ISASINDIA Newsletter

Vol 23, No. 1 *January-March, 2023*

From Editor's Desk

Happy New Year to ISAS Members

It gives me immense pleasure in bringing first issue of the Year.

ISAS is full of continuously engaged vibrant activities. It is matter of delight that ISAS is organizing symposium at Kochi , during march 23-25, 2023.

Variety of articles have been compiled in the present issue.

Suggestions from the readers are most welcome.

Dr. Pradeep Kumar

Chief Editor, ISAS

Message from President ISAS.

I am happy to know that the ISAS News Letter Jan-March 2023 issue is ready for issue.

Parallely, the final touches for the Indian Analytical Science Congress (IASC- 2023), scheduled to be held during 23-25, March, 2023 at IMA Hall, Kochi are underway with Chairman,ISRO as the Chief Guest and the DG CSIR as Chairman BRNS as the Guests of Honour.

Many leading Indian Scientists and Technologists, will be conferred upon with the prestigious ISAS Awards, which include the **ISAS Award for Global Indian Scientists** being conferred upon Chairman ISRO as well as Director BARC, amongst many other leading performers in Indian Science and Technology Scenario, on 23rd March 2023 during the Inaugural Function of IASC-2023.
I request all in the ISAS Community to take note of these great strides taken by ISAS, to record a high level of performance standard, achieved by this EC under the dynamic leadership provided by me as President. I also request all of you to actively contribute and partake in the ISAS Activities in a large scale, in the times ahead.

I shall be handing over the charge of President to the incumbent in the next EC, soon after the AGM of ISAS gives the final approval for the recently elected new EC (2023-2026) of ISAS.
I convey my best wishes and regards to all our Esteemed Members of ISAS Community, spread all over India through 10 Chapters, through the medium of this ISAS News Letter.

Jai Hind.

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

We could get messages back from spacecraft sent through a wormhole

A simulation of these theoretical cosmic tunnels reveals wormholes don't snap shut instantly

Source : https://www.sciencenews.org/article/get-messages-sent-through-wormhole-relativity

By James R. Riordon

January 3, 2023 at 9:00 am

If you ever happen to fall through a wormhole in space, you won't be coming back. It will snap shut behind you. But you may have just enough time to send a message to the rest of us from the other side, researchers report in the Nov. 15 Physical Review D.No one has yet seen a wormhole, but theoretically they could provide shortcuts to distant parts of the universe, or to other universes entirely, if they exist (SN: 7/27/17). Physicists have long known that one of the most commonly studied types of wormholes would be extremely unstable and would collapse if any matter entered it. It wasn't clear, though, just how fast that might happen or what it means for something, or someone, heading into it.

Now, a new computer program shows how one type of wormhole would respond when something travels through it. "You build a probe and you send it through" in the wormhole simulation, says Ben Kain, a physicist at the College of the Holy Cross in Worcester, Mass. "You're not necessarily trying to get it to come back, because you know the wormhole is going to collapse — but could a light signal get back in time before a collapse? And we found that it is possible." Prior studies of wormholes have concluded that the cosmic passageways could potentially stay open for repeated trips back and forth, Kain says, provided they're supported by a form of matter that's so exotic it's called "ghost matter." Theoretically, ghost

A spaceship diving into a wormhole (illustrated) is never returning, but it could theoretically send back video from the other side before the hole closes behind it.

gremlin/E+/Getty

matter responds to gravity in exactly the opposite way to normal matter. That is, a ghost matter apple would fall up from a tree branch instead of down. While allowed by Einstein's theory of general relativity, ghost matter almost certainly doesn't exist in reality, Kain says (SN: 2/3/21). Nevertheless, Kain simulated ghost matter traveling through a wormhole and found that it caused the hole to expand as expected, rather than collapsing. It was a different story with anything made of normal matter; that would trigger a collapse that pinches the hole closed and leaves something resembling a black hole behind, Kain's simulation confirmed. But it would happen slowly enough for a fast-moving probe to transmit light-speed signals back to our side just before the wormhole completely closes.

Kain doesn't imagine ever sending humans through a wormhole, if such things are ever found. "Just the capsule and a video camera. It's all automated," he says. It'll be a one-way trip, “but we can at least get some video seeing what this device sees.” The idea should be approached with a fair bit of skepticism, says physicist Sabine Hossenfelder of the Munich Center for Mathematical Philosophy. “[It] requires one to postulate the existence of [things] that for all we know do not exist…. Lots of things you can do mathematically have nothing to do with reality.” Still, Kain says, it’s a valuable effort that might reveal ways to make wormholes that don’t rely on ghost matter to stay open long enough for us to travel back and forth throughout the universe or beyond.

How to make recyclable plastics out of CO_2 to slow climate change

Chemists are manipulating the greenhouse gas to make clothing, mattresses, shoes and more

By Ann Leslie Davis ,September 9, 2022 at 7:00 am

It’s morning and you wake on a comfortable foam mattress made partly from greenhouse gas. You pull on a T-shirt and sneakers containing carbon dioxide pulled from factory emissions. After a good run, you stop for a cup of joe and guiltlessly toss the plastic cup in the trash, confident it will fully biodegrade into harmless organic materials. At home, you squeeze shampoo from a bottle that has lived many lifetimes, then slip into a dress fashioned from smokestack emissions. You head to work with a smile, knowing your morning routine has made Earth’s atmosphere a teeny bit carbon cleaner.

Sound like a dream? Hardly. These products are already sold around the world. And others are being developed. They’re part of a growing effort by academia and industry to reduce the damage caused by centuries of human activity that has sent CO2 and other heat-trapping gases into the atmosphere (SN: 3/12/22, p. 16). The need for action is urgent. In its 2022 report, the United Nations

Intergovernmental Panel on Climate Change, or IPCC, stated that rising temperatures have already caused irreversible damage to the planet and increased human death and disease (SN: 5/7/22 & 5/21/22, p. 8). Meanwhile, the amount of CO2 emitted continues to rise. The U.S. Energy Information Administration predicted last year that if current policy and growth trends continue, annual global CO2 emissions could rise from about 34 billion metric tons in 2020 to almost 43 billion by 2050.

Carbon capture and storage, or CCS, is one strategy for mitigating climate change long noted by the IPCC as having "considerable" potential. A technology that has existed since the 1970s, CCS traps CO2 from smokestacks or ambient air and pumps it underground for permanent sequestration. Today, 27 CCS facilities operate around the world — 12 in the United States — storing an estimated 36 million tons of carbon per year, according to the Global CCS Institute. The 2021 Infrastructure Investment and Jobs Act includes $3.5 billion in funding for four additional U.S. direct capture facilities.

But rather than just storing it, the captured carbon could be used to make things. This year for the first time, the IPCC added carbon capture and utilization, or CCU, to its list of options for drawing down atmospheric carbon. CCU captures CO2 and incorporates it into carbon-containing products like cement, jet fuel and the raw materials for making plastics. Still in early stages of development and commercialization, CCU could reduce annual greenhouse gas emissions by 20 billion tons in 2050 — more than half of the world's global emissions today, the IPCC estimates.

Such recognition was a big victory for a movement that has struggled to emerge from the shadow of its more established cousin, CCS, says chemist and global CCU expert Peter Styring of the University of Sheffield in England. Many CCUrelated companies are springing up and collaborating with each other and with governments around the world, he adds.

The potential of CCU is "enormous," both in terms of its volume and monetary potential, said mechanical engineer Volker Sick at a CCU conference in Brussels in April. Sick, of the University of Michigan in Ann Arbor, directs the Global CO2 Initiative, which promotes CCU as a mainstream climate solution. "We're not talking about something that's nice to do but doesn't move the needle," he added. "It moves the needle in many, many aspects."

The plastics paradox

The use of carbon dioxide in products is not new. CO_2 is used to make soda fizzy, keep foods frozen (as dry ice) and convert ammonia to urea for fertilizer. What's new is the focus on making products with CO_2 as a strategy to slow climate change. Today's CCU market, estimated at $2 billion, could mushroom to $550 billion by 2040, according to Lux Research, a Boston-based market research firm. Much of this market is driven by adding CO_2 to cement — which can improve its properties as well as reduce atmospheric carbon — and to jet fuel, which can lower the industry's large carbon footprint. CO_2-to-plastics is a niche market today, but the field aims to battle two crises at once: climate change and plastic pollution.

Plastics are made from fossil fuels, a mix of hydrocarbons formed by the remains of ancient organisms. Most plastics are produced by refining crude oil, which is then broken down into smaller molecules through a process called cracking. These smaller molecules, known as monomers, are the building blocks of polymers. Monomers such as ethylene, propylene, styrene and others are linked together to form plastics such as polyethylene (detergent bottles, toys, rigid pipes), polypropylene (water bottles, luggage, car parts) and polystyrene (plastic cutlery, CD cases, Styrofoam).

But making plastics from fossil fuels is a carbon catastrophe. Each step in the plastics life cycle — extraction, transport, manufacture and disposal — emits massive amounts of greenhouse gases, mostly CO_2, according to the Center for International Environmental Law, a nonprofit law firm based in Geneva and Washington, D.C. These emissions alone — more than 850 million tons of greenhouse gases in 2019 — are enough to threaten global climate targets.

And the numbers are about to get much worse. A 2018 report by the Paris-based intergovernmental International Energy Agency projected that global demand for plastics will increase from about 400 million tons in 2020 to nearly 600 million by 2050. Future demand is expected to be concentrated in developing countries and will vastly outstrip global recycling efforts. Plastics are a serious crisis for the environment, from fossil fuel use to their buildup in landfills and oceans (SN: 1/16/21, p. 4). But we're a society addicted to plastic and all it gives us — cell phones, computers, comfy Crocs. Is there a way to have our (plastic-wrapped) cake and eat it too? Yes, says Sick. First, he argues, cap the oil wells. Next, make plastics from aboveground carbon. Today, there are products made of 20 to over 40 percent CO_2. Finally, he says, build a circular economy, one that reduces resource use, reuses products, then recycles them into other new products.

"Not only can we eliminate the fossil carbon as a source so that we don't add to the aboveground carbon budget, but in the process we can also rethink how we make plastics," Sick says. He suggests they be specifically designed "to live very, very long so that they don't have to be replaced … or that they decompose in a benign manner."

But creating plastics from thin air is not easy. CO2 needs to be extracted, from the atmosphere or smokestacks, for example, using specialized equipment. It often needs to be compressed into liquid form and transported, generally through pipelines. Finally, to meet the overall goal of reducing the amount of carbon in the air, the chemical reaction that turns CO_2 into the building blocks of plastics must be run with as little extra energy as possible. Keeping energy use low is a special challenge when dealing with the carbon dioxide molecule.

A bond that's hard to break

There's a reason that carbon dioxide is such a potent greenhouse gas. It is incredibly stable and can linger in the atmosphere for 300 to 1,000 years. That stability makes CO_2 hard to break apart and add to other chemicals. Lots of energy is typically needed for the reaction. "This is the fundamental energy problem of CO_2," says chemist Ian Tonks of the University of Minnesota in Minneapolis. "Energy is necessary to fix CO_2 to plastics. We're trying to find that energy in creative ways." Catalysts offer a possible answer. These substances can increase the rate of a chemical reaction, and thus reduce the need for energy. Scientists in the CO_2-to-plastics field have spent more than a decade searching for catalysts that can work at close to room temperature and pressure, and coax CO_2 to form a new chemical identity. These efforts fall into two broad categories: chemical and biological conversion.

First attempts

Early experiments focused on adding CO_2 to highly reactive monomers like epoxides to facilitate the reaction. Epoxides are three-membered rings composed of one oxygen atom and two carbon atoms. Like a spring under tension, they can easily pop open. In the early 2000s, industrial chemist Christoph Gürtler and chemist Walter Leitner of Aachen University in Germany found a zinc catalyst that allowed them to break open the epoxide ring of polypropylene oxide and combine it with CO_2. Following the reaction, the CO_2 was joined permanently to the polypropylene molecule and was no longer in gas form — something that is true of all CO_2-to-plastic reactions. Their work resulted in one of the first commercial CO_2

products — a polyurethane foam containing 20 percent captured CO_2. Today, the German company Covestro, where Gürtler now works, sells 5,000 tons of the product annually in mattresses, car interiors, building insulation and sports flooring. More recent research has focused on other monomers to expand the variety of CO_2-based plastics. Butadiene is a hydrocarbon monomer that can be used to make polyester for clothing, carpets, adhesives and other products.

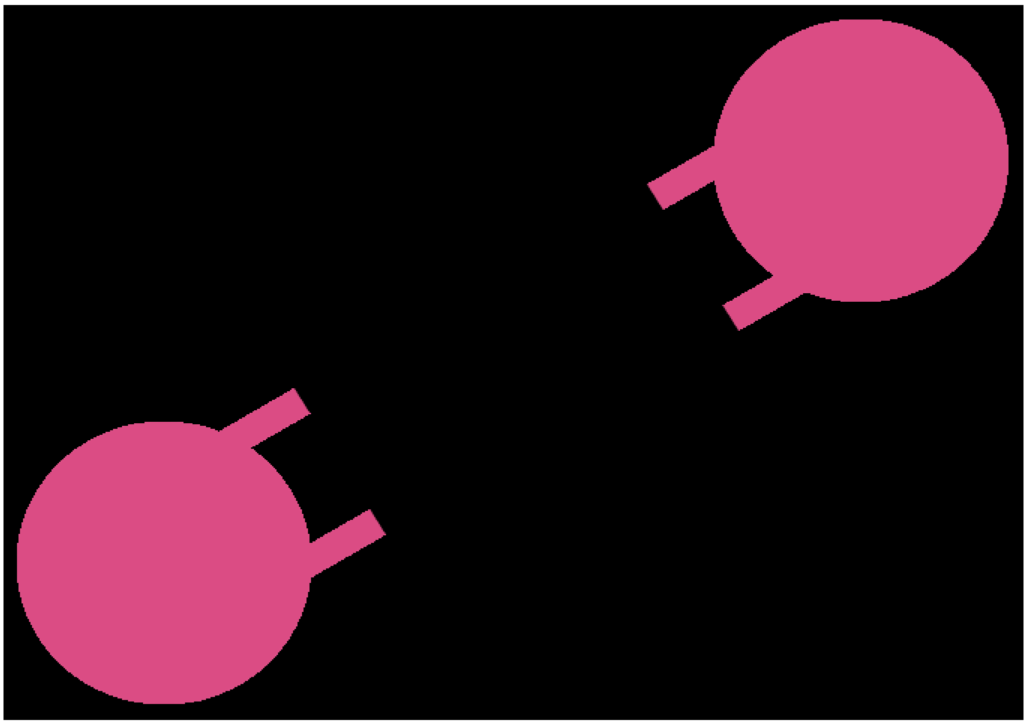
In 2020, chemist James Eagan at the University of Akron in Ohio mixed butadiene and CO_2 with a series of catalysts developed at Stanford University. Eagan hoped to create a polyester that is carbon negative, meaning it has a net effect of removing CO_2 from the atmosphere, rather than adding it. When he analyzed the contents of one vial, he discovered he had created something even better: a polyester made with 29 percent CO_2 that degrades in high pH water into organic materials.

Chemistry is like cooking," Eagan says. "We took chocolate chips, flour, eggs, butter, mixed them up, and instead of getting cookies we opened the oven and found a chicken potpie." Eagan's invention has immediate applications in the recycling industry, where machines can often get gummed up from the nondegradable adhesives used in packaging, soda bottle labels and other products. An adhesive that easily breaks down may improve the efficiency of recycling facilities.

Tonks, described by Eagan as a friendly competitor, took Eagan's patented process a step further. By putting Eagan's product through one more reaction, Tonks made the polymer fully degradable back to reusable CO_2 — a circular carbon economy goal. Tonks created a start-up this year called Loop CO_2 to produce a variety of biodegradable plastics.

Anatomy of CO_2

It takes a lot of energy to break the strong double bonds between the carbon (black) and oxygen atoms (red) in a carbon dioxide molecule. To save energy, researchers are experimenting with chemical and bioinspired catalysts.



Microbial help

Researchers have also harnessed microbes to help turn carbon dioxide into useful materials including dress fabric. Some of the planet's oldest-living microbes emerged at a time when Earth's atmosphere was rich in carbon dioxide. Known as acetogens and methanogens, the microbes developed simple metabolic pathways that use enzyme catalysts to convert CO_2 and carbon monoxide into organic molecules. In the atmosphere, CO will react with oxygen to form CO_2. In the last decade, researchers have studied the microbes' potential to remove these gases from the atmosphere and turn them into useful products. LanzaTech, based in Skokie, Ill., uses the acetogenic bacterium Clostridium autoethanogenum to metabolize CO_2 and CO emissions into a variety of industrial chemicals, including ethanol. Last year, the clothing company Zara began using LanzaTech's polyester fabric for a line of dresses.

The ethanol used to create these products comes from LanzaTech's two commercial facilities in China, the first to transform waste CO, a main emission from steel plants, into ethanol. The ethanol goes through two more steps to become polyester. LanzaTech partnered with steel mills near Beijing and in north-central China, feeding carbon monoxide into LanzaTech's microbe-filled bioreactor. Steel production emits almost two tons of CO_2 for every ton of steel made. By contrast, a life cycle assessment study found that LanzaTech's ethanol production process lowered greenhouse gas emissions by approximately 80 percent compared with ethanol made from fossil fuels. In February, researchers from LanzaTech, Northwestern University in Evanston, Ill., and others reported in Nature Biotechnology that they had genetically modified the Clostridium bacterium to produce acetone and isopropanol, two other fossil fuel–based industrial chemicals. Company CEO Jennifer Holmgren says the only waste product is dead bacteria, which can be used as compost or animal feed. Other researchers are skipping the living microbes and just using their catalysts. More than a decade ago, chemist Charles Dismukes of Rutgers University in Piscataway, N.J., began looking at acetogens and methanogens as a way to use atmospheric carbon. He was intrigued by their ability to release energy when making carbon building blocks from CO_2, a reaction that usually requires energy. He and his team focused on the bacteria's nickel phosphide catalysts, which are responsible for the energy-releasing carbon reaction.

Dismukes and colleagues developed six electrocatalysts that are able to make monomers at room temperature and pressure using only CO_2, water and electricity. The energy--releasing pathway of the nickel phosphide catalysts "lowers the required voltage to run the reaction, which lowers the energy consumption of the process and improves the carbon footprint," says Karin Calvinho, a former student of Dismukes who is now chief technical officer at RenewCO_2, the start-up Dismukes' team formed in 2018. Renew CO_2 plans to sell its monomers, including monoethylene glycol, to companies that want to reduce their carbon footprint. The group proved its concept works using CO_2 brought into the lab. In the future, the company intends to obtain CO_2 from biomass, industrial emissions or direct air capture.

Barriers to change

Yet researchers and companies face challenges in scaling up carbon capture and reuse. Some barriers lurk in the language of regulations written before CCU existed. An example is the U.S. Environmental Protection Agency's program to provide tax credits to companies that make biofuels. The program is geared toward plant-based fuels like corn and sugar-cane. LanzaTech's approach for making jet fuel doesn't qualify for credits because bacteria are not plants.

Other barriers are more fundamental. Styring points to the long-standing practice of fossil fuel subsidies, which in 2021 topped $440 billion worldwide. Global government subsidies to the oil and gas industry keep fossil fuel prices artificially low, making it hard for renewables to compete, according to the International Energy Agency. Styring advocates shifting those subsidies toward renewables.

“We try to work on the principle that we recycle carbon and create a circular economy,” he says. “But current legislation is set up to perpetuate a linear economy.” Doing the carbon math

MoMo Productions/DigitalVision/Getty Images Plus

As companies try to reduce their carbon footprint, many are doing life cycle assessments to quantify the full carbon cost of their products. The happy morning routine that makes the world carbon cleaner is theoretically possible. It’s just not the way the world works yet. Getting to that circular economy, where the amount of carbon above ground is finite and controlled in a never-ending loop of use and reuse will require change on multiple fronts. Government policy and investment, corporate practices, technological development and human behavior would need to align perfectly and quickly in the interests of the planet. In the meantime, researchers continue their work on the carbon dioxide molecule. “I try to plan for the worst-case scenario,” says Eagan, the chemist in Akron. “If legislation is never in place to curb emissions, how do we operate within our capitalist system to generate value in a renewable and responsible way? At the end of the day, we will need new chemistry.”

The James Webb telescope found six galaxies that may be too hefty for their age

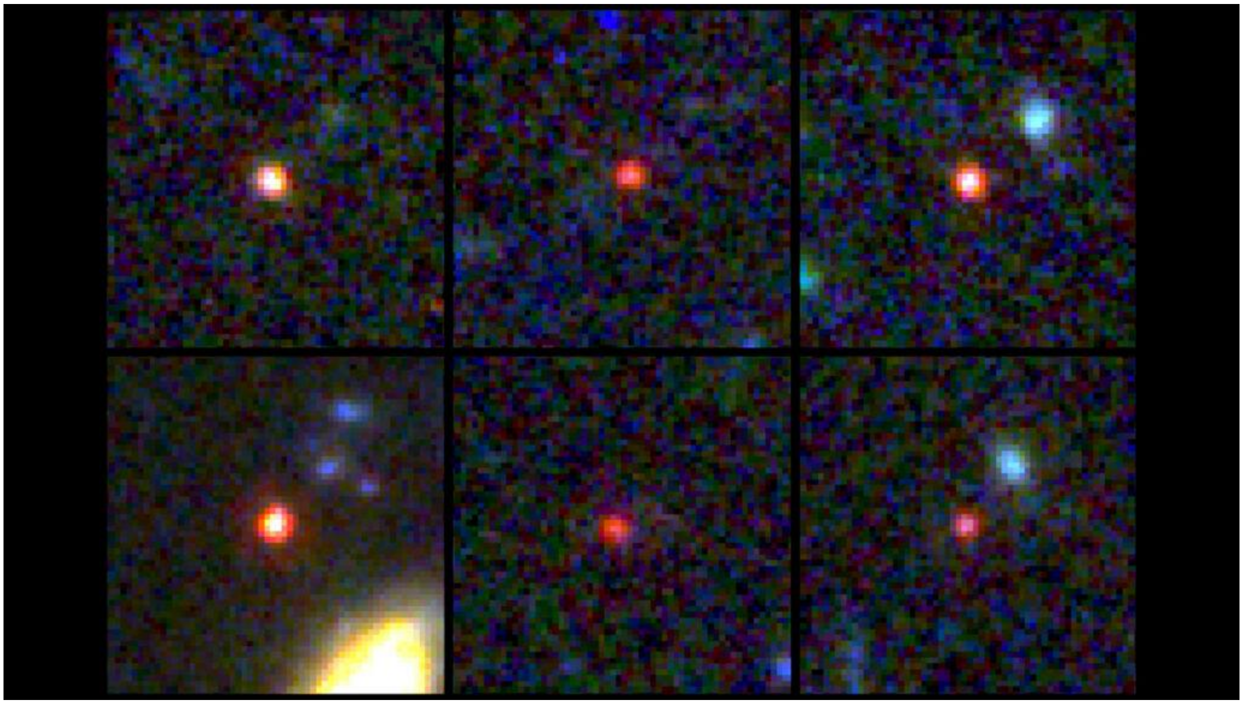
Source : www.sciencenews.org/article/james-webb-telescope-six-galaxies-old?utm_source=email&utm_medium=email&utm_campaign=latest-newsletter-v

The James Webb Space Telescope’s first peek at the distant universe unveiled galaxies that appear too big to exist.

Six galaxies that formed in the universe’s first 700 million years seem to be up to 100 times more massive than standard cosmological theories predict, astronomer

Ivo Labbé and colleagues report February 22 in Nature. “Adding up the stars in those galaxies, it would exceed the total amount of mass available in the universe at that time,” says Labbé, of the Swinburne University of Technology in Melbourne, Australia. “So you know that something is afoot. The telescope, also called JWST, released its first view of the early cosmos in July 2022 (SN: 7/11/22). Within days, Labbé and his colleagues had spotted about a dozen objects that looked particularly bright and red, a sign that they could be massive and far away.

“They stand out immediately, you see them as soon as you look at these images,” says astrophysicist Erica Nelson of the University of Colorado Boulder. Measuring the amount of light each object emits in various wavelengths can give astronomers an idea of how far away each galaxy is, and how many stars it must have to emit all that light. Six of the objects that Nelson, Labbé and colleagues identified look like their light comes from no later than about 700 million years after the Big Bang. Those galaxies appear to hold up to 10 billion times the mass of our sun in stars. One of them might contain the mass of 100 billion suns. “You shouldn’t have had time to make things that have as many stars as the Milky Way that fast,” Nelson says. Our galaxy contains about 60 billion suns’ worth of stars — and it’s had more than 13 billion years to grow them. “It’s just crazy that these things seem to exist.”



These images from the James Webb Space Telescope zoom in on six bright, red, extremely distant galaxies that appear to be too massive to exist.

I. Labbé/Swinburne University of Technology, CSA, ESA, NASA. Image processing: G. Brammer/Niels Bohr Institute's Cosmic Dawn Center/University of Copenhagen. In the standard theories of cosmology, matter in the universe clumped together slowly, with small structures gradually merging to form larger ones. “If there are all these massive galaxies at early times, that's just not happening,” Nelson says. One possible explanation is that there's another, unknown way to form galaxies, Labbé says. “It seems like there's a channel that's a fast track, and the fast track creates monsters.”

But it could also be that some of these galaxies host supermassive black holes in their cores, says astronomer Emma Curtis-Lake of the University of Hertfordshire in England, who was not part of the new study. What looks like starlight could instead be light from the gas and dust those black holes are devouring. JWST has already seen a candidate for an active supermassive black hole even earlier in the universe’s history than these galaxies are, she says, so it’s not impossible. Finding a lot of supermassive black holes at such an early era would also be challenging to explain (SN: 3/16/18). But it wouldn’t require rewriting the standard model of cosmology the way extra-massive galaxies would. “The formation and growth of black holes at these early times is really not well understood,” she says. “There’s not a tension with cosmology there, just new physics to be understood of how they can form and grow, and we just never had the data before.”

To know for sure what these distant objects are, Curtis-Lake says, astronomers need to confirm the galaxies’ distances and masses using spectra, more precise measurements of the galaxies’ light across many wavelengths (SN: 12/16/22).

JWST has taken spectra for a few of these galaxies already, and more should be coming, Labbé says. “With luck, a year from now, we’ll know a lot more.

How Nuclear Waste will Help Spacecraft Explore the Moon —and ..

02 January 2023

| by Aabha Sharma

Nature 612, 385-386 (2022) doi: https://doi.org/10.1038/d41586-022-04247-6

Source website link: https://www.inferse.com/386852/how-nuclear-waste-will-help-spacecraft-explore-the-moon-and-nature-com/

The European Space Agency hopes that its Argonaut Moon missions (artist"s impression) will be powered by batteries that use the radioactive element americium.Credit: ESA

European scientists are developing a breed of battery for space missions that is powered by nuclear waste. The European Space Agency (ESA) hopes that the technology will, by the end of the decade, allow it to operate spacecraft that don't rely on solar panels and can explore the Moon and far-off reaches of the Solar System without relying on equipment from international partners.

Ministers at ESA's ministerial council meeting in Paris on 22 and 23 November agreed to fund a €29-million (US$30-million) programme called European Devices Using Radioisotope Energy (ENDURE). This aims to develop long-lasting heat and electricity units powered by the radioactive element americium-241, in time for a series of ESA Moon missions in the early 2030s.

―If we want to have autonomy in exploration, we need these capabilities,‖ says Jason Hatton, a co-leader of ENDURE, based at the European Space Research and Technology Center (ESTEC) in Noordwijk, the Netherlands. ESA‘s growing space ambitions mean it needs its own source of long-lasting power, says Hatton. Americium, a by-product of plutonium decay, has never been used as a fuel. For missions in which solar power would not suffice — either because of shade or because of distance from the Sun — ESA has relied on US or Russian partners, which have used plutonium-238 batteries to power missions since the space race. NASA built plutonium batteries, for example, that warmed the Huygens probe during its descent to Saturn‘s moon Titan in 2005. But plutonium-238 has been in short supply over the past decade and is expensive to produce.

And ESA severed ties with Russia after the country invaded Ukraine. The current political situation demonstrates that you cannot always rely on partners‖, says Athena Coustenis, an astrophysicist at the Paris Observatory in Meudon, France, who chairs an ESA advisory committee that backed the new programme.

The lack of a power source has long restricted the solo missions that European scientists propose, and limited others. The agency felt its lack of radioisotope power keenly in 2014, when its comet-landing Philae probe was operational for less than three days because it ended up in a shaded spot where its solar panels were useless. For years, European scientists have been saying that if you want to go far, or to dark and cold places, there is no other way,‖ says Coustenis. Americium‘s big advantage over plutonium is that it is cheaper and more abundant, repurposing waste that would otherwise be useless, says Véronique Ferlet-Cavrois, who co-leads the ENDURE initiative at ESTEC.

Plutonium-238 is made in a two-stage process that involves irradiating a neptunium target with neutrons. Researchers at the UK government‘s National

Nuclear Laboratory (NNL) in Sellafield have shown that americium can be extracted from reprocessed nuclear fuel used in civil power plants and made into fuel pellets, which form the core of the batteries. Part of the ENDURE programme will include raising americium production capacity to what is needed for batteries, says Hatton. Americium has a longer half-life than plutonium-238, which means it lasts longer but packs less power per gram. But because americium is more readily available, producing one watt of power costs about one-fifth as much as it does using plutonium, says Markus Landgraf, who coordinates work on future lunar missions at ESTEC.

Over the next three years, the ENDURE team will develop prototypes into models that can be tested in mission-like conditions, as precursors to usable devices. In a collaboration with NNL, a team at the University of Leicester, UK, has developed two types of device: a radioisotope heating unit, which warms instruments with heat produced in the decaying americium, and radioisotope thermoelectric generators (RTGs), which use the heat to produce electricity by creating a temperature difference across metal plates.

The researchers designed both types of device to account for americium‘s higher volume for a given power output, and cooler temperatures, compared with plutonium, says Richard Ambrosi, a physicist and specialist in space power systems, who leads the team at the University of Leicester.

Safety is also crucial, because of the use of radioactive materials. The units are encapsulated in layers including a platinum alloy, which seal in the americium while allowing heat to escape, he says. The programme‘s next phase will focus on safety testing, so that the americium units can be certified for launch. Tests will include monitoring the behaviour of components at high temperatures and under impact ,for example, during an explosion on the launch pad to ensure that radioactive material would not leak. We have to be able to survive a significant set of very extreme scenarios, says Ambrosi.

Once developed, the same basic power system could be reused on any missions for which solar energy is unavailable, says Ferlet- Cavrois. This is the case during nights on the Moon, which last 14 Earth days, and on expeditions to the Solar System beyond Jupiter.

To survive the harsh lunar night, China‘s active Moon rover, Chang‘e-4, uses plutonium heating units built in collaboration withRussia. ESA‘s first target for launching americium power sources is its Argonaut Moon lander, scheduled to launch in the early 2030s. The Argonaut missions would conduct long studies on the lunar surface and support astronauts working there, says Landgraf. And in the 2040s, ESA hopes to power a mission to the ice giants Uranus and Neptune, says Ferlet-Cavrois. These planets have been studied only during fly-bys by NASA‘s Voyager 2 probe in the 1980s.

Americium‘s availability, and the challenges of producing plutonium-238, mean that NASA might want to use it too, says Landgraf. The agency is assessing its ability to produce enough RTGs for its coming missions. For its Artemis programme, which aims to establish a long-term presence on the Moon, ―they consider our americium very interesting‖, he says. It has taken more than a decade of research to get the americium technology to the stage at which it can be developed for real missions, says Ambrosi. ―The excitement is actually quite palpable at the moment. We‘ve been working on this for a long time,‖ he says.

Government Accords Sanction for setting up 10 Nuclear Power Reactors in the Country with Total Capacity of 7000 MW

08 February, 2023 | by OdAdmin

Source website links https://orissadiary.com/govt-accords-sanction-for-setting-up-10-nuclear-power-reactors-in-the-country-with-total-capacityof-7000-mw/

The government has accorded sanction for setting up ten nuclear power reactors in the country with a total capacity of 7000 MW. In a written reply in the Lok Sabha, the Minister of State for Personnel, Public Greivances & Pensions and Prime Minister’s Office Dr Jitendra Singh said 11 reactors with a total capacity of 8700 MW are under various stages of construction or commissioning.

The Minister said the present policy of the Centre puts atomic energy in the list of prohibited sectors, but added that the Atomic Energy Act of 1962 has been amended to enable joint ventures with public sector undertakings to enhance atomic energy production.

India Has Potential to Be ‘Vishwaguru’: Dr Kakodkar

https://www.thegoan.net/goa-news/india-has-potential-to-be-%E2%80%98vishwaguru%E2%80%99-dr-kakodkar/95059.html

India has the intelligence, capability, and potential to lead the world in today’s knowledge-based economy that requires the application of science and technology in all sectors to elevate economically to be a powerful nation. We only have to focus on few things to reach this goal of becoming a ‘Vishwaguru’, stated eminent nuclear scientist, Dr Anil Kakodkar, while speaking on ‘Indian Science: 75 years and beyond’ at the ‘Vicharvedh’ lecture series sponsored by Fomento at Gomant Vidya Niketan, Margao. The nuclear physicist who is associated with India’s atomic energy programme for six decades has been awarded Padma Shri, Padma Bhushan and Padma Vibhushan by the government of India and Gomant Vibhushan by the Goa government for his major role in nuclear energy research. Delivering the late Srinivas Naik lecture in Govind Kare auditorium, Dr Kakodkar stated that science has played an important role in human evolution, enabling us to observe nature,think and create comforts and resources by value additions. Respecting India’s traditional knowledge of science and medicinal plants, the scientist of Goan origin said that till 1700 Indian GDP was largest than any other country in the world.

“We traded with many other civilisations in the East and the West when some of the countries like US didn’t even exist. But for variety of reasons, foreign rule and exploitation, and other hurdles we missed the industrial revolution and slowly started retracting. We were at our lowest in 1947 with very low GDP percentile. But as we celebrate

Dr Anil Kakodkar speaks at the programme

'Azadi ka Amrut Mahotsava' we are in the Amrut Kal, and far ahead in today's knowledge era," he said. "So, if we question ourselves, can India regain its past glory and become number one, the answer is yes. Blessed with demographic dividend, if we build products ahead of other countries applying cutting-edge technology, our economy will grow. Growth of economy is a natural thing to happen, but quality of average Indian should be comparable to the best of the world. And to me, that is real development," said Dr Kakodkar.

If GDP has to go up, India needs to fulfil certain requirements. The country has great academic institutions, but the ranking of our universities is low compared to world standards. Our scientific publications and output is the fastest in the world, but most of our scientific interest is driven by the western world. We need to do research to solve problems and challenges in our own country. India is large, we can create a pool of researchers. Collaborations with the west are important but the focus should be to develop our own products that can be useful to India. We have fundamental challenges, so we must go through socio-economic transformations to translate technology into scientific progress, said Dr Kakodkar.

India has the best of doctors, engineers, scientists and other professionals, and there is progress, but that's not enough. We need to instil confidence in ourselves and shed our fears of failure. India has done much progress in space, missiles, atomic energy fields because we were forced to do research, as others would not share their technology with us. Now we are ahead, though it took us 20 years. Today Brahmos is the most powerful missile in the world, these are knowledge-driven products. Exports are happening on a large scale. Should that make you a powerful country, he asked.

When the country becomes economically powerful, we need a mission, a mindset and people who leverage the economy to the larger communities. Pointing to artificial Intelligence, cognition and genetics as the key technologies, Dr Kakodkar said that India needs to have inhouse R&D technology that is globally competitive. To move into that era, we need money, support system and government policies – all going hand in hand. India has missed the semiconductors 20 years ago, despite having knowledge. But we didn't have investment from the industries and the government. New areas require platforms, additional conditions, and ecosystem. India needs Triple Helix architecture, where research, industries and government work together to create conducive atmosphere for the country to grow, stated the scientist.

R&D should provide a roadmap for translating opportunities into reality and industries should step forward to invest while policymaking should support and do concurrent working, and the trio should take risk together. At a time when artificial intelligence is taking control of your life, India has the market, data and people.

India is the largest custodian of data. We have to be conscious, be in the race but not become vulnerable otherwise we could create cultures of very different kind. Looking at these things only fundamentally will be short sited, warned the Padma Vibhushan awardee. We talk of diversity, and say that we must preserve it even in Nature and avoid monoculture. Our education system should recognise this diversity too, and understanding that no two persons are equal, we must allow students to learn at their own pace, and create a student-centric education system. Students have different capabilities, some are weak, slow and need remedial action, but we should not hold someone back because he cannot compete with others. The curriculum needs to be evaluated and made learn ercentric, suggested Dr Kakodkar.

We need to address issues at multiple levels and make different minds come together. Indians are intelligent as individuals, but we need to create an environment that Indian superior minds should think of performing in India. Indians are welcomed abroad where there is talent search policy. But they should contribute their knowledge for the betterment of their own country. As we approach Amrut Kal, we should grab every opportunity to regain the past glory and make India walk towards being a ‘Vishwaguru’, concluded the atomic researcher.

Source website links:

India Announces Discovery of 5.9 Million Tonnes of Lithium

Source website links: https://www.mining-technology.com/news/india-lithium-discovery/

The Indian Ministry of Mines reported the discovery of 5.9 million tonnes of inferred lithium ore on their Twitter on Thursday. This deposit alone makes India the country with the fifth-largest lithium reserves in the world. The deposit, lies in the Reasi district in the provinces of Jammu and Kashmir. Lithium is used in the production of batteries for electronic vehicles (EVs), solar panels and electronic devices. Production of minerals necessary for the clean energy transition could increase by as much as 500% between 2020 and 2050 according to the World Bank. Geological Survey of India has for the first time established 5.9 million tonnes inferred resources (G3) of lithium in Salal-Haimana area of Reasi District of Jammu & Kashmir (UT).According to the International Lithium Association, demand is set to increase 6-fold between 2021 and 2040, due to growing interest in EVs and renewable technologies.

India announces discovery of 5.9 million tonnes of lithium ore.
Photo by Tuul & Bruno Morandi via Getty images.

This is the first major discovery of lithium in India with the only other being a small deposit of 1600 tonnes found in Karnataka two years ago.As India seeks to become a major competitor in the development of EVs this discovery could improve their standing. India is currently reliant on imports of lithium for its manufacturing sector, principally from Argentina, Chile and Australia. Importedlithium forms around 80% of the total lithium used in the country.

Discovery could break open the "lithium triangle"

This discovery could draw dominance away from the "lithium triangle", made up of Chile, Argentina and Bolivia. Approximately,75% of the world's lithium supply lies beneath the salt flats of these three nations. The Indian government has celebrated the discovery as part of president Modi's movement towards Atmanirbhar", a slogan roughly translating to "self-reliance". While lithium is associated with efforts towards carbon neutrality, experts have cautioned against the environmental impacts of the mine itself. The Himalayan region between Jammu and Kashmir is an eco-sensitive region, mining could lead to a loss of biodiversity. Ecologically sensitive zones are designated by the Ministry of Environment Forests and Climate Change in India. In these areas, often surrounding national parks, commercial activities are restricted to ensure their protection.

NTPC to Have 2,000 MW Nuclear Power by 2032, and 20,000 MW by 2050

Source website links: https://www.moneycontrol.com/news/business/companies/ntpc-to-have-2000-mw-nuclear-power-by-2032-and-20000-mwby-2050-10068911.html

The two plants in the pipeline will have pressurized heavy water reactors (PHWR), which is almost indigenized, and the power tariff from them would translate into Rs 7.36 per unit approximately. India's largest electricity producer, state-run NTPC Limited, will build a clutch of nuclear power plants to help the country's target of achieving net-zero emissions by 2070. As per the its initial plan, the power major will start generating 2,000 MW of nuclear energy by 2032, 4,200 MW by 2035 and eventually scale up to 20,000 MW by 2050, senior NTPC officials shared with Money control.

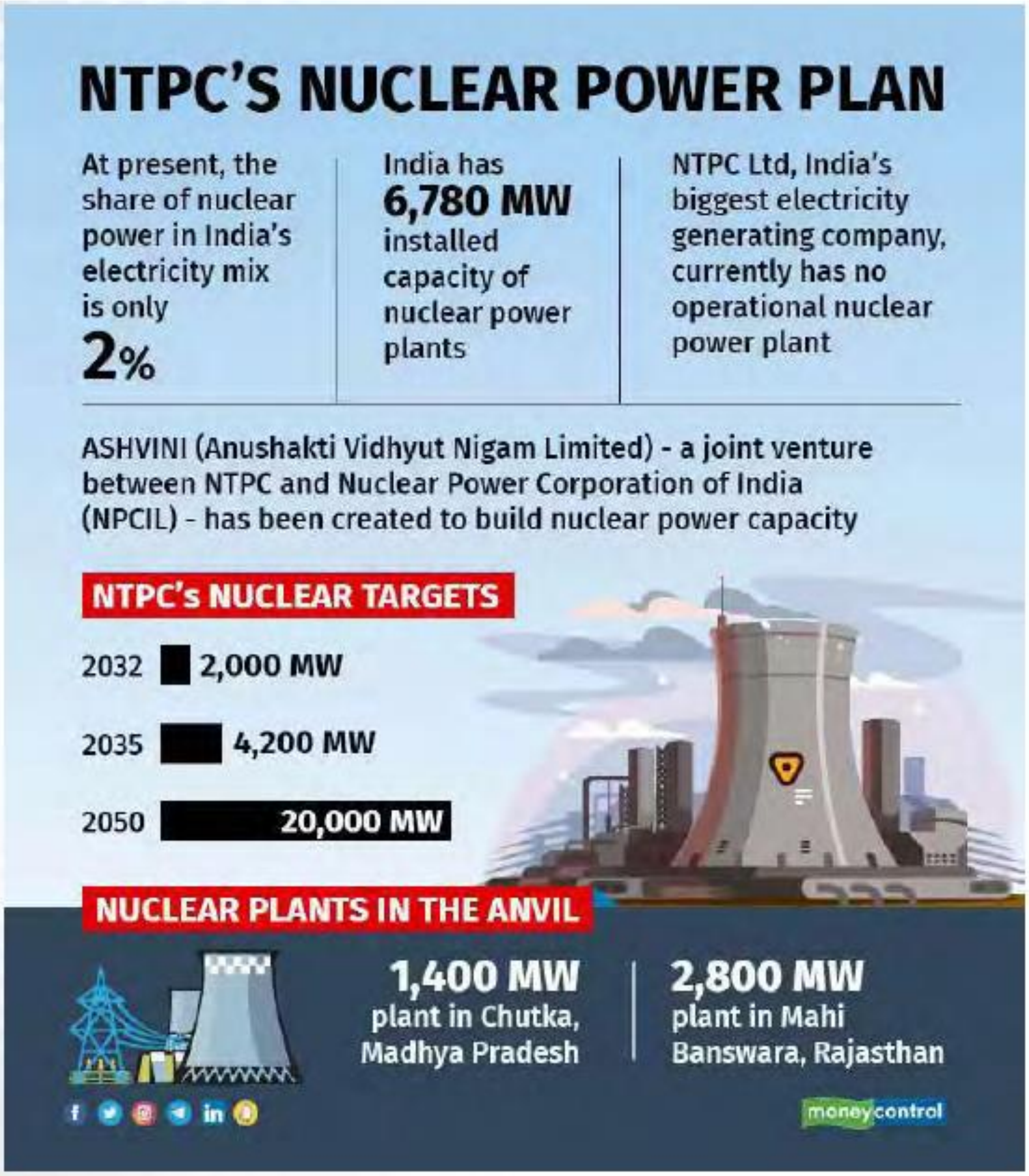
Apart from capacity addition through pressurised heavy water reactors (PHWR), NTPC is also planning to add nuclear capacity through small modular reactors. It also intends to do fuel tie-ups with Uranium Corporation of India Ltd to ensure requisite feedstock availability.

"Two nuclear power plants with a total capacity of 4,200 MW have been finalised so far. One project of 1,400 MW will come up in Chutka, Madhya Pradesh, having two units of 700 MW each. The second one will be of 2,800 MW (4x700 MW) at Mahi Banswara in Rajasthan. The two plants will have PHWR, which is almost indigenised, and the power tariff from them would translate into Rs 7.36 per unit approximately," said a senior official, requesting anonymity. While the company did not respond to an email query from Moneycontrol, it states NTPC is also working with NITI Aayog on nuclear capacity addition and has signed a Statement of Intent for preparing the "Net Zero" plan for the firm in line with the country's commitment. NTPC has a total installed power generation capacity of 71,544 MW (including 12,615 MW through joint ventures/subsidiaries. But it does not have a nuclear power plant as of now. As per the Central Electricity Authority data, till March 2022, India had an installed nuclear power capacity of 6,780 MW, which is just 2 percent of the total energy (thermal, hydro, and renewables) mix in the country. Nuclear is a zero-emission clean energy source. It generates power through fission, which is the process of splitting uranium atoms to produce energy. The heat released by fission is used to create steam that spins a turbine to generate electricity without the harmful byproducts emitted by fossil fuels. Globally, the fusion method is not yet utilised to generate electricity because scientifically, it is difficult to sustain a fusion reaction. However, there are a few downsides to nuclear power which the government needs to simultaneously look into. These include disposal and storage of nuclear waste and that uranium decomposes into harmful sub-atomic masses.

Asked if the relatively higher tariff of about Rs 7.36 per unit from such plants would have enough takers in the market, the NTPC official said the cost assessment is based on a plant load factor (PLF) of 68 percent. “If we increase it to 80 percent, the tariff will come down. Another advantage is that it is a single-part tariff (not having fixed and variable costs separately) and a must-run plant, so it ranks high in the merit order.”

These nuclear projects will be implemented through ASHVINI - a joint venture between NTPC and Nuclear Power Corporation of India (NPCIL). The approximate cost of the Chutka plant will be Rs 25,000 crore and Rs 50,000 crore for the Mahi Banswara plant. During NTPC’s third-quarter earnings conference call on January 28, the company stated that it was also looking at nuclear capacity addition through implementation of small modular reactors (SMRs) and pressurised water reactors with government-to-government agreements.

All this is being done as a step towards India achieving the net-zero target by 2070. Net-zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions reabsorbed from the atmosphere, by oceans and forests, for instance. According to the International Atomic Energy Agency, nuclear power capacity globally needs to double to 812 gigawatts (GW) by 2050 from 413 GW in 2022. In the 2030s, annual additions of nuclear power capacity needs to reach 27 GW, it added.



A look at NTPC's nuclear power plan. A look at NTPC's plan of harnessing nuclear power.

Princeton Scientists Measure Quantum Correlations between Molecules for the First Time

07 February, 2023 | by Tom Garlinghouse

Source website link:https://www.princeton.edu/news/2023/02/07/princeton-scientists-measure-quantum-correlations-between-molecules-firsttime

Physicists are increasingly using ultra cold molecules to study quantum states of matter. Many researchers contend that molecules have advantages over other alternatives, such as trapped ions, atoms or photons. These advantages suggest that molecular systems will play important roles in emerging quantum technologies. But, for a while now, research into molecular systems has advanced only so far because of long-standing challenges in preparing, controlling and observing molecules in a quantum regime.

Now, as chronicled in a recent paper in the journal Nature, Princeton researchers have achieved a major breakthrough by microscopically studying molecular gases at a level never before achieved by previous research. The Princeton team, led by Waseem Bakr, associate professor of physics, was able to cool molecules down to ultracold temperatures, load them into an artificial crystal of light known as an optical lattice, and study their collective quantum behavior with high spatial resolution such that each individual molecule could be observed. “We prepared the molecules in the gas in a well-defined internal and motional quantum state. The strong interactions between the molecules gave rise to subtle quantum correlations which we were able to detect for the first time,” said Bakr. This experiment has profound implications for fundamental physics research, such as the study of many-body physics, which looks at the emergent behavior of ensembles of interacting quantum particles.

The research also might accelerate the development of large-scale quantum computer systems. In the quest to build large-scale quantum systems, both for quantum computing and for more general scientific applications, researchers have used a variety of different alternatives , everything from trapped ions and atoms to electrons confined in "quantum dots." The goal is to transform these various alternatives into what are called qubits, which are the building blocks of a quantum computer system.

Quantum computers have much greater computing power and capacity exponentially greater than classical computer systems, and can solve problems classical computers have difficulty solving. Although so far no single type of qubit has emerged as the front runner, Bakr and his team believe that molecular systems, while less explored than other platforms, hold particular promise.

One important advantage of using molecules in experimental settings — and especially as potential qubits — is the fact that molecules can store quantum information in an abundance of new ways not available to single atoms. For example, even for a simple molecule made of just two atoms, which can be visualized as a tiny dumbbell, quantum information can be stored in the rotational motion of the dumbbell or the shaking of its constituent atoms relative to each other. Another advantage of molecules is that they often have long range interactions; they can interact with other molecules many sites away in an optical lattice, whereas atoms, for example, can only interact if they occupy the same site. When using molecules to study many-body physics, these advantages are expected to enable researchers to explore fascinating new quantum phases of matter in these synthetic systems. However, a major problem, which Bakr and his team have been able to overcome in this experiment, is the microscopic characterization of these quantum states. "The ability to probe the gas at the level of individual molecules is the novel aspect of our research," said Bakr. "When you're able to look at individual molecules, you can extract a lot more information about the many-body system." What Bakr means by extracting more information is the ability to observe and document the subtle correlations that characterize molecules in a quantum state — for example, correlations of their positions in the lattice or their rotational states.

"Researchers had prepared molecules in the ultracold regime before, but they couldn't measure their correlations because they couldn't see the single molecules," said Jason Rosenberg, a graduate student in Princeton's Department of Physics and the co-lead author of the paper. "By seeing each individual molecule, we can really characterize and explore the different quantum phases that are expected to emerge." While researchers have been studying many-body physics with atomic quantum gases for over two decades, molecular quantum gases have been much harder to tame. Unlike atoms, molecules can store energy by vibrating and rotating in many different ways. These various excitations are known as "degrees of freedom" — and their abundance is the characteristic that makes molecules difficult to control and manipulate experimentally.

"In order to study molecules in a quantum regime, we need to control all their degrees of freedom and place them in a well-defined quantum mechanical state," said Bakr. The researchers accomplished this precise level of control by first cooling two atomic gases of sodium and rubidium down to incredibly low temperatures that are measured in nanokelvins, or temperatures one-billionth of a degree Kelvin. At these ultra cold temperatures, each of the two gases transition into a state of matter known as a Bose-Einstein condensate. In this ultracold environment, the researchers coax the atoms into pairing up into sodium-rubidium molecules in a well-defined internal quantum state. Then they use lasers to transfer the molecules into their absolute ground state where all rotations and vibrations of the molecules are frozen. To maintain the quantum behavior of the molecules, they are isolated in a vacuum chamber and held in an optical lattice made of standing waves of light.

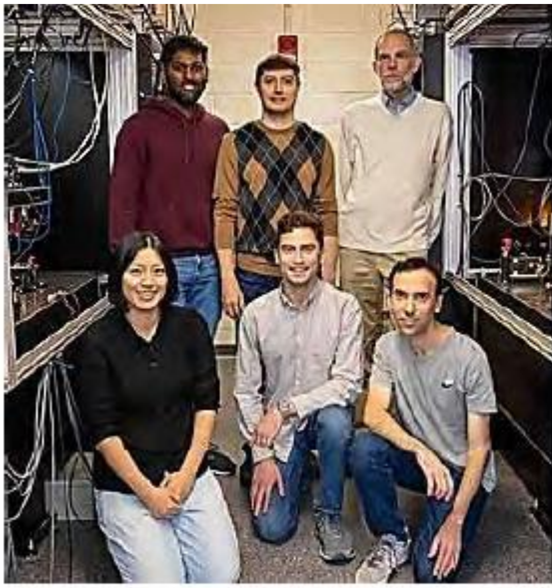
“We interfere a set of laser beams together and, from this, we create a corrugated landscape resembling an ‘egg carton’ in which the molecules sit,” said Rosenberg.

In the experiment, the researchers captured about one hundred molecules in this “egg carton” lattice.

Then the researchers pushed the system out of equilibrium and tracked what happened in the strongly interacting system. “We gave the system a sudden ‘nudge,’” said Lysander Christakis, a graduate student and co-lead author of the paper. “We allowed the molecules to interact and build up quantum entanglement. This entanglement is reflected in subtle correlations, and the ability to probe the system at this microscopic level allows us to reveal these correlations and learn about them.”

Entanglement is one of the most fascinating and perplexing properties of many-body quantum states. It describes a property of the subatomic world in which quantum elements whether molecules, electrons, photons, or whatever become inextricably linked with each other no matter the distance separating them.

Entanglement is especially significant in quantum computing because




Left: Members of the Princeton research team. Front row (from left to right) Dr. Zoe Yan, Lysander Christakis, Jason Rosenberg. Back row (from left to right) Ravin Raj, Prof. Waseem Bakr, Prof. David Huse.

Right: The researchers used a novel microscopy apparatus to probe the quantum state of individual ultracold molecules in an optical lattice and measure quantum correlations arising from interactions between them.

it acts as a sort of computational multiplier. It is the crucial ingredient underlying the exponential speedup in solving problems with quantum computers. The unparalleled control the researchers achieved in preparing and detecting the molecules has clear implications for quantum computing. But the researchers emphasize that, ultimately, the experiment is not necessarily about creating the most advanced qubits. Rather, it is, most importantly, a huge step forward in fundamental physics research. “This research opens up a lot of possibilities to study really interesting problems in many-body physics,” said Christakis. “What we’ve demonstrated here is a complete platform for using ultracold molecules as a system to study complex quantum phenomena.” Rosenberg concurred. “In this experiment, the molecules were frozen into individual sites on the lattice and quantum information was only stored in the rotational states of the molecules. Moving forward, it will be exciting to explore a whole other realm of interesting phenomena that appear when you allow the molecules to 'hop' from site to site. Our research has opened the door to investigating ever more exotic states of matter that can be prepared with these molecules, and now we can characterize them very well," he concluded. Other members of the Princeton team are graduate student Ravin Raj, post-doc Dr. Zoe Yan, undergraduate Sungjae Chi and theorists Alan Morningstar and Prof. David Huse. The research was supported by the National Science Foundation and the Packard Foundation.

New Insights into the Complex Nature of the Liquid-To-Glass Transition

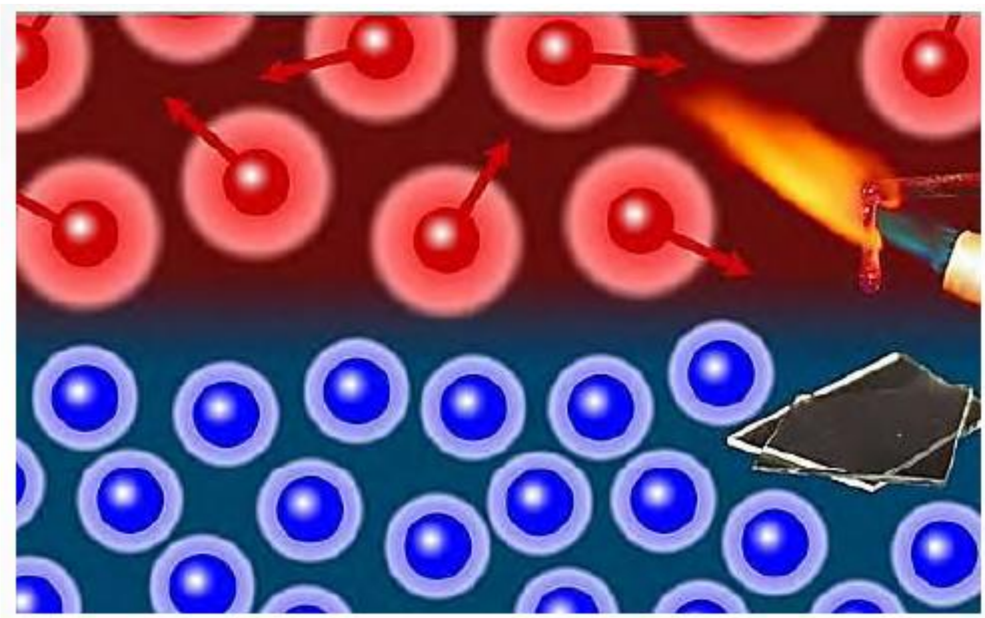
07 February, 2023 | by Universität Augsburg
Source website link: https://phys.org/news/2023-02-insights-complex-nature-liquid-to-glass-transition.html

In a recently published article in the journal Nature Physics, a team of researchers with the participation of the University of Augsburg reports about unexpectedly universal correlations between the thermal expansion and the glass-transition temperatures of glass forming materials, providing new insights into the complex nature of the transition from liquid into solid glass.

Glasses are solid materials, however lacking the crystalline structure with a regular arrangement of the atoms that is typical for conventional solids. The melting of crystalline materials is well understood within the theoretical framework of the so-called Lindemann criterion: Upon heating, the thermal vibrations of the atoms or molecules become so vigorous that they break free from their crystalline, lattice-like arrangement and the material melts. In contrast, the microscopic processes at the transition of a glass into a liquid (or vice versa) are not well understood, even though glasses are some of the oldest materials used by mankind.

In their recent publication in Nature Physics, titled "Thermal expansion and the glass transition," Prof. Dr. Alois Loidl and PD Dr. Peter Lunkenheimer (both University of Augsburg), together with colleagues from Göttingen, Berlin, and Milan, now report that the solid-liquid transition of glasses is determined by additional factors.

While vibrations also play a role, in addition one has to take into account that the motion of the atoms or molecules in a glass-forming liquid typically is "cooperative" (i.e., the particles do not move independently), which can lead to a significant increase of the energy needed to liquefy a glass. The scientists found evidence for this



Thermal expansion in glass melt and solid glass Credit: University of Augsburg

behavior by analyzing the thermal expansion and the glass-transition temperatures of more than 200 glasses and liquids published during the past 100 years. Glasses are of immense technological relevance and are almost omnipresent in our daily life. This not only includes common applications as containers or windows, but also optical fibers for data transmission or advanced electrolyte materials in batteries and fuel cells. Moreover, metallic glasses having superior material properties compared to conventional metals, the large group of the polymers, and even various types of biological matter are regarded as glasses from a physical point of view.

The glass transition: No conventional phase transition

Usually, glasses are prepared by simple cooling of a melt. In contrast to the sudden solidification found for other liquids, which is typical for a phase transition, glass melts solidify in a continuous way.

Correspondingly, a glass does not liquefy abruptly. A common theoretical view explains the transition from the liquid into the glass state by the freezing of the atoms or molecules into disordered, but nevertheless well-defined positions. This is accompanied by an increase of the cooperativity of the interacting atoms or molecules upon cooling.

The mentioned atomic vibrations, which become stronger with increasing temperature, are also responsible for the thermal expansion of solid materials. If the basic ideas behind the Lindemann criterion are correct, the latter should be stronger for materials with lower melting temperatures, leading to an inverse proportionality of both quantities, which is considered as well fulfilled for crystalline materials.

In cooperation with their colleagues Birte Riechers (Bundesanstalt für Materialforschung und -prüfung, Berlin), Alessio Zaccone (University Milan, Italy), and Konrad Samwer (University Göttingen), the physicists at the University of Augsburg now have provided evidence that an analogous correlation of thermal expansion and glasstransition temperature does not exist, implying that the Lindemann criterion is invalid for the glass transition.

This was revealed by the analysis of thermal-expansion data and glass-transition temperatures of more than 200 materials, partly belonging to very different material classes like conventional silicate glasses, molecular, ionic, and metallic glasses, and polymers. The researchers could trace back this qualitatively different behavior of glass melting to the growing number of cooperatively moving atoms or molecules, a characteristic property of glass-forming liquids when approaching the glass transition. The degree of cooperativity of the particle dynamics is different for each glass and can be quantified by the so-called fragility index.

When dividing the thermal expansion coefficients of the different glasses by their fragility indices, glass-forming materials also exhibit an inverse proportionality of this scaled quantity with the glasstransition temperature. This evidences a significant influence of cooperativity on the glass transition. Interestingly, this universal behaviour then also enables the prediction of the glass-transition temperature from measurements of the thermal-expansion and vice versa.

Fixed factor despite different mechanisms

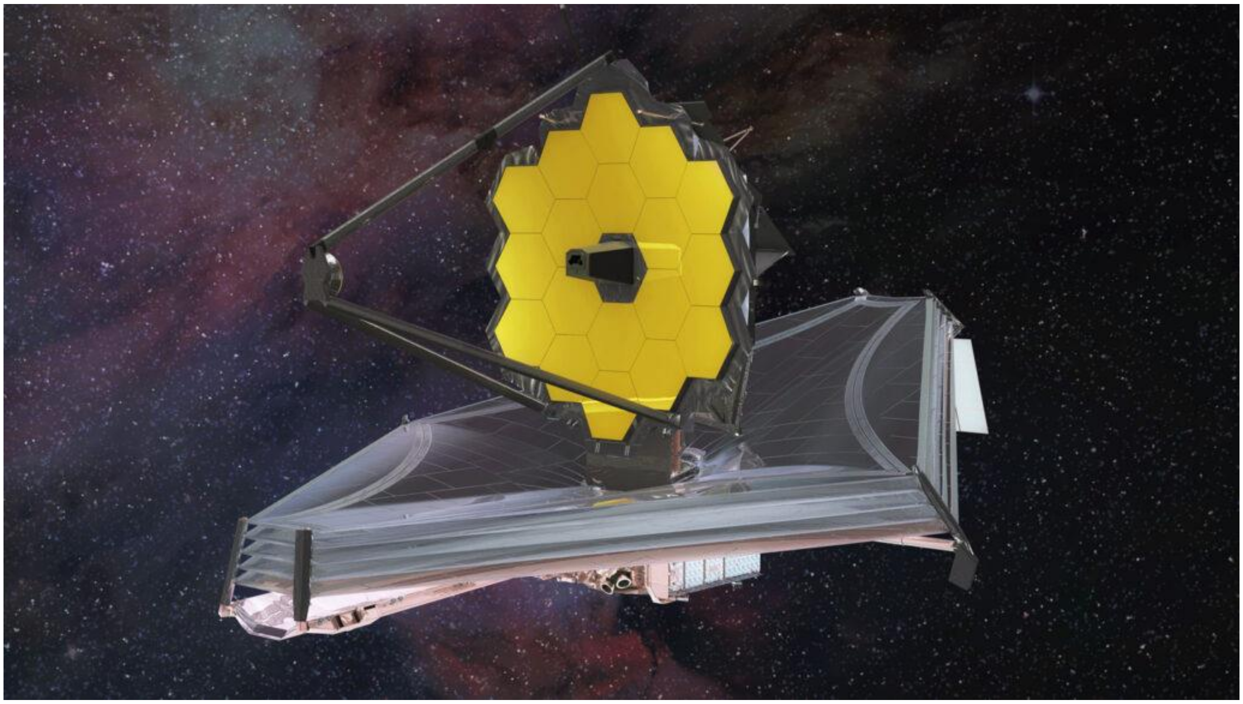
The vast set of data collected in the framework of the present research reveals another surprisingly universal correlation: Just as the thermal expansion of the glass state, the expansion in the liquid state is also correlated with the glass-transition temperature and, moreover, it is by a factor of about three larger than in the glassy state of a material, irrespective of the particular material class. This is astonishing because the thermal expansion in both states of matter is commonly believed to be governed by fundamentally different mechanisms: Vibrations in the solid glass, in contrast to dominant translational motions in the liquid.

"Our data analysis shows that the solid-liquid transition of glasses cannot be regarded as a simple melting process and, instead, correlated particle motions play an important role," says Lunkenheimer and feels confident that the found universalities will significantly contribute to a better understanding of such different materials as silicate-based everyday glasses, amorphous polymers, and metallic glasses..”

The James Webb telescope spotted the earliest known ‘quenched’ galaxy

By Lisa Grossman

February 14, 2023 at 8:00 am



The James Webb Space Telescope, shown in this artist’s illustration, spotted the most distant known galaxy that suddenly stopped forming stars.

The galaxy may have been shut off by an actively feeding black hole. The James Webb Space Telescope has spotted the earliest known galaxy to abruptly stop forming stars. The galaxy, called GS-9209, quenched its star formation more than 12.5 billion years ago, researchers report January 26 at arXiv.org. That’s only a little more than a billion years after the Big Bang. Its existence reveals new details about how galaxies live and die across cosmic time. “It’s a remarkable discovery,” says astronomer Mauro Giavalisco of the University of Massachusetts Amherst, who was not involved in the new study. “We really want to know when the

conditions are ripe to make quenching a widespread phenomenon in the universe." This study shows that at least some galaxies quenched when the universe was young. GS-9209 was first noticed in the early 2000s. In the last few years, observations with ground-based telescopes identified it as a possible quenched galaxy, based on the wavelengths of light it emits. But Earth's atmosphere absorbs the infrared wavelengths that could confirm the galaxy's distance and that its star-forming days were behind it, so it was impossible to know for sure. So astrophysicist Adam Carnall and colleagues turned to the James Webb Space Telescope, or JWST. The observatory is very sensitive to infrared light, and it's above the blockade of Earth's atmosphere (SN: 1/24/22). "This is why JWST exists," says Carnall, of the University of Edinburgh. JWST also has much greater sensitivity than earlier telescopes, letting it see fainter, more distant galaxies. While the largest telescopes on the ground could maybe see GS-9209 in detail after a month of observing, "JWST can pick this stuff up in a few hours." Using JWST observations, Carnall and colleagues found that GS-9209 formed most of its stars during a 200-million-year period, starting about 600 million years after the Big Bang. In that cosmically brief moment, it built about 40 billion solar masses' worth of stars, about the same as the Milky Way has. That quick construction suggests that GS-9209 formed from a massive cloud of gas and dust collapsing and igniting stars all at once, Carnall says. "It's pretty clear that the vast majority of the stars that are currently there formed in this big burst." Astronomers used to think this mode of galaxy formation, called monolithic collapse, was the way that most galaxies formed. But the idea has fallen out of favor, replaced by the notion that large galaxies form from the slow merging of many smaller ones (SN: 5/17/21).
"Now it looks like, at least for this object, monolithic collapse is what happened," Carnall says. "This is probably the clearest proof yet that that kind of galaxy evolution happens." As to what caused the galaxy's star-forming frenzy to

suddenly stop, the culprit appears to be an actively feeding black hole. The JWST observations detected extra emission of infrared light associated with a rapidly swirling mass of energized hydrogen, which is a sign of an accreting black hole. The black hole appears to be up to a billion times the mass of the sun. To reach that mass in less than a billion years after the birth of the universe, the black hole must have been feeding even faster earlier on in its life, Carnall says (SN: 3/16/18). As it gorged, it would have collected a glowing disk of white-hot gas and dust around it. "If you have all that radiation spewing out of the black hole, any gas that's nearby is going to be heated up to an incredible extent, which stops it from falling into stars," Carnall says. More observations with future telescopes, like the planned Extremely Large Telescope in Chile, could help figure out more details about how the galaxy was snuffed out.