ISASINDIA Newsletter

Vol 22, No. 3 *July -September- 2022*

From Editor's Desk

Happy Dussehra to all ISAS Members

It is matter of great pleasure that third issue of ISAS newsletter is being published. Scientific articles from diverse fields are included like various flowers in garden .

Scientists from BARC have attempted to spread the awareness about nuclear energy in very unique way. BARC scientists embarked on a 1700 Km cyclethon from India Gate to Mumbai's Gateway of India. The former chairman of Atomic Energy Commission of India, Dr. Anil Kakodkar in an interview revealed that nuclear energy is much cheaper than wind and solar energy. In one article, importance of Large Hadron Collider has been described in very elegant way for the understanding of the readers. The ever built largest space telescope, James Webb Space Telescope has captured the pictures showing parts of the universe as they were 13 billion years ago. It is privilege that three Indian origin scientist are part of the team of NASA scientists involved in this historical achievement. Lucknow-born Dr Hashima Hasan is the Deputy Project Scientist of the James Webb Space Telescope. She also worked at Bhabha Atomic Research Centre (BARC). Kalyani Sukhatme was Project Manager, Mid-Infrared Instrument (MIRI), which was used on the telescope. She grew up in Mumbai and did her Bachelors in Technology (B.Tech) from IIT Bombay. Kartik Sheth, Programme scientist, Astrophysics division, NASA's Science Mission Directorate. Working of particle accelerators and their use has been described in one article. Scientists have discovered 10 times more abundance of ^{3}He which is fuel for fusion reactor. The Higgs boson could have kept our universe from collapsing. Properties of Hogg's boson indicates towards existence of multiverse of parallel worlds and only worlds having tiny Higgs boson would survive. Professor Lluïsa Pérez-García University of Barcelona succeeded in developing light-controlled artificial molecular machine. New study by the University of Bonn and the Technical University of Darmstadt suggests that the protons are probably actually smaller than assumed. ISRO Scientists demonstrated hack-proof communication between two places separated by 300 meters, using real-time Quantum Key Distribution. MIT scientists realized a rare form of matter having antiferromagnet and a metallic state in the same material by manuplating light. On exposing to light pulse the insulator NiPS3 turned into metallic while maintaining its magnetism. The latest atomic clock is so precise that it will only lose one second every 300 billion years, enabling more accurate measurements of gravitational waves, dark matter, and other physical phenomena. Nuclear Science Helps Fruits and Vegetables Survive and Thrive. In 2021, the Joint FAO/IAEA Centre provided technical support for the development and release of 36 new plant varieties during the year. Scientists at the U.S. Department of Energy‘s Brookhaven National Laboratory have discovered a long-predicted magnetic state of matter called an ―antiferromagnetic excitonic insulator.Future space missions could have new options opened up by nuclear technology. A Direct fusion Device (DFD) can produce specific power several orders of magnitude higher than other systems, reducing trip times and increasing payloads, thus enabling us to reach deep space destinations much faster.

Dr. Pradeep Kumar
Chief Editor, ISAS

Message from President, ISAS

Happy to see that the latest ISAS Newsletter is ready for release on the eve of New year, 2023.

Wish you all a happy reading of this ISAS News Letter.

The term of this EC of ISAS will be ending on 31.3 2023, after setting an Outstanding Performance Record, that could be achieved due to Dynamic Leadership, Swift Policy Decisions, Out of the Box Thinking leading to Variety of Activities such as, Committed Efforts to Streamlining the ISAS Records, Updating the Membership List, Creating and Operating an Impressive ISAS Website (isasbharat.in), Embarking on the ISAS Journal (first of its kind in India), Conducting Two ISACs (IASC-2019 and IASC-2022) and embarking upon the third IASC (IASC-2023), Organizing the vibrant AKAM Series of 75 Weekend ISAS Webinars overcoming the limitations imposed by the Covid Pandemic, Instituting many ISAS Awards including The ISAS Analytical Scientist of the Year Award, starting from 2019-20,the ISAS Sastra Pitamaha Award, the ISAS Atma Nirbharta Award, ISAS Homi Bhabha Award, The ISAS Raja Ramanna Award, The ISAS Dr M.Sundaresan Memorial Award, ISAS Awards for Indian Analytical Instrument Manufacturers, ISAS Hon. Fellowships to Outstanding Indian Scuentific Performers, etc.

ISAS could set such an Excellent Functional Track Record, only by adopting a Practical Management Approach sans clerical approaches and resultant bottlenecks.

(Dr. P. P. Chandrachoodan)
President,
ISAS.

A Unique Initiative to Promote Nuclear Energy, 1700 Km. Scientists Are Holding a Long Cycle Rally

14 August, 2022 | by Muhammad |arytvnews.com

Source website links: https://arytvnews.com/a-unique-initiative-to-promote-nuclear-energy-1700-km-scientists-are-holding-a-long-cycle-rallyatn-news/

The Cyclothon features senior scientists from Bhabha Atomic Research Centre (BARC). Which will spread awareness about nuclear energy as a clean, green and safe source of electricity among the people it meets on the way.

BARC scientists embarked on a 1700 km cyclethon from India Gate to Mumbai's Gateway of India. Image credit source: TV9

Senior scientists at Bhabha Atomic Research Centre (BARC) have taken a unique initiative to promote nuclear energy. Cyclothon starts from India Gate to Gateway of India, Mumbai "Cyclothon will end on 23rd August 2022 at Gateway of India, Mumbai. A team of nuclear scientist cyclists pointed out that nuclear reactors and bicycles are synonymous in terms of being clean, green and safe. Both are indispensable options for addressing the challenges of climate change. There is also a theme for this event. Nuclear power, like cycling, is the cleanest, greenest and safest. Speaking on the occasion, Mr. Sinha said, "This is a great initiative by the Department of Atomic Energy. Will influence their opinions in a positive way.

What is the specialty?

The Cyclothon features senior scientists from Bhabha Atomic Research Centre (BARC). Which will spread awareness about nuclear energy as a clean, green and safe source of electricity among the people it meets on the way. This will encourage common people. The campaign is named Chain Reaction, inspired by the fundamentals of both nuclear reactions and cycles.

Atoms and cycles

On this occasion, the team of cyclists said that nuclear reactors and bicycles are the same in terms of being clean, green and safe. Both are indispensable options for addressing the challenges of climate change. They claim that this is also the main theme of the event, which states that "nuclear energy is the cleanest, greenest and safest, like cycling".

What is Department of Atomic Energy?

The Department of Atomic Energy (DAE) is under the direct charge of the Prime Minister. It is engaged in the development of applications of radiation technology in nuclear energy technology, agriculture, medicine, industry and basic research. The department consists of 6 R&D centres, 5 PSUs, 3 industrial and 3 service organisations. It has two boards for the promotion and funding of extramural research in nuclear and allied fields, mathematics and a national institution (deemed university). It also supports ten institutions of international repute engaged in research in basic science, astronomy, astrophysics, cancer research and education. It also has an educational society at its bottom.

Atomic Energy Cheaper than Solar, Wind for End Consumers, Says Nuclear Scientist Anil Kakodkar

29 July, 2022 | by The Print Team

Source website links: https://theprint.in/theprint-otc/atomic-energy-cheaper-than-solar-wind-for-end-consumers-says-nuclear-scientist-anilkakodkar/1059993/

In Off the Cuff conversation with The Print, the former chairman of Atomic Energy Commission of India spoke of the country's nuclear energy plans & people's fear of accidents & radioactive leaks.

Nuclear energy might be capital intensive, but the cost to the consumer is much lower than that of other renewable resources, like solar and wind, said Anil Kakodkar, nuclear scientist and former chairman of the Atomic Energy Commission of India, Thursday.

Kakodkar was in conversation with The Print's Editor-in-Chief Shekhar Gupta and Senior Associate Editor Manasi Phadke during a virtual session of Off the Cuff'. The nuclear scientist touched on the various aspects of nuclear science, the inhibitions around the technology and why India needs to expand its renewable power production.

Talking about how India's use of thorium can reduce the generation of radioactive waste, Kakodkar said: ―Thorium can essentially limit the amount of spent fuel coming out of uranium reactors. He pointed out that although India's nuclear resource endowment — that is, its uranium resources — are modest, the country has vast resources of thorium.

―Our objective is ultimately to be able to extract energy out of thorium on a very large scale, he added. However, a nuclear reaction required for energy generation can not begin with thorium. Uranium is required to set forth a chain of reactions required for energy generation.

Thus India‘s nuclear plant would be divided in three stages — uranium reactor, fast breeder reactor, and thorium reactors. Most importantly, the three stage process ensures that the nuclear waste generated is just about two to five per cent of the waste generated by a country that only uses uranium reactors, Kakodkar explained.

On India's nuclear energy plan

Around 10 to 11 per cent of the world‘s electricity is supplied by nuclear energy now, although there was a time when this was as high as around 17 per cent, Kakodkar said.

―With the emphasis and awareness about the global warming, and the need to resort to energy sources that do not emit carbon dioxide, nuclear will become even more important, he added.

This is because it is the only large-scale dispatchable power or baseload power which has the potential to grow, Kakodkar explained. Hydro power is also of that kind, he added, but it has almost reached saturation — at least in India. Base load power refers to the minimum amount of electric power needed to be supplied to the electrical grid at any given time. Maintaining baseload power is very important to manage large grids. Unless baseload power is managed, the grid starts entailing higher and higher capital investments, either in the form of additional capacity or storage, said Kakodkar. The scientist added: ―These investments are very large. Studies have shown that variable renewable energy costs (such as wind and solar) are very low at the generation end, from the consumer end it can become three to four times higher. Although nuclear projects are capital intensive, the per capita delivery cost is comparable to solar energy, he said. Kakodkar also said that energy is one of the very important inputs to support development. Energy makes a significant difference in human development index, life expectancy at birth and a variety of other development parameters, he said.

―Initially, there is a sharp contribution as the energy input increases, this development parameter sharply goes up. And then the point comes when it saturates, he added. ―Most of the advanced countries in the world which have high human development index enjoy per capita energy consumption at a level higher than some threshold. India‘s energy consumption in per capita terms is much lower than this. So increase in energy utilisation is very important for India, to improve its quality of life, people‘s quality, and it‘s not necessarily so in advanced countries, he said.

Other benefits of atomic or nuclear science

According to Kakodkar, one of the key benefits of nuclear science is its applications in the health sector. ―One of the challenges in the health area relates to cancer. And radiation is an important treatment modality for treating cancer, he said. There are also applications of nuclear science in agriculture and waste management. In the past, Kakodkar noted, Bhabha Atomic Research Centre (BARC) had successfully carried out experiments involving irradiating seeds with nuclear radiation, to create new mutant varieties, with desirable plant traits. ―The varieties developed through nuclear mutation are contributing significantly to India‘s pulses story, as well as oil seeds. he said.

On genetically modified crops

Talking about the fear around genetically modified (GM) crops, Kakodkar said missing out on the development would cost India dearly. He noted that any scientific development is brought about with a lot of care. ―There are modalities for developing GM crops. You carry out confined trials in fields, making sure that nothing can go outside. Once these modalities are done, then we should not fear, he added. However, ―ideological fixes‖ in people‘s minds is a societal problem that needs to be addressed, said the nuclear physicist. ―I think it‘s very unfortunate that we are in that trap,‖ he said. Now even for conducting genetic modification research there‘s a lot of a lot of insecurity, he added.

Fear of nuclear accidents and leaks

Kakodkar said that the public‘s first exposure to nuclear energy came about by the Hiroshima incident, referring to the bombing of the Japanese town by the US during the Second World War He explained that the trauma linked to the large-scale evacuation, following the Chernobyl or Fukushuma nuclear power plant disasters, has left a mark on people‘s psyche. ―However, if you asked me today, the nuclear technology is a vast improvement over the technology which went in Chernobyl or Fukushima reactors, he added.Although nobody can say no accident will take place, Kakodkar said that, if there is an accident, reactors are now designed to prevent the radiation from leaking, so that human exposure is limited. ―But I think it will take time for that field to vanish from the minds of people, he added.

National Technology Day: know how 28 years ago India rose as a Global Nuclear Superpower

Source website links: https://newsonair.com/2022/05/11/national-technology-day-know-how-24-years-ago-india-rose-as-a-global-nuclearsuperpower

Today at 15:45 hours, India conducted three underground nuclear tests in the Pokhran range. These tests conducted today, there is a fission device, a low yield device, and a thermonuclear device, these were the words of former Prime Minister of India, Atal Bihari Vajpayee when India successfully carried out the Pokhran nuclear tests – a series of five explosions under "Operation Shakti" at the Indian Army‘s Pokhran Test Range in Rajasthan on 11th May 1998. Following the successful conduct of nuclear tests, spearheaded by the former President and aerospace engineer Dr APJ Abdul Kalam, India became the sixth country to join the elite group of "the nuclear club".

To commemorate the achievements of the Indian scientists, engineers and innovators involved in the significant milestone, today, i.e 11th May, the entire nation is observing "National Technology Day" to honour the architects of such technological innovations.

Prime Minister Modi hails the efforts on this occasion

Today, on National Technology Day, we express gratitude to our brilliant scientists and their efforts that led to the successful Pokhran tests in 1998. We remember with pride the exemplary leadership of Atal Ji who showed outstanding political courage and *statesmanship. pic.twitter.com/QZXcNvm6Pe— Narendra Modi (@narendramodi) May 11,2022)*

On the occasion of Nation Technology Day, Prime Minister Modi took to Twitter to express his gratitude towards scientists and their efforts that led to the successful Pokhran tests in 1998. On this day, PM also remembers former Prime Minister of India, Atal Bihari Vajpayee for his exemplary leadership during the test.

https://twitter.com/narendramodi/status/1524229192212426752

Operation Shakti: The epitome of technological innovation Under Operation Shakti, a series of five nuclear tests were carried out by the Indian Army along with the scientists of the Defence Research and Development Organisation (DRDO), Atomic Minerals Directorate for Exploration and Research (AMDER) and Bhabha Atomic Research Centre (BARC). In terms of technology, the nuclear tests were conducted in Pokhran but the plutonium used in it was brought from the Bhabha Atomic Research Centre (BARC) in Mumbai. About 10 days before the tests, the Indian Air Force (IAF) swung into action with its AN-32 aircraft that took off from Mumbai's Santacruz airport with the six wooden crates. Inside the crates, there was a metal shield and inside it, were explosive plutonium shells.

These shells were manufactured by the scientific community of Bhabha Atomic Research Centre (BARC) in Mumbai and each sphere weighed around 5kgs to 10kgs. IAF's AN-32 reached Jodhpur, Rajasthan within 2 hours and from there, those crates were taken to the Pokhran at night. As soon as the plutonium shells reached, scientists began assembling them with triggers and explosive detonators.

On May 11 1998, all the nuclear tests were tested at 3:45 pm. After that, the test data was analysed by a group of scientists who confirmed the tests' success.

―Defense Research and Development Organisation (DRDO) and Department of Atomic Energy (DAE) have affectively and effectively coordinated and integrated their respective technological strength in the national mission to confer the country with the capability to vacant the nuclear threat,‖ said the then President of India Dr APJ Abdul Kalam at a press conference after the nuclear tests. Prime Minister Atal Bihari Vajpayee declared May 11 as theNational Technology day and said, "This is the most historical day in the history of modern India, as history was made and India proved its technological prowess under the leadership of President Dr Kalam."

The first flight of Hansa-1 and DRDO's Trishul missile Besides honouring India's scientific and technological prowess, May 11 also marks a significant achievement for several other innovations. These include India's first-ever indigenous aircraft, Hansa-1's maiden test flight, in which the light two-seater aircraft flew over Bengaluru in Karnataka for the first time. The plane was designed by National Aerospace Laboratory (NAL) for pilot training, surveillance, and reconnaissance purposes. Country defense research arm, DRDO also tested a short-range missile with a quick reaction time – the surface-to-air – Trishul missile. They later got inducted into the Indian Army and Air Force as part of India's Integrated Guided Missile Development Programme.

Why the Large Hadron Collider is Important

Source website links: https://fiorreports.com/why-the-large-hadron-collider-is-important/

The latest state of physics lies in a beam of subatomic particles racing in circles at almost the speed of light in an underground tunnel in central Europe. That beam just as quickly tumbles in the other direction in another race. The resulting collision creates a barrage of other particles, which are caught by detectors before disappearing. This is standard practice at the Large Hadron Collider (LHC), which recently turned back on for the first time since 2018 and now has its beams stronger than ever. The LHC, located at the European Organization for Nuclear Research (CERN) near Geneva, is the world's largest particle accelerator: a mammoth machine that literally smashes together subatomic particles and lets scientists watch the fountain of quantum debris that spews it out. That might seem unnecessarily violent for a physics experiment, but physicists have a good reason for the destruction. Within these collisions, physicists can peel away the layers of our universe to see how it ticks on the smallest scales.

The physicists behind the machine

The ―big‖ in the LHC's name is no exaggeration: the collider cuts a 17-mile magnetic loop, entirely underground, beneath the Geneva suburbs on either side of the rugged Franco-Swiss border (home to CERN headquarters). Shadows on the eastern slopes of the French Jura mountains and back again. Putting such a colossus together took time. The LHC was first proposed in the 1980s and approved in the mid-1990s. The LHC took over a decade to build before its beam was first turned on in 2008. It cost $4.75 billion to build, most of which came from the coffers of various European governments. LHC consumes enough electricity to power a small town. Even before the current upgrades, the LHC experiments were

producing a petabyte of data per day, enough to store over 10,000 4K movies – after CERN‘s computer network filtered out the excess. This data runs through the computers of thousands of scientists from all parts of the world, although some parts of the world are better represented than others. Time, money and human power continue to flow into the collider as physicists attempt to answer the universe‘s most fundamental questions. For example, what causes mass to exist? Answering this question has been one of the LHC‘s most public triumphs to date. In 2012, LHC scientists announced the discovery of a long-sought particle known as the Higgs boson. The boson is the product of a field which, when particles interact with the field, gives mass to those particles. The discovery of the Higgs boson was the final brick in the wall known as the Standard Model. It‘s at the heart of modern particle physics, a scheme that represents a dozen or so subatomic particles and how they fit neatly together to create the universe we see.

But with each passing year, the standard model seems less and less adequate to answer fundamental questions. Why is there so much more matter in the universe than antimatter, its opposite? What makes up the massive part of our universe that appears invisible and unseen? And why is there gravity? The answers are anything but simple. The answers could come in the form of yet undiscovered particles. But so far they have eluded even the most powerful particle accelerators. ―We have not yet found any non-Standard Model particles at the LHC,‖ says Finn Rebassoo, a particle physicist at Lawrence Livermore National Laboratory in California and an LHC collaborator.

Upgrade the giant

Although the COVID-19 pandemic disrupted the LHC‘s reopening (it was originally scheduled for 2020), the Collider‘s stewards have not been sitting idle since 2018. As part of a series of technical upgrades, they‘ve augmented the Collider‘s beam, boosting energy by about 5 percent. That may seem like a pittance (and it certainly pales in comparison to the planned high-luminosity LHC upgrade later this decade, which will increase the number of collisions). But scientists say it still makes a difference.

"This means an increased likelihood of producing interesting physics," says Elizabeth Brost, a particle physicist at Brookhaven National Laboratory on Long Island and an LHC collaborator.

As a personal favorite example, we now get 10 percent more events involving pairs of Higgs bosons. The Standard Model says that paired Higgs bosons should be extremely rare – and maybe they are. But when the LHC produces pairs in abundance, it‘s a sign that something undiscovered is at play. —It‘s a win-win situation: either we will soon observe the production of Higgs pairs, which implies new physics, says Brost, or we will eventually be able to use the full LHC dataset to predict the Standard Model. to confirm. The improvements also offer the opportunity to observe things that have never been seen before. —Each additional bit offers more potential for discovering new phenomena, says Bo Jayatilaka, a particle physicist at Fermilab in suburban Chicago and an LHC collaborator. It wasn‘t long ago that potential observational material surfaced — not from CERN, but from an old, now-closed, accelerator at Fermilab outside Chicago. Researchers poring over old data found that the W boson, a particle responsible for radioactive decay inside atoms, appeared to have a heavier mass than expected. If true, it could blow the Standard Model way up.

Of course, particle physicists want to make sure it‘s true. They are already planning to repeat this W boson measurement at CERN, both with data from previous experiments and with new data from experiments yet to come. It will likely take some time for the LHC to reach its newfound full capacity.

Typically, the LHC restart is a slow restart, which means that the amount of data in the first year is not quite as large as in the following years, says Rebassoo. And even analyzing the data produced takes time, even for the large mass of scientists working at the collider.

But we could see results as early as 2023 — by harnessing the collider‘s newfound energy boost, Jayatilaka speculates. Muons spill secrets about Earth‘s hidden structures. Inside Egypt‘s Great Pyramid of Giza lies a mysterious cavity, its void unseen by any living human, its surface untouched by modern hands. But luckily, scientists are no longer limited by human senses. To feel out the contours of the pyramid‘s unexplored interior, scientists followed the paths of tiny subatomic...

James Webb Space Telescope: 3 Indians Helped NASA Capture Universe‘s Deepest Images‘

Source website links: https://www.thebetterindia.com/290634/nasa-james-webb-space-telescope-first-image-universe-indian-scientist/

NASA has shared the first image of the universe taken by the James Webb Space Telescope — the largest space telescope ever built. Did you know that 3 Indian scientists helped in making this historic photo possible?

The largest space telescope ever built. Did you know that 3 Indian scientists helped in making this historic photo possible? The sharpest image of the universe, dating back several billion years, has been released by National Aeronautics and Space Administration (NASA). The picture was taken by NASA‘s James Webb Space Telescope. The pictures show parts of the universe as they were 13 billion years ago.

In a press release, NASA stated that the telescope has produced the deepest and sharpest infrared image of the distant universe to date.

"It‘s here the deepest, sharpest infrared view of the universe to date"

Webb‘s First Deep Field. Previewed by @POTUS on July 11, it shows galaxies once invisible to us. The full set of @NASAWebb s first full -color images & data will be revealed July 12: https://t.co/63zxpNDi4I pic.twitter.com/zAr7YoFZ8C

-----NASA (@NASA) July 11, 2022

"These images are going to remind the world that America can do big things, and remind the American people especially our children that there‘s nothing beyond our capacity. We can see possibilities no one has ever seen before. We can go places no one has ever gone before, said President Biden in the NASA press release.

NASA will be releasing the full series of the first colour images taken by the telescope on 12 July. The first full-colour image from the telescope reveals thousands of galaxies, including the faintest objects ever observed in the infrared‘.

This is the deepest and sharpest infrared image of the distant universe, so far. This image covers a patch of sky approximately the size of a grain of sand held at arm‘s length. It‘s just a tiny sliver of the vast universe, said NASA Administrator Bill Nelson.

First image from NASA‘s James Webb Space Telescope. Image: NASA

The $10 billion telescope was launched last year and is set to provide detailed infrared images of the universe. And there are three Indian-origin scientists and experts who were part of the team responsible for this historic feat.

Here‘s taking a look at their contribution:

Dr Hashima Hasan

Dr Hashima Hasan, Deputy Project Scientist, James Webb Space Telescope. Image: JWST/NASA

Lucknow-born Dr Hashima Hasan is the Deputy Project Scientist of the James Webb Space Telescope. The James Webb Space Telescope website states that as Deputy Program Scientist, she works on monitoring and managing the science program for the telescope. She ensures that _its mission remains possible and true to NASA strategic objectives‘. Her love for space started when she was five years old. In a video published by NASA, Dr Hasan spoke about how she got interested in space.

—I grew up in India, and first got fascinated with space when my grandmother took us all to the backyard to see Sputnik. I was five at that time. I was really excited and wanted to become a scientist, said Hasan. She did her undergraduate at Aligarh Muslim University and studied at the Tata Institute of Fundamental Research

(TIFR), Mumbai. **She also worked at Bhabha Atomic Research Centre (BARC).** She received her doctorate from Oxford University in Theoretical Nuclear Physics. She joined NASA in 1994 and has been a program scientist for several missions.

Kalyani Sukhatme

Kalyani Sukhatme was Project Manager. Mid-Infrared Instrument (MIRI), which was used on the telescope. Image: JWST/NASA

According to the website, Kalyani Sukhatme was the project manager for the Mid-Infrared Instrument or MIRI, one of the four science instruments on the James Webb Space Telescope. She now works at NASA's Jet Propulsion Laboratory, California Institute of Technology. She grew up in Mumbai and did her Bachelors in Technology (BTech) from IIT Bombay. Post that, she did her Master's in physics and Doctorate in physics from University of California. She joined NASA's Jet Propulsion Laboratory (JPL) as a postdoctoral fellow in 1998. She won the European Space Agency James Webb Space Telescope award for significant achievement in 2012. She took over as MIRI project manager at JPL in April 2010. She has contributed to the technology development of infrared detectors and their operation for spaceflight missions.

Kartik Sheth

Indian-origin Kartik Sheth is a programme scientist in the astrophysics division within NASA's Science Mission Directorate. His current portfolio includes the James Webb Space Telescope, SOFIA, Spitzer and the Origins Space Telescope, and the Hubble fellowship programme.

Kartik Sheth, Programme scientist, Astrophysics division, NASA's Science

Mission Directorate. Image: JWST/NASA

—For the past seven years, he has been a programme scientist in both the Astrophysics and Earth Science Divisions at NASA, overseeing space missions, and research and development programs in cutting-edge technology and working towards some of the United Nations‘ sustainable development goals, according to NASA.

He did MS and PhD in Astrophysics from the University of Maryland. He worked at Caltech before joining NASA. He was a tenured astronomer at the National Radio Astronomy Observatory in Charlottesville. In 2022, he received NASA‘s Diversity, Equity and Inclusion Award for his work leading the Anti-Racism Action group.

What are Particle Accelerators?

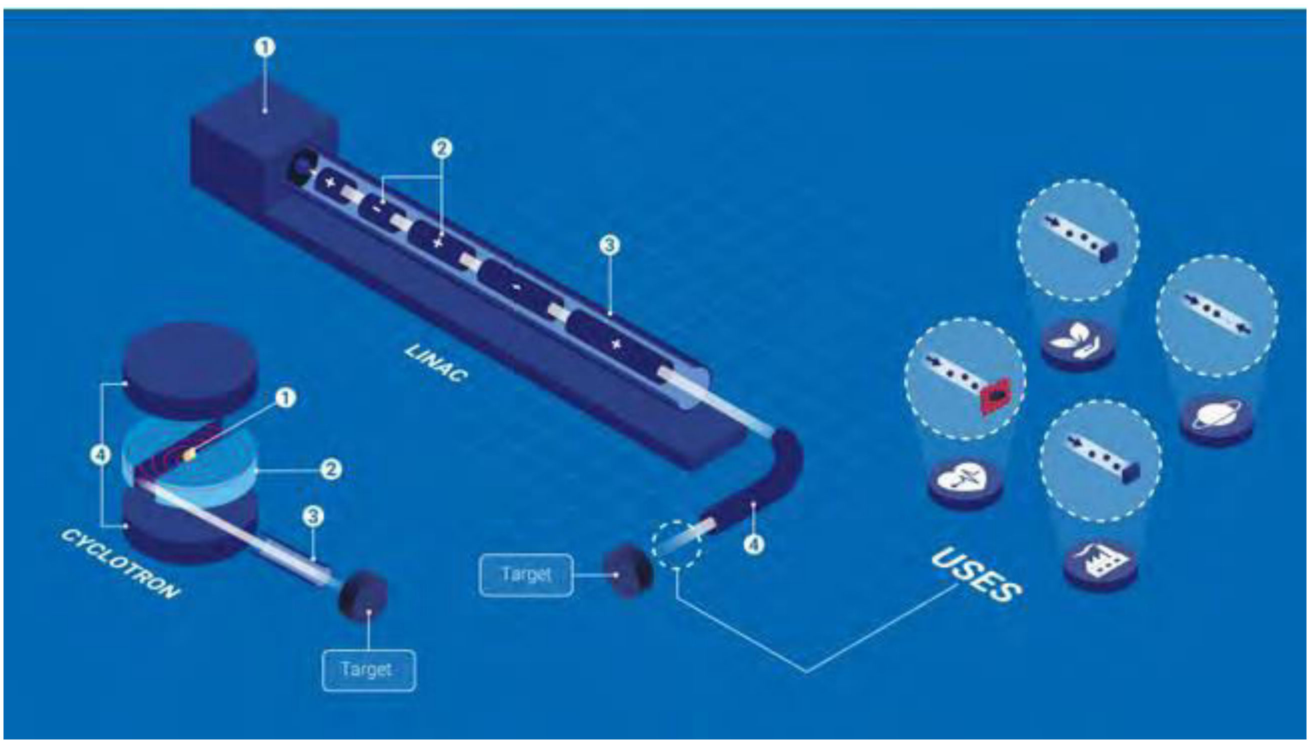
Source website links: https://www.iaea.org/newscenter/news/what-are-particle-accelerators

particle accelerators produce and accelerate beams of charged particles, such as electrons, protons and ions, of atomic and sub-atomic size. They are used not only in fundamental research for an improved understanding of matter, but also in plethora of socioeconomic applications related to health, environmental monitoring, food quality, energy and aerospace technologies, and others.

If you want to join researchers, policy makers, entrepreneurs and accelerator operators for the International Conference on Accelerators for Research and Sustainable Development: From Good Practices Towards Socioeconomic Impact‘ from 23-27 May, we‘ve got you covered. Exploring cutting-edge scientific results, innovation in applications, socioeconomically impactful success stories and case studies, and best practices in managing accelerator facilities, the conference will be streamed to the world and observers can still register for virtual attendance. If you‘re not an expert, here is what you need to know.

How do they work?

Particle accelerators can be linear (straight) or circular in shape and have many different sizes. They can be tens of kilometers long or fit in a small room, but all accelerators feature four principal components



(1) A source which produces the charged particles.
(2) A composite device to add energy to the particles and speed them up by applying a static or an oscillating electric field;
(3) A sequence of metallic tubes in vacuum to allow the particles to move freely in without colliding with air molecules or dust which can dissipate the beam;
(4) A system of electromagnets to steer and focus the beam particles or change their trajectories before being bombarded on a target sample.

How are particle beams used?

Health

Beams can be used to sterilize medical equipment and can produce radioisotopes required to synthesize radiopharmaceuticals for cancer diagnosis and therapy. Large accelerators are also used to destroy cancer cells, reveal the structure of proteins and viruses, and optimize vaccines and new drugs.

Research

A few accelerators — the largest ones — are used to make subnuclear particles collide at nearly the speed of light to advance our knowledge of the origins of our universe. Some of these accelerators are also used to produce neutrons, normally offered for diverse usage by nuclear research reactors.

Environment

Typically proton beams can be used to detect trace chemical elements in the air, water or soil. For example, chemicals in air samples are collected with special filters which are studied with analytical techniques. The results reveal the concentration and composition of the different pollutants and provide a unique signature of the air quality.

Industry

Beams can interact with the atoms of a target materials to make the material, for example, more durable.

What is a Particle Accelerator?

Particle accelerators have many applications in medicine, industry and research. These machines accelerate charged particles, such as electrons and protons, to high speeds, sometimes even close to the speed of light.

[Watch video at https://youtu.be/oUz-g2JTchk]

What are the different types of particle accelerators?

Ion implanters

Ion implanters are widely used in industry to, for example, make materials more resistant to damage from wear and usage. Around 12 000 ion implanters around the world help fabricate semiconductors for cell phones and solar panels. They are also used in metal, ceramic and glass finishings to harden surfaces, make them more durable and improve their longevity. Ion implanters can also improve the reliability of materials used for medical implants, so they are safer to use in the body.

Electron beam accelerators

With almost 10 000 machines in operation globally, electron beam accelerators are an industry work horse. They, for example, help make materials more durable in extreme temperatures or resistant against chemicals. Electron beams are also widely used for sterilizing medical products and foods, and to disinfect sewage water. They are used widely in the automotive and aerospace industries, machine construction and medical product manufacturers.

Linacs

Linear accelerators (linacs) may vary in length, from a couple of meters to a few kilometres. Many of them are used in scientific research. The most widely known are the medical linacs installed at hospitals, which create bursts of X-rays that are guided towards tumour cells to destroy them. There are about 1000 medical Linacs operating worldwide.

Cyclotrons

More than 1200 cyclotrons around the world create proton or deuteron beams for medical uses. They produce radioisotopes that are used for medical imaging to diagnose and subsequently treat cancers. Many cyclotrons are located at hospitals to produce lifesaving radiopharmaceuticals containing short-lived radioisotopes for patients.

Synchrotrons

The more than 70 synchrotrons are the giants among particle accelerators. They are used for scientific research and are best known for helping us understand the fundamental laws of our universe but also for numerous applications. Scientists use synchrotrons to study chemistry, biomedicine, natural and cultural heritage, the environment, and much more.

Electrostatic accelerators

Electrostatic accelerators, notably tandems accelerators, are less expensive, and scientists use them to investigate material properties, monitor the environment, support biomedical research,study cultural heritage objects and more. With recent boosts in their capacity, experts expect the current 300 machines to grow in numbers in the coming years.

Scientists Discover Unexplained Abundance of Rare Nuclear Fusion Fuel on Earth

Source website links: https://www.vice.com/en/article/7kbndq/scientists-discover-unexplained-abundance-of-rare-nuclear-fusion-fuel-onearth

Scientists have discovered evidence that a key rare resource, called helium-3, is potentially ten times more common on Earth than previously known though the source of all this extra supply remains mysterious, reports a new study. The finding is important because helium-3 could serve as a foundation of limitless clean power for our civilization, but has been seen as inaccessible since it is largely found in outer space locations, especially the Moon. Helium-3 is an isotope of helium, which means it contains the same number of protons as this common element but a different number of neutrons. This isotope is considered a potentially powerful energy source for future fusion reactors, making it a star of science fiction as well as a sought-out resource in the real world. However, while small amounts of the substance are produced by geological processes and from the fallout of nuclear weapons testing, there is thought to be very little helium-3 available on Earth.

Now, scientists led by Benjamin Birner, a postdoctoral scholar in geosciences at the University of California San Diego, have captured evidence for a previously unknown abundance of helium-3 in the atmosphere, which —presents a major puzzle in the helium 3 budget and —motivates a search for missing helium -3 sources on Earth, especially since helium-3 is considered an important, yet scarce, resource, according to a study published on Monday in Nature Geoscience. Known sources of helium-3 on Earth only account for 10 percent of the surplus, the researchers said.

Birner and his colleagues serendipitously uncovered this inferred surplus of helium-3 (3He) while tackling another challenging problem: measuring the overall rise in atmospheric helium as a result of human consumption of fossil fuels. The team pioneered a first-of-its-kind technique for estimating these anthropogenic helium emissions by examining another isotope, helium-4 (^{4}He), which in turn led to the perplexing conclusion that there is some unknown source of helium-3 on our planet. We only measured the change in atmospheric ^{4}He, Birner said in an email.

However, previous work by other researchers indicates that the helium isotopic ratio of the atmosphere (^{3}He/^{4}He) is roughly stable. Together these observations imply an increase in atmospheric ^{3}He that matches the rise in 4He or we would see a change in the atmospheric isotope ratio.

Helium-3 could be the ideal fuel for nuclear fusion, a potential energy source that mimics the same process that powers stars. Though nuclear fusion may not materialize as a practical power source for decades, assuming it is feasible at all, its potential to provide clean and limitless energy to the global human population makes it a tantalizing area of study. To that end, scientists across fields are likely to be interested in locating this unexplained surplus of helium-3 on Earth that has been implied by the new research.

That increase of ^3He is quite puzzling because we don't have a good explanation for the source of this ^3He so far, Birner noted. —It's quite an important puzzle to solve also because ^3He is an important and scarce resource for nuclear fusion reactors. Based on the reported uncertainties in previous studies of the atmospheric $^3He/^4He$ trend, the buildup of ^3He looks significant, but our study clearly motivates a closer look at the atmospheric $^3He/^4He$ trend.

Helium is the second lightest and most abundant element in nature after hydrogen, but it can also be produced by human consumption of fossil fuels, especially natural gas. Helium belongs to a special class of elements, called noble gasses, that are relatively unreactive with other substances. As a result, it is not considered a greenhouse gas or a dangerous pollutant, in contrast to other anthropogenic emissions such as carbon dioxide and methane. But though atmospheric helium does not contribute to human-driven climate change, it is an important tracer of those other, more dangerous emissions.

The atmospheric change in helium is a decades-old question in atmospheric chemistry and helium should be able to inform our understanding of fossil fuel usage,‖ Birner explained. —Since the 1980s people have been suspecting that there should be a build up of 4He in the atmosphere but clear observational evidence was lacking.

My colleagues and I have worked on atmospheric noble gasses as indicators of ocean temperature change for a while but hadn't applied the same analytical approach to helium so far, he added.

It was a logical next step in a way because thanks to its link to fossil fuel use, helium is quite an interesting noble gas to study. Previous studies have produced anthropogenic helium estimates by focusing on the ratio between ^3He and ^4He, but the small amounts of ^3He make that an extremely hard measurement, Birner noted.

To get around this problem, the team developed a sophisticated method that measures the ratio of 4He against nitrogen gas (N_2), which is both the most abundant element in the atmosphere and one that has relatively stable concentrations over time.

Our approach not only avoids measuring the rare isotope, meaning ^3He——which improves our measurement precision, but also normalizes the abundance of ^4He to N_2,‖ said Birner, who also led a study last year in Atmospheric Measurement Techniques that delves deeper into the many conceptual advances and technical innovations of this new method.

N_2 has been very stable in the atmosphere which makes $^4He/N_2$ an indicator of the helium concentrations. $^3He/^4He$ in contrast could change because the numerator or the denominator changes, he noted.

The team applied the new technique to 46 air samples acquired between 1974 and 2020, producing a new estimate of atmospheric helium-4 changes across a timescale of decades. The results revealed that helium-4 concentrations have increased significantly over the past five decades‖ and that consequently the abundance of helium-3 greatly exceeds estimates of anthropogenic emissions from natural gas, nuclear weapons, and nuclear power generation, suggesting potential problems with previous isotope measurements or an incorrect assessment of known sources, according to the new study.

When we started, we weren't sure at all how large the atmospheric change in helium would be and if we would be able to measure it at all, Birner said. It took three years to develop and hone the analytical method for 4He/N2 so when I made the first repeatable measurements we were all really excited to see all that hard work come to fruition. The implications for ^{3}He we only realized later as we were looking at our data and comparing it to previous work, and it did come as a surprise to me. The inferred ^{3}He change is more than 10x the natural geological fluxes, Birner added. ―We know that 3He is produced also by decay of tritium. Tritium was released by humans in nuclear bomb tests, by the current stockpile of nuclear warheads and is probably also made in some nuclear power plants. However, our estimate of these sources suggest they can only account for about 10% of the inferred 3He increase. It is not clear at all where the rest comes from.

Birner and his colleagues hope to root out this hidden supply of helium-3, whether it is natural or anthropogenic. More broadly, the researchers plan to apply their new technique toward untangling the various sources of anthropogenic greenhouse gasses on Earth, an effort that can help to inform our response to human-driven climate change.

Helium can help us disentangle and verify the proportion of carbon emissions from natural gas vs other sources such as coal or oil, Birner said. Scientists often perform so-called inversions‘ to infer local to global scale carbon dioxide (CO_2) emissions. In an inversion, you use observed concentrations of CO_2 in different places and infer how large the emissions of CO_2 must have been to yield these concentrations.

Now if you measure CO_2 alone, the inversion will tell you the flux of CO_2 but by also using helium, we may also be able to say what fraction of that CO2 came from natural gas burning because helium should be associated with natural gas but not as much with other emission sources such as car traffic,‖ he concluded. I am now working on further developing the method to detect local changes of helium in San Diego. With some more tweaks, I am confident that precision will be good enough to see daily local variability in helium concentrations.

Physicists Solve the 100-Year-Old Problem of Radiation Reactions

26 January, 2022 | By katewinslet

Source website links: https://floridanewstimes.com/physicists-solve-the-100-year-old-problem-of-radiation-reactions/414708/

black hole-driven jet of electrons and subatomic particles flowing from the center of the galaxy M87. Blue light is synchrotron radiation and should cause a radiative reaction. Credits: NASA and Hubble Heritage Team (STScI / AURA)

Lancaster physicists have proposed a fundamental solution to the problem of how charged particles, such as electrons, respond to their own electromagnetic fields. This question was challenged physicist For over 100 years, mathematical physicist Dr. Jonathan Gratus has proposed another approach. Journal of Physics A: Mathematical and Theoretical in a controversial sense. It is well established that when the point charge accelerates, it generates Electromagnetic radiation. There is both energy and momentum, which must come from somewhere. They usually derive from the energy and momentum of charged particles and are thought to attenuate motion. The history of attempts to calculate this radiation response (also known as radiation attenuation) dates back to 1892 in Lorenz. Since then, many well-known physicists have made significant contributions, including Planck, Abraham, Wolfgang Pauli, Bourne, Shot, Pauli, Dirac and Landau. Active research continues to this day, and many articles are published each year. The challenge, according to Maxwell's equations, is that the electric field at the actual point where the point particle is present is infinite. Therefore, the force applied to the point particle must also be infinite.

Various methods have been used to renormalize this infinity. This leads to the established Lorenz-Abraham-Dirac equation. Unfortunately, this equation has a well-known pathological solution. For example, a particle that follows this equation can accelerate forever without external force, or it can accelerate before a force is applied. There is also a quantum version of radiation attenuation. Ironically, this is one of the few phenomena in which quantum versions occur at lower energies than the classic ones. Physicists are actively looking for this effect. This requires very high energy electrons and a strong —collision. laser Beams, challenges because the largest particle accelerators are not located near the most powerful lasers. However, when a laser is fired at the plasma, high-energy electrons are generated.

This requires only a powerful laser. Current results show that quantum radiation reactions exist.

Another approach is to consider many charged particles. Each particle reacts to the field of all other charged particles, but not to itself. This approach has been rejected in the past because it was not expected to save energy and momentum. But Dr. Gratus said this assumption was wrong, energy and the momentum of the radiation of one particle coming from the external field used to accelerate it. He said, ―The controversial implication of this result is that there is no classical radiation response. Therefore, the discovery of a quantum radiation response can be considered similar to the discovery of Pluto. Pluto's discovery showed that Neptune's motion-corrected calculations were consistent as well. It was predicted, discovered, and shown to be unnecessary. Collaboration enables clear study of radiation reactions. For more information:

Jonathan Gratus, Maxwell-Lorenz, No Self-Interaction: Conservation of Energy and Momentum, Journal of Physics A: Mathematical and Theoretical (2022). DOI: 10.1088 / 1751-8121 / ac48ee

World First for Nuclear-Powered Pink Hydrogen as Commercial Deal Signed in Sweden

Source website links: https://www.rechargenews.com/energy-transition/world-first-for-nuclear-powered-pink-hydrogen-as-commercial-dealsigned-in-sweden/2-1-1155202

Industrial gases giant Linde to buy an undisclosed amount of the H2 produced at the Oskarshamn atomic power station owned by Uniper and Fortum

A Swedish nuclear power plant owned by Uniper and Fortum is to sell pink hydrogen to industrial gases giant Linde in the first-ever commercial deal for nuclear-derived H2.

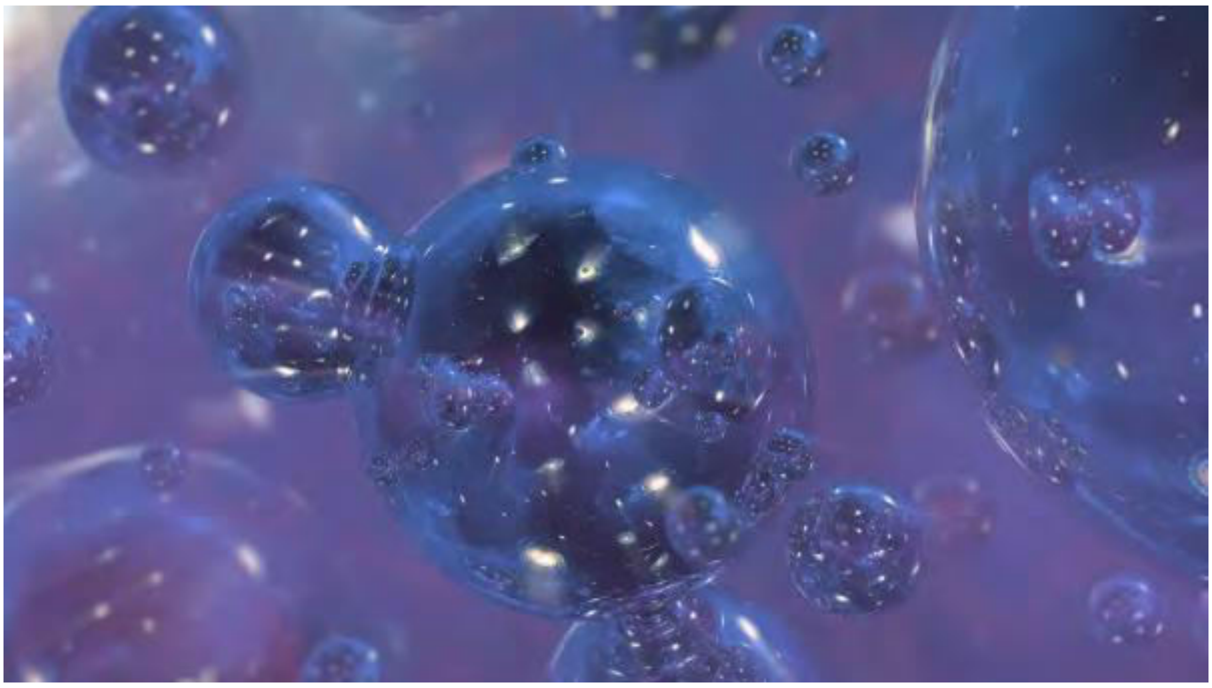
OKG, which operates the Oskarshamn 3 power station, has been producing hydrogen from electrolysers powered by its own electricity since 1992 — for use in reactor coolant. But since the Oskarshamn 1 and 2 reactors were permanently closed in 2016 and 2017, its electrolysis facility has been able to produce more H2 than the site needs.

So OKG is modernising its electrolysis plant — which can currently produce 12kg of pink hydrogen per day — and selling its excess H2 to Linde. —Initially, it is about relatively small volumes, said OKG chief executive Johan Lundberg. —But we have expertise as well as plant and infrastructure, and I see a very good potential to expand this business. —The need for hydrogen will increase gradually, and we have received strong support from our owners Uniper and Fortum to develop this business opportunity." Uniper Sweden boss Johan Svenningsson added: —Our ambition is to develop the growing market for hydrogen together with Fortum. The Swedish electricity system is virtually fossil-free, and we therefore have good conditions for producing large volumes of hydrogen.

The exact size of the deal and its value has not been disclosed. French president Emmanuel Macron said last October that using its nuclear plants to produce hydrogen could be a —primary asset for the country, while state-owned EDF (Électricité de France) said it wants to produce pink H2 at its controversial planned Sizewell C nuclear facility in the UK — an idea that was described by influential analyst and investor Michael Liebreich as —daft. OKG is 54.5% owned by German utility Uniper, and 45.5% owned by Finnish state-owned power giant Fortum. Fortum also owns 75.01% of Uniper.

The Higgs Boson could have Kept Our Universe from Collapsing

Source website links: https: //www.livescience.com/higgs-particle-universe-collapse-in-multiverse



Physicists have proposed our universe might be a tiny patch of a much larger cosmos that is constantly and rapidly inflating and popping off new universes. In our corner of this multiverse, the mass of the Higgs boson was low enough that this patch did not collapse like others may have. (Image credit: MARK GARLICK/SCIENCE PHOTO LIBRARY via Getty Images)

The Higgs boson, the mysterious particle that lends other particles their mass, could have kept our universe from collapsing. And its properties might be a clue that we live in a multiverse of parallel worlds, a wild new theory suggests. That theory, in which different regions of the universe have different sets of physical laws, would suggest that only worlds in which the Higgs boson is tiny would survive. If true, the new model would entail the creation of new particles, which in turn would explain why the strong force — which ultimately keeps atoms from collapsing — seems to obey certain symmetries. And along the way, it could help reveal the nature of dark matter — the elusive substance that makes up most matter.

A tale of two Higgs

In 2012, the Large Hadron Collider achieved a truly monumental feat; this underground particle accelerator along the French-Swiss border detected for the first time the Higgs boson, a particle that had eluded physicists for decades. The Higgs boson is a cornerstone of the Standard Model; this particle gives other particles their mass and creates the distinction between the weak nuclear force and the electromagnetic force. But with the good news came some bad. The Higgs had a mass of 125 giga electron volts (GeV), which was orders of magnitude smaller than what physicists had thought it should be. To be perfectly clear, the framework physicists use to describe the zoo of subatomic particles, known as the Standard Model, doesn't actually predict the value of the Higgs mass. For that theory to work, the number has to be derived experimentally. But back-of-the-envelope calculations made physicists guess that the Higgs would have an incredibly large mass. So once the champagne was opened and the Nobel prizes were handed out, the question loomed: Why does the Higgs have such a low mass?

In another, and initially unrelated problem, the strong force isn't exactly behaving as the Standard Model predicts it should. In the mathematics that physicists use to describe high-energy interactions, there are certain symmetries. For example, there is the symmetry of charge (change all the electric charges in an interaction and everything operates the same), the symmetry of time (run a reaction backward and it's the same), and the symmetry of parity (flip an interaction around to its mirror-image and it's the same. In all experiments performed to date, the strong force appears to obey the combined symmetry of both charge reversal and parity reversal. But the mathematics of the strong force do not show that same symmetry. No known natural phenomena should enforce that symmetry, and yet nature seems to be obeying it. What gives?

The world's largest atom smasher, the Large Hadron Collider, forms a 17-mile-long (27 kilometers) ring under the French-Swiss border. (Imagecredit: Maximilien Brice/CERN)

A matter of multiverses

A pair of theorists, Raffaele Tito D'Agnolo of the French Alternative Energies and Atomic Energy Commission (CEA) and Daniele Teresi of CERN, thought that these two problems might be related. In a paper published in January to the journal Physical Review Letters, they outlined their solution to the twin conundrums. Their solution: The universe was just born that way. They invoked an idea called the multiverse, which is born out of a theory called inflation. Inflation is the idea that in the earliest days of the Big Bang, our cosmos underwent a period of extremely enhanced expansion, doubling in size every billionth of a second. Physicists aren't exactly sure what powered inflation or how it worked, but one outgrowth of the basic idea is that our universe has never stopped inflating. Instead, what we call "our universe" is just one tiny patch of a much larger cosmos that is constantly and rapidly inflating and constantly popping off new universes, like foamy suds in your bathtub.

Different regions of this "multiverse" will have different values of the Higgs mass. The researchers found that universes with a large Higgs mass find themselves catastrophically collapsing before they get a chance to grow. Only the regions of the multiverse that have low Higgs masses survive and have stable expansion rates, leading to the development of galaxies, stars, planets and eventually high energy particle colliders.

To make a multiverse with varying Higgs masses, the team had to introduce two more particles into the mix. These particles would be new additions to the Standard Model. The interactions of these two new particles set the mass of the Higgs in different regions of the multiverse. And those two new particles are also capable of doing other things.

Time for a test

The newly proposed particles modify the strong force, leading to the charge-parity symmetry that exists in nature. They would act a lot like an axion, another hypothetical particle that has been introduced in an attempt to explain the nature of the strong force.

The new particles don't have a role limited to the early universe, either. They might still be inhabiting the present-day cosmos. If one of their masses is small enough, it could have evaded detection in our accelerator experiments, but would still be floating around in space.

In other words, one of these new particles could be responsible for the dark matter, the invisible stuff that makes up over 85% of all the matter in the universe. It's a bold suggestion: solving two of the greatest challenges to particle physics and also explaining the nature of dark matter. Could a solution really be this simple? As elegant as it is, the theory still needs to be tested. The model predicts a certain mass range for the dark matter, something that future experiments that are on the hunt for dark matter, like the underground facility the Super Cryogenic Dark Matter Search, could determine. Also, the theory predicts that the neutron should have a small but potentially measurable asymmetry in the electric charges within the neutron, a difference from the predictions of the Standard Model.

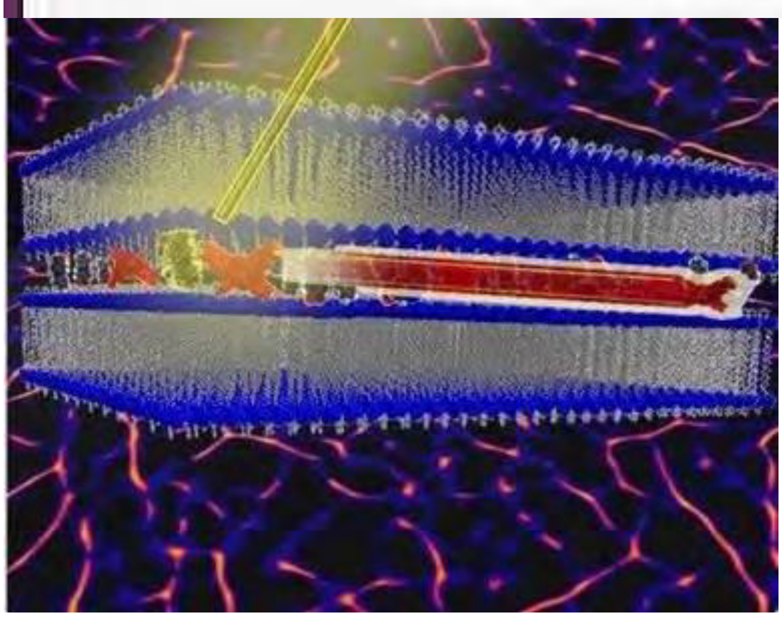
Unfortunately, we're going to have to wait awhile. Each of these measurements will take years, if not decades, to effectively rule out— or support - the new idea.

Scientists Build a Unique Artificial Molecular Machine with Light as its Energy Source

Source website links: https://www.azooptics.com/News.aspx?newsID=27350

January, 2022 | Reviewed by Bethan Davies A molecular machine can be defined as a series of molecules that can conduct different mechanical movements as a reaction to a stimulus. This is an important structure for the development of various cellular functions. Professor Lluïsa Pérez-García, from the Faculty of Pharmacy and Food Sciences of the University of Barcelona (UB), participated in an international study directed by the University of Nottingham, which has developed a light-controlled artificial molecular machine. This study has been published in the journal Nature Chemistry and is a primary step for the creation of a new category of these molecular structures with probable applications both in the domains of nanomedicine and energy.

> *"In this study, we showed that a synthetic self-made molecular fibre in a liquid behaves like a path for the movement of a molecular traveller over a distance 10,000 times its length. The light acts as fuel to favour movement, while a molecular switch mixed into the system propels the traveller into its way.*
>
> *Lluïsa Pérez-García, Researcher and Professor, Faculty of Pharmacy and Food Sciences, Institute of Nanoscience and Nanotechnology, UB*



An image showing the light excited by a molecular switch (yellow shape between the blue molecular layers that are the path) and the motion of the red molecule along the path. The background is a colored image obtained with the optical microscope used to observe the movement.
(Image Credit: University of Barcelona).

Imitating Cellular Molecular Motors

A crucial part of the workings of the cells in living organisms is that molecular motors (a type of molecular machine) move through molecular-specific paths. The new system shows, for the first time, a movement of the kind which occurs along the fibers of the cells.

According to the researchers, the outcomes of the study would be the example of an artificial molecular machine that is perhaps —more similar to cellular molecular motors. The scientists employed interactions between oppositely charged chemical groups to produce movement in this static system: a self assembled cationic molecule forming fibers (the path), to which a fluorescent anionic molecule is incorporated (the traveler). The third element is an anionic molecule that acts as a molecular switch which, when it irradiates with blue-purple light, diminishes the interaction of the traveler molecules with the path as well as boosts the movement of these across the path. The molecular switches discharge the heat when irradiated, an effect that stimulates the molecular traveler to travel, so that the mechanical movement of the switch, and the discharged heat, are key for the system to function. To perceive these effects, the scientists used a unique optical microscope that allowed concurrent stimulation of the molecules— causing them to move — and observation of them when they irradiated, as the traveler molecules were fluorescent.

Transporting Charged Molecules from One Place to Another

The next challenge for the scientists is to make other molecules travel from one place to another in a regulated manner and to imitate nature so that these can transport a charge, but using light as a source of energy.

Another possible application is to discover new approaches to using light energy.

Journal Reference: Samperi, M., et al. (2021) Light-controlled micron-scale molecular motion. Nature Chemistry. doi.org/10.1038/s41557-021-
00791-2.

> *“ This system could be used to conduct chemical tasks, perhaps in miniaturized devices to detect chemical products, and in the application of light-activated drugs.*
>
> *Lluïsa Pérez-García, Researcher and Professor, Faculty of Pharmacy and Food Sciences, Institute of Nanoscience and Nanotechnology, UB*

> *Since we work moving travellers from one place to another, if we take the energy this new system produces, it would be a simple way of getting energy.*
>
> *Lluïsa Pérez-García, Researcher and Professor, Faculty of Pharmacy and Food Sciences, Institute of Nanoscience and Nanotechnology, UB*

Protons are Probably Actually Smaller than Previously Thought

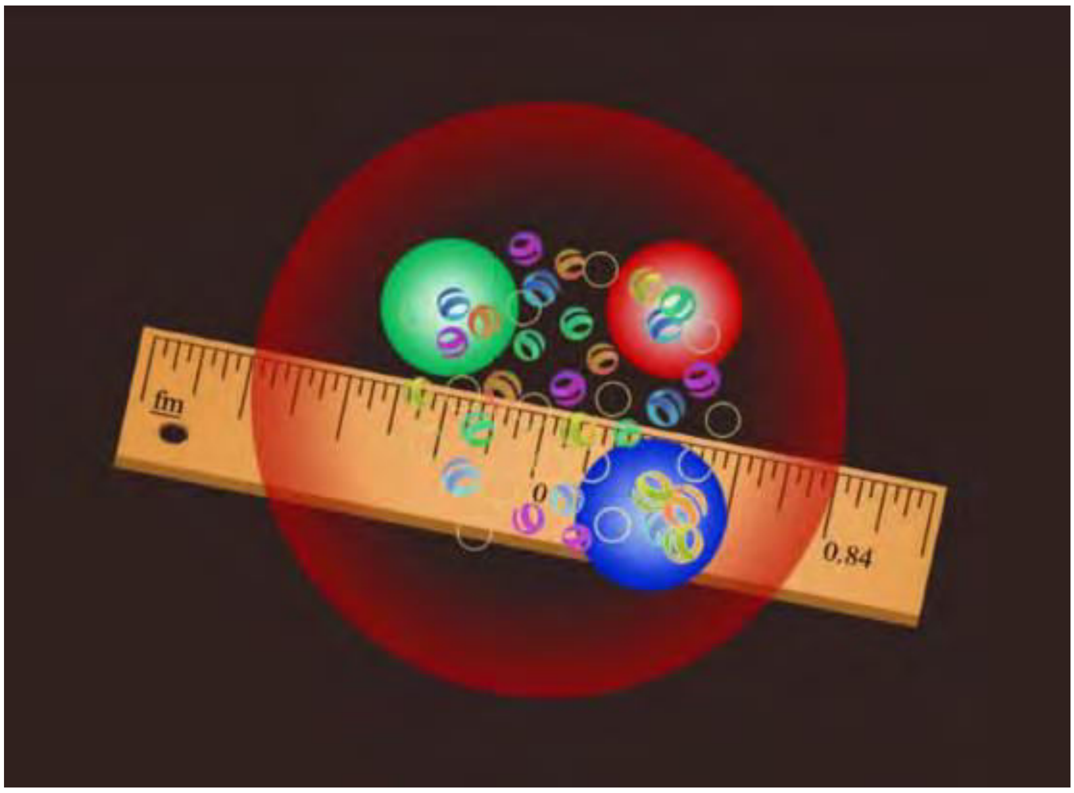
Source website links: https://www.techexplorist.com/protons-probably-actually-smaller-previously-thought/44580/

The study suggests errors in the interpretation of older measurements.

The proton (red) - has a radius of 0.84 femtometers (fm). Also shown in the figure are the three quarks that make up the proton and the gluons that hold them together. Figure: Dr. Yong-Hui Lin/University of Bonn

In the 1990s, protons were thought to be 0.88 femtometers. But a new study by the University of Bonn and the Technical University of Darmstadt suggests that the protons are probably actually smaller than assumed since the 1990s. This discovery comes as a surprise to the scientific community- some researchers even believed that the Standard Model of particle physics would have to be changed. Physicists have created a method that allows them to analyze the results of older and more recent experiments much more comprehensively than before. This results in a smaller proton radius: 0.84 femtometers (a femtometer is a quadrillionth of a meter).

Prof. Dr. Ulf Meißner from the Helmholtz Institute for Radiation and Nuclear Physics at the University of Bonn said, ―However, our analyses indicate that this difference between the old and new measured values does not exist at all. Instead, the older values were subject to a systematic error that has been significantly underestimated so far. Elastic scattering is one way to determine the radius of a proton. It involves bombarding an electron beam to a proton in



An accelerator. When an electron collides with the proton, both change their direction of motion. The larger the proton, the more frequently such collisions occur. Its expansion can therefore be calculated from the type and extent of the scattering. Meißner said, ―The higher the velocity of the electron beam, the more precise the measurements. However, this also increases the risk that the electron and proton will form new particles when they collide. At high velocities or energies, this happens more and more often.

―In turn, the elastic scattering events are becoming rarer. Therefore, for measurements of the proton size, one has so far only used accelerator data in which the electrons had relatively low energy. Prof. Dr. Hans-Werner Hammer of TU Darmstadt said, ―We have developed a theoretical basis with which such events can also be used to calculate the proton radius. This allows us to take into account data that have so far been left out. Using their method, scientists reanalyzed readings from older and very recent experiments, including those that previously suggested a value of 0.88 femtometers. However, with their method, the scientists arrived at 0.84 femtometers; this is the radius found in new measurements based on a completely different methodology. The method also offers new insights into the fine structure of protons and their uncharged siblings, neutrons.

ISRO Conducts Breakthrough Demonstration of Hack-Proof Quantum Communication

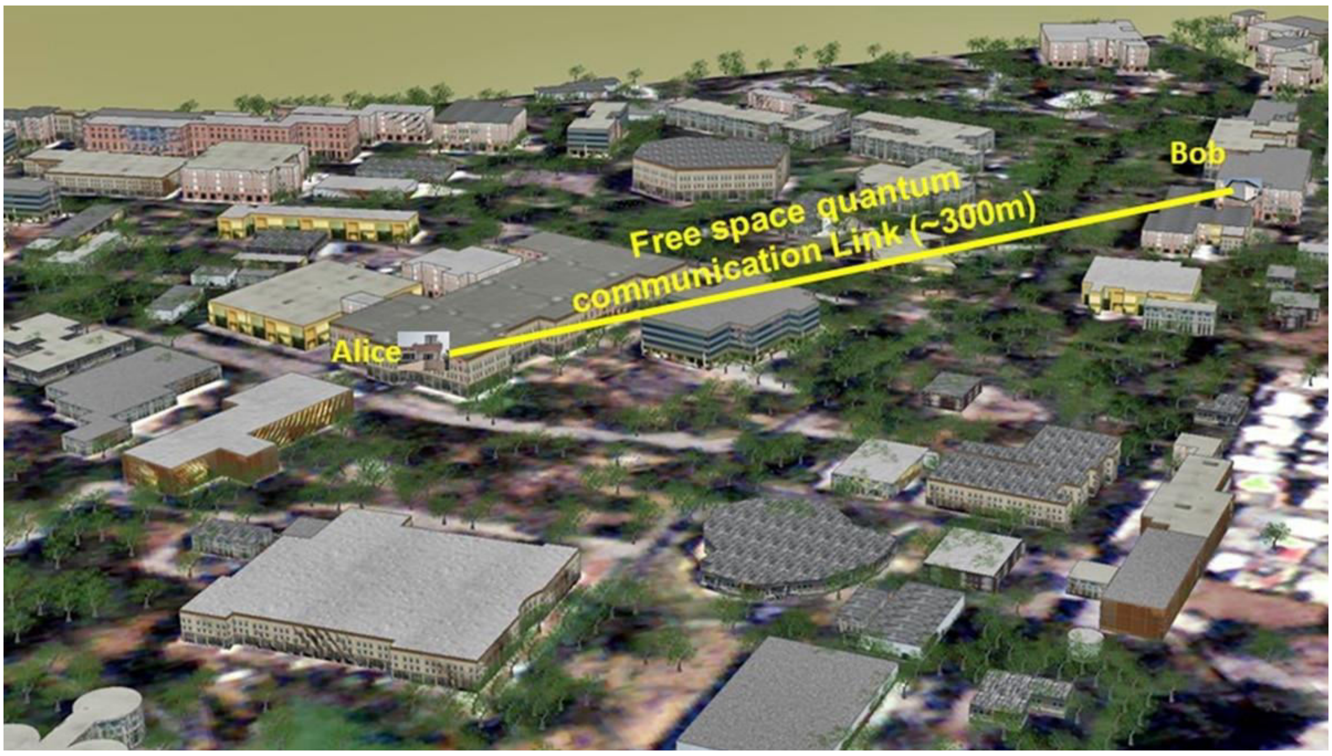
Source website links: https://www.indiatoday.in/science/story/isro-conducts-breakthrough-demonstration-of-hack-proof-quantumcommunication-1907344-2022-02-01

During the demonstration, scientists managed to create an atmospheric channel on the ground to enable sharing of quantum-secure text, image transmission and quantum-assisted two-way video calling.

The latest breakthrough comes on the back of an earlier demonstration of quantum secure video-conferencing in free space. (Photo: Getty)

In a major step forward towards satellite-based quantum communication, scientists from Ahmedabad-based Space Applications Centre and Physical Research Laboratory successfully demonstrated quantum entanglement. Using real-time Quantum Key Distribution (QKD), they conducted hack-proof communication between two places separated by 300 meters. Quantum communication is one of the safest ways of connecting two places with high levels of code and quantum cryptography that cannot be decrypted or broken by an external entity.

If a hacker tries to crack the message in quantum communication, it changes its form in such a manner that would alert the sender and would cause the message to be altered or deleted. During the demonstration, scientists managed to create an atmospheric channel on the ground to enable sharing of quantum-secure text, image transmission and quantum-assisted two-way video calling. The experiment was conducted between two buildings separated by 300 meters at the Space Applications Centre. "This experiment and demonstration were repeated over several nights to ensure the repeatability and robustness of an indigenously developed QKD system capable of seamlessly generating and utilizing secure keys for various applications," ISROsaid in a statement, adding that this is yet another significant step towards the development of the planned Satellite-Based Quantum Communication.



The demonstration was conducted at SAC, Ahmedabad, between two buildings separated by a distance of 300 m. (Photo: ISRO)

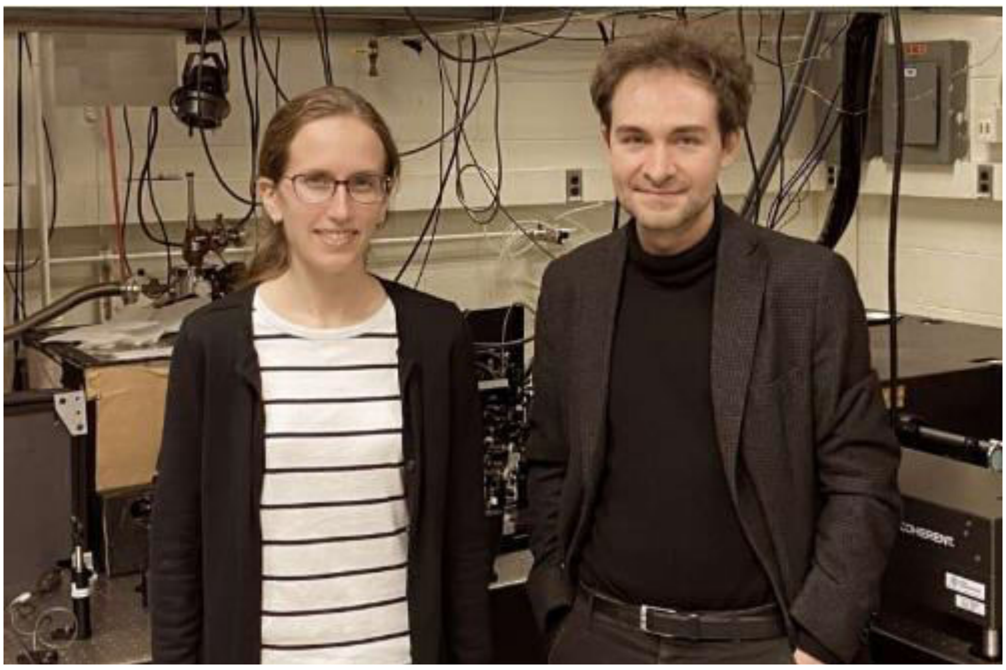
ISRO chief S. Somnath was present to witness the demonstration during which various images were encrypted using a generated quantum key and transmitted over a classical channel from one building to another building. They were then decrypted at the receiving terminal in real-time. ISRO said that to achieve the feat, scientists developed various key technologies like robust & high brightness entangled photon source (EPS), BBM92 protocol implementation, NavIC enabled synchronization, polarization compensation techniques, among others. A cryptographic application software suite with integrated quantum security has also been developed and demonstrated for text, image, video encryption/decryption.

"The Department of Space is getting ready for satellite-based demonstrations of fundamental quantum mechanics experiments as well as quantum communication for future-proof data security," ISRO said. The latest breakthrough comes on the back of an earlierdemonstration of quantum secure video-conferencing in free space, over a distance of 300 meters in March last year. Former ISRO chief K Sivan had said that the space agency was working on a hackproof communication system. He had said that Isro's work will make the relay faster and much more secure in the coming era of quantum computers that explore quantum mechanics. China already has a satellite dedicated to quantum information science, Micius, and demonstrated quantum communication in a laboratory over a coiled optical fibre up to 404 kilometres long. Click here for IndiaToday.in's complete coverage of the coronavirus pandemic.

Physicists Manipulate Magnetism with Light

Source website links: https: //phys.org/news/2022-02-physicists-magnetism.html

With the help of a "playground" they created for observing exotic physics, MIT scientists and colleagues have not only found a new way to manipulate magnetism in a material with light but have also realized a rare form of matter. The former could lead to applications including computer memory storage devices that can read or write information in a much faster way, while the latter introduces new physics.



Physicists Carina Belvin (left) and Edoardo Baldini work in the MIT lab of Professor Nuh Gedik. They and colleagues have found a new way to manipulate magnetism in a material with light. Credit: Tianchuang Luo

A solid material is composed of different types of elementary particles, such as protons and neutrons. Also ubiquitous in such materials are "quasiparticles" that the public is less familiar with. These include excitons, which are composed of an electron and a "hole," or the space left behind when light is shone on a material and energy from a photon causes an electron to jump out of its usual position. Through the mysteries of quantum mechanics, however, the electron and hole are still connected and can "communicate" with each other through electrostatic interactions. "Excitons can be thought of as packets of energy that propagate through a system," says Edoardo Baldini, one of two lead authors of a paper on the work in Nature Communications. Baldini, now a professor at the University of Texas at Austin, was an MIT postdoctoral associate when the work was conducted in the laboratory of Nuh Gedik, an MIT professor of physics. The other lead author is Carina Belvin, a doctoral student in the Gedik group. "The excitons in this material are rather unique in that they are coupled to magnetism in the system. It was quite impressive to beable to "kick" the excitons with light and observe the associated changes in the magnetism," says Gedik, who is also associated with MIT's Materials Research Laboratory.

Manipulating Magnetism

The current work involves the creation of unusual excitons in the material nickel phosphorus trisulfide (NiPS3). These excitons are "dressed" or affected by the environment that surrounds them. In this case that environment is the magnetism. "So what we found is that by exciting these excitons we can actually manipulate magnetism in the material," Belvin says.

A magnet works because of a property of electrons called spin (another, more familiar property of electrons is their charge). The spin can be thought of as an elementary magnet, in which the electrons in an atom are like little needles orienting in a certain way. In the magnets on your refrigerator, the spins all point in the same direction, and the material is known as a ferromagnet. In the material used by the MIT team, alternating spins point in opposite directions, forming an antiferromagnet.

The physicists found that a pulse of light causes each of the little electron "needles" in NiPS3 to start rotating around in a circle. The rotating spins are synchronized and form a wave throughout the material, known as a spin wave. Spin waves can be used in spin electronics, or spintronics, a field that was introduced in the 1960s. Spintronics essentially uses electrons' spin to go beyond electronics, which is based on their charge. The ability to create spin waves in an antiferroelectric material could lead to future computer memory devices that can read or write information in a much faster way than those based on electronics alone. "We are not there yet. In this paper we've demonstrated a process that underlies coherent domain switching: the next step is to actually switch domains," Baldini says.

Rare Form of Matter

Through their work, the team also demonstrated a rare form of matter. When the physicists exposed NiPS3 to intense pulses of light, they found that it turned into a metallic state that conducts electrons while maintaining its magnetism. NiPS3 is ordinarily an insulator (a material that does not conduct electrons). "It is very rare to have an antiferromagnet and a metallic state in the same material," Belvin says.

The physicists believe this happens because the intense light causes the excitons to collide with each other and break apart into their constituents: electrons and holes. "We are basically destroying the excitons, so that the electrons and holes can move around like those in a metal," Baldini says. But these mobile particles do not interact with the localized electron spins participating in the spin wave, so the magnetism is retained.

Baldini describes the experimental setup as a "playground for observing many-body physics," which he defines as "the elegant interplay between different bodies like excitons and spin waves." He concludes, "what I really liked about this work was that it shows the complexity of the world around us." Other authors of the paper from MIT are Professor of Physics Senthil Todadri, Ilkem Ozge Ozel (Ph.D. '18), Dan Mao (Ph.D. '21, now at Cornell University), Hoi Chun Po (postdoctoral fellow '18-'21, now at Hong Kong University of Science and Technology), and Clifford Allington (a graduate student in chemistry). Additional authors are Suhan Son, Inho Hwang, and Je-Geun Park of the Institute for Basic Science (Korea) and Seoul National University; Beom Hyun Kim of the Korea Institute for Advanced Study; and Jae Hoon Kim and Jonghyeon Kim of Yonsei University.

We‘re all Radioactive – So Let‘s Stop Being Afraid of It

Source website links: https://theconversation.com/were-all-radioactive-so-lets-stop-being-afraid-of-it-175267

any people are frightened of radiation, thinking of it as an invisible, man-made and deadly force, and this fear often underpins opposition to nuclear power. In fact, most radiation is natural and life on Earth wouldn‘t be possible without it. In nuclear power and nuclear medicine we‘ve simply harnessed radiation for our own use, just as we harness fire or the medical properties of plants, both of which also have the power to harm. Unlike some toxins found in nature, humans have evolved to live with exposure to low doses of radiation and only relatively high doses are harmful. A good analogy for this is paracetamol – one tablet can cure your headache, but if you take a whole box in one go it can kill you.

The Big Bang, nearly 14 billion years ago, generated radiation in the form of atoms known as primordial radionuclides (primordial meaning from the beginning of time). These now are part of everything in the universe. Some have very long physical half-lives, a measure of how long it takes for half of their radioactivity to decay away: for one radioactive form of thorium it is 14 billion years, for one of uranium 4.5 billion and one of potassium 1.3 billion.

Primordial radionuclides are still present in rocks, minerals and soils today. Their decay is a source of heat in the Earth‘s interior, turning its molten iron core into a convecting dynamo that maintains a magnetic field strong enough to shield us from cosmic radiation which would otherwise eliminate life on Earth. Without this radioactivity, the Earth would have gradually cooled to become a dead, rocky globe with a cold, iron ball at the core and life would not exist.

Radiation from space interacts with elements in the Earth‘s upper atmosphere and some surface minerals to produce new ―cosmogenic‖ radionuclides including forms of hydrogen, carbon

aluminium and other well-known elements. Most decay quickly,

except for one radioactive form of carbon whose 5,700-year halflife enables archaeologists to use it for radiocarbon dating.

Primordial and cosmogenic radionuclides are the source of most of the radiation that surrounds us. Radiation is taken up from the soil by plants and occurs in food such as bananas, beans, carrots, potatoes, peanuts and brazil nuts. Beer for instance contains a radioactive form of potassium, but only about a tenth of that found in carrot juice.

Radionuclides from food largely pass through our bodies but some remain for periods of time (their biological half-life is the time for our bodies to remove them). That same radioactive form of potassium emits high energy gamma rays as it decays which escape the human body, ensuring that we are all slightly radioactive.

Living with radioactivity

Historically, we have been oblivious to the presence of radioactivity in our environment but our bodies naturally evolved to live with it. Our cells have developed protective mechanisms that stimulate DNA repair in response to damage by radiation. Natural radioactivity was first discovered by French scientist Henri Becquerel in 1896. The first artificial radioactive materials were produced by Marie and Pierre Curie in the 1930s, and have since been used in science, industry, agriculture and medicine. For instance, radiation therapy is still one of the most important methods for treatment of cancer. To increase the potency of therapeutic radiation, researchers are currently trying to modify cancer cells to make them less able to repair themselves.

Brazil nuts are the most radioactive common food. New Africa / shutterstock

(For internal circulation only)

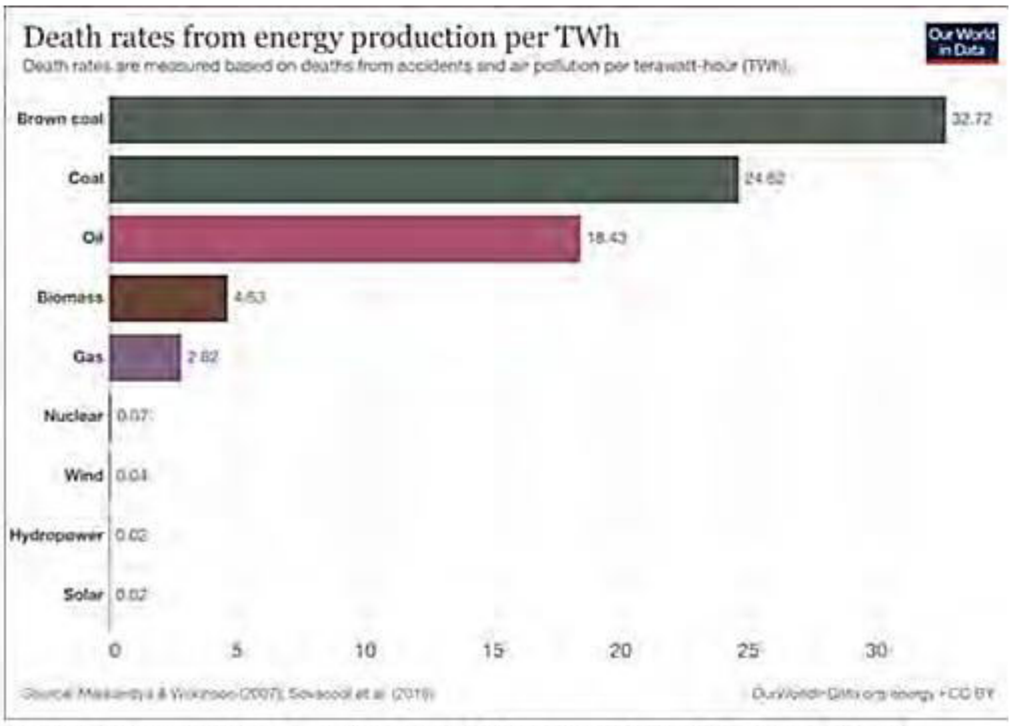
NUCLEAR NEWS WEB DIGEST

We use radioactive material for both diagnosis and treatment in —nuclear medicine. Patients are injected with specific radionuclides depending on where in the body the treatment or diagnosis is needed. Radioiodine, for example, collects in the thyroid gland, whereas radium accumulates chiefly in the bones. The emitted radiation is used to diagnose cancerous tumours. Radionuclides are also used to treat cancers by targeting their emitted radiation on a tumour. The most common medical radioisotope is ^{99m}Tc (technetium), which is used in 30 million procedures each year worldwide. Like many other medical isotopes, it is manmade, derived from a parent radionuclide that itself is created from fission of uranium in a nuclear reactor.

Radiation fear could boost fossil fuels

Despite the benefits that nuclear reactors offer us, people fear the radiation they create either due to nuclear waste, or accidents such as Chernobyl or Fukushima. But very few people have died due to nuclear power generation or accidents in comparison to other primary energy sources.

Becquerel in the lab. unknown / wiki, CC BY-SA



Despite high-profile accidents, nuclear is responsible for a tiny fraction of the deaths caused by fossil fuels. Our World in Data, CC BY-SA

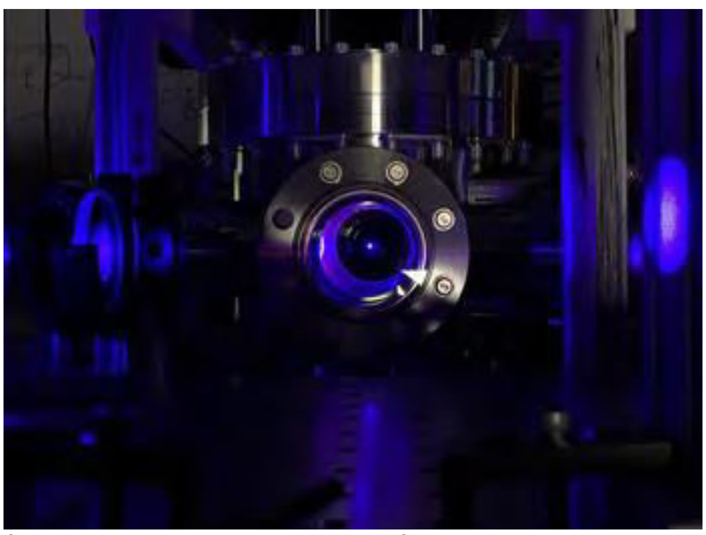
We worry that fear of radiation is harming climate mitigation strategies. For instance, Germany currently generates about a quarter of its electricity from coal, but considers nuclear dangerous and is closing down its remaining nuclear power stations.

But modern reactors create minimal waste. This waste, along with legacy wastes from old reactors, can be immobilised in cement and glass and disposed of deep underground. Radioactive waste also generates no carbon dioxide, unlike coal, gas or oil. We now have the understanding to harness radiation safely and use it to our and our planet‘s benefit. By fearing it too much and rejecting nuclear power as a primary energy source, we risk relying on fossil fuels for longer. This – not radiation – is what puts us and the planet in the greatest danger.

This New Atomic Clock Loses Only One Second Every 300 Billion Years – One of the Highest Performing Clocks Ever

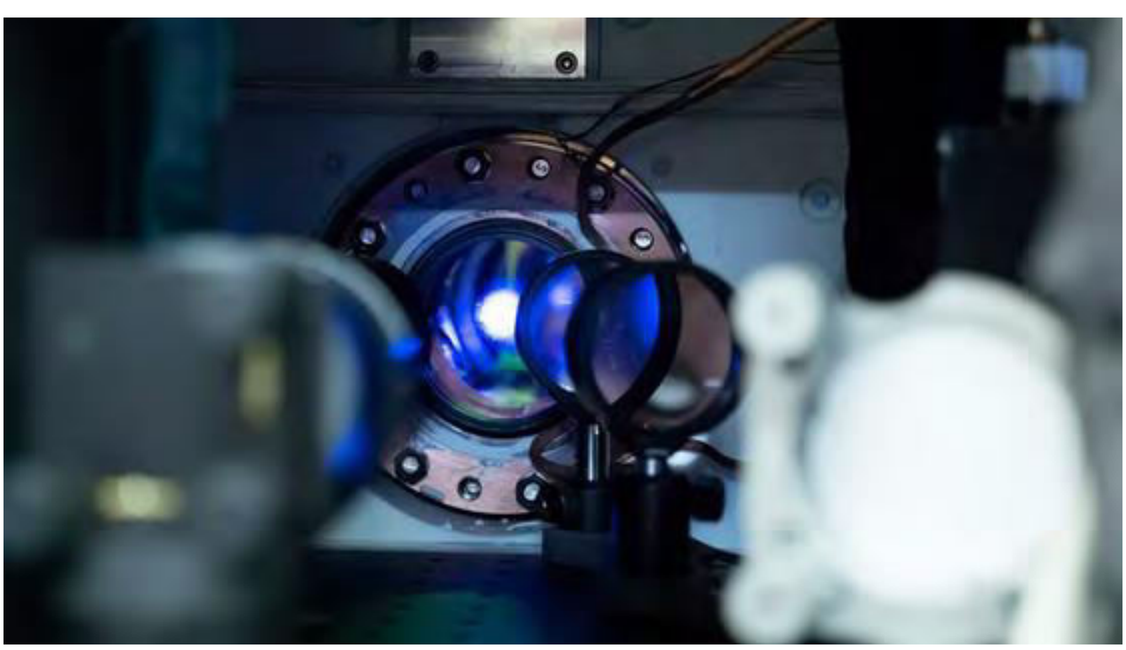
Source website links: https://wonderfulengineering.com/this-new-atomic-clock-loses-only-one-second-every-300-billion-years-one-of-thehighest-performing-clocks-ever/

A group of scientists has announced the creation of one of the most powerful atomic clocks ever built. The gadget is supposed to be so precise in measuring the time that it will only lose one second every 300 billion years, enabling more accurate measurements of gravitational waves, dark matter, and other physical phenomena. A paper based on the UW-Madison research was published in the journal Nature.—Optical lattice clocks are already the best clocks in the world, and here we get this level of performance that no one has seen before, Shimon Kolkowitz, a University of Wisconsin-Madison physics professor and senior author of the study, said in a statement.―We‘re working to both improve their performance and to develop emerging applications that are enabled by this improved performance.



(For internal circulation only)

Atomic clocks, in general, are clocks that follow the resonances of atom frequencies, most often cesium or rubidium atoms. This method enables such clocks to measure time with high precision. NASA‘s Deep Space Atomic Clock is an example of a space-based experiment in which the technology was tested in orbit for two years.



Atomic clocks operate by monitoring electron energy levels.

―When an electron changes energy levels, it absorbs or emits light with a frequency that is identical for all atoms of a particular element,‖ the university explained. ―Optical atomic clocks keep time by using a laser that is tuned to precisely match this frequency, and they require some of the world‘s most sophisticated lasers to keep accurate time.‖ In the new study, strontium atoms were sorted into a line in a single vacuum chamber using a multiplexed clock. The team utilized a ―relatively lousy laser,‖ as Kolkowitz put it, yet it nevertheless managed to achieve near-world-record precision in measurement. If they just focused the laser on one clock, it only stimulated electrons in the same number of atoms for one-tenth of a second. However, with two clocks running simultaneously, the atoms remained excited for 26 seconds. NASA‘s Deep Space Atomic Clock, shown here in an artist‘s rendering, will put new technologies for deep-space navigation to the test. Normally, our laser would limit the performance of these clocks, Kolkowitz said. But because the clocks are in the same environment and experience the exact same laser light, the effect of the laser drops out completely. The scientists then tried to detect clock discrepancies carefully because two groups of atoms in slightly different settings may tick at different speeds due to magnetic fields or gravity variations. The scientists repeated the experiment 1,000 times to determine the difference, discovering more precision in that measurement with time. The researchers eventually discovered a difference in the ticking rate of two atomic clocks ―that would correspond to them disagreeing with each other by only one second every 300 billion years — a measurement of precision timekeeping that sets a world record for two spatially separated clocks according to the university.

How Nuclear Science Helps Fruits and Vegetables Survive and Thrive

24 February, 2022 | by Elodie Broussard (IAEA Office of Public Information and Communication)

The IAEA, in cooperation with the FAO, helps countries meet and maintain international food safety requirements for their fruits and vegetables export markets, with the use of nuclear techniques. (Photo: E.Broussard/IAEA)

Source news/article/mumbai-university-gets-game-changing-carbon atingfacility- 23214028

Getting fruits and vegetables from seed to plate is an obstacle course that involves navigating climate changes, pests and diseases, soil and water pollution, desertification and ultimately high-level controls to ensure food is safe for consumption and exports. For all of these challenges, nuclear science offers proven, effective solutions.

The IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), supports countries to produce fruits and vegetables under challenging environmental conditions and helps them meet and maintain international food safety requirements to retain and expand their export markets, with the use of nuclear techniques. As the United Nations International Year of Fruits and Vegetables officially comes to a close today, here are some highlights of the achievements from the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture over the last year, in support of farmers, traders, consumers and ecosystems.

Nuclear techniques for more resilient plants

Since 2009, FAO/IAEA collaboration has helped over a hundred countries enhance their ability to improve food production and security through plant mutation breeding, which uses irradiation to produce higher quality and higher yielding plant varieties, as well as varieties that have greater resilience to climate change and environmental stresses. In 2021, the Joint FAO/IAEA Centre

provided technical support for the development and release of 36 new plant varieties during the year. In 2021, Cuba, facing rising temperatures, changing rainfall patterns, longer periods of droughts and the intrusion of salty waters along coastal areas, harvested new crop varieties of tomato and soybean for the first time with improved yields thanks to this technique. These varieties followed 21 other crop varieties in previous years, including rice, green beans and a species of hibiscus, developed by Cuba's National Institute of Agricultural Science (INCA) in partnership with the Joint FAO/IAEA Centre, through breeding programmes using irradiation and biotechnology. The Joint FAO/IAEA Center works to explore innovative new technologies to accelerate the pace at which new and improved crop varieties can be developed for food security and climate change adaptation. These technologies include the use of newer sources of irradiation, genomics technologies, big data and artificial intelligence.

Nuclear techniques to the rescue of bananas

Bananas are among the most produced, traded and consumed fruits globally, according to the FAO. About 150 million tons of bananas are produced per year, mostly in Asia, Africa and South and Central America, and their trade worldwide has expanded to unprecedented heights in recent years.

Thanks to nuclear techniques, new tomato varieties have been planted and harvested in Cuba in 2021. They have higher yields than the mainstream varieties. (Photos: M.C. Gonzalez-Cepero/INCA)

In late August 2021, the Andean countries of Bolivia, Colombia, Ecuador and Peru reached out to the IAEA for help in combatting the spread of the latest variation of the Panama wilt, the most lethal banana disease in the world. With the Joint FAO/IAEA Centre‘s support, experts in South America have been using the nuclear-derived technique of polymerase chain reaction (PCR) – or DNA sequencing – for early detection of the disease in new areas, to help halt the spread. To prevent future outbreaks, experts in the Asia Pacific region participating in a Coordinated Research Project of the Joint FAO/IAEA Centre have developed banana lines with resistance to disease using irradiation. One banana variety with resistance to the Fusarium Wilt was also developed through mutation breeding as part of the project last year.


In 2021, experts are seeing the Fusarium Wilt disease in many banana plantations across Latin America. (Photo: M. Dita/Biodiversity International, Colombia)

Shortage of water is currently the most limiting factor for banana production worldwide, and with temperatures increasing due to climate change this is foreseen to get worse. In 2021, experts and PhD students took part in a research project at the Joint FAO/IAEA

Centre on the use of stable isotopic techniques in assessing drought stress in banana crops. Their findings, which showed that stable carbon isotopes and leaf temperature were highly sensitive indicators for drought stress in banana, were published in Agricultural Water Management journal this month.


Scientists discussed sampling technology with local partners in Tanzania.
(Photo: S. Ramadhani)

Nuclear techniques for suppressing agricultural pests

Ecuador, whose fruit and vegetable export portfolio includes bananas, plantain, mangoes and more recently dragon fruit, tree (tomatoes and goldenberries, kept pests under control last year by importing 3 million sterile male Mediterranean fruit flies each week from Guatemala. The male flies – sterilized by radiation with the Sterile Insect Technique (SIT), a type of birth control for insects – were released to mate with wild females, resulting in no offspring and a decline in the target insect population. The Joint FAO/IAEA Centre trained Ecuadorian agronomists to monitor and control the fruit fly populations using SIT within a framework of a National Fruit Fly Management Project. SIT has been used for over 60 years to suppress and eradicate agricultural pests such as the Mediterranean fruit fly.

To keep insect pests at bay, Mexico last year opened a new state of the art Mediterranean fruit fly facility with FAO/IAEA support, which produces one billion sterile flies a week. The facility‘s establishment helps to consolidate the current pest containment barrier at Mexico's border with Guatemala, after the Mediterranean fruit fly eradication from Mexico in 1982. Last year the FAO and the IAEA also released a publication highlighting advances in use of nuclear techniques to fight insect pests titled Sterile Insect Technique: Principles and Practice in Area-Wide Integrated Pest Management‘. The 1200-page publication covers the latest developments in the use of the SIT in detail, including economic, environmental and management considerations.

Tree tomato is now exported to markets in the United States, Latin America and the European Union. (Photo: AGROCALIDAD)

Nuclear techniques to support food safety

The Joint FAO/IAEA Center also helps countries to meet food safety requirements for export and to protect consumer health. It does this through training and technology transfer relating to nuclear and isotopic techniques, to support the detection of contaminants in food, and the post-harvest applications of food irradiation. Food irradiation involves gamma, electron beam or X ray irradiation that prevents insects from being able to reproduce and establish in new areas after export. It is a chemical-free way of enabling trade while meeting importers' requirements on food safety, and is used on a range of products including fruits and vegetables.

In 2021, the Joint FAO/IAEA Centre launched a new coordinated research project to study nine pest groups important for fruits and vegetable trade, and supported Algeria, among other countries, to enhance food safety analytical capabilities for the detection of chemical hazards, such as antimicrobial and pesticide residues and natural toxins in a range of foods, including dates. In 2020, Algeria was the world's sixth leading exporter of dates, worth approximately USD 129 million.

Last year, the Joint FAO/IAEA Centre also kept supporting farmers around the world to develop climate-smart agriculture practices (see CRP on greenhouse gases in agriculture), reduce the use of fertilizer, combat desertification and prevent contamination by pollutants present in the soil or water. It also kept helping internally displaced people in Nigeria grow cucumber, watermelon and okra with reduced water use.

Scientists in Algeria conducting radioreceptor assay screening of foods including dates, eggs and honey for chemical residues. (Photo: H. Irekti/INRAA)

Moving ahead to 2022, in July the IAEA will host its International Symposium on Managing Land and Water for Climate-smart Agriculture to further help countries improve agricultural practices for a range of crops including fruits and vegetables, within a changing climate.

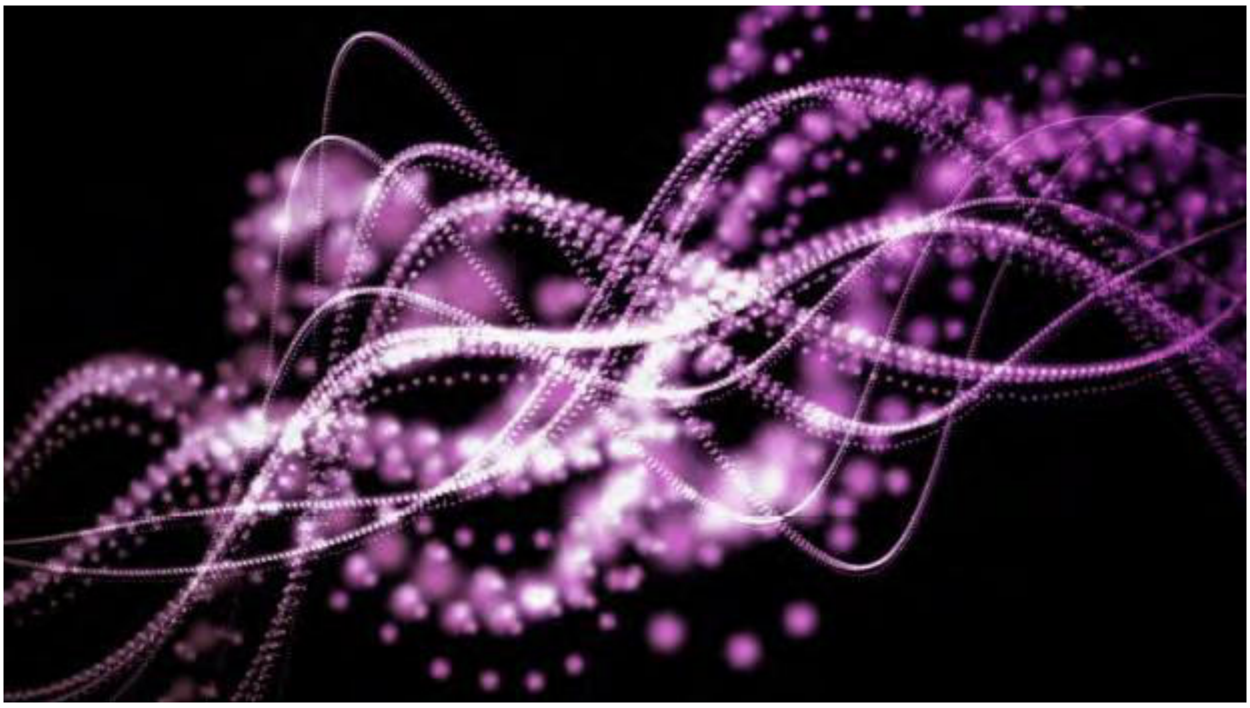
Source website links: https://www.mid-day.com/amp/mumbai/mumbai-

Scientists have Discovered an Exotic Magnetic State of Matter

22 February, 2022 | by Brookhaven National Laboratory

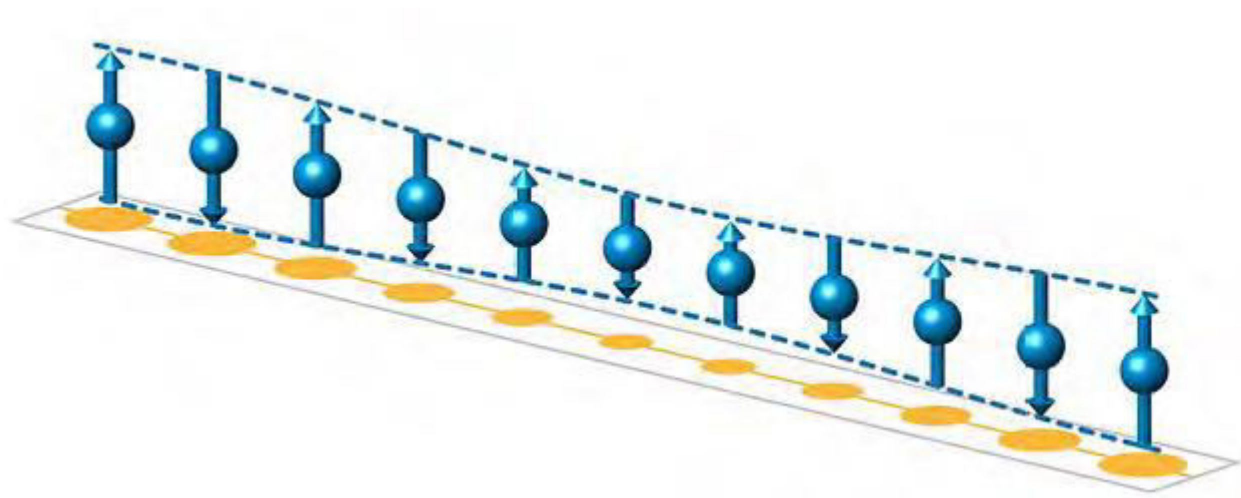
Source website links: https://scitechdaily.com/scientists-have-discovered-an-exotic-magnetic-state-of-matter/

Scientists at the U.S. Department of Energy‘s Brookhaven National Laboratory have discovered a long-predicted magnetic state of matter called an —antiferromagnetic excitonic insulator.


Scientists identify a long-sought magnetic state predicted nearly 60 years ago.

Broadly speaking, this is a novel type of magnet, said Brookhaven Lab physicist Mark Dean, senior author on a paper describing the research just published in Nature Communications. Since magnetic materials lie at the heart of much of the technology around us, new types of magnets are both fundamentally fascinating and promising for future applications. The new magnetic state involves strong magnetic attraction between electrons in a layered material that make the electrons want to arrange their magnetic moments, or ―spins, into a regular up-down ―antiferromagnetic‖ pattern. The idea that such antiferromagnetism could be driven by quirky electron coupling in an insulating material was first predicted in the 1960s as physicists explored the differing properties of metals, semiconductors, and insulators.

―Sixty years ago, physicists were just starting to consider how the rules of quantum mechanics apply to the electronic properties of materials,‖ said Daniel Mazzone, a former Brookhaven Lab physicist who led the study and is now at the Paul Scherrer Institut in Switzerland. ―They were trying to work out what happens as you make the electronic energy gap' between an insulator and a conductor smaller and smaller. Do you just change a simple insulator into a simple metal where the electrons can move freely, or does something more interesting happen?



An artist‘s impression of how the team identified this historic phase of matter. The researchers used x-rays to measure how spins (blue arrows) move when they are disturbed and were able to show that they oscillate in length in the pattern illustrated above. This special behavior occurs because the amount of electrical charge at each site (shown as yellow disks) can also vary and is the fingerprint used to pin down the novel behavior. Credit: Brookhaven National Laboratory

The prediction was that, under certain conditions, you could get something more interesting: namely, the ―antiferromagnetic excitonic insulator‖ just discovered by the Brookhaven team. Why is this material so exotic and interesting? To understand, let‘s dive into those terms and explore how this new state of matter forms.

In an antiferromagnet, the electrons on adjacent atoms have their axes of magnetic polarization (spins) aligned in alternating directions: up, down, up, down and so on. On the scale of the entire material those alternating internal magnetic orientations cancel one another out, resulting in no net magnetism of the overall material. Such materials can be switched quickly between different states. They‘re also resistant to information being lost due to interference from external magnetic fields. These properties make antiferromagnetic materials attractive for modern communication technologies.

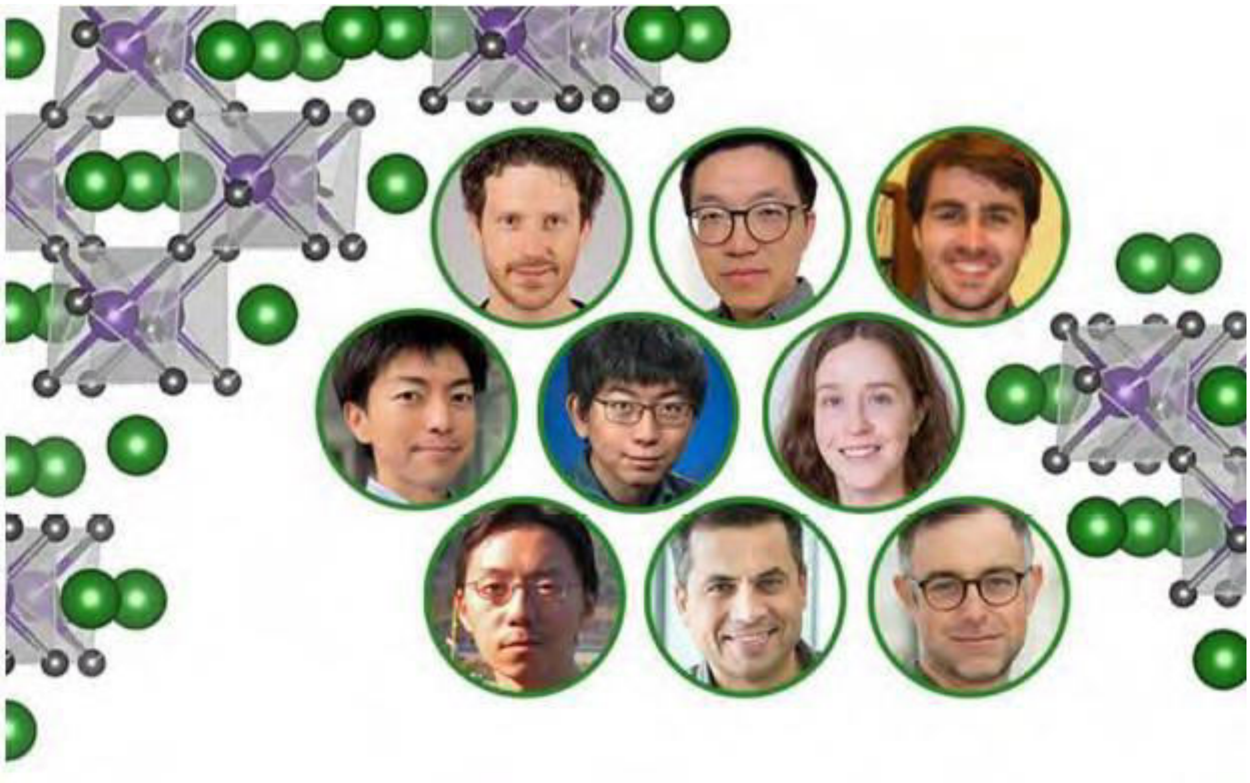
Next we have excitonic. Excitons arise when certain conditions allow electrons to move around and interact strongly with one another to form bound states. Electrons can also form bound states with ―holes,‖ the vacancies left behind when electrons jump to a different position or energy level in a material. In the case of electron-electron interactions, the binding is driven by magnetic attractions that are strong enough to overcome the repulsive force between the two like-charged particles. In the case of electron-hole interactions, the attraction must be strong enough to overcome the material‘s ―energy gap, a characteristic of an insulator. ―An insulator is the opposite of a metal; it‘s a material that doesn‘t conduct electricity,‖ said Dean. Electrons in the material generally stay in a low, or ―ground,‖ energy state. ―The electrons are all jammed in place, like people in a filled amphitheater; they can't move around,‖ he said. To get the electrons to move, you have to give them a boost in energy that's big enough to overcome a characteristic gap between the ground state and a higher energy level.

In very special circumstances, the energy gain from magnetic electron-hole interactions can outweigh the energy cost of electrons jumping across the energy gap. Now, thanks to advanced techniques, physicists can explore those special circumstances to learn how the antiferromagnetic excitonic insulator state emerges.

A collaborative team worked with a material called strontium iridium oxide (Sr3Ir2O7), which is only barely insulating at high temperature. Daniel Mazzone, Yao Shen (Brookhaven Lab), Gilberto Fabbris (Argonne National Laboratory), and Jennifer Sears (Brookhaven Lab) used x-rays at the Advanced Photon Source—a DOE Office of Science user facility at Argonne National Laboratory—to measure the magnetic interactions and associated energy cost of moving electrons. Jian Liu and Junyi Yang from the University of Tennessee and Argonne scientists Mary Upton and Diego Casa also made important contributions.

The team started their investigation at high temperature and gradually cooled the material. With cooling, the energy gap gradually narrowed. At 285 Kelvin (about 53 degrees Fahrenheit), electrons started jumping between the magnetic layers of the material but immediately formed bound pairs with the holes they'd left behind, simultaneously triggering the antiferromagnetic alignment of adjacent electron spins. Hidemaro Suwa and Christian Batista of the University of Tennessee performed calculations to develop a model using the concept of the predicted antiferromagnetic excitonic insulator, and showed that this model comprehensively explains the experimental results.

―Using x-rays we observed that the binding triggered by the attraction between electrons and holes actually gives back moreenergy than when the electron jumped over the band gap, explained Yao Shen. ―Because energy is saved by this process, all the electrons want to do this. Then, after all electrons have accomplished the transition, the material looks different from the high-temperature state in terms of the overall arrangement of electrons and spins. The new configuration involves the electron spins being ordered in an antiferromagnetic pattern while the bound pairs create a ‗locked-in' insulating state.The identification of the antiferromagnetic excitonic insulator completes a long journey exploring the fascinating ways electrons choose to arrange themselves in materials. In the future, understanding the connections between spin and charge in such materials could have potential for realizing new technologies.



Members of the research team include: Daniel Mazzone (formerly of Brookhaven Lab, now at the Paul Scherrer Institute in Switzerland), Yao Shen (Brookhaven Lab), Gilberto Fabbris (Argonne National Laboratory), Hidemaro Suwa (University of Tokyo and University of Tennessee), Hu Miao (Oak Ridge National Laboratory—ORNL), Jennifer Sears* (Brookhaven Lab), Jian Liu (U Tennessee), Christian Batista (UTennessee and ORNL), and Mark Dean (Brookhaven Lab). Credit: Various sources including *DESY, Marta Mayer

Brookhaven Lab's role in this research was funded by the DOE Office of Science, with collaborators receiving funding from a range of additional sources noted in the paper. The scientists also used computational resources of the Oak Ridge Leadership Computing Facility, a DOE Office of Science user facility at Oak Ridge National Laboratory.

Reference: ―Antiferromagnetic Excitonic Insulator State in Sr3Ir2O7‖ by D. G. Mazzone, Y. Shen, H. Suwa, G. Fabbris, J. Yang, S.-S. Zhang, H. Miao, J. Sears, Ke Jia, Y. G. Shi, M. H. Upton, D. M. Casa, X. Liu, Jian Liu, C. D. Batista and M. P. M. Dean, 17 February 2022, Nature Communications.

DOI: 10.1038/s41467-022-28207-w

Nuclear Power in Space is Focus of IAEA and UN Events

21 February, 2022 | by Web Developer

Source website links: https://www.world-nuclear-news.org/Articles/Nuclear-power-in-space-is-focus-of-IAEA-and-UN-eve

Future space missions could have new options opened up by nuclear technology, experts attending an International Atomic Energy Agency event have said. "Nuclear technology has long played a vital role in prominent space missions, but future missions could rely on nuclear-powered systems for a much broader spectrum of applications - our pathway to the stars runs through the atom," said Mikhail Chudakov, IAEA deputy director general.

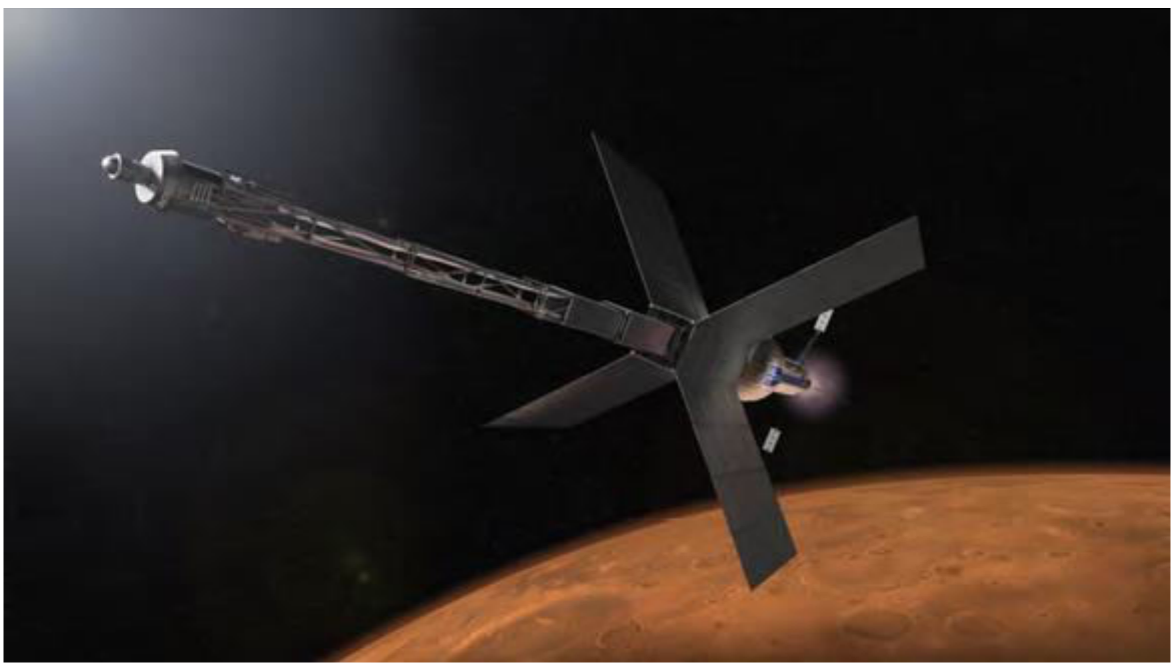


Illustration of a Mars transit habitat and nuclear propulsion system (Image: NASA)

He was speaking at the IAEA virtual event - Atoms for Space: Nuclear Systems for Space Exploration - attended by 500 people from 66 countries. "Crewed interplanetary missions of the future will almost certainly require propulsion systems with performance levels greatly exceeding that of today's best chemical engines," said William Emrich, former lead project engineer at NASA. Hui Du of the Beijing Institute of Spacecraft System Engineering, citing a China Academy of Space Technology study, said: "For space missions that need high electric power output, such as a human Mars mission or space ferries, a fission reactor-based power system can be a very competitive choice."

What are the nuclear power options?

One option is nuclear thermal propulsion (NTP), which is where a nuclear fission reactor heats up a liquid propellant, like hydrogen, converting it into a gas which expands through a nozzle to provide thrust and propel a spacecraft. Compared with traditional chemical rockets this could cut travel time to Mars by up to 25%.

Another option is nuclear electric propulsion (NEP) where the reactor‘s thermal energy is converted into electrical energy. This method's thrust is lower but continuous and with far greater fuel efficiency it has higher speeds and could cut 60% off the Mars travel time of the traditional chemical rockets. Research work is also on-going into possible future nuclear fusion rockets which would have a direct fusion drive (DFD) which would directly convert the energy of the charged particles produced in the fusion reactions into propulsion. Stephanie Thomas, vice president of Princeton Satellite Systems, who are developing a fusion rocket concept, said: "A DFD can produce specific power several orders of magnitude higher than other systems, reducing trip times and increasing payloads, thus enabling us to reach deep space destinations much faster."

What about other uses of nuclear power in space?

In addition to providing thrust for rockets, there is also the need for electrical power on board and nuclear reactors could also be used to provide astronauts with power for extended exploratory missions or long-term communities on other planets.

"NASA‘s priority focus remains on designing, building and demonstrating a low-enriched uranium fission surface power system that has broad applications for the lunar surface initiative as well as our eventual mission to Mars with humans, scalable to power levels above 100 kWe, and has the potential to advance NEP system needs," said Anthony Calomino, space nuclear technology portfolio manager at NASA. "Use of nuclear fission reactors, carrying out continuous chain reactions for many years, is inevitable both for space propulsion and for extraterrestrial surface power," said Vivek Lall, chief executive of General Atomics Global Corporation. The United Nations has also been considering safety issues. The issue of nuclear technology in space, and the likely use for a variety of purposes and possibly by commercial entities as well as nation states, were issues considered by a meeting of the United Nations Office for Outer Space Affairs scientific and technical subcommittee.

A working paper to the Committee on the Peaceful Uses of Outer Space, prepared by the UK and European Space Agency, notes that since 2010 the sub-committee‘s working group had been successful "in promoting the safe use of nuclear power source applications in outer space among States interested in the use of such applications".

But it adds that "the international space sector is evolving … private commercial entities are interested in the use of space nuclear power sources and are starting to propose and engage in the development and use of space nuclear power sources".

"The potential future use of nuclear reactors in the frame of long term human installations raises a number of new safety-related questions." It proposes an international forum to "gather and exchange information on plans and projects to develop and use space nuclear power sources by new actors, including commercial entities." In a draft report published after a meeting earlier this month, the subcommittee also adds that "the view was expressed that it was the responsibility of States to ensure that the use of nuclear power sources in outer space was strictly for peaceful purposes, avoiding at all costs the placement in Earth orbit of any object carrying nuclear weapons or any other type of weapon of mass destruction, as well as avoiding at all costs the placement of such weapons on celestial bodies and the placement of weapons in outer space in any other form."

It added: "The subcommittee welcomed the fact that some States and an international intergovernmental organisation were developing, or considering developing, legal and regulatory instruments on the safe use of nuclear power sources in outer space, taking into account the content and requirements of the Principles Relevant to the Use of Nuclear Power Sources in Outer Space and of the Safety Framework for Nuclear Power Source Applications in Outer Space, which was developed jointly by the Subcommittee and the International Atomic Energy Agency."