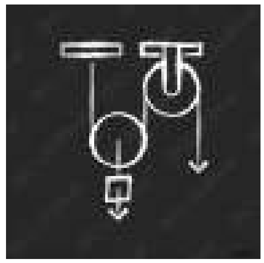


PHYSICS NEWSLETTER

September 2021

Hey everyone!

The Physics Newsletter is back with a bang. We're sad to announce that this will be our last edition, but we'll be handing over the torch to our Year 12s, so you can still expect interesting articles every month.

At the end of this newsletter we have a few competitions and lectures we recommend so you can take a look at those if you're interested.

If you have any questions about our articles or would like to contribute to the next edition of the newsletter, feel free to email us :)

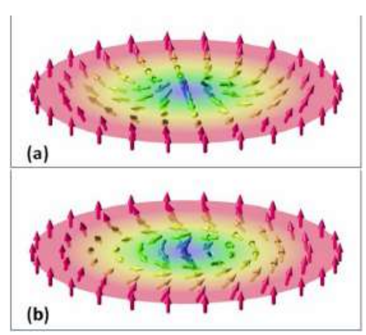
In this edition we will cover:

- Magnetic Skyrmions and Their Role in Climate Change ~ Vanshika Gupta (15guptav699@kechg.org.uk)
- Particles! ~ Vaidehi Kadhane (15kadhane570@kechg.org.uk)
- Did Dark Matter Kill the Dinosaurs? ~ Maheen Abir (15abir780@kechg.org.uk)

Magnetic Skyrmions and Their Role In Climate Change

Climate change is one the most prominent issues of our world today with its effects making highlights everyday on the news. The revolution of the industrial age has led to a rise in our emissions today and unless technology becomes greener to adapt to our modern lifestyles today - we may have to move to mars. Data storage is surprisingly a pivotal part in our lives today, yet also plays a major part in our global emissions. Data centres are acre long cites which consume a lot of energy (produced through unsustainable sources) and give off a lot of waste heat energy- meaning that the cites in also inefficient leading to more consumption of energy. The use of magnetic skyrmions for data storage would mean that we are more efficient in using energy and the size of data centres would reduce.

What are Magnetic Skyrmions?

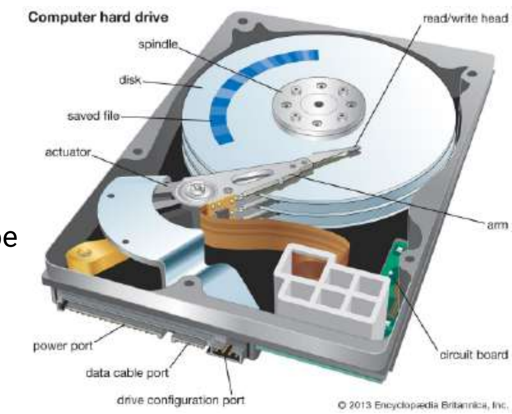


Magnetic skyrmions are a type of quasiparticle - a recent discovery in the field of material science. They were theorised in 1961 and experimental evidence of their existence was found in 2009. Quasiparticles are defined as 'elementary excitations in solids'. They are not fundamental particles but they behave like particles and they cannot exist independently. For example Skyrmions have to manipulate the magnetic field lines of a magnetic material- without the material they cannot exist. Magnetic skyrmions are like 'knots' of magnetic field lines or you can say magnetic moments. A magnet moment is the excess of the amount of spin up electrons and spin is an intrinsic property of subatomic particles- like charge. They are also topologically stable meaning it would take a 'large event' to destroy them such as a large current, light pulse etc. This all being said, you can not find them on your kitchen magnet- you have to manipulate and excite magnetic field lines in such a way to create a vortex of magnetism somehow.

It's basically just a particle :)

How can these particles help our climate change crisis?

Currently data is coded using hard disks and these have circular paths. Each path is split further into sectors and this translates to binary code which is read by a device (the read/write head in the image). In data which uses skyrmions, instead of the disk rotating to be read by a device, the material which contains skyrmions would stay still, but the skyrmions would move around the material to be read. That's why this type of memory storage is called racetrack data, almost like the particles are racing each other. For coding, the absence of a skyrmion could translate to a 0 in the binary system and the presence of one could be represented by a one.



Magnetic Skyrmions, specifically, can revolutionize data as we know it because a lot of data can be packed onto a small strip since these particles are 700-2000nm. As a cherry on top, they are also topologically stable meaning it would be very hard to destroy them- so our data would not get lost easily. The particles would also use hardly any energy to go around the reader.

Overall, this method would save a lot of energy compared to our current method of continuously rotating millions of disks to store data and then using more energy to cool data centres down.

Conclusion

Ultimately, a sustainable method- or at least a method with less carbon footprint needs to be used in the future. Statistical predictions say that by 2025 energy consumption by data centres will be no less than a fifth of global electricity. By 2040, the storage of digital data will generate 14% of the world's emissions. The use of skyrmions will significantly reduce our carbon footprint as the human population increases and may be the future of data. It's good to know that there are options that could be feasible for a greener future.

This article was brought to you by
~ Vanshika Gupta 13P

..short but 'sweet'- thak you for reading :)
Let me know if you have any questions physics related or school

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Particles!

Hi everyone, hope you're all keeping safe. Here's a super interesting article on particle accelerators, ChipIr applications (including Hyper K and Super K). Hope you enjoy it!

The two types of Particle accelerators I'll be discussing are the Diamond Light Source and the ISIS Neutron and Muon Source.

The LHC

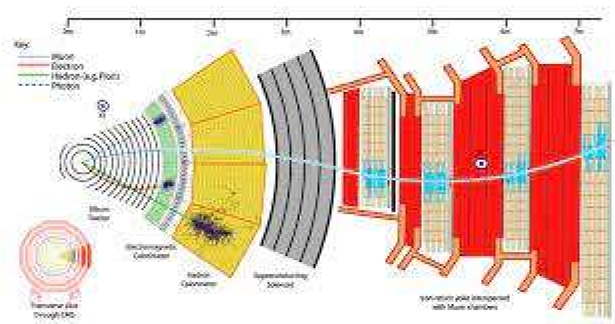
But before we start looking at specific ones, let's talk about the LHC, Large Hadron Collider located in CERN, which is the 'world's largest and most powerful hadron collider'!

^On the image to the right, you can see just how big it is in comparison to the people standing at the bottom.

But firstly, *what IS the use of a particle accelerator?*

Wikipedia would be able to explain it faster and more concisely than I could: ‘A particle accelerator is a machine that uses electromagnetic fields to propel charged particles to very high speeds and energies, and to contain them in well-defined beams. Large accelerators are used for basic research in particle physics.’.

Coming back to the LHC, scientists use it to recreate the conditions that occurred one billionth of a second after the Big Bang



- The LHC mainly accelerates protons.
- An electric field is used to strip away the electron from the Hydrogen.
- Two beams of protons are accelerated in opposite directions, in two different vacuum tubes.

[Why vacuum, you may be wondering? This is because if we carried this out in the air, the protons would colliding with the particles found in air, including oxygen, Nitrogen etc.]

- These beams travel close to the speed of light and are made to collide with each other at 4 specific collision points.
- CMS is one of the detectors built around a proton-proton collision point.

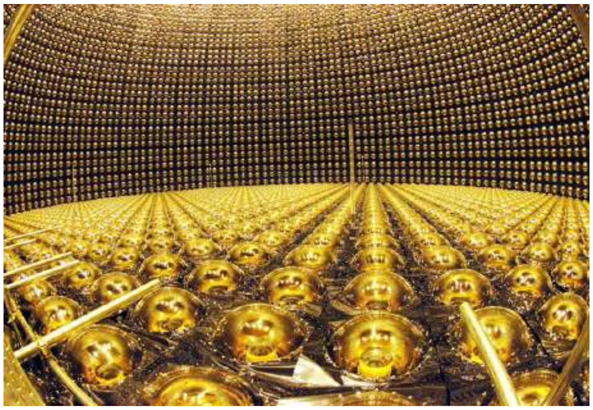
The parts in the detector:
Tracker: tracks the path of the particles
Electromagnetic calorimeter: collects the energy of the electromagnetic particles (particles that consist of quarks eg. protons and neutrons)
Muon detector: Detects muons (a type of particle)

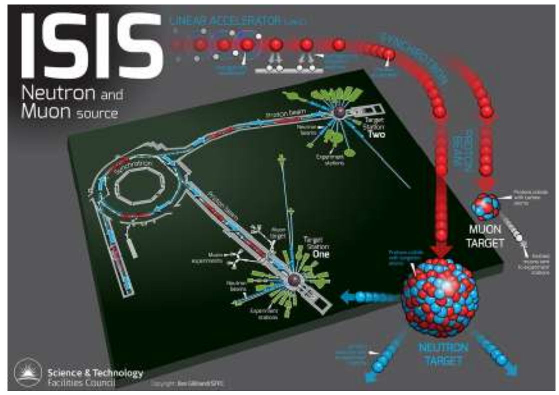
Diamond Light Source

This is a particle accelerator that accelerates electrons to very high speeds, which creates bright beams of light. These beams of light are studied by scientists

ISIS neutron and muon source

This is a proton accelerator that produces pulses of protons.





ChipIr (Applications)

What is ChipIr?

At ChipIr, we take an atmospheric neutron beam, and the neutron produced for this is ‘filtered’, such that you get a spectrum of energies of these neutrons similar to what you’d find in the atmosphere. For this, an object will be sitting in the path of the beam, such that the beam will have to pass through it.

Some uses of ChipIr include rapid testing of electronics, moon rock testing, Hyper K and Super K.

Hyper K + Super K- a neutrino observatory

These tubes you can see on the right have a high voltage across them. The detector has one million tonnes of water. With a little bit of light incident on them, they produce a cascade of electrons, which can create current and therefore we can detect the presence of neutrinos.

Neutrinos, if you’re not aware, are tiny, almost massless particles.

Well, that was a whistle-stop tour of particles, and hopefully you learnt a thing or two about particle physics!

~ Vaidehi

Did Dark Matter Kill the Dinosaurs?

Earth's history is peppered with devastating mass extinctions in which millions of years of evolution are wiped out in the blink of an eye. The most notorious of these is, of course, the demise of the dinosaurs 66 million years ago due to the impact of an asteroid colliding with the Earth in the Yucatán Peninsula[1]. The 200-mile-wide crater that still exists at the site today serves as a grim reminder of the sheer scale of what was lost. However, even the extinction of the dinosaurs pales in comparison to the Great Dying, another of the 'Big Five' mass extinctions that Earth has witnessed. Nine out of ten species on the planet were wiped out in this event 252 million years ago in the Permian-Triassic Era. And it isn't as if the mass extinctions end at the Big Five; it is speculated there were dozens more smaller scale mass extinctions in the past as well. Additionally, these events are not all caused by massive impacts; some might be related to heightened volcanic activity that led to drastic climate change and loss of habitat.

So the question is: why? Why do mass extinctions happen? Could they just be bad days on Earth, when several catastrophic events like impacts and supervolcano eruptions happen to occur simultaneously? Or could there be other unseen factors at play?

The first thing to note is that evidence for a pattern of mass extinction has been found in the fossil record with a time period of 26 million years since the Great Dying. It was discovered in the 1980s by palaeontologists David Raup and Jack Sepkoski. This time period seems to match the differences between the Big Five events. Since Raup and Sepkoski's findings, many other researchers have also examined the Earth's fossil record and come to a conclusion of a 30-million-year time period which reaches back half of a billion years. But why? What is the reason for this cosmic clock of doom?

Let me introduce to you the concept of dark matter, a hypothetical form of matter thought to compromise 85% of the total matter in the Universe and which happens to be pretty much invisible, since it does not interact with the electromagnetic field and therefore does not emit, absorb or reflect electromagnetic radiation.

But what could this strange form of matter have to do with mass extinctions? The theory, proposed by Lisa Randall and Matthew Reece, Harvard physicists, goes that the dark matter in the Milky Way could exist as a thin disc embedded in the galaxy's plane. Randall and Reece call this disc 'double disc dark matter'. They state that whilst the Solar System orbits the centre of the galaxy, it passes through this disc, which then pulls on the comets within the Oort Cloud at the fringes of the system and might even manage to send one of them Earth-bound – such as in the case of the dinosaur extinction. And their theory also incorporates an idea that has in recent years gained traction within the scientific community – a new class of dark matter named 'self interacting dark matter', which is theoretically able to collide or, as the name suggests, interact with itself. It's one of the more outlandish ideas that physicists have proposed, going so far as to suggest that there could be an entire 'dark universe' that exists right under our noses that we are unable to see, complete with dark atoms, stars and planets.

Things don't end with Randall and Reece's proposition. Whilst their theory only applied dark matter's believed properties to the periodicity of impacts, geoscientist Michael Rampino of New York University believes that dark matter could also explain the periodicity of mass volcanic activity on Earth. He says that if dark matter forms dense clumps instead of being distributed evenly throughout the disc, large quantities of dark matter particles could be captured by Earth's gravity and would fall to the Earth's core. Upon reaching this, they would attain sufficient density to annihilate each other, leading the core to become overheated and causing giant magma plumes to be thrust upwards towards the surface. This, in turn, would give rise to the devastating volcanic eruptions that have accompanied so many mass extinctions, tearing apart continents like paper, altering sea levels and drastically changing the climate. Along with the bombardment by comets disturbed by the Solar System's passage through the dark matter disc, it is really no wonder that life on Earth didn't have a chance. The most surprising thing is that anything was left at all.

But I do have to remind you that this is all purely theoretical. Rampino's dark matter clump theory fits very few of the current models we have of the elusive substance. Randall states that even if the clump idea was true, Earth wouldn't pass through the dark matter disc often enough to explain every mass extinction, given how the distance between objects in the galaxy is incomprehensibly vast. She also says that the clumped dark matter would annihilate occasionally and produce gamma rays – but so far none have been detected. Though, there is one thing going for this disc theory: observations of small satellite galaxies orbiting Andromeda have yielded evidence of the existence of a similar dark matter disc there.

Perhaps it is simply too much to hope that every catastrophic event on Earth fits neatly into one apocalyptic box. After all, there is no shortage of factors that could lead to disaster. Reece, Randall and Rampino's theories have been met with a sceptical reception as often as not in the scientific community.

So did dark matter kill our favourite prehistoric animals? Possibly. If nothing else, it does make for an intriguing idea, and it does make us question our current theories about dark matter and its properties.

As always, I hope you enjoyed this article, and look forward to the next edition of the physics newsletter!

~ Maheen :)

1: Here's a link to a cool video I found about the day the dinosaurs died https://www.youtube.com/watch?v=dFCbJmgeHmA

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Competitions and lectures you can attend

Regular Oxford lectures

- **https://www.physics.ox.ac.uk/engage/public-and-community/public-lectures-and-online-talk**

UK Space Design: **https://uksdc.org/**

Books

- **A Brief History Of Time -** a great and 'brief' introduction into basically all astrophysics
- **Feynman Lectures (the book or YouTube videos) -** Physical concepts explained in such a philosophical matter but on a deeper level
- **The Elegant Universe -** a book on string theory, relativity and much more explained in a nice way
- **The End Of Everything-** A fascinating walkthrough of potential futures for our universe