MILLAIS SCHOOL

VOLUME 1

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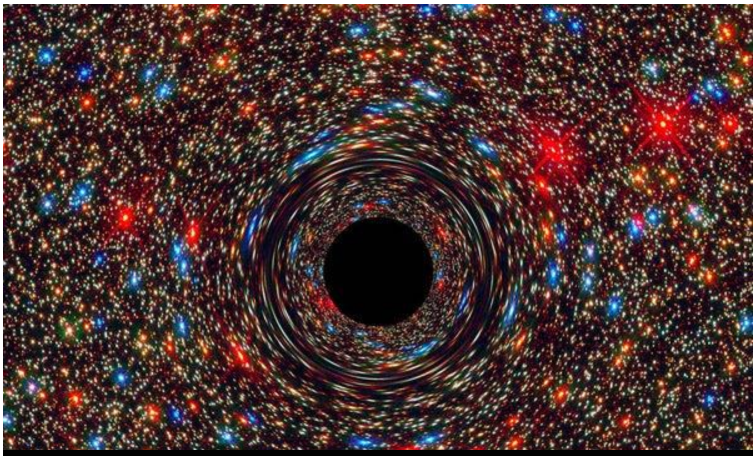
Charged Up!

EDITED BY MRS KLIMI



Computer-simulated image shows a supermassive black hole at the core of a galaxy. By *NASA, ESA, and D. Coe, J. Anderson, and R. van der Marel (STScI)*

Unlocking the Mysteries of Black Holes!

By Alanna Biju, year 10. From stellar remnants to supermassive giants, discover what makes black holes the most puzzling objects in the universe. Learn how they bend space, trap light, and hold secrets to cosmic evolution! **PAGE 2**

The Mysterious Phantom Galaxy!

By Aine Burke, year 11. Discover why the elusive M74, known as the Phantom Galaxy, is so hard to capture yet so captivating. Learn about its mysterious low brightness, dazzling spiral arms, and the James Webb Telescope's breathtaking infrared images that reveal its star-forming secrets. **PAGE 4**

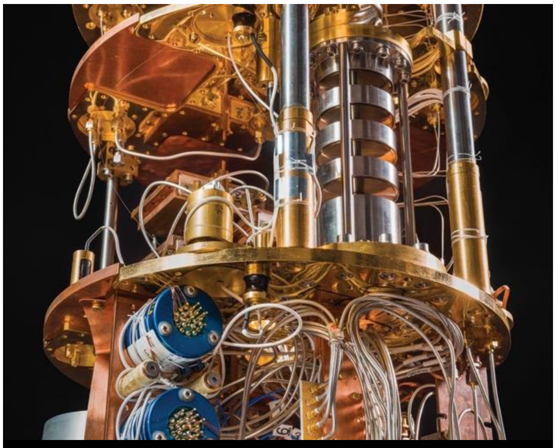
NASA's James Webb telescope captured this image of the Phantom Galaxy using its Mid-InfraRed Instrument.

What is light? The visible spectrum and beyond.

Discover how visible light bends, reflects, and mixes to create the stunning spectrum we see every day. Learn how physics paints our world! **PAGE 3**

Rainbows show how visible light is a combination of many colours

What are Quantum Computers?



IBM's new quantum computers look like props from a sci-fi film

By Summer Mac Robert Smith, year 10. Quantum computers, like IBM's Osprey with its 433 qubits, use the strange rules of quantum physics to solve really hard problems super quickly, helping us tackle challenges in science, medicine, and technology that normal computers can't handle. **PAGE 4**

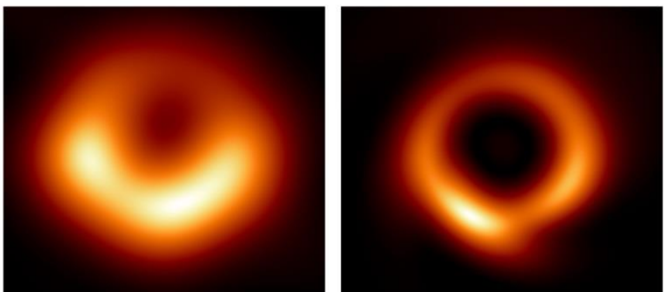
Black Hole Special

What are Black Holes? By Alanna Biju.

Black holes are among the most mysterious cosmic objects, much studied but not fully understood. These objects aren't really holes. They're huge concentrations of matter packed into very tiny spaces. A black hole is so dense that gravity just beneath its surface, the event horizon, is strong enough that nothing – not even light – can escape. The event horizon isn't a surface like Earth's or even the Sun's. It's a boundary that contains all the matter that makes up the black hole.

There is much we don't know about black holes, like what matter looks like inside their event horizons. However, there is a lot that scientists *do* know about black holes.

Black holes can be surrounded by rings of gas and dust, called accretion disks, that emit light across many wavelengths, including X-rays. A supermassive black hole's intense gravity can cause stars to orbit around it in a particular way. Astronomers tracked the orbits of several stars near the center of the Milky Way to prove it houses a supermassive black hole, a discovery that *won the 2020 Nobel Prize*. When very massive objects accelerate through space, they create ripples in the fabric of space-time called gravitational waves. Scientists can detect



Researchers used computer simulations of black holes to generate a revised version (right) of the famous first image of a real black hole (left). *Medeiros et al 2023*

some of these by the ripples' effect on detectors. Massive objects like black holes can bend and distort light from more distant objects. This effect, called gravitational lensing, can be used to find isolated black holes that are otherwise invisible. Wormholes. They don't provide shortcuts between different points in space, or portals to other dimensions or universes. Cosmic vacuum cleaners. Black holes don't suck in other matters. From far enough away, their gravitational effects are just like those of other objects of the same mass.

BLACK HOLE FACTS

WHICH BLACK HOLE IS…

THE CLOSEST?
The nearest known black hole, called Gaia BH1, is about 1,500 light-years away.

THE FARTHEST ?
The most distant black hole detected, at the center of a galaxy called QSO J0313-1806, is around 13 billion light-years away.

THE BIGGEST?
The most massive black hole observed, TON 618, tips the scales at 66 billion times the Sun's mass.

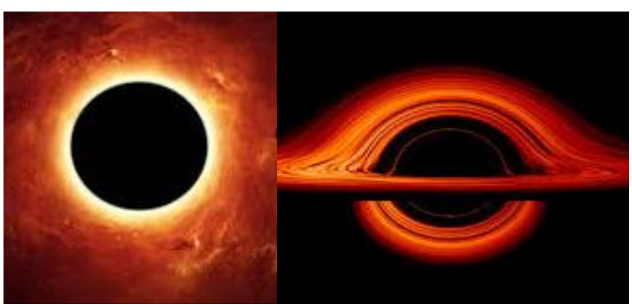
THE SMALLEST?
The lightest-known black hole is only 3.8 times the Sun's mass. It's paired up with a star.

DO BLACKHOLES SPIN?
All black holes spin. The fastest-known – named GRS 1915+105 – clocks in at over 1,000 rotations per second.

Black hole week!
The first week of May is celebrated as black hole week.

Types of Black Holes

Astronomers generally divide black holes into three categories according to their mass: stellar-mass, supermassive, and intermediate-mass.



Stellar Black Holes. When a star with more than eight times the Sun's mass runs out of fuel, its core collapses, rebounds, and explodes as a supernova. What's left behind depends on the star's mass before the explosion. If it was near the threshold, it creates a city-sized, superdense neutron star. If it had around 20 times the Sun's mass or more, the star's core collapses into a stellar-mass black hole.

Supermassive Black Holes. Some supermassive black holes formed in the first billion years after the birth of the universe. It's possible these black holes began with the collapse of supermassive stars in the early universe, which gave them a head start. Scientists know supermassive black holes can grow by feeding on smaller objects, like their stellar-mass relatives and neutron stars. They can also merge with supermassive black holes when galaxies collide.

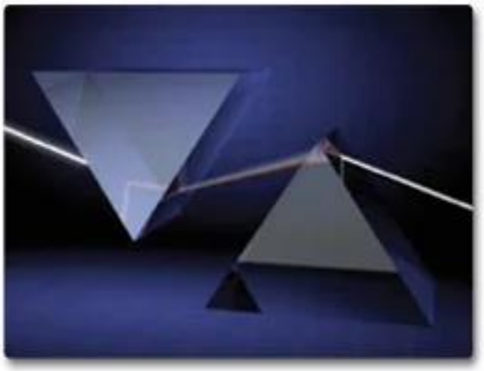
Intermediate Black Holes. They think there should be a continuum of sizes because, over cosmic time, collisions between stellar-mass black holes should have created some intermediate-mass black holes. These should range from around one hundred to hundreds of thousands of times the Sun's mass – or tens of thousands, depending on how supermassive black holes are defined.

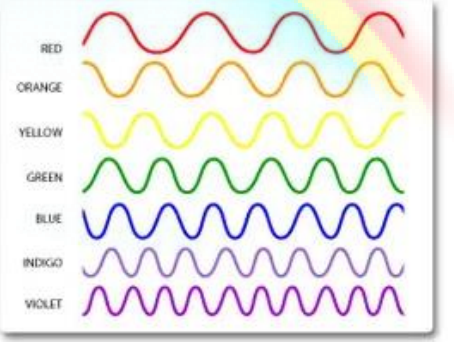
TEST your PHYSICS KNOWLEDGE!

Scan the code, log in to your school account, and take the quiz

The Physics of Colour

Physics paints our world. By Gia Sunassy.





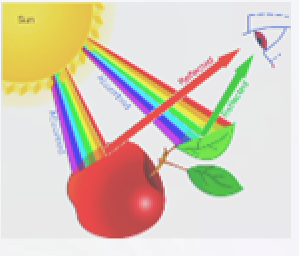
What is visible light? Visible light is the segment of the electromagnetic spectrum that the human eye can view. In short, this range of wavelengths is called visible light and typically the human eye can detect wavelengths from 380 to 700 nanometers.

Wavelengths of visible light. All electromagnetic radiation is light, but we can only see a small portion of this radiation, which we call visible light. Special cells called cones, found in our eyes act as receivers, tuned to the wavelengths in this narrow band of the spectrum. Other portions of the spectrum have wavelengths too large or too small and energetic for the limitations of our perception, which is why we cannot see them, like with UV light. As the full spectrum of visible light travels through a prism, the wavelengths separate into the colors of the rainbow because each color is a different wavelength. Violet has the shortest wavelength, at around 380 nanometers, and red has the longest wavelength, at around 700 nanometers. This is proven by Isaac Newton's experiment in 1665, which showed that a prism bends visible light and that each color refracts at a slightly different angle depending on the wavelength of the color. Each colour in a rainbow corresponds to a different wavelength of the electromagnetic spectrum.

Colour is reflected light. All objects are either: Transparent: they transmit light so objects on the other side can be seen clearly **Translucent**: they transmit light, but the rays are scattered so objects cannot be seen clearly through them, e.g.: frosted glass. **Opaque**: they either reflect or absorb all light incident on them, so no light passes through them. When an opaque object appears coloured, it reflects light of that particular wavelength, and it absorbs other wavelengths. For example, the colour red is not “in” an apple. The surface of the apple reflects the light of the red wavelength and absorbs all the rest of the wavelengths.

Seeing and creating colour

What colours do animals see? Birds, fish, and many other mammals perceive the full spectrum. Some insects, especially bees, can see ultraviolet colours invisible to the human eye. In fact, colour camouflage, one of nature's favorite survival mechanisms, depends on the ability of the predator to distinguish colours. The predator is expected to be fooled by the colour matching of the prey. Until recently, it was thought that dogs didn't see any colour at all. Recent studies now show, however, that dogs can differentiate between red and



blue and can even pick out subtle differences in shades of blue and violet.

Mixing colours. Colour can be created by combining or removing light. Additive and subtractive colour mixing are two different ways of combining colours to create new ones. Additive colour mixing is used when working with light. If different coloured lights are combined, they create a new colour. For example, when red, green, and blue lights are mixed in equal amounts, they create white light. Adding fewer colours or reducing the intensity of the combined colours will result in different shades and hues. This is how computers, televisions and other electronic displays create colours. Subtractive colour mixing is used when working with pigments, inks or dyes. If different pigments are mixed, they subtract wavelengths of light, and the result is a new colour that is a combination of the remaining wavelengths. For example, when cyan, magenta and yellow pigments are mixed in equal amounts, they create black. Adding fewer colours or reducing the amount of combined colours will result in different shades and hues. This is how printers create colour.

Additive colour

Subtractive colour

The Phantom Galaxy!

The Why, The Where and The What? By Aine Burke.

The Phantom Galaxy – its a spooky name that certainly raises interest, but what is it and why is it named that way? The Phantom Galaxy (known scientifically as M74) gains it's name from it's incredibly low brightness. In fact, it has the 2nd lowest brightness of all deep-space objects in the Messier catalogue (a collection of outer space objects discovered by French astronomer Charles Messier). This makes the galaxy extremely hard to find and take pictures of – even with incredibly powerful telescopes like Hubble or James Webb.

So that's the why – let's talk about where in the universe it is. M74 can be found in the constellation Pices, facing directly towards Earth. It is about 32-million lightyears away meaning if we built a rocket that could travel at the speed of light (which is the fastest speed we know of) it would still take 32 million years to get there! That's a long roadtrip! It has a gorgeous and clear spiral shape with arms of stars and space dust stretching out on either side. The James Webb telescope has recently taken some beautiful pictures using clever infrared photography and viewing longer wavelengths of light than what the human eye can see. These images a crystal clear and some of the best pictures taken of the galaxy so far and a lack of gas covering the middle has revealed an unobstructed view of the incredible nuclear star cluster at the centre. These photos will allow astronomers to pick apart what gases are present in the galaxy. They'll also allow astronomers a more detailed look into the star-forming regions of the galaxy and accurately measure mass and age of star clusters.

These observations are part of a larger effort to chart 19 nearby star-forming galaxies in the infrared by the international PHANGS collaboration. This information can be used alongside other observations from telescopes that cover a wide range of the electromagnetic spectrum, providing a greater insight than ever before from any telescope – even one as powerful as Webb - and will be a huge step in understanding the formation of our universe!

Breathtaking Image of the Phantom Galaxy, also known as M74 captured by the James Webb Space Telescope

QUANTUM COMPUTERS

WHAT IS ALL THE FUSS ABOUT?

By Summer Mac Robert Smith & Mrs Klimi

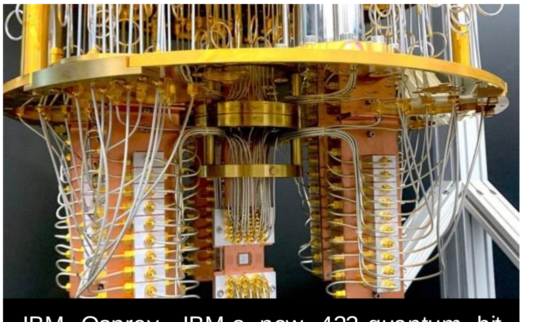
Quantum computers are super-powerful machines that work completely differently from the computers we use every day. While regular computers use bits that are either 0 or 1, quantum computers use special quantum bits, or "qubits," that can be 0 and 1 at the same time - kind of like being able to be in two places at once! This magical ability lets quantum computers solve incredibly complex problems much faster than traditional computers. Companies like IBM are leading the way in developing these incredible machines, creating quantum computers that can potentially tackle huge challenges in science, medicine, and technology.

Imagine being able to solve math problems that would take a regular computer *thousands of years* to figure out in just a few minutes! That's the incredible potential of quantum computing!

These computers use the weird and wonderful rules of quantum mechanics, which are like a secret superpower that allows them to process information in ways we've never been able to do before. Scientists are excited about how quantum computers might help us understand complicated things like climate change, discover new medicines, or even help us explore space more effectively.

Advances in Quantum Computing

In November of 2022, the IBM quantum summit announced a new breakthrough in the advancements of quantum hardware and software, and outlining its pioneering vision of quantum centric supercomputing.



IBM Osprey—IBM,s new 433-quantum bit (qubit) processor

IBM Osprey has the largest qubit count of any IBM quantum processor, more than tripling the 127 qubit on the IBM Eagle processor, unveiled in 2021. This new processor has the ability to run complex computation well beyond the capability of the classic computer.