PHYSICS NEWSLETTER

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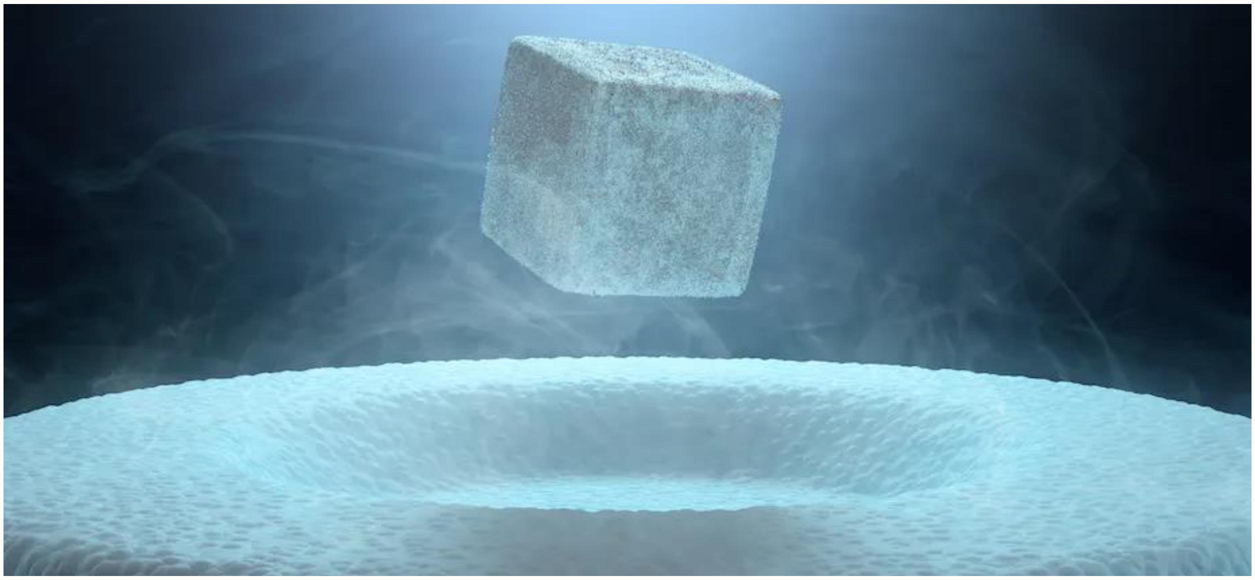
17th Edition - Festivities



Welcome to the 17th edition of the Physics Newsletter. What better way is there to enjoy the long cold winter nights than reading about physics phenomena?

A big thank you to all the people who contributed to this edition of the newsletter: Alice, Raga and Ruth.

If you would like to be featured in any of our upcoming newsletters, please email Alice (17billwilks551@kechg.org.uk)!

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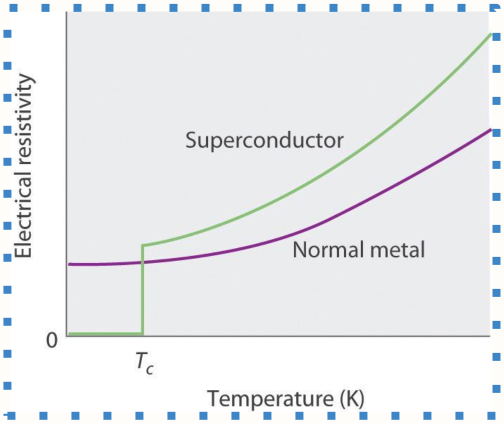
Keeping up to date...

Physics in the News - The golden age of superconductors

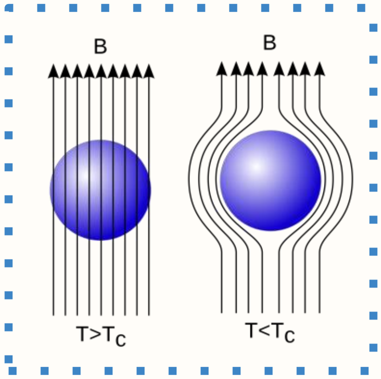
One of the main issues of a growing population, as we surpassed 8 billion last year, is the rising energy consumption. How can we obtain such a significant amount of energy, that too by sustainable means? Or rather encourage efficient use of the energy generated? The first obstacle occurs due to how much electricity is wasted in simply transporting it. In fact, a tenth of electricity being generated is lost in the National Grid. There is a solution to this- room temperature superconductors.



However, researchers are still in the pursuit to find a room temperature superconductor. A superconductor is when a material conducts direct current, but there is no electrical resistance and resistivity at or below critical temperature. Think of $P=I^2R$ in the case of the National Grid, the greater the resistance, the greater the power dissipated to the surroundings, so ideally it should be zero. This is the main obstacle, as critical temperatures for these superconductors are too low for everyday use, with a "high temperature" superconductor being defined as a material which experiences this property at a critical temperature of around 77K(-196°C). There have been higher temperature superconductors, for example this has been attained using hydrogen sulphide(H_2S), but under a pressure of 155GPa. Atmospheric pressure is only 101000 Pa.

In the summer of this year, there was a wave of hope when news spread across the internet of a material experiencing superconducting properties in the preferable conditions. The source was a paper yet to be peer-reviewed including the research led by two South Korean scientists, Sukbae Lee and Ji-Hoon Kim. This highly sought-out material was referred to as LK-99, composed of Pb10−xCux(PO4)6O. When scientists at CSIR-National Physical Laboratory (NPL), India and Beihang University, China attempted to replicate the superconductor at first, there was no success. Further attempts were made by Princeton University, USA and the Beijing National Laboratory for Condensed Matter Physics, China. The material seemed to behave like a superconductor, as the resistance plummeted at a certain temperature, but it was not because of superconductivity. The results were concluded to be perhaps due to impurities in the original sample causing some characteristics reminiscent of superconductivity.

The magnetic effects of a superconductor is also a condition to be considered with the electric resistance. For instance, a wire with an electric current flowing creates a magnetic field and the reverse also happens. When a magnet is placed on a superconductor which is at or below critical temperature, a certain quantum phenomenon occurs. It is the levitating effect as shown in the cover picture for this edition of the Physics Newsletter, this effect is called the Meissner effect. In this situation, the magnetic field is expelled by the superconductor, as it creates a magnetic field mirroring that of the magnet which causes a repulsive force. The magnetic field of the superconductor is from the current induced by the magnetic field of the magnet on top. A levitating effect occurs when the repulsive force is equal to the gravitational force of the magnet. In reality, the stronger the magnetic field, the more difficult it is for the superconductor to mirror the magnetic field of the magnet. A complete expulsion does not take place as there can be partial penetration of the magnetic field at varying levels.



Superconductors are already in use for MRI machines, in order to generate strong magnetic fields and Maglev trains. With the discovery of a room temperature superconductor, not only is the transport of electricity made more efficient, but the functioning of every electronic device would be transformed. The necessity of a coolant will also become redundant which will reduce expenses of superconductor use. Sustainably sourced energy, such as solar energy, would also be boosted as the superconductors can facilitate more efficient solar panel technology and therefore more clean energy.

Sources and some suggested links:
Levitating Superconductor on a Möbius strip
A physical demonstration of a superconductor
https://physicsworld.com/a/room-temperature-superconductor-lk-99-fails-replication-tests/
More about the research itself
https://theconversation.com/superconductivity-at-room-temperature-remains-elusive-a-century-after-a-nobel-went-to-the-scientist-who-demonstrated-it-below-450-degrees-fahrenheit-213959
History of the research of superconductors

Sai Raga Navili 13P

The Physics Behind... The Star of Bethlehem

Most of us will be familiar with the Nativity story, in which the Star of Bethlehem Inspires the three wise men to travel to Jerusalem. But was it an actual star? An astronomer from the 17th century, Johannes Kepler, supported the theory that it was a supernova explosion, which would explain the star's alleged brightness. However, there is no Western astronomical record for this and Chinese records only have one mention of a possible supernova over the potential time Jesus was born. There is also no known supernova remnant, which we should expect to find if a supernova had occurred at that time.

An even older theory is that the Star of Bethlehem was a comet. A common argument for this theory is that comets move across the sky and thus the star moved as it directed the three wise men to Jesus Christ in this way. However, it is unlikely that they followed a comet as its position would have changed as the Earth rotated, so the comet would not have led them in a single direction, especially if their journey took several months. Or the star they followed was not just one star. Perhaps the three wise men were astrologers (a plausible theory seeing as they were from the area of Babylon) and they may have read a hidden meaning in the stars due to a particular alignment of planets and stars.

Now, onto the most promising theory. The Star of Bethlehem may have been a conjunction. A conjunction occurs when two or more celestial bodies appear to meet in the night sky from our location on Earth. This would make it seem like there was a very bright object in the sky, easily mistaken for a star bearing special news. A conjunction can occur every night in a similar location for days or weeks, so it is possible that if the three wise men had followed the conjunction they would have been led in a certain direction. If the star was indeed a conjunction, there are several alignments that could have caused it. One option is the conjunction of Jupiter, Saturn, the Moon and the Sun in the constellation of Aries on April 17, 6 B.C. This conjunction happened in the early morning which fits the Gospel's description of the Star of Bethlehem as a rising morning star. The three wise men lost sight of the star before seeing it come to rest above the stable where Jesus was born, which could have been the result of Jupiter's retrograde motion - this means that Jupiter appeared to change direction in the sky as Earth's orbit overtook it. Another possible conjunction is that of Jupiter, Venus and the star Regulus in the constellation of Leo on June 17, 2 B.C. This conjunction does not match up as closely with the actual Bible story but we can take a closer look at the meaning behind these particular celestial bodies. Jupiter is viewed as the king of the planets and Regulus is Latin for prince or ‘little king’. Add in the fact that Venus can be viewed as a symbol of birth and these three objects in combination can be interpreted as the birth of the ‘King of Kings’ - aka Jesus Christ.

Of course we may never truly know what the Star of Bethlehem was or if it even really happened without building a time machine. But astronomers continue to speculate and it is a question that inspires scientists and historians alike.

Here is an image of a conjunction between Jupiter, Venus and the moon, taken by ESO’s Very Large Telescope Observatory.

References:

https://www.space.com/star-of-bethlehem

https://www.rmg.co.uk/stories/topics/what-was-christmas-star

Ruth Rafeeq 13MP

Women in Physics: Nobel Prize Edition

The Nobel Prize in Physics

The Nobel Prize in Physics 2023
Anne L'Huillier
“for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter”

The Nobel Prize in Physics 2020
Andrea Ghez
“for the discovery of a supermassive compact object at the centre of our galaxy”

The Nobel Prize in Physics 2018
Donna Strickland
“for groundbreaking inventions in the field of laser physics”
“for their method of generating high-intensity, ultra-short optical pulses.”

The Nobel Prize in Physics 1963
Maria Goeppert Mayer
“for their discoveries concerning nuclear shell structure”

The Nobel Prize in Physics 1903
Marie Curie, née Sklodowska
“in recognition of the extraordinary services they have rendered by their joint researches on the radiation phenomena discovered by Professor Henri Becquerel”

At the beginning of October, three scientists were awarded the Nobel Prize for physics: Pierre Agostini, Ferenc Krausz and Anne L'Huillier. The award was presented to them in recognition of their work on producing extremely short pulses of light that can be used to study processes inside atoms and molecules. However, although this is the 117th prize presented in physics, Anne L'Huillier is only the fifth woman to receive the prize.

The first woman to win any Nobel Prize was Marie Skłodowska Curie. She also happens to be the only woman to have won it twice - once each in Physics and Chemistry. Even then, only four other people have ever won two (and they were all men). Despite Marie Curie’s fame, you may not know very much about her work - this was unfortunately true for me. For example, I didn’t realise that it was Curie and her husband who coined the term ‘radioactivity’ when investigating ‘uranium rays’ discovered by Henri Becquerel. (Incidentally, Becquerel is the SI unit for radioactivity, while Curie is the non-SI unit.)

Curie systematically tested the entire periodic table for these ‘rays’, concluding that they were unique to uranium and thorium. When studying the natural ores containing these elements, she detected radiation four to five times the expected amount from the uranium content, suggesting that another substance was present. By 1898, Marie and Pierre Curie identified an element 300 times more strongly radioactive than uranium and named it polonium. They later went on to discover a second element, radium, which Marie Curie won a second Nobel prize for isolating in 1911.

It took 60 years for the Physics Nobel Prize committee to name another female laureate: Maria Goeppert Mayer. She spent many years working between the University of Chicago’s Institute for Nuclear Studies and Argonne National Laboratory. (During this time, she worked alongside Edward Teller - the father of the hydrogen bomb.) Through studying isotopes, she recognised that nuclei with 2, 8, 20, 28, 50, 82, or 126 protons or neutrons were especially stable. These ‘magic numbers’ led Goeppert Mayer to suggest a shell structure for nuclei, just like the electron shell structure in atoms determined by Bohr.

In the nuclear shell model, the orbits of each nucleon (proton or neutron) form a series of shells of increasing energy. Nuclei with completely filled outer shells are most stable. While this relationship had been noticed before, many physicists favoured an alternative model, the liquid drop model. Through treating the nucleus as a homogeneous blob, this model had been successful in explaining nuclear fission and avoided a problem: physicists assumed nucleon interactions were too strong to be accurately described by the shell model, which treats nucleons as independent particles.

Goeppert Mayer then considered other nuclear properties, and found they also supported the nuclear shell model. Although standard quantum mechanics couldn’t account for the magic numbers higher than 20, with key insight from Enrico Fermi, Goeppert Mayer was able to calculate energy levels and explain the sequence of magic numbers. Maria shared the 1963 Nobel Prize with Hans Jensen who independently came up with the same result.

In the last 5 years, 3 women have won the Nobel Prize in physics - a number that sounds encouraging until you realise that there have been 19 winners in total. Donna Strickland won her award in 2018 within the same field as Anne L’Huillier: optics. The 2018 prize recognised Strickland’s method of generating ultrashort laser pulses. Previously, the maximum power of pulsed lasers was greatly limited: as the light intensity increased, the laser components would become severely damaged by ‘nonlinear’ processes. This meant that laser systems had to be large and expensive. Using chirped pulse amplification (CPA), facilities with the most powerful systems can now generate pulses with peak powers measured in petaWatts - over 1000000000000000 Watts. The unprecedented high peak intensity of these lasers has led to many discoveries about the fundamental properties of matter, as well as the invention of laser surgery. (Using ultrashort laser pulses allows a target material time to cool - so in laser surgery cells don’t overheat and die.)

On the opposite end of the scale, Andrea Ghez works in the field of astrophysics. Ghez won the 2020 Nobel Prize for leading a team that carefully measured the movements of stars at the centre of the MIlky Way (our galaxy). She was then able to show that these stars were revolving around something incredibly heavy - a supermassive object. Ghez identified the object as a black hole, named Sagittarius A*, which is thought to have played an important role in the formation of our galaxy. Furthermore, Ghez developed a new technique known as speckle imaging, which combines many short exposures from a telescope into a single, crisper image.

Science has the incredible ability to unify people and ideas in unexpected ways. In the age of the internet, it has never been easier for scientists to collaborate across the world, working in multinational, multidisciplinary teams. There is still a long way to go before female scientists can be equally represented, recognised and rewarded in physics, but with each female Nobel Prize laureate, I think we come one step closer.

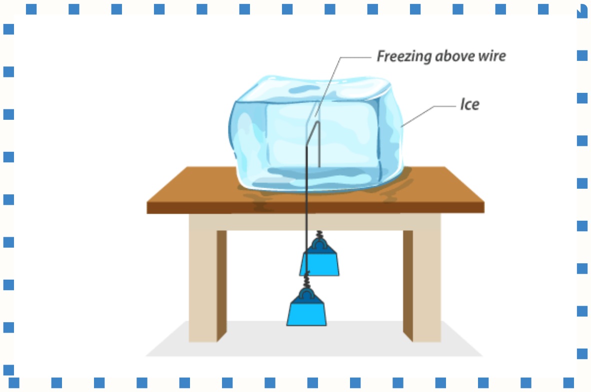
References-
L'Huillier: https://www.theguardian.com/science/2023/oct/03/nobel-prize-in-physics-awarded-to-three-scientists-for-work-on-electrons
Curie: https://awis.org/historical-women/marie-curie/#:~:text=Marie%20Sk%C5%82odowska%20Curie%2C%20a%20Polish,%2Dactive%E2%80%9D%20to%20describe%20them.
Goeppert Mayer: https://www.aps.org/publications/apsnews/200808/physicshistory.cfm
Strickland: https://physics.aps.org/articles/v14/134 ,
https://www.scientifica.uk.com/neurowire/womeninscience-donna-strickland-winner-of-the-2018-nobel-prize-in-physics
Ghez: https://news.uchicago.edu/story/astronomer-andrea-ghez-responsibility-comes-nobel-prize#:~:text=Ghez%20led%20a%20team%20that,the%20formation%20of%20our%20galaxy.

For women who have won the Prize in other disciplines:
https://www.nobelprize.org/prizes/lists/nobel-prize-awarded-women/

Alice Bill Wilks 13CL

Physics in the Real World: Ice regelation

Regelation is defined as the phenomenon of ice melting under pressure and refreezing when the pressure is reduced. Ice can be compressed and turned into water, solidifying again once the force compressing the ice is removed. There is an experiment that demonstrates the regelation of ice - all that is required is a block of ice and a metallic wire with weights attached to it.

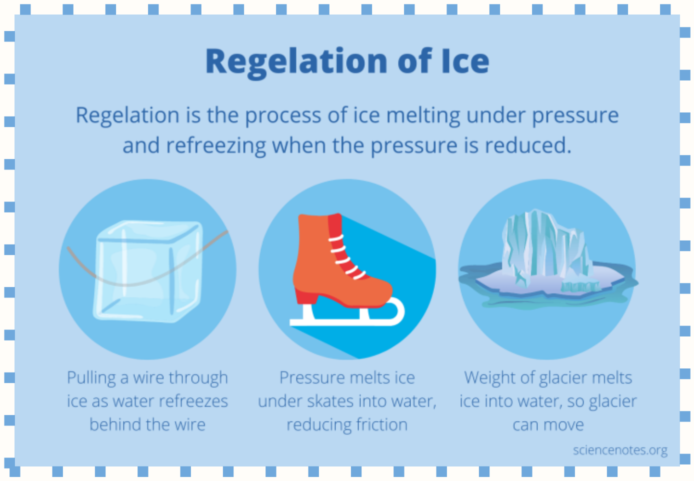


In this experiment, the wire passes through the ice block without splitting it, and it's all thanks to regelation. This is because the ice melts at a lower temperature due to the increase in pressure just below the wire. The wire is able to cross through the water that just formed and once the wire has crossed, the water above the wire solidifies.

The melting point of ice decreases when the pressure increases, the volume decreases because pressure and volume are inversely proportional. Water fills a smaller volume when it is a liquid rather than a solid so the melting point is lowered to allow more ice to become water.

One example of ice regelation in real life is glacial activity. Glaciers act as the source of a river due to regelation because the huge mass of the glacier exerts pressure on the lower surface. This lowers the melting point of ice at the base of the glacier. The ice melts and the glacier can slide over the newly formed water. Under certain conditions, liquid water can flow from the base of the glacier to lower altitudes when the temperature of the air is above the freezing point of water ($0^{\circ}C$).

The process of ice regulation also occurs in the Arctic and Antarctic, when ice sheets are exposed to warmer air temperatures. It is also seen when thin pieces of sea ice that have broken off from an ice shelf come into contact with each other or other objects such as rocks at lower elevations.



References:

Regelation - Definition, Examples and Regelation Of Ice - BYJU'S

Why does increased pressure lower the melting point of ice? Can we use the First Law of Thermodynamics to explain?.

Ice Regelation

Definition, Example and Regelation of Ice

Ruth Rafeeq 13MP

Experience: Beamline for Schools

This time last year I was blissfully unaware that the Beamline for Schools competition had begun. By the time I heard about it in late February, I was so intrigued by the idea that I decided to enter anyway.

Beamline for Schools is a competition run by CERN - the European Organization for Nuclear Research - and DESY - the German Electron Synchrotron. Teams of secondary school students submit proposals for particle experiments with the chance of winning a trip to CERN or DESY to perform their experiments at a fully-equipped particle accelerator.

I was admittedly on the back foot. Not only had the competition been already running for months, but I had not yet studied particles at all in school. Although this should have discouraged me from registering, I was even more excited: I could try something new with no expectations and nothing to lose. The first step was to expand my one (wo)man team, so I approached Ms Nicholson with the idea. We advertised the opportunity on the year group google classroom to see if anyone was interested in taking part and the team began to grow.

With a group size guideline of 5 to 9, initially gaining the interest of 13 people was a surprising success! As the first Camp Hill School team, we had no idea what to expect so I was very eager to set up a meeting and start working on possible ideas. After some stressful back and forth about going ahead, the most pressing issue was the deadline: 12th April. We had five weeks to teach ourselves about particles and particle accelerators, read about existing particle experiments, identify areas of potential development and choose an original and insightful idea around which to design an experiment. It turns out that designing a large scale particle experiment from scratch is quite difficult.

In my slideshow, I outlined a plan: "1. Come up with an idea. 2. Pre-register. 3. Research the technical details. 4. Write the proposal". If only it were that simple. After setting up our own google classroom, we hit a bit of a wall. First we had too few ideas and then we had too many. In order to eliminate seven of our eight ideas, we had to scrutinise the competition specifications and figure out whether our ideas were even feasible. (Let me remind you that we had never studied particles before.) In the end, we combined the best two and titled our proposal "A Matter of Antimatter" - we wanted to calculate the efficiency of photon generation by pair production.

Our hypothesis was that by “using different initial electron beam energies, it would be possible to determine the optimal conditions for efficient photon beam generation”. In other words, we could repeat the experiment multiple times to determine which initial conditions produced the best result. We thought that findings from the investigation could be used to both develop insight into the structure of matter and improve radiotherapy techniques.

The experimental theory was to fire high energy electrons at a dense nucleus to create a beam of photons and then initiate pair production using these photons. By measuring the momentum and therefore energy of the particle-antiparticle pair produced, we would be able to calculate the energy of the photon beam. This would tell us how much energy was transferred and how efficient this method of photon generation wass when compared to the initial energy of the electron beam. We thought carefully about the necessary equipment, deciding that a tungsten target, with its high proton density and melting point favoured a large production of photons, while dipole magnets would be necessary to focus the electrons into a beam. Furthermore,it was important to consider the limitations of our set up. For example, using a cloud chamber would allow us to easily detect the protons, but measuring the radius of the proton’s path would have a high uncertainty as the proton would continually lose energy.

After managing to condense all of our ideas into just over 1000 words, we submitted the proposal. Alongside the feeling of relief, I definitely felt a sense of achievement. I was proud of how committed my team had been, successfully submitting a complete proposal based on new physics that we had taught ourselves. Not winning didn’t change this.

So if you are considering taking part in Beamline - or any other competition - I would thoroughly recommend that you follow it through. Take it as a chance to learn something. (And it’ll look good on your personal statement!)

Alice Bill Wilks 13CL

Dates to know:

1. **Beamline for Schools Competition: submissions from January to April 2024**

   An international competition for designing an experiment to be performed at a high energy particle accelerator. For Beamline for Schools 2024, the three winning teams will realise their experiments at CERN and DESY. All winners will be supported by a team of professional scientists.

   https://beamline-for-schools.web.cern.ch/sites/default/files/Invitation_BL4S_2024.pdf

2. **Isaac Physics Mentoring Scheme: any time from September**

   For Years 11 to 13, this is a super-curricular opportunity (great for your personal statement!) where you get set weekly problem solving activities. At the end of the school year you will receive a certificate with the number of questions completed.

   https://isaacphysics.org/pages/mentor_menu?stage=all

3. **University of Oxford Physics Department events**

   For Years 10 and 12 - have a look (for lots of taster days and programmes)!

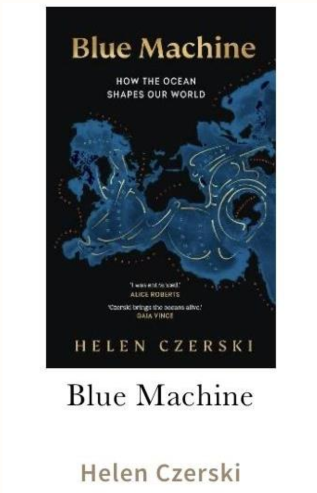
   https://www.physics.ox.ac.uk/engage/schools/secondary-schools

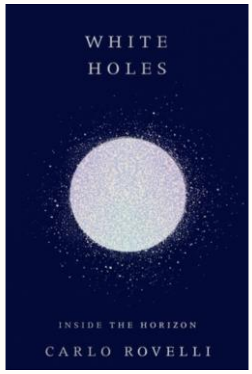
4. **Physics society is every Tuesday Week B in Lab 10, second half of lunch!**

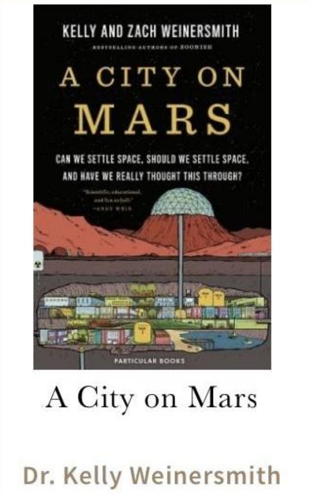
5. **Engineering society is every Thursday in Room 27 at 1pm!**

Secret Santa!

Here are some book recommendations for physics lovers in your life (including yourself!):



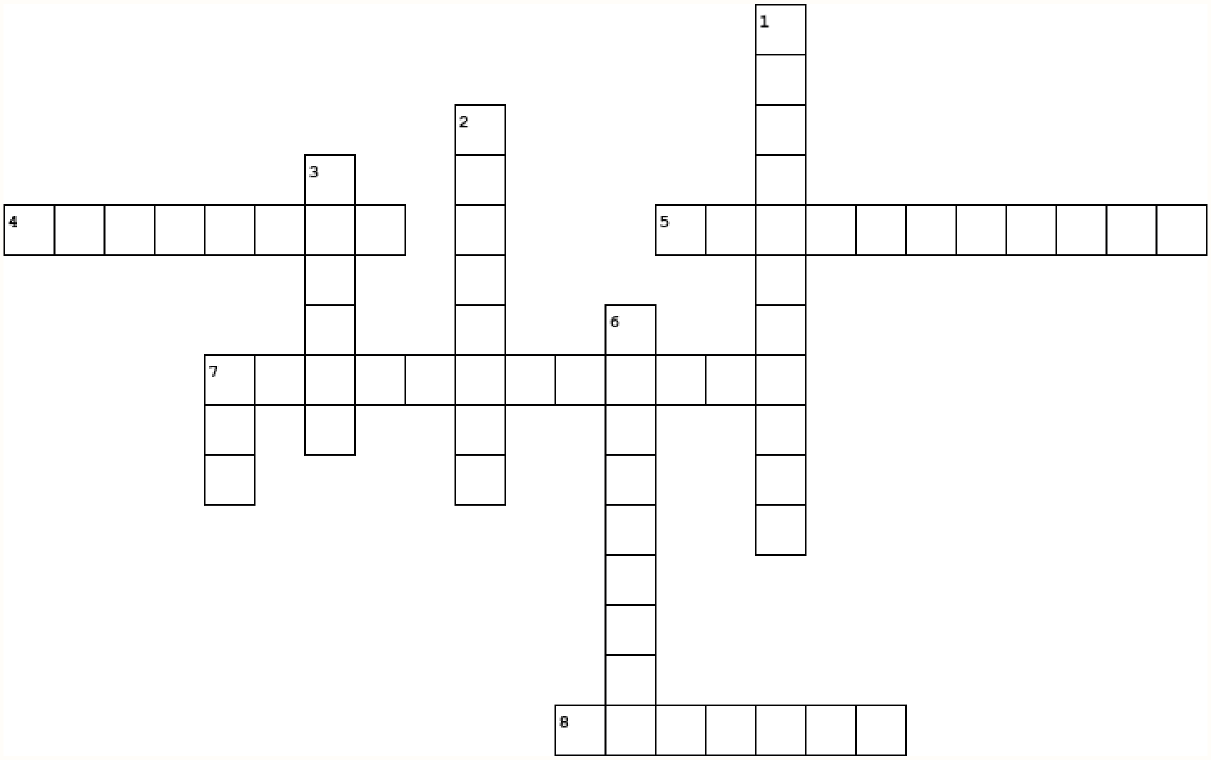




Crossword

A very very special mention to Sunnie in Year 13 for completing the previous crossword puzzle!

The Physics of Christmas



Across

4. - part of the electromagnetic spectrum that we feel as heat

5. - a popular Christmas pudding and former model of the atom

7. - Santa would have to travel close to this speed in order to deliver all his presents

8. - what happens to a snowman when the temperature rises

Down

1. - when two or more celestial bodies appear to meet in the night sky from our location on Earth (astronomers speculate that this might have been the Star of Bethlehem)

2. - Santa could use these to manipulate space-time and deliver presents at his leisure

3. - the type of circuit Christmas lights generally use

6. - another part of the electromagnetic spectrum that is useful when we have to heat up mince pies

7. - the celestial body responsible for Earth's seasons

conjunction • infrared • melting • microwave • plum pudding • series • speed of light • Sun • wormhole

Submit your answers to 17billwilks551@kechg.org.uk for a mention in the next newsletter!

Answers to the previous crossword: