IUPAP International Union of Pure and Applied Physics

Newsletter

SEPTEMBER 2020

President: **Michel Spiro** • Editor-in-Chief: **Kok Khoo Phua** • Editors: **Maitri Bobba; Judy Yeo**

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PRESIDENTS' NOTE

The Presidents believe that IUPAP should develop a Strategic Plan (below) to guide its development through the start of its second century, and have prepared this preliminary version. It is distributed in this Newsletter with the request that all stakeholders offer their proposals for changes in content and emphasis. It is anticipated that the Strategic Plan will be further discussed in the Zoom meeting of the Council and Commission Chairs in October, so your reply should be received before **25th September 2020** to be part of the input for those discussions.

The Future of IUPAP

During the three years between now and 2023, the year of the centenary of our first General Assembly, the International Union of Pure and Applied Physics (IUPAP) will be continuing its major initiatives of the past, commencing new activities, and working with our members to decide the format we will implement in our second century in order to continue to fulfil our mission, "to assist in the worldwide development of physics, to foster international cooperation, and to help in the application of physics toward solving problems of concern to humanity".

IUPAP at present

IUPAP has 60 members which are organisations representing physicists in 60 countries or regions around the world. It does not have individual members or corporate members. Its income is primarily the dues paid by its members, supplemented from time to time by grants to permit it to carry out projects. It has just one staff member, and depends on volunteers to do its work — in the executive council (16 volunteers), 19 commissions (about 250 volunteers), 11 working groups (about 100 volunteers), and the 60 liaison committees of its members (about 250 volunteers).

These volunteers are working to realise the mission by sponsoring international meetings and awards; fostering communication within the physics community, and with the general public; encouraging research and education; fostering free circulation of scientists; promoting international agreements on symbols & units; and cooperating with other organisations on disciplinary and interdisciplinary problems. Activities which we have worked very hard on for some time and will be continuing include:

1. Reducing the Gender Gap in Physics and empowering women in Physics. In the last three years, we have played a major role in a project to reduce the Gender Gap in the Sciences, and will be continuing this project in conjunction with many other scientific unions.

2. Promoting the teaching of physics, and research in physics, in less developed countries. In particular, we have conducted many workshops in these countries which have led to a better realisation of the way in which physics can contribute to their development.

3. We have, through our Young Scientist Prizes, enhanced the recognition of the vital role that young physicists play. We want to build on that by finding more ways to incorporate these young physicists into our activities.

4. IUPAP has long worked to ensure that the interaction between physicists from different countries, which is key for the progress of physics, can continue even when relations between the countries are strained. In the present international climate, this activity is as important as it was 50 years ago.

New activities being developed to play a key role in IUPAP.

1. IUPAP is collaborating with and leading fellow unions and other partners to promote and to organise an International Year for Basic Sciences for Sustainable Development in 2022. In 2019, UNESCO recommended that the United Nations proclaim this International Year. We are now working hard to bring that UN proclamation into place.

2. Managing the international conferences that IUPAP sponsors in a way that does not unreasonably contribute to CO2 emissions has become an important marker of our ethical behaviour. Perhaps, the way in which these conferences are managed in the face of the restrictions on meetings and travel during the Covid-19 pandemic will help us find the best way to advance in this regard.

3. The majority of physicists do not work in research and academic institutions, but in industry, companies and government. We have established a working group on physics in industry to help us develop better connections with these physicists and to use these connections to better enable the promotion of development through the use of physics.

4. To strengthen IUPAP and to expand its worldwide network of connections, we are actively recruiting new members.

Entering our second century

We are consulting our 60 members to find out how they want their organisation to change to better carry physics and physicists forward. This will help us to better satisfy our members and hopefully to attract new members. We will be holding our 30th General Assembly in Beijing in October 2021 which will serve as an opportunity to remodel IUPAP and to bring that new IUPAP to the 31st General Assembly.

The launch of the International Year of Basic Sciences for Sustainable Development will be a part of the IUPAP Centenary Celebrations, with a Symposium taking place in Geneva as well as involving CERN and the local community (to this end, we have already established contact with Foundation H. Dudley Wright).

We will be bringing revised Statutes to the 2021 General Assembly to provide a framework for this remodelling.

During the difficult times of the Covid-19 pandemic, we believe that people are learning to appreciate the value of science and scientific expertise, of shared reliable information, of collaborative efforts and of informed decisions. This will be an asset for the future and for the world not only to fight against epidemics but also to face global challenges like global warming, loss of biodiversity, waste management, shortage of clean water, clean energy and sustainable development and to reinforce, in that way, worldwide friendship and peace.

In all these aspects, physicists and physics and, more generally, basic sciences and scientists can and must contribute by:

- Developing smart and powerful modelling;
- Inventing new tools, if possible, widely affordable and clean from the point of view of the environment;
- Sharing knowledge and allowing remote access to tools and data, but also continuing to promote the necessary face to face-to-face interaction that will lead to a better understanding of each other, acceptance of diversity and peace;
- Engaging in outreach activities to attract more young people to STEM fields and keeping citizens informed of the latest advances of science.

Michel Spiro
President of IUPAP
Chair, Steering Committee for the proclamation of IYBSSD 2022

Bruce McKellar
Past President

Silvina Ponce Dawson
Acting President Designate

Dr. Cathy Foley appointed Officer of the Order of Australia in June 2020

Silvina Ponce Dawson, Acting President Designate, Gillian Butcher, *Acting Vice President* (*Gender Champion*), Bruce McKellar, *Past President*

On 8 June 2020, Dr. Cathy Foley, Chair of the Local Organizing Committee of the 7th International Conference on Women in Physics, was appointed an Officer of the Order of Australia. She received this prestigious award for her “distinguished service to research science, to the advancement of women in physics, and to professional scientific organisations”. Dr Foley is a world-renowned physicist whose work has been very influential in promoting the understanding of superconducting materials and the development of devices for a variety of applications including the detection of valuable deposits of minerals. She has received several prizes and distinctions during her career. Among them, she was elected Fellow of the Australian Academy of Science last May. Dr. Foley’s work has not been limited to her research in physics. She has made significant contributions to the scientific community as president of several scientific societies and a member of advisory committees on scientific and technological matters for the Australian Government. Cathy has been a very active advocate of the advancement of women in physics. She has participated in various International Conferences on Women in Physics and was the leader behind the proposal that won the bid to organize its 7th edition that was scheduled to be held in July 2020 and was postponed by one year due to the COVID19 pandemic. Hopefully we will be able to gather again in Melbourne in July 2021, celebrate with women in physics from all over the world and congratulate Cathy personally.

Gender Gap Project and Standing Committee for Gender in Science

Silvina Ponce Dawson, *Acting President Designate*; Gillian Butcher, *Acting Vice President (Gender Champion)*; Igle Gledhill, *Past Chair Working Group on Women in Physics*

Online meeting of the Gender Gap Project partners on July 1st, 2020

The final report of the Project *"A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?"* was released in February 2020. The IUPAP and ten other international partners took part in this project which, with the initial funding of the International Science Council, performed three tasks: a Global Survey of Scientists, an Analysis of Publication Patterns discriminated by gender and the elaboration of a Database of Good Practices. The report describing the results on these **three** tasks and their impact **worldwide** is available online (https://zenodo.org/record/3882609#.X0MxfMgzaUI). Paper copies in the form of a book with nice illustrations by Lèa Castor can be ordered through different retailers. An 8 page-booklet summarizing the main results in English, French, Spanish, Chinese, and German is also available for download from the project´s website (https://gender-gap-in-science.org/project-book-booklet).

What was supposed to mark the end of a far-reaching project was actually the beginning of a renovated effort.

The tasks of the Gender Gap Project will continue to be performed with some financial support from its partners. In this regard, members of the Project gathered online on July 1st to present the most recent developments and discuss how to continue. Future plans include anonymization of the survey responses to enable sharing of the data with researchers interested in their analysis, new studies of gender-segregated publication patterns and the updating of the good practice database.

To expand the work most of the international organizations that took part in the project signed a memorandum of understanding to create the **Standing Committee for Gender Equality in Science** (SCGES). The SCGES founding partners are the IUPAP, the International Astronomical Union (IAU), the International Council of Industrial and Applied Mathematics (ICIAM), the International Mathematical Union (IMU), the International Union of Biological Sciences (IUBS), the International Union of History and Philosophy of Science and Technology (IUHPST), the International Union of Pure and Applied Chemistry (IUPAC), the Association for Computing Machinery (ACM) and GenderInSITE. IUPAP's Vice-President at Large and Gender Champion, **Gillian Butcher** (University of Leicester, UK) and IUPAP's Associate Secretary General, **Rudzani Nemutudi** (iThemba LABS, South Africa) are IUPAP's representatives at SCGES.

The main goal of SCGES is to continue the fruitful interdisciplinary collaboration initiated by the Gender Gap Project and advance with the analysis and elaboration of policies to help reduce the gender gap in STEM.

Highlights in Astrophysics (C19)

Pietro Ubertini, Giulia Mantovani, and Gerard Gilmore (*Chair, C19*)

Astronomy is currently in a phase of remarkable discovery and growth. Nobel physics prizes in 2019 (Jim Peebles - cosmology, Michel Mayor and Didier Queloz - exoplanets), 2017 (Rainer Weiss, Kip Thorne and Barry Barish – gravitational waves), 2011 (Saul Perlmutter, Brian Schmidt and Adam Reiss – observational cosmology), 2006 (John Mather and George Smoot – observational cosmology) and 2002 (Riccardo Giacconi – X-ray astronomy, Ray Davis Jr and Masatoshi Koshiba – astrophysical neutrinos) are a very public recognition of this impact. The whole field of astrophysics is very broad and a top-level overview of some of the recent progress is discussed in the following text. Gravitational waves and Astrophysical counterpart search: Gravitational waves (GWs), predicted as a natural consequence of general relativity in 1916, recently detected with the discovery of GW150914 proving the existence of a large number of heavy stellar mass Black-Hole Binaries mergers with mass as high as 50-60 times our sun.

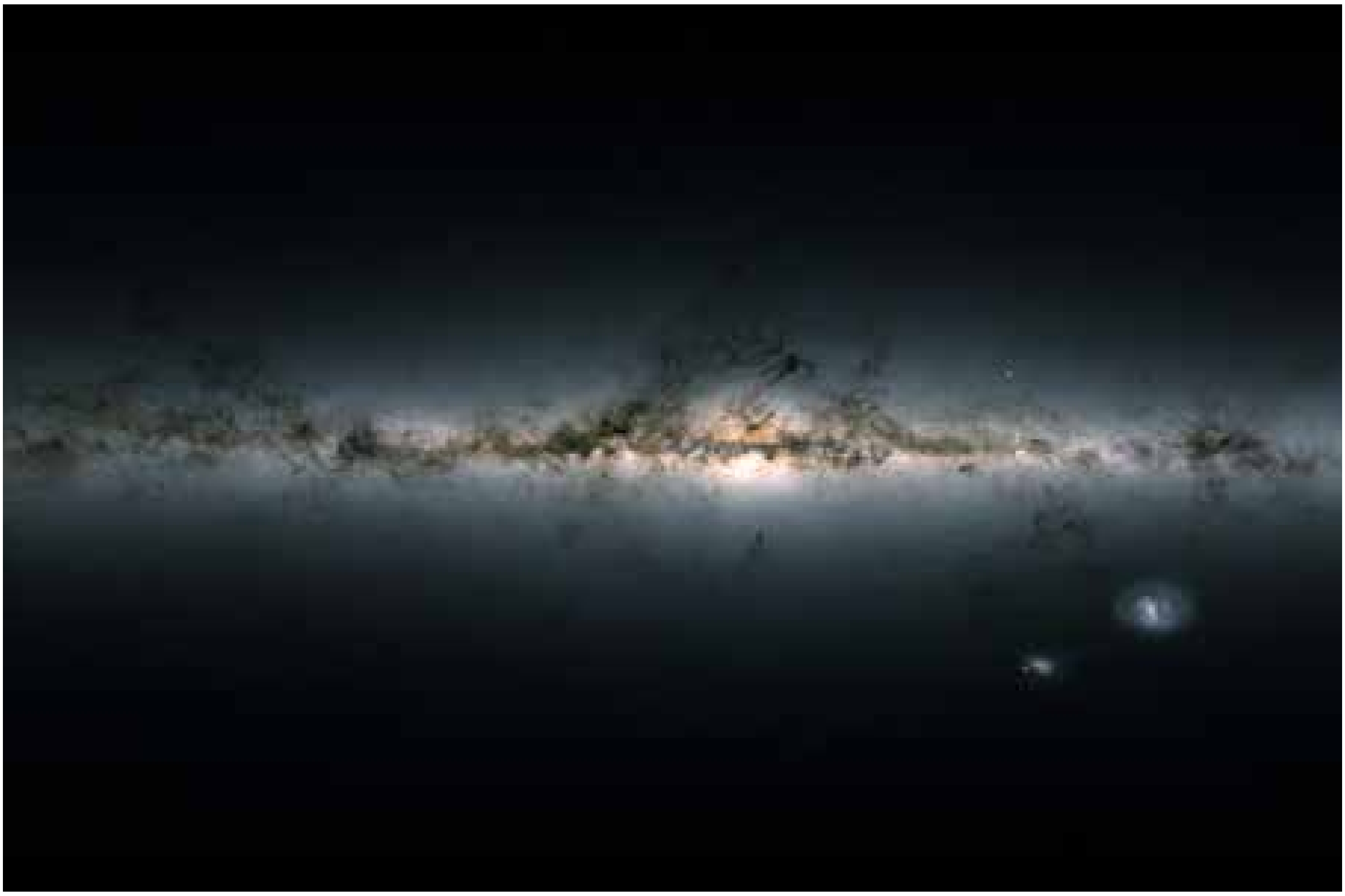
NS-NS Mergers: first Gravitational Wave counterpart detection: On August 17, 2017, Fermi and INTEGRAL gamma-ray satellites detected a short γ-ray burst (GRB 170817A) linked to GW70817 caused by the merger of two neutron stars. The 1.7s time lag between the arrival time of the GW and the γ-rays, after 120My travel time, imposed constraints on the difference between the speeds of light and gravity, placed new bounds on the violation of Lorentz invariance, and presented a new test of the equivalence principle.

Gamma-ray bursts (GRBs) detected at TeV: GRBs are brief and extremely powerful cosmic explosions, suddenly appearing in the sky, about once per day. On January 14th, 2019, GRB 190114C was detected the Neil Gehrels Swift Observatory and the Fermi Telescope: the MAGIC TeV telescopes pointed, just 50 seconds after, to its sky position detecting for the first time TeV photons from a GRB. In the same energy range the HESS telescopes detected very high-energy photons from the afterglows of two GRBs, namely GRB 180720B and GRB 190829A. In the first case, the detection succeeded 10 hours after the prompt GRB, thus unexpectedly deep in the afterglow phase.

Fast Radio Bursts (FRB) are bright extra-galactic radio flashes of unknown nature that last for a few milliseconds.To date, only a handful of FRBs have been precisely localized and associated with host galaxies. On April 28, 2020 a very bright and short radio pulse, resembling a FRB, was detected from SGR 1935+2154, a galactic Magnetar (isolated neutron star powered by extremely high magnetic field) characterized by the emission of powerful bursts of hard X-rays, but never seen to emit FRB-like bursts. At the time of the radio pulse emission, several X/gamma-ray satellites detected a particularly hard burst from SGR 1935+2154.

Origins of a Cosmic Neutrino: On September 22, 2017, IceCube detected a neutrino with an energy of about 290 TeV, which indicated that the particle could have been produced in a faraway astrophysical object. The Fermi gamma-ray observatory reported the direction of the neutrino was coincident with the blazar TXS 0506+056, and VERITAS telescopes reported high energy photons up to at least 0.5 TeV, making the blazar a potential candidate for the neutrino source.

Protoplanetary disks and exoplanets: The Atacama Large Millimeter Array started to operate in 2014 with unprecedented angular resolution, stimulating research on the structure and evolution of protoplanetary disks around young stars. The recent



Gaia's view of the sky. Credit: ESA/Gaia/DPAC, CC BY-SA 3.0 IGO.

ALMA survey of 20 nearby protoplanetary disks discovered the surprising pervasiveness of structures like gaps, rings, vortices, and spiral arms, resolved at scales of a few astronomical units. To date, there are more than 4170 confirmed exoplanets, many of them in multiplanetary systems.

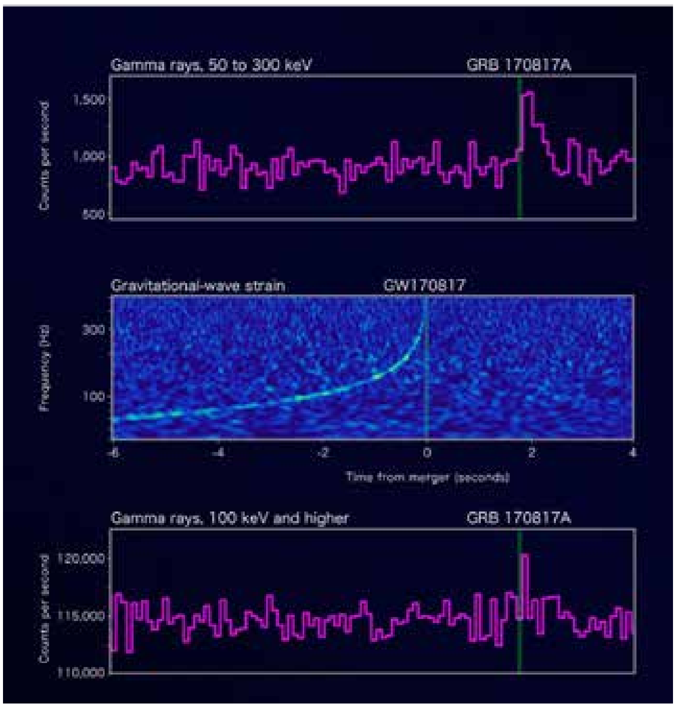
Gaia: This ESA satellite, launched in 2013, is creating the most accurate three-dimensional map of the local Universe. Observations are planned until the exhaustion of the fuel required for precision pointing, currently predicted to be early 2025. As of June 2020, some 1.5 trillion astrometric observations have been recorded. Nowadays, with astrometric and photometric data with unprecedented accuracy already published for more than 1.7 billion stars, solar system bodies and quasars, Gaia is revolutionizing many areas of astrophysics.

Asteroseismology: Aside from their crucial input for the study of exoplanets, the 4-year µmag-precision photometric light curves assembled by the Kepler satellite brought us into the renaissance of stellar astrophysics. This is thanks to the method of asteroseismology, which exploits the frequencies of non-radial oscillations of stars detected in the light curves.

2D stellar structure models

The Kepler data reveal that numerous intermediate-mass stars rotate at a high fraction of their critical rotation rate, demanding the development of a novel theory of stellar structure in 2D to understand the evolution of those rapid rotators which are among the main producers of metals in the Universe and form the basis of computations for the chemical evolution of galaxies.

Proposed figures



Joint, multi-messenger, detection of GW170817 and GRB 170817A (adapted from Abbott et al. 2017, ApJ 848, L13).

Two-dimensional materials and the highly innovative development of spintronic devices based on such materials

Cheng Dong (2020 – C8 YSP winner) ***University of Maryland, College Park, USA***

Two-dimensional (2D) layered materials have continued to be at the forefront of condensed matter physics and materials science, since the discovery of graphene – the single atomic layer of carbon – in 2004. The boom of 2D materials research in 2004-2017 had centered on electrical transport properties of semi-metallic graphene and optoelectronic properties of semiconducting transition metal dichalcogenide (TMD), and an appreciable amount of interest can also be found in other 2D materials such as anisotropic black phosphorene. As evident, the vast majority of excitements in 2D physics and functional devices (e.g., transistor, photodetector and optical modulator) derived from electron's charge degree of freedom, whereas 2D spintronics was still in its infancy, primarily hindered by the lack of long-range ferromagnetic order that is crucial for macroscopic magnetic effects.

In order to harvest long-range magnetic order in 2D materials, tremendous efforts had been made in the community based on schemes such as defect engineering, proximity effect and band structure engineering, but these schemes can only create magnetic moments locally or extrinsically. In 2017, together with collaborators, I reported the intrinsic ferromagnetism in 2D materials for the first time [1, 2]. Theoretical rationale is: the Curie temperature (above which the magnetic order will be thermally randomized) usually drops dramatically in 2D systems compared to that in 3D counterparts due to the strong thermal fluctuations in reduced dimensions, and a uniaxial magnetic anisotropy typically arising from the spin-orbit coupling is a prerequisite for sustaining the long-range magnetic order against the thermal agitation. We found that Cr2Ge2Te6 is such a promising layered material that exhibits intrinsic ferromagnetism and uniaxial magnetic anisotropy. Through magneto-optical Kerr microscopy, we visualized its intrinsic magnetism in atomic-thin regime. Strong dimensionality effect was clearly revealed by the dramatic thickness dependence of Curie temperature. More remarkably, we found a small external magnetic field on the order of 0.1 Tesla (about three orders of magnitude weaker than exchange interactions in magnetic materials) can prominently change the transition temperature, via modifying the magnetic anisotropy and opening the spin wave excitation gap. The phenomenon of magnetic field control of transition temperature is unprecedented, which highlights the fundamental role of magnetic anisotropy in 2D magnetism, echoing the spirit of Mermin-Wagner theorem [3].

The discovery of magnetic 2D materials prompts the development of novel spintronic devices. My contributions to this end include the development of 2D heterostructure multiferroics [4] and 2D half metal based spin field effect transistors (FET) [5].

Multiferroics – materials that simultaneously possess multiple ferroic orders – hold great promises for the efficient electrical control of magnetism. Implementing this concept in 2D atomic crystals will open new avenues to achieving energy-efficient spintronic devices. However, despite the progress, past efforts have witnessed the fundamental challenges confronted by 2D magnetism (i.e., the strong thermal fluctuation) and 2D ferroelectricity (i.e., the enhanced depolarization field). Therefore, it is reasonable to envision that realizing multiple ferroic orders in single-phase 2D materials would encounter

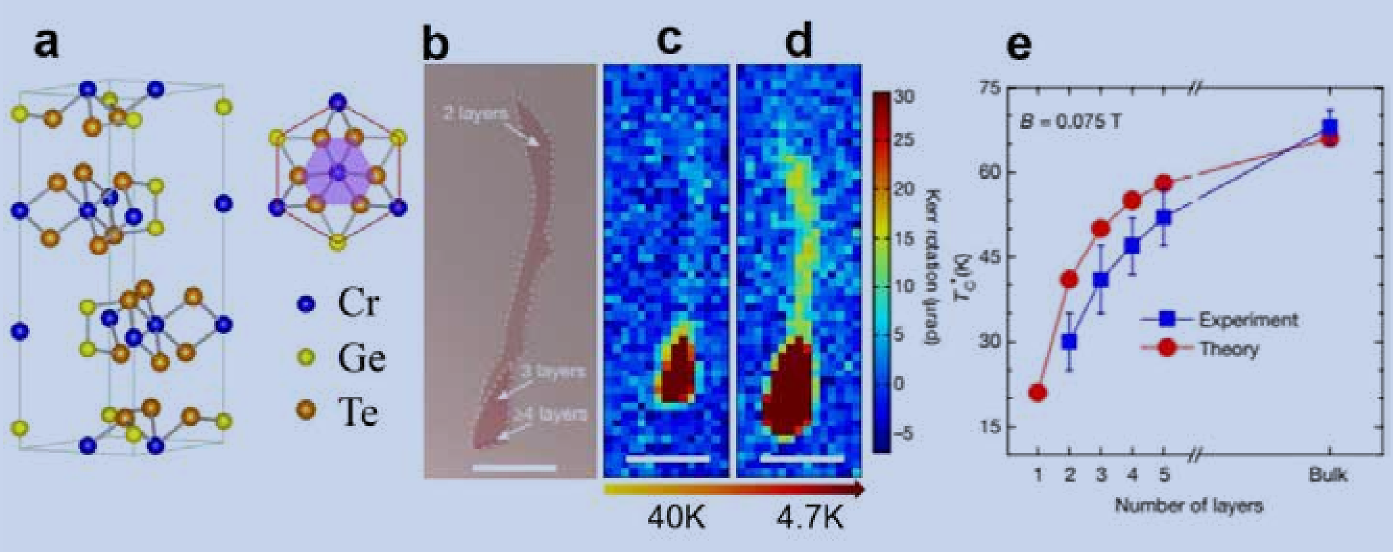


Fig. 1. Atomic structure of Cr2Ge2Te6 crystal (a), optical image of exfoliated atomic-thin Cr2Ge2Te6 on SiO2/Si (b), Kerr images of the Cr2Ge2Te6 sample at 40 K (c) and 4.7 K (d), and thickness dependent transition temperature of Cr2Ge2Te6 under 0.075 T magnetic field (e) [1].

even greater challenges. Fortunately, 2D materials provide unique building blocks that can be stacked up layer by layer to create heterostructures. Standing upon the recent success in 2D magnets and 2D ferroelectrics, we constructed the theoretical model of $Cr_2Ge_2Te_6$-In_2Se_3 heterostructures, and found that the strong cross-layer magnetoelectric coupling exists. Specifically, the opposite ferroelectric polarizations in In_2Se_3 can cause the magnetic anisotropy of $Cr_2Ge_2Te_6$ to change between out-of-plane and in-plane orientations. In return, the changed magnetic properties in $Cr_2Ge_2Te_6$ will alter the spin polarizations in In_2Se_3 via magnetic proximity effect. We coined the term “dual multiferroicity” to denote the coexistence of multiferroic $Cr_2Ge_2Te_6$-In_2Se_3 heterostructure and multiferroic In_2Se_3. The discovery of 2D multiferroics with the strong cross-layer magnetoelectric coupling implicates technological applications in energy-efficient nanoscale spintronics.

Half metallicity – a physical property that electrons of one spin polarization are metallic whereas those of the opposition polarization are insulating – holds significance for high-efficiency spintronics, owning to the 100% spin polarized conductive electrons. Based on bilayer A-type antiferromagnets (intralayer ferromagnetism and interlayer antiferromagnetism), we found the cross-layer electric field will change the relative energy levels of the two constituent monolayers, thus reducing the energy gap of one spin-polarized band and enlarging that of the other. While the electric field surpasses a critical value, the band gap of one spin-polarized band will vanish, leading to half-metallicity. The half-metallicity can be switched ON/OFF by electric field, and can be polarized with spin-up or -down Fermi electrons by a positive/negative electric field. These switching and polarizing functions make the new class of spin FET analogous to but fundamentally different from the conventional charge-based FET. Given the 100% spin polarized conductive electrons in half metals, the spin FET developed here will benefit the high-efficiency spintronics.

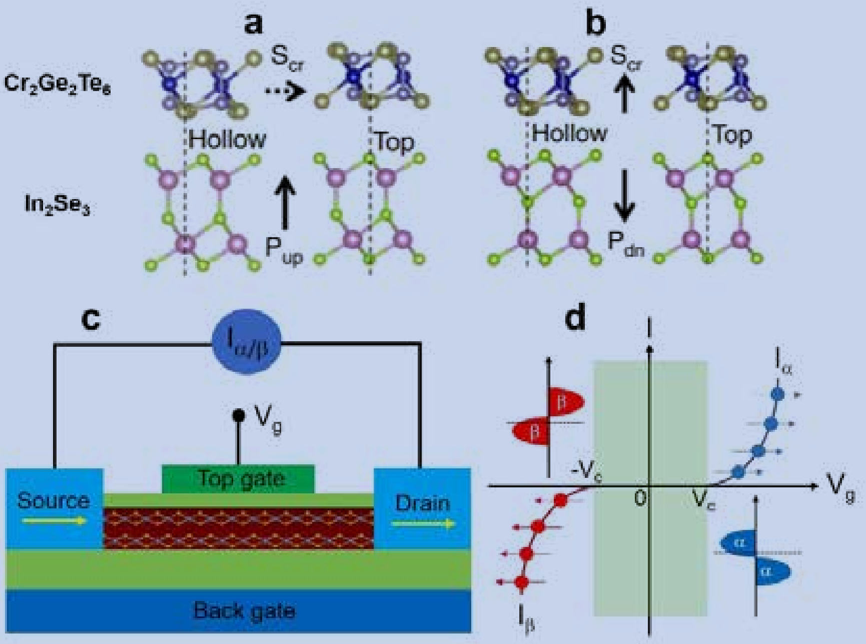


Fig. 2. Atomic structures of Cr2Ge2Te6-In2Se3 heterostructures (a,b) [4], illustration of spin FET based on a bilayer A-type antiferromagnet (c) [5], and illustrated I-Vg characteristics of the spin FET (d) [5].

References:

1. C. Gong et al., Discovery of intrinsic ferromagnetism in two-dimensional van der Waals crystals, Nature 546, 265-269 (2017).

2. C. Gong, X. Zhang, Two-dimensional magnetic crystals and emergent heterostructure devices, Science 363, eaav4450 (2019).

3. N. D. Mermin, H. Wagner, Absence of ferromagnetism or antiferromagnetism in one- or two-dimensional isotropic Heisenberg models. Phys. Rev. Lett. 17, 1133-1136 (1966).

4. C. Gong et al., Multiferroicity in atomic van der Waals heterostructures, Nat. Commun. 10, 2657 (2019).

5. S.-J. Gong,* C. Gong,* et al., Electrically induced 2D half-metallic antiferromagnets and spin field effect transistors, Proc. Natl. Acad. Sci. 115, 8511-8516 (2018).

Perovskite materials for a sustainable energy future

Michael Saliba (2020 – C8 YSP winner) ***Stuttgart University, Germany***

Michael Saliba is the director of the Institute for Photovoltaics (ipv) at Stuttgart University (@SalibaLab) with a dual appointment as Helmholtz Young Investigator at the Research Center Jülich, Germany. His research focuses on a deeper understanding of novel semiconductor materials such as perovskites which can be used in applications such as solar cells, light-emitting devices and sensors.

Prof. Saliba has from the very beginning been part of the perovskite photovoltaics field. „Perovskites“ are named in honour of the Russian mineralogist Lev Perovski and are now the namesake for any material with an AMX3 structure, thus denominating a vast material group. In 1978, a specific perovskite comprised of organic and inorganic components was described for the first time (see Figure 1).1 Almost 40 years later, in 2009, this novel perovskite material group was used in a solar cell for the first time. Since then, the perovskite solar cells have shown unprecedented efficiency gains from 3.8% (in 2009) to 25.2% (in 2020), approaching established materials such as Si, CdTe or GaAs.[2,3]

Prof. Saliba has focused on developing and investigating the fundamental properties of perovskite materials. One challenge for perovskites is phase- and temperature-instability where the A-cation plays a crucial role. Here, especially the usage of mixed cations, comprised of Rb, Cs, methylammonium (MA) and formamidinium (FA), with a majority of FA and a reduced amount of the volatile MA molecule has led to perovskite materials with a substantially suppressed amount of detrimental impurities. This resulted in a higher temperature, humidity and phase stability with performances close to the theoretical limit.[4–6] Importantly, solar cell operation at elevated temperature, which is an industrial prerequisite, was successfully demonstrated, which is a key breakthrough for commercialization. The new material design principle has established a new standard for perovskites which is followed by research and industry groups worldwide.

Moreover, using multiple cations alludes to a broader theme, i.e. multicomponent perovskite where every component is varied. Figure 1 shows all the recent high-performance components in perovskite solar cells, i.e. five cations, two metals and three halides. Combinatorially this permits for 651 possible perovskite structures of which many are not reported yet. These materials are of interest for future developments from a fundamental point of view and for applications such as LEDs or sensors.

(left side) Reported highperformance cations (in the blue box), metals (black box), and anions (green box) in an AMX3 perovskite structure (right side). The combinatorial possibilities from these components alone are $(2^5 - 1)(2^2 - 1)(2^3 - 1) = 651$ of which many are not reported yet.[7]

References

1. Weber, D. CH3NH3PbX3, ein Pb(II)-System mit kubischer Perowskitstruktur CH3NH3PbX3, a Pb(II)-System with Cubic Perovskite Structure. 33, 1443–1445 (1978).
2. Kojima, A., Teshima, K., Shirai, Y. & Miyasaka, T. Organometal halide perovskites as visible-light sensitizers for photovoltaic cells. J. Am. Chem. Soc. 131, 6050–1 (2009).
3. Saliba, M., Correa-Baena, J.-P., Graetzel, M., Hagfeldt, A. & Abate, A. Perovskite solar cells from the atomic to the film level. Angew. Chemie Int. Ed. n/a-n/a doi:10.1002/anie.201703226.
4. Saliba, M. et al. Cesium-containing triple cation perovskite solar cells: improved stability, reproducibility and high efficiency. Energy Environ. Sci. 9, 1989–1997 (2016).
5. Saliba, M. et al. Incorporation of rubidium cations into perovskite solar cells improves photovoltaic performance. Science (80-.). 354, 206 LP – 209 (2016).
6. Turren-Cruz, S. H., Hagfeldt, A. & Saliba, M. Methylammonium-free, high-performance, and stable perovskite solar cells on a planar architecture. Science (80-.). 362, 449–453 (2018).
7. Saliba, M. Polyelemental, Multicomponent Perovskite Semiconductor Libraries through Combinatorial Screening. Adv. Energy Mater. 9, 1–8 (2019).

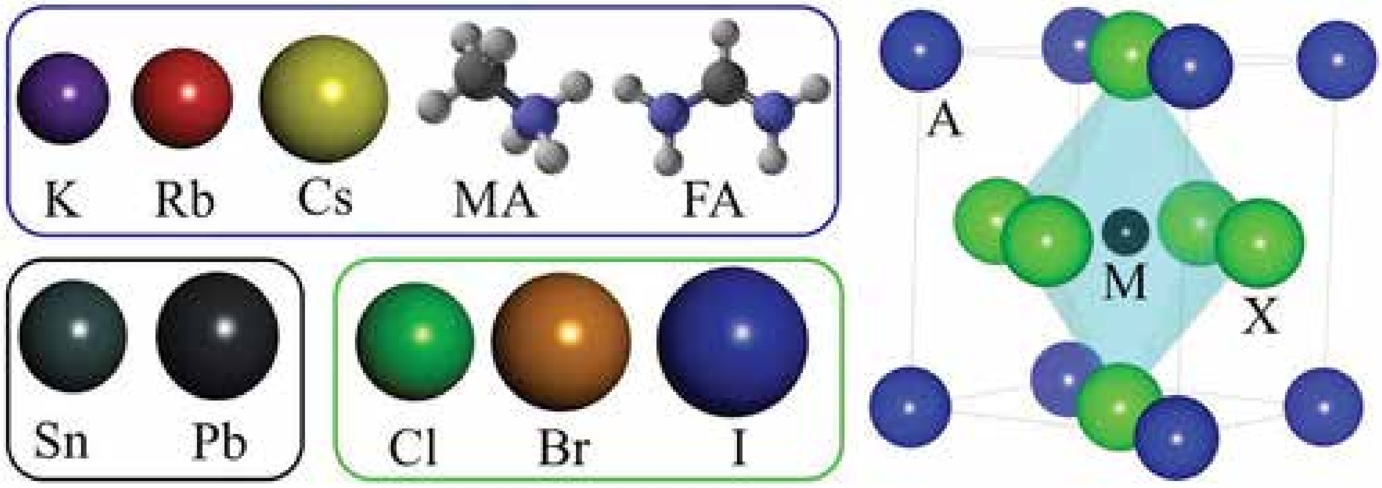


Figure 1. Many possibilities for metal-halide perovskite materials.

Topological spin textures in novel magnetic materials

Jiadong Zang (2020 – C9 YSP winner) ***University of New Hampshire, USA***

Topology as a fundamental mathematical language describing equivalence under continuous deformation meets magnetism in materials hosting noncollinear magnetic structures [1]. Many magnetically topological textures and defects, such as domain walls, vortices, skyrmions, etc., have been observed and found themselves useful in broad applications. In particular, skyrmions emergent in chiral magnets have been extensively studied for their deep physics and appealing application as information carrier in next generation memory devices[2]. Dr. Zang, awarded the YSP in the field of magnetism for 'outstanding theoretical studies of the interplay between magnetism and topology', has made contributions to the physics of skyrmions and beyond.

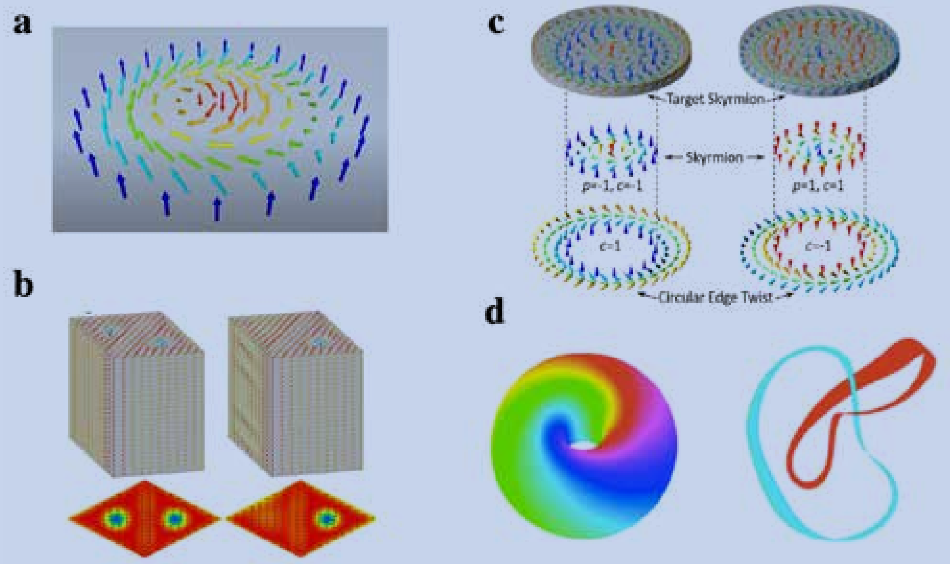


Figure: (a) A typical skyrmion configuration. (b) Skyrmion tubes consisting 2 or one skyrmions in MnSi nanowire. (c) Zero-field target skyrmion in FeGe nanodisk. (d) A typical hopfion configuration where equal spin trajectories linked to each other.

In chiral magnets, the spatial inversion symmetry is broken. Consequently, the antisymmetric and off-diagonal spin interaction, the Dzyaloshinskii-Moriya interaction (DMI), is emergent. Different from the common Heisenberg interaction, the DMI promotes noncollinear spin configurations instead, and the skyrmions are thus induced. A magnetic skyrmion is a nanostructured spin texture in which magnetic moments point in all directions wrapping a unit sphere. The central and surrounding spins are pointing in opposite directions, while spins in between are swirling around. The one-to-one correspondence between a skyrmion and a unit sphere grants the skyrmion a nontrivial topology. The skyrmion reveals its nontrivial topology by not only the extra stability, but also novel dynamical properties. It can be driven by electric current[3], temperature gradient[4] or electric field[5]. Furthermore, electron traversing a skyrmion feels a fictitious magnetic field and moves sideway, leading to a Hall motion of the skyrmion simultaneously[3].

Skyrmions have prominent potential to carry binary information; 1 for each skyrmion and 0 for no skyrmion. It is thus important to systematically study the skyrmions in nanometer-sized confined geometries, including nanowires and nanodisks [6,7]. In many of these constricted samples, skyrmions are found to be stable even under zero fields. In addition to skyrmions, other topological spin textures, like 2pi vortex, magnetic monopoles and hopfions are emergent therein. In particular, the magnetic hopfion is a three-dimensional generalization of skyrmions. In each hopfion, spins with the same z-component form torus planes. Furthermore, any two equal-spin lines, dubbed as the preimages, are linked by integer times. Dr. Zang has made the first prediction of magnetic hopfion realized in a chiral magnet nanodisk sandwiched by two spin polarized layers [8]. Under a dc electric current, the hopfion exhibits novel dynamics such as rotation, dilation, and Hall motions [9].

The physics of topological spin textures is not isolated, but intertwined with other exciting developments of condensed matter physics. The DMI is fundamentally driven by spin-orbit physics, which has recently led to rich physics such as topological insulators and Weyl semimetals. The band structures in these novel materials exhibit nontrivial topology in the momentum space, which is analogous to topological spin textures in real space. Dr. Zang has taken part in initiating studies of the interplay of topology in both spaces, especially in strongly correlated materials.

References

[1] J. Zang, V. Cors, and A. Hoffmann, "Topology in Magnetism", Solid State Science Series, Springer, (2018). ISBN 978-3-319-97334-0.

[2] W. Jiang, G. Chen, K. Liu, J. Zang, S. G. E. te Velthuis, and A. Hoffmann, "Skyrmions in Magnetic Multilayers", Physics Report, 704, 1 (2017).

[3] J. Zang, M. Mostovoy, J. H. Han, and N. Nagaosa, "Dynamics of skyrmion crystal in metallic thin films", Phys. Rev. Lett. 107, 136804 (2011).

[4] L. Kong, and J. Zang, "Dynamics of insulating skyrmion under temperature gradient", Phys. Rev. Lett. 111, 067203 (2013).

[5] J. S. White, et. al., "Electric field-induced Skyrmion distortion and lattice rotation in the magnetoelectric insulator Cu2OSeO3", Phys. Rev. Lett. 113, 107203 (2014).

[6] H. Du, et. al., "Electrical probing of field-driven cascading quantized transitions of skyrmion cluster states in MnSi nanowires", Nat. Commun. 6, 7637 (2015).

[7 F. Zheng, et. al., "Direct imaging of zero-field target skyrmion and its polarity switch in chiral magnetic nanodisk", Phys. Rev. Lett. 119, 197205 (2017).

Enabling picosecond timing at particle colliders with crystals and silicon photo-multipliers

Marco Lucchini (2020 – C11 YSP winner) ***Princeton University, USA***

Particle detectors involved in future collider experiments will have to face unprecedented challenges and require major R&D efforts on many technological fronts.

The next High Luminosity phase of the Large Hadron Collider (HL-LHC) at CERN, for instance, will feature a rate of proton-proton collisions up to 7 times larger than the current LHC conditions. This will allow physicists to study known Standard Model mechanisms in greater detail and observe rare new phenomena that might reveal themselves.

Nonetheless, the higher luminosity of the collider calls for an upgrade of the detectors to deal with the extremely high pileup, i.e. the number of simultaneous proton-proton interactions at each bunch crossing which will grow up to 200 compared to 40 in the current LHC. In addition, all detector components will be exposed to high flux of radiation and need to be designed as such to maintain their high performance in a harsh environment.

To address the issue of pileup, which challenges current detector capability to disentangle interaction vertices based on their spatial location, exploitation of the temporal dimension represents a promising path which has been explored by the ATLAS and CMS experiments [1,2].

This novel approach requires a technology capable of detecting a minimum ionizing particle (MIP) with a time resolution at the level of 30 picoseconds. Such precision would allow one to «slice» the beam spot into consecutive time exposures of about 30 ps each, thus reducing the number of vertices per exposure to the pileup level of the current LHC.

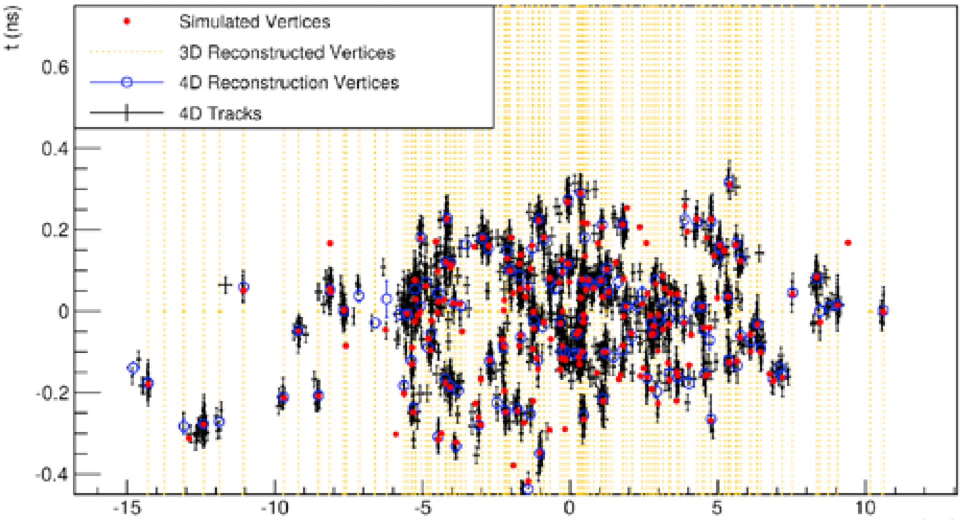


Illustration 1: Simulated and reconstructed vertices in a HL-LHC bunch crossing with 200 pileup interactionsassuming a MIP timing detector with 30 ps time resolution covering the barrel and endcaps. Picture from the CMS MTD TDR [7].

This new possibility triggered the interest of several groups in the High Energy Physics community and many industrial partners involved in the production of silicon detectors and scintillators. In this context, several technologies have shown rapid progress over the past decade (e.g. low gain avalanche detectors, micropattern gas detectors, microchannel plates). Among these technologies, detector elements consisting of inorganic scintillators (crystals) readout with Silicon Photomultipliers (SiPMs) represent a flexible option with intrinsic advantages for instrumentation of large area detectors, such as cost, channel count and power consumption.

The possibility of achieving a time resolution of the order of few tens of picoseconds in crystal-based detectors requires a deep understanding and optimization of all the processes involved in the detection chain, such as the scintillation mechanism, light transport, light detection and readout electronics [3]. For instance, optimization of the crystal scintillation key parameters for timing applications, such as light yield and time constants, was demonstrated to be possible by co-doping cerium-activated scintillators with divalent ions (e.g. Mg^{2+}, Ca^{2+}) [4].

Test beam results have demonstrated that a time resolution better than 30 ps can be achieved for a variety of co-doped crystals readout with state-of-the-art SiPMs [5]. In particular, with an optimized configuration of LSO:Ce,Ca crystals and SiPM sensors, we showed that a time resolution to minimum ionizing particles as good as 10 picoseconds can be achieved [6].

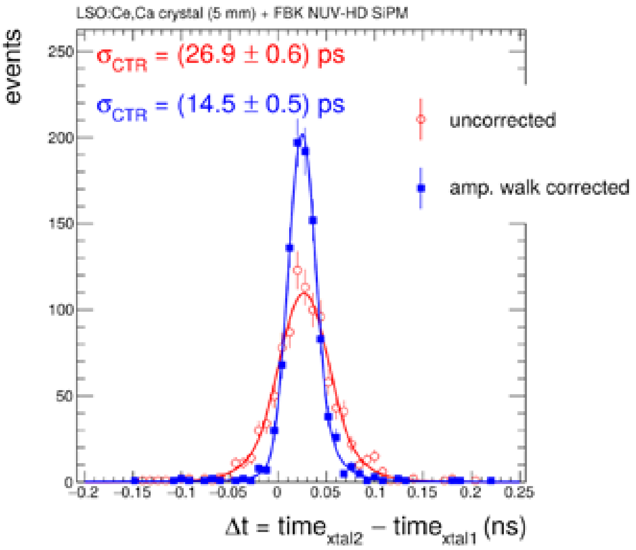


Illustration 2: Coincidence time resolution obtained with two identical LSO:Ce,Ca crystals readout with Silicon Photomultipliers and traversed by a MIP. A single detector time resolution of 10 ps is achieved. Picture from [6].

Encouraged by these first results, and followed by extensive R&D efforts, the CMS Collaboration has recently proposed, in view of the HL-LHC upgrade, a new MIP Timing Detector that features LYSO:Ce crystals and SiPMs in its barrel region [7].

The combination of excellent timing capabilities and energy resolution that crystal-based detectors can provide also opens new perspectives for the design of novel detectors for future collider experiments [8].

References:

[1] The ATLAS Collaboration, ATLAS Phase-II Upgrade, Scoping document, (2015) CERN-LHCC-2015-020LHCC-G-166.

[2] The CMS Collaboration, Technical Proposal for the Phase-II Upgrade of the CMS Detector, (2015) CERN-LHCC-2015-010. LHCC-P-008. CMS-TDR-15-02.

[3] Stefan Gundacker et al., High-frequency SiPM readout advances measuredcoincidence time resolution limits in TOF-PET, 2019 Phys. Med. Biol.64 055012

[4] M. Lucchini, V. Babin, P. Bohacek, S. Gundacker, K. Kamada, M. Nikl, A. Petrosyan, A. Yoshikawa, E. Auffray, Effect of Mg2+ ions co-doping on timing performance and radiation tolerance of Cerium doped Gd3Al2Ga3O12 crystals , Nuclear Instruments and Methods in Physics Research, A 816 (2016) 176 – 183.

[5] M. Lucchini, S. Gundacker, P. Lecoq, A. Benaglia, M. Nikl, K. Kamada, A. Yoshikawa, E. Auffray, Timing capabilities of garnet crystals for detection of high energy charged particles, Nuclear Instruments and Methods in Physics Research, A 852 (2017) 1 – 9.

[6] A. Benaglia, S. Gundacker, P. Lecoq, M. Lucchini, A. Para, K. Pauwels, E. Auffray, Detection of high energy muons with sub-20ps timing resolution using L(Y)SO crystals and SiPM readout , Nuclear Instruments and Methods in Physics Research, A 830 (2016) 30 – 35.

[7] CMS Collaboration, A MIP Timing Detector for the CMS Phase-2 Upgrade , Technical Report CERN-LHCC-2019-003. CMS-TDR-020, CERN, Geneva (Mar 2019).

[8] M. Lucchini, W. Chung, S. Eno, Y. Lai, L. Lucchini, M. Nguyen, C. Tully, New perspectives on segmented crystal calorimeters for future colliders, arXiv:2008:00338, (Aug 2020).

The evolving search for particle dark matter

Benjamin R. Safdi (2020 – C11 YSP winner) ***University of Michigan, Ann Arbor, USA***

Dark Matter (DM) is the most abundant source of matter in our Universe, but its microscopic nature remains unknown. Identifying the particle nature of DM is one of the most outstanding questions in modern physics. My research bridges the theoretical, observational, and experimental domains to try to further this search. This article provides a brief overview of a few of my more important works that have contributed to our understanding of DM.

The search for particle DM is at a turning point. For decades, the dominant theory of particle DM has been that of weakly interacting massive particle (WIMP) DM, where the particle was created thermally in the early Universe and has a mass near the electroweak scale. However, searches for WIMP DM at underground direct detection experiments such as XENON1T, at collider experiments such as those at the Large Hadron Collider, and indirect searches with astrophysical observatories such as the Fermi Gamma Ray Telescope have so far failed to detect evidence for this DM candidate and have constrained its possible parameter space. In my research I follow two paths, strongly influenced by these experimental results: (i) I work to make sure that no stone is left unturned in the search for WIMP DM, which may be hiding right around the corner, and (ii) I work to broaden the search for particle DM beyond the WIMP DM paradigm.

One possible exception to the null results for WIMP DM is the Fermi Galactic Center Excess, which is an excess of ~GeV gamma-rays observed around the center of the Galaxy by the Fermi Telescope. This excess has received a significant amount of attention because of the possibility that it arises from annihilating WIMP DM. However, in my paper (Lee et al. 2016) I provided some of the first concrete evidence that the statistics of the excess points towards an astrophysical explanation, for example from a population of dim millisecond pulsars, instead of an annihilating DM interpretation. The main insight in (Lee et al. 2016) and subsequent works is that while DM annihilation flux would appear smoothly distributed in the sky, flux from a population of dim astrophysical point sources would appear more clustered. Moreover, if the Galactic Center Excess arises from annihilating DM, then annihilation flux should be visible in other astrophysical systems. In my work (Lisanti et al. 2018) I showed that strong sensitivity to DM annihilation may be obtained by searching for gamma-ray signatures in extragalactic galaxy groups; the limits from that work also disfavor the annihilating DM interpretation of the Galactic Center Excess.

Beyond the Galactic Center Excess, much of my work focuses on developing physics-based statistical methods for searching for evidence of particle DM in complicated astrophysical data sets. For example, in (Dessert at al. 2020), I pointed out that a promising way to search for decaying sterile neutrino DM in the X-ray band with space-based telescopes is to search for signatures of DM decay from our own Milky Way's DM halo in otherwise blank regions of the sky. We analyzed archival data from the XMM-Newton Space Telescope to search for evidence of DM decay at 3.5 keV in order to rule out or confirm the previously-observed 3.5 keV X-ray line, which had been discussed as possibly arising from sterile neutrino DM decay; we found no evidence of sterile neutrino DM and were able to rule out that possibility for the 3.5 keV line.

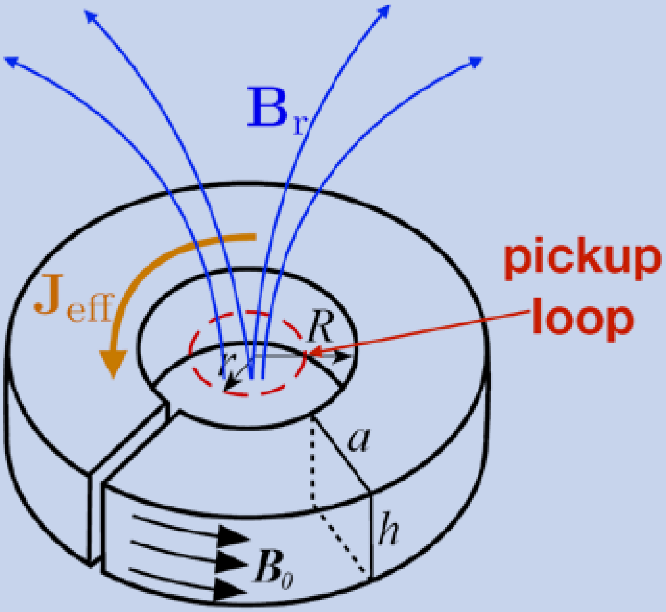


Figure 1: The ABRACADABRA experiment (Kahn et al. 2016) works by having a strong laboratory toroidal magnetic field. In the presence of axion DM an effective current is induced (Jeff), which follows the magnetic field lines and oscillates at a frequency determined by the axion mass. This induces a real secondary magnetic field (Br), which creates a detectable, oscillating current in the pickup loop.

One of the DM models that I find most compelling is the axion, which is well motivated because in addition to explaining the observed abundance of DM it may explain the strong CP problem related to the absence of a neutron electric dipole moment. A particularly well-motivated axion model is that where the axion is generated at the scale of Grand Unification. However, this theory is notoriously hard to research for in the laboratory. In (Kahn et al. 2016), I proposed a novel laboratory research, called “A Broadband/Resonant Approach to Cosmic Axion Detection with an Amplifying B-field Ring Apparatus” (ABRACADABRA), for looking for axion DM in the mass range predicted by Grand Unification. The central idea is that a strong external magnetic field generates an effective electric current, oscillating at a frequency uniquely determined by the mass of the axion particle, which may generate a secondary oscillating magnetic field (see Fig. 1). In ABRACADABRA, we proposed having a toroidal magnetic field and then searching for the oscillating magnetic flux produced in the center of the toroid by using a superconducting pickup loop. Since (Kahn et al. 2016) I helped found the ABRA-10 cm experimental collaboration, which built a small-scale version of the experiment. Our first physics results appeared in (Ouellet et al. 2019) where we set strong constraints on the existence of axion DM and paved the way for future, larger experiments that will probe the axion at the Grand Unification scale. Between ABRACADABRA, the indirect searches for axion DM that I have proposed — such as the radio telescope search for axion conversion in neutron star magnetospheres in (Hook et al. 2018) — along with my theoretical work understanding axion cosmology in the Early Universe (Buschmann et al. 2020), my work has strived to help achieve the community goal of discovering or ruling out the axion in the next ~10-15 years.

References

1. S. K. Lee, M. Lisanti, B. R. Safdi, T. R. Slatyer and W. Xue, “Evidence for Unresolved gamma-Ray Point Sources in the Inner Galaxy," Phys. Rev. Lett. 116, no.5, 051103 (2016)
2. M. Lisanti, S. Mishra-Sharma, N. L. Rodd and B. R. Safdi, ``Search for Dark Matter Annihilation in Galaxy Groups,'' Phys. Rev. Lett. 120, no.10, 101101 (2018)
3. C. Dessert, N. L. Rodd and B. R. Safdi, ``The dark matter interpretation of the 3.5-keV line is inconsistent with blank-sky observations,'' Science 367, 1465 (2020)
4. Y. Kahn, B. R. Safdi and J. Thaler, ``Broadband and Resonant Approaches to Axion Dark Matter Detection,'' Phys. Rev. Lett. 117, no.14, 141801 (2016)
5. J. L. Ouellet, C. P. Salemi, J. W. Foster, R. Henning, Z. Bogorad, J. M. Conrad, J. A. Formaggio, Y. Kahn, J. Minervini, A. Radovinsky, N. L. Rodd, B. R. Safdi, J. Thaler, D. Winklehner and L. Winslow,``First Results from ABRACADABRA-10 cm: A Search for Sub-μeV Axion Dark Matter,'' Phys. Rev. Lett. 122, no.12, 121802 (2019)
6. A. Hook, Y. Kahn, B. R. Safdi and Z. Sun, ``Radio Signals from Axion Dark Matter Conversion in Neutron Star Magnetospheres,'' Phys. Rev. Lett. 121, no.24, 241102 (2018)
7. M. Buschmann, J. W. Foster and B. R. Safdi, ``Early-Universe Simulations of the Cosmological Axion,'' Phys. Rev. Lett. 124, no.16, 161103 (2020)

Quantum technologies: From solving quantum many-body dynamics to quantum-enhanced sensors

Philipp Hauke (2020 – C15 YSP winner) *University of Trento, Italy*

Modern technological society would be unthinkable without devices that inherently exploit quantum properties. Well-known examples include the scanning tunneling microscope or the laser, with applications that range from nano-fabrication over optical data storage to eye surgery. In the last few decades, the abilities to manipulate quantum systems have taken further decisive steps. Setups now exist, where single quantum particles can be controlled. For example, individual ions and neutral atoms can be confined in respective electrodynamical optical traps, where they can be manipulated by focused laser beams. The pristine level of control in these and similar devices opens up tantalizing new possibilities.

One particularly promising application is to investigate how complex properties emerge at a macroscopic scale. Many examples of quantum many-body systems, ranging from magnetic compounds to the quark-gluon plasma, are governed by underlying microscopic equations that appear deceivingly simple. Yet, these equations are extremely hard to solve when a large number of particles is involved, because the quantum mechanical superposition principle requires to treat exponentially many quantum states at the same time. Currently, not even the best existing supercomputers can predict the exact behavior that emerges once many quantum particles come together.

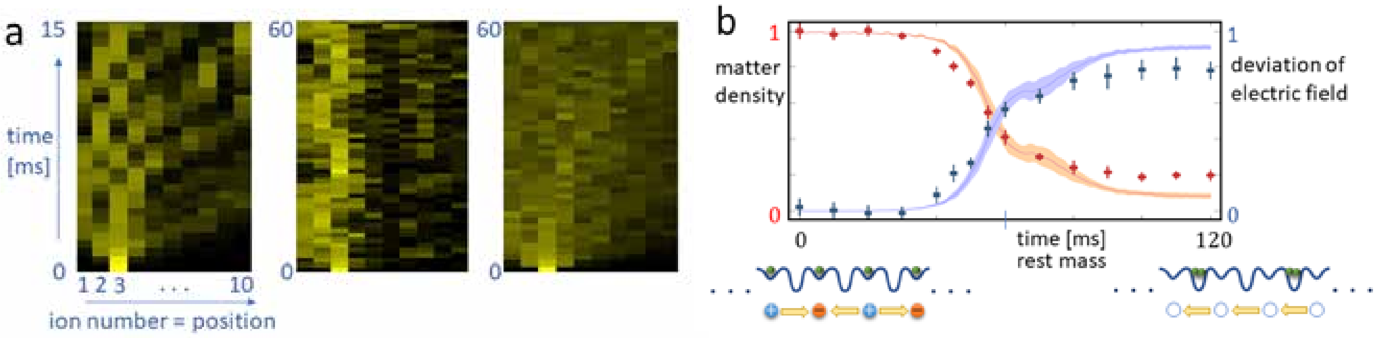


Figure 1: (a) Quantum transport of magnon quasi-particles, microscopically resolved in a trapped-ion quantum simulator. Ballistic quantum transport (left), characterized by wave-like interference patterns, can be suppressed by engineered disorder (center). Controlled dephasing can restore transport but renders it diffusive (right). Adapted from (Maier et al., 2019). (b) A discretized version of quantum electrodynamics, simulated with neutral atoms in an optical lattice (sketches at bottom). Electrons and positrons annihilate as their rest mass is tuned across a quantum phase transition. Adapted from (Yang et al., 2020). ©SciPris: DOI:https://doi.org/10.1103/PhysRevLett.122.050501

With a new generation of quantum devices, however, it becomes now possible to assemble designer quantum systems from the bottom up. The main idea, known as quantum simulation (e.g., Hauke, Cucchietti, et al., 2012), is to reproduce a target model under well-controlled laboratory conditions and thus solve the model by experiment. In past years, within international and interdisciplinary collaborations, we were responsible for developing the theoretical basis for a series of breakthrough results. These include the microscopic simulation of magnetic and topological quantum systems (Hauke et al., 2012, 2014; Jurcevic et al., 2014; Smith et al., 2016; Maier et al., 2019) as well as the dynamics of electrons and positrons in discretized versions of quantum electrodynamics (Martinez et al., 2016; Mil et al., 2020; Yang et al., 2020), see Figure 1. While the status quo is still mostly at the level of proofs of concept, the potential for applications of this research is vast, ranging from fundamental questions about nature over material fabrication to medical drug design.

But the potential impact of new quantum devices does not stop here. So-called quantum annealers could solve hard classical optimization problems by "tunneling" into the right solution, with potential impact for many scientific disciplines (Hauke, Katzgraber et al., 2020). Recently, for example, together with colleagues at Trento we have designed a quantum-annealing scheme for predicting the conformational dynamics of large biomolecules (Hauke, Mattiotti, Faccioli, 2020).

Quantum devices may even yield a novel generation of sensors: Clouds of ultracold atoms or photons in nano-fabricated waveguides may be manipulated to detect minuscule changes of magnetic fields, temperature, or refractive index, with unprecedented precision. This enhancement may be achieved thanks to massively distributed entanglement. We have developed methods based on induced quantum dynamics that allow one to detect the presence of this entanglement—and thus to make it possible to certify a potential quantum advantage (Hauke et al., 2016; Costa de Almeida and Hauke, 2020).

The field is currently witnessing an exciting technological and conceptual progress, but still many challenges remain open. Funded by the ERC Starting Grant StrEnQTh (Project-ID 804305), the Q@TN initiative, and the Provincia Autonoma di Trento, my group at the INO-CNR BEC-Center and the Department of Physics of the University of Trento currently investigates questions such as: *What are potential scenarios where quantum machines can offer an edge over classical devices? How can we efficiently detect resources that grant a quantum enhancement? And how can we ensure the reliable working of the quantum device once it reaches large scale, where we know classical laws will take over?*

At the quantum level, a whole new world awaits, with new rules, new challenges, but also new and exciting possibilities.

References

R. Costa de Almeida and P. Hauke
From entanglement certification with quench dynamics to multipartite entanglement of interacting fermions; arXiv:2005.03049 [quant-ph] (2020).
P. Hauke, F. Cucchietti, L. Tagliacozzo, I. Deutsch, and M. Lewenstein
Can one trust quantum simulators?; ***Rep. Prog. Phys. 75***, 082401 (2012).

P. Hauke, O. Tieleman, A. Celi, Ch. Ölschläger, J. Simonet, J. Struck, M. Weinberg,
P. Windpassinger, K. Sengstock, M. Lewenstein, and A. Eckardt
Non-Abelian gauge fields and topological insulators in shaken optical lattices; ***Phys. Rev. Lett.*** 109, 145301 (2012)

P. Hauke, M. Lewenstein, and A. Eckardt
Tomography of band-insulators from quench dynamics; ***Phys. Rev. Lett. 113***, 045303 (2014)

P. Hauke, M. Heyl, L. Tagliacozzo, and P. Zoller
Measuring multipartite entanglement via dynamic susceptibilities; ***Nat. Phys. 12***, 778 (2016).

P. Hauke, H. G. Katzgraber, W. Lechner, H. Nishimori, and W. D. Oliver
Perspectives of quantum annealing: Methods and implementations; ***Rep. Prog. Phys. 83***, 054401 (2020).

P. Hauke, G. Mattiotti, and P. Faccioli
Dominant Reaction Pathways by Quantum Computing; arXiv:2007.13788 [quant-ph] (2020).

P. Jurcevic, B. P. Lanyon, P. Hauke, C. Hempel, P. Zoller, R. Blatt, and C. F. Roos
Quasiparticle engineering and entanglement propagation in a quantum many-body system
Nature 511, 202 (2014).

J. Smith, A. Lee, P. Richerme, B. Neyenhuis, P. W. Hess, P. Hauke, M. Heyl, D. A. Huse, and C. Monroe
Many-body localization in a quantum simulator with programmable random disorder; ***Nat. Phys. 12***, 907 (2016).

Ch. Maier, T. Brydges, P. Jurcevic, N. Trautmann, C. Hempel, B. Lanyon, P. Hauke, R. Blatt, and Ch. Roos
Environment-assisted quantum transport in a 10-qubit network; ***Phys. Rev. Lett. 122***, 050501 (2019).

E. A. Martinez, C. Muschik, P. Schindler, D. Nigg, A. Erhard, M. Heyl, P. Hauke, M. Dalmonte, T. Monz, P. Zoller, and R. Blatt
Real-time dynamics of lattice gauge theories with a few-qubit quantum computer; ***Nature 534***, 516 (2016).

A. Mil, T. V. Zache, A. Hegde, A. Xia, R. P. Bhatt, M. K. Oberthaler, P. Hauke, J. Berges, and F. Jendrzejewski
Realizing a scalable building block of a U(1) gauge theory with cold atomic mixtures; ***Science 367***, 1128-1130 (2020).

B. Yang, H. Sun, R. Ott, H.-Y. Wang, T. V. Zache, J. C. Halimeh, Z.-S. Yuan, P. Hauke, and J.-W. Pan
Observation of gauge invariance in a 71-site optical-lattice quantum simulator; arXiv:2003.08945 [cond-mat.quant-gas] (2020).

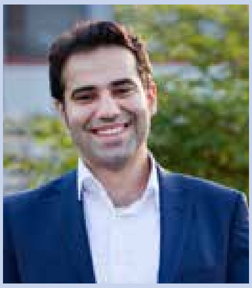
YOUNG SCIENTIST PRIZE WINNERS 2020

Commission on Semiconductors (C8)

Cheng Gong

"For pioneering the experimental discovery and understanding of novel two-dimensional materials and the highly innovative development of spintronic devices based on such materials."

Cheng Gong has been an assistant professor in the Department of Electrical & Computer Engineering and Quantum Technology Center (QTC) at the University of Maryland, College Park since 2019. His group focuses on magnetic, electronic and optical properties of two-dimensional (2D) materials, nanostructures and nanodevices, studied by a variety of optical and electrical approaches in synergy with density functional theory calculations. From 2014 to 2019, he was a postdoctoral fellow at University of California, Berkeley, where he pioneered the discovery of the first magnetic 2D material and innovated the development of spintronic devices based on magnetic 2D materials and heterostructures. He received his PhD in 2013 in Materials Science and Engineering at the University of Texas at Dallas, where he conducted a series of experimental and theoretical work on the topics of metal-graphene contact, metal-TMD (transition metal dichalcogenides) contact, graphene synthesis and optimization, and graphene oxide reduction and intercalation.



Michael Saliba

“For developing a family of highly efficient, reproducible, and stable multication perovskites.”

Michael Saliba (@miliba01) is a full professor and the director of the Institute for Photovoltaics (ipv) at Stuttgart University (@SalibaLab) with a dual appointment as Helmholtz Young Investigator at the Research Center Julich, Germany.

Previously, he was a professor at TU Darmstadt, a Group Leader at the University of Fribourg, and a Marie Curie Fellow at EPFL (with a research visit at Stanford), Switzerland. He completed his PhD at Oxford University in 2014 (with a research visit at Cornell) working on crystallization behaviour and plasmonic nanostructures in perovskites. He obtained his MSc in physics at the Max Planck Institute for Solid State Research on simulation methods for plasmonic oligomers.

In 2016, Saliba was awarded the Young Scientist Award of the German University Association. In 2017, he was awarded the Science Award of the Fraunhofer UMSICHT institute, the René Wasserman Award of EPFL, and the Postdoctoral Award of the Materials Research Societ (MRS). He was also named as one of the World’s 35 Innovators Under 35 by the MIT Technology Review for his pioneering discoveries in the field of perovskite solar cells and optoelectronics. In 2020, he was awarded the Heinz Maier Leibnitz Prize by the German Research Foundation (DFG). In the same year, he was elected as a Board Member of the National Young Academy of Germany, a Young Scientist at the World Economic Forum as well as the Co-Chair of the Global Young Academy.

Michael Saliba has published over 100 works in the topics of plasmonics, lasers, LEDs, and perovskite optoelectronics. Times Higher Education considers him the 3rd most influential scientist in perovskite research based on the number of publications and quality. Since 2018, he is listed as an ISI Highly Cited Researcher.

Saliba was part of many of the early discoveries in the perovskite field. His research focuses on a deeper understanding of novel semiconductor materials such as perovskites which can be used in applications such as solar cells, light-emitting devices, and sensors. He developed and investigated the fundamental properties of a new family of perovskites by adding more stable inorganic metal ions. The new generation of perovskite materials has a substantially suppressed amount of detrimental impurities resulting in a higher temperature, humidity and phase stability with performances close to the theoretical limit. Importantly, solar cell operation at elevated temperature, which is an industrial prerequisite, was successfully demonstrated, which is a key breakthrough for commercialization. The new material design principle has established a new standard for perovskites which is followed by research and industry groups worldwide.

Commission on Particles and Fields (C11)

Marco Lucchini

“For his pioneering work in the development of fast crystal sensors for the precision timing of charged particles.”

Marco Lucchini has been a Postdoctoral Research Associate at Princeton University since 2018. He received his PhD from the University of Milano-Biccocca in Italy and worked as a Fellow at CERN from 2015. Since 2017 he started to lead, within the CMS experiment, detector R&D efforts for the novel Mip Timing Detector to tackle some of the challenges of the High Luminosity LHC era. He recently received a Fellini Fellowship Grant from the Italian Institute of Nuclear Physics (INFN) to develop his project (TiMe-LAPseD) on fast timing detectors with crystals and SiPMs.

Ben Safdi

“For groundbreaking theoretical contributions to the search for dark matter, in particular the development of innovative techniques to search for axion dark matter, and to separate dark matter signals from astrophysical backgrounds.”

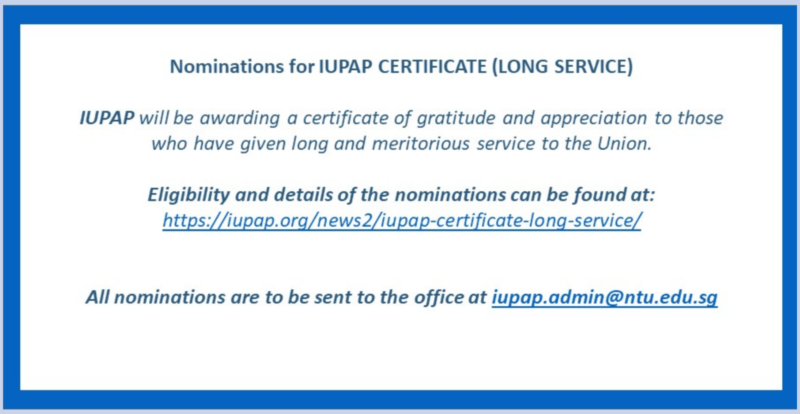
Ben Safdi is an assistant professor in the Department of Physics at the University of Michigan, Ann Arbor. His research investigates the microscopic nature of dark matter, which is currently unknown. He has helped establish pathways towards potentially discovering some of the most well-motivated dark matter candidates, such as axion dark matter, with novel laboratory experiments and astrophysical probes. In addition, he has developed data-analysis techniques that have helped to foster better understanding of how to search for signatures of dark matter in complicated astrophysical datasets. Before arriving in Michigan, Dr. Safdi was a Pappalardo Fellow in Physics at the Massachusetts Institute of Technology. He received his undergraduate degree from the University of Colorado at Boulder, a Master of Advanced Study from Cambridge University, as a Churchill Scholar, and his PhD from Princeton University.

CONFERENCE REPORTS – 2019

30th Texas Symposium on Relativistic Astrophysics, held in Portsmouth, UK from 15/12/2019 - 20/12/2019 showcased plenary talks, that included results from the Event Horizon Telescope which revealed the first picture of the black-hole shadow in the centre of M87 galaxy (Dimitrios Psaltis), results obtained with the IceCube South Pole Neutrino Observatory and the first association between high energy neutrinos and an astronomical source (Elisa Resconi), recent progress in modelling the inspiral and merger of binary neutron stars (Tanja Hinderer and Luciano Rezzolla), scale-symmetry as a new guiding principle in understanding the quantum structure of spacetime (Astrid Eichhorn), open questions in cosmology and unresolved fundamental issues (Joe Silk).

International Workshop on Nanomagnetic Materials, Applications & Properties (InMAP-2019), held in Odessa, Ukraine from 15/09/2019 - 20/09/2019 brought together a broad international community of scientists, engineers, and educators who are already involved in defining a future where the understanding and controlling of matter at the nanoscale will ultimately lead to revolutionary technological and industrial advances. It had notable lectures by Prof. P Weiss, Dr. M. Meyyapan, Dr. S. Bader, Prof. M. Rivas, Prof. Ichiyanagi Yu, Dr T. Nakamura T, Prof. A. Hirohata and Dr. B. Maiorov.

OPEN FOR NOMINATION



Nominations for IUPAP CERTIFICATE (LONG SERVICE)

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