matter experiment.

Recordings can be found on the Sanford Underground Research Facility’s Facebook, YouTube and Vimeo channels.

# 2020 – a year of challenges

***Dr Jost Migenda (****Kings College, London) and* ***Dr Cheryl Patrick*** *(UCL)*

With a global pandemic that shut down research, a wave of anti-racism protest that saw thousands of physicists join a one-day strike, and a US election that saw Science, Nature and other scientific journals take a stand, 2020 delivered poignant reminders that even a field as far removed from worldly concerns as astrophysics is inextricably linked with politics and the societies in which our research takes place. During 2020, organisations at all levels (from learned societies and experimental collaborations to universities and individual departments) have published statements acknowledging the unequal impact of the pandemic and anti-Black racism on marginalised groups and promising change. While welcome, these statements now need to be backed up by hard work to implement that change—otherwise, they are about as useful as a Letter of Intent for an experiment that never gets built.

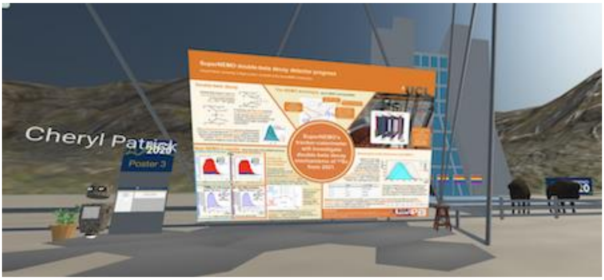
## Black Lives Matter, racism and inequality in STEM

In the summer, the deaths of George Floyd, Breonna Taylor and other Black people from police violence sparked a wave of protest across the globe. Thousands of physicists and astronomers around the world (including staff at the arXiv, IOP and other organisations) took part in an academic strike on June 10th and spent the day learning about, reflecting on, and starting action against anti-Black racism. Here are some resources to help your reflection:

- Particles for Justice (https://www.particlesforjustice.org) Radio 1Xtra Talks hosted two specials relating to the Black Lives Matter movement: https://www.bbc.co.uk/programmes/m000k3yt and https://www.bbc.co.uk/programmes/m000kx8d
- The Black British in STEM network https://bbstem.co.uk/ was recently highlighted in Nature
- POC Squared https://poc2.co.uk/, run by three women-of-colour physics graduates, aims to instil systematic change in academia

## Physics in the time of COVID

The COVID-19 pandemic has been tough on everyone. In our community, this has variously meant the stress of isolation; cramped living and working conditions; caring and home-schooling challenges; teaching overload; career uncertainty for ourselves and our families; and fear for our loved ones, often far across the world. Travel restrictions, while saving lives, cause havoc for experiments, in a field so reliant on hands-on work from international collaborators.



*A SuperNEMO poster at the virtual Neutrino 2020 conference*

Much-anticipated conferences, now held online, brought our community together, and at Neutrino 2020, this raised the question: should these remote conferences continue? Reduced air travel helps the planet, and savings on travel, accommodation and fees widen accessibility. Online chat led to lively discussion during and after presentations, and some participants found it easier to engage in a virtual forum, where race and gender are not immediately apparent, and language difficulties may be eased. Others raised the positives of in-person meetings, where isolated workers can see old friends and early-career scientists build new connections. While some parents found childcare a challenge when travelling, others were distracted by family needs when working from home – and many found day-to-day work responsibilities intruded during remote meetings. Zoom fatigue was a problem, and some participants were nervous to ask questions in writing to large groups of senior colleagues. Could a hybrid model be the solution – or risk a two-tier system that disadvantages less well-funded participants? One thing is clear – times are changing, and we need creative thinking to ensure our field is as accessible and welcoming as possible.

# 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

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