JUNE 2025
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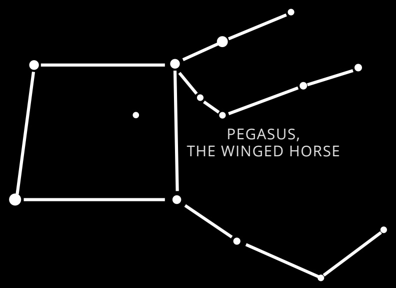


ASTRO DIGEST

DOUBLE TROUBLE

A PAIR OF WHITE DWARVES ARE INSPIRALLING AND WILL EVENTUALLY COLLIDE – AND WE KNOW WHEN!!

HISTORICAL GUESTS

ANCIENT ASTRONOMICAL RECORDS OF SUPERNOVAE EXPLOSIONS

EINSTEIN TELESCOPE

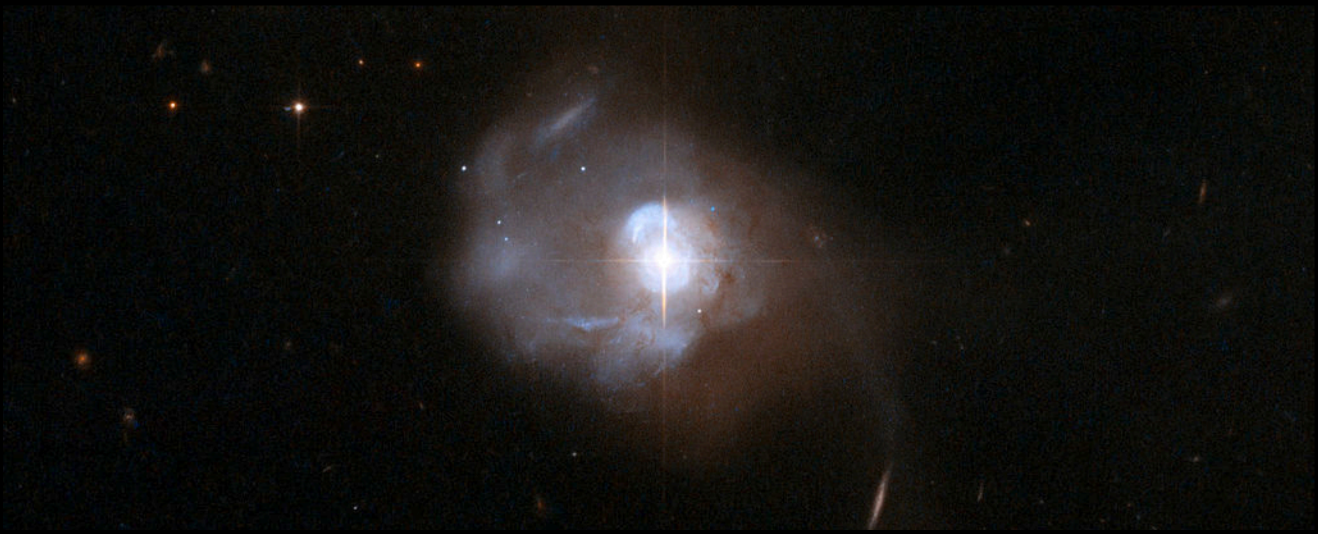
IF YOU THOUGHT LIGO WAS COOL, WAIT TILL YOU HERE ABOUT THIS ONE

TRIVIA

BECAUSE THE UNIVERSE LOVES TO KEEP US GUESSING!

EVENTS & STARGAZING

FEATURED STARGAZING LOCATION & OBJECTS



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DOUBLE TROUBLE

Grab your sunscreen, beach chair, and block out your calendars for we have a supernova explosion incoming – in precisely 23 billion years! That's right, we know exactly when it is going to occur, as detailed by a landmark paper in the prestigious journal Nature. As far as we know, while supernovae have been indirectly predicted in the past, they have only been done so indirectly. Specifically, through duplicated images of gravitationally lensed supernovae. This recent discovery presents a direct prediction of a supernova, making it an incredibly novel find.

TYPE IA SUPERNOVA. SOURCE: DALL-E

The above is an artist's depiction of a Type Ia supernova. The spiky outflows of ionised gas imply the tremendous speed and energy of the supernova explosion.

First and foremost - what are supernovae? They are the transient last stage of many stars, extremely energetic explosions, often outshining their host galaxy where the outer envelope of the star is blown off.

While the common denominator for all supernovae is their characteristic explosion, the preceding and postceding events vary greatly in nature. Our supernova of interest, called a Type Ia supernova (dubbed SNIa – SN: Supernova, Ia: Type Ia), takes a very specific pathway. Central to a SNIa is a white dwarf star, which is yet another end product of stellar evolution; it's a dense ball, usually consisting of carbon and oxygen, with sometimes also magnesium and neon. The white dwarf star accretes mass from a companion star, eventually reaching a critical mass where the right conditions are met for fusion to reignite in the core. This fusion undergoes a chain reaction, causing the entire core to start fusing at roughly the same time, causing tremendous outward pressure, which in turn causes the outer layers to explode outward at relativistic speeds. This explosion is nothing other than the supernova itself!

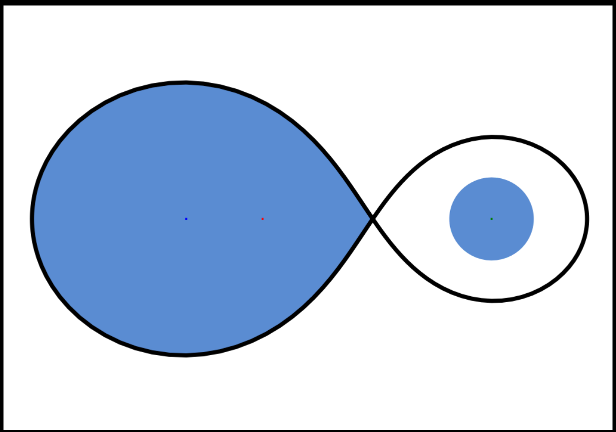
DOUBLE WHITE DWARF MERGER, ARTIST'S DEPICTION. SOURCE: WIKIMEDIA

DOUBLE TROUBLE

It turns out that, regardless of how or what type of mass is accreted, the supernova occurs beyond a very specific mass, 1.4 solar masses, and the resulting explosion too happens in a set manner as will now be described. This mass is the Chandrasekhar limit, discovered by the late Nobel laureate and astrophysicist Subrahmanyan Chandrasekhar. It is one of the few results in physics that was entirely theoretically derived and later observationally verified. As an aside, you might wonder how we can observationally verify that white dwarfs explode beyond the Chandrasekhar limit. Turns out, this is pretty hard to achieve. But neatly enough, if we can statistically verify the contrapositive of this – namely “If a white dwarf does not explode, then it did not exceed the Chandrasekhar limit” – then we have indeed verified the initial implication. Satisfyingly enough, all known white dwarfs to date fall below this limiting mass. The heaviest known white dwarf, ZTF J1901+1458, happens to be 1.35 solar masses, falling just marginally shy of the limit – satisfying!

Our system of concern happens to be even more interesting – it is a double white dwarf binary, and both stars are set to explode in a spectacular double SNIa! What’s more unique is their accretion process.

Most SNeIa we know of occur due to a white dwarf slowly accreting matter from its main-sequence companion. In this system, however, the white dwarfs are expected to remain dormant for an extremely long period. In fact, there is no main-sequence star involved! That begs the question: how are the stars going to accrete matter for their inevitable cataclysmic end? Surely it can’t be that one of them will transfer mass to the other, right? They are, after all, extremely tightly held due to their compact size and humongous mass. Well, that’s just it! Over billions of years, these hapless binaries will fall closer and closer to each other, gradually losing gravitational energy through gravitational waves, eventually getting close enough such that one will fill its Roche lobe due to tidal distortions and the mass transfer to the other will begin.

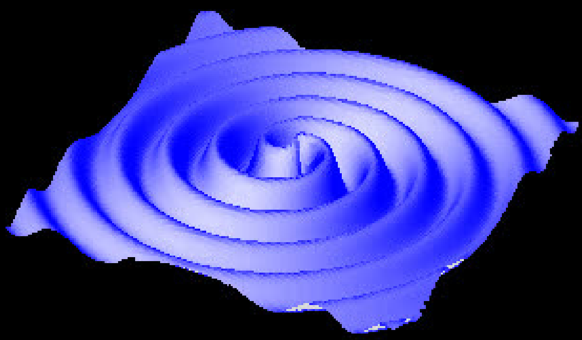


FILLING OF THE ROCHE LOBE. SOURCE: WIKIMEDIA

DOUBLE TROUBLE

There's a lot of heavy terminology used there, so let's unpack that. Firstly, what are gravitational waves? You may have heard this in the context of LIGO, or the Laser Interferometer Gravitational-wave Observatory, which first detected gravitational waves back in 2015. To understand this, we have to invoke Einstein's theory of general relativity, which showed that gravity is nothing other than the bending of space and time in the presence of mass and energy. This bending can also be dynamic, particularly when mass is made to accelerate, causing the bend itself to travel through space. This is also known as a wave! A close analogy to this would be when you push your hand on still water, making a wave that propagates away carrying the kinetic energy your hand gives to the water. Going back to our double white dwarf binary system, conservation of energy demands that the energy for the gravitational waves must come from somewhere, whose source you probably already guessed: the system's gravitational potential energy! As this potential energy is lost, the dwarves inevitably fall closer together.

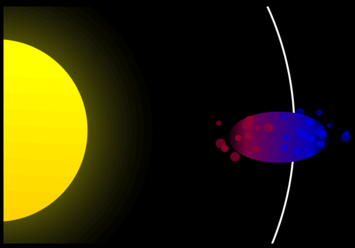
Next, we have to understand the concept underlying the Roche limit, which the minimum distance an object can remain gravitationally bound in the presence of an external object's gravitational field.



GRAVITATIONAL WAVES
As two compact objects orbit their common centre of mass, they slowly spiral in, emitting gravitational waves in the process.

Since gravity from a spherical source is not uniform, different parts of an object orbiting a larger body feel different amounts of tug from that body. Assuming gravity is the only force holding the object together (i.e., ignoring electrostatic forces between the clumps of matter comprising the orbiting body), it will get ripped apart if it gets too close to the body it is orbiting, as the force difference between the closest and farthest point (see the diagram on the next page) of the orbiting body, with respect to the host body, becomes too large. The minimum distance where it is not ripped apart is known as the Roche limit. Going back to our double white dwarf system, their inspiralling leads to the mass transfer from the lighter to the more massive white dwarf, as the former approaches its Roche limit first. We will label the more massive one as the primary.

DOUBLE TROUBLE



ROCHE LIMIT. SOURCE: WIKIMEDIA
As an orbiting body approaches the roche limit of its host body, the former rips apart and forms a ring around the latter. Some or all of the material falls into the host body.

As the mass transfer progresses, localised compression and heating occur on the primary due to the infalling matter. Eventually, ignition conditions are reached, such that the helium on the surface begins to fuse, sending shockwaves toward the core, causing the carbon in the core to ignite and start fusing. In this process, called carbon detonation, the fusion occurs explosively, unlike in the core of main-sequence stars where carbon fusion occurs gradually and steadily. This explosive fusion causes the primary star to entirely explode, leaving no matter behind in the core, and the force of the shockwave from this explosion ignites the helium on the secondary dwarf, incepting a similar process that causes it too to explode, thereby giving us a double supernova!

Interestingly enough, though, this double supernova is classified as a subluminous SNIa, as its peak luminosity happens to be less than that of a conventional SNIa. That is not to say it released less energy – it actually releases a comparable amount to a conventional SNIa – but its progression is much different from a normal, single binary SNIa resulting in a less luminous supernova.

Regardless, because the actual (and difficult to model) mass-accretion period is negligible compared to the well-modelled and calculable inspiralling period, we can to a fair degree of precision calculate when the merger will happen: 22.6 ± 1.0 Gyr.

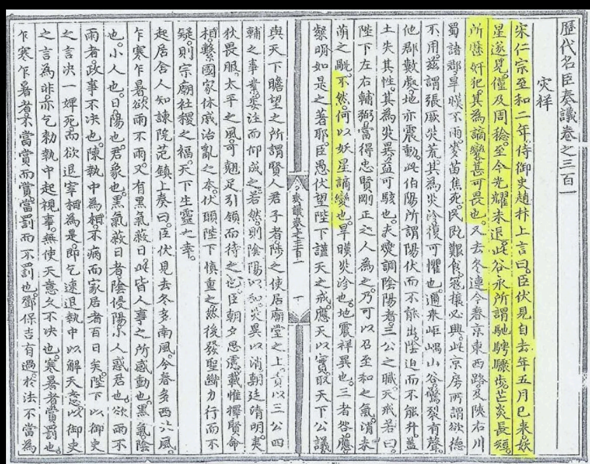
Such double detonation SNeIa have far-reaching consequences for our understanding of stellar evolution. Particularly, there presently exists a discrepancy between the observed rate of SNeIa originating from super Chandrasekhar mass systems, standing at 0.000044 per year, and the theoretically predicted rate of ≥ 0.0006 per year. Such discoveries help us close the gap and open doors in other areas in astronomy, such as cosmology, that critically rely on our understanding of SNeIa. Either way, see you later at the supernova party!

HISTORICAL GUESTS

Even though our predecessors lacked the technological and scientific advancements we have now, it is clear that they were just as curious and meticulous with their surroundings as our astronomers. Numerous archives of works and great buildings were erected from the careful observations of our shared night skies. Not only did the night sky represent their timekeeping, the calendars that were indispensable to their agricultural way of life, it also represented the powers that were literally and figuratively above them, their gods, their myths, their origins. By exploring the oldest records of our oldest science, we gain a greater understanding of our ancestors and their culture.

The celestials may seem static and eternal to them, but, there would have been times where the veil would falter for just a moment; the most drastic would be supernovae. These luminous explosions would be impossible to miss by early scientists. New stars from nothing, stars that would rival the planets or the Moon in brightness, stars visible in the day; how are ancestors interpreted them reflects their outlook and interpretations of their surroundings, and these vivid reflections have been cemented in their records of such events. The concept of supernovae, and our ways of astronomy would have been perplexing to these ancient people.

Likewise, their astronomy would have been hard to understand. Many ancient records allude to astronomical events that may allude to observations of a supernova, the earliest of which comes from records from ancient Chinese astronomers. As opposed to their counterparts from other ancient astronomers, ancient Chinese astronomers were state-appointed and acted as full-time civil servants. This resulted in a very meticulous record of observations spanning from the 6th Century BCE. There are numerous instances of “guest stars” in this wealth of records, used to refer to observations of stars showing up in areas where none existed previously, disappearing some time after. Living in the modern age, we can identify them as variable stars, comets, and supernovae.



OUR OLDEST RECORDS OF SUPERNOVAE COME FROM ANCIENT CHINESE RECORDS. SOURCE: JOURNAL OF ASTRONOMICAL HISTORY AND HERITAGE (ISSN 1440-2807), VOL. 9, NO. 1, P. 77 - 82 (2006)

HISTORICAL GUESTS

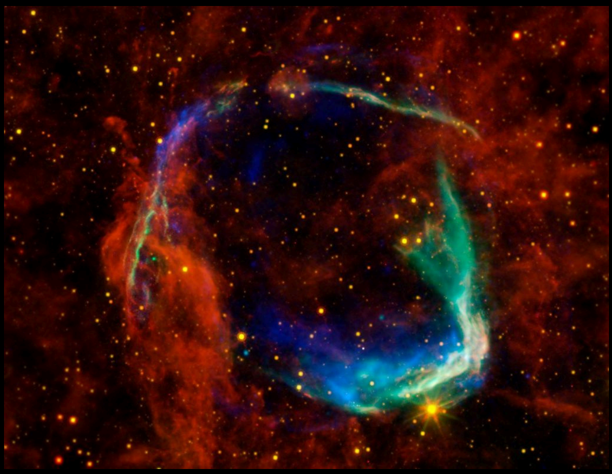
The oldest supernova candidate is a guest star recorded “On the day kuei-hai in the tenth month of the second year of the Chung-p'ing reign period,” corresponding to the 7th of December 185 CE. The guest star was visible in the night until the “Sixth month of the year following the next year,” lasting 20 or 8 months, depending on the interpretation of the original text. The guest star was described shining in various stars, and was described to be located in the middle of the “Southern Gate,” a Chinese asterism that contains Alpha Centauri and epsilon Centauri.

A gaseous shell, RCW 86, has since been observed in the vicinity of the asterism. Recent calculations have put the age of the debris cloud to be around 2000 years, linking the cloud to our Guest Star!

The above record was found in the chronicles of the Han Dynasty, which later comments on the meaning of the guest star, drawing a connection between the appearance of the star with the series of political instabilities in the capital transpiring 5 months later. Guest stars were often seen as omens, signs of great change.

To explore reactions from other cultures of similar events, we point our scopes to Messier 1, the Crab Nebula. Charles Messier may have mistaken it for a comet, triggering him to create his famous Messier Catalogue, but this object's history of fooling astronomers goes further back.

To many early astronomers looking at that region between 10 July 1054 and 12 April 1056, it may have appeared that a star had just appeared out of the abyss. This supernova appearing in 1054 (SN 1054), one of the most widely observed supernovae, was recorded by Chinese, Japanese, European, Islamic, Native American and Aboriginal cultures!



RCW 86. SOURCE: NASA
RCW86 contains the remnants of the oldest documented supernova we currently know of. Its bow shock clearly looks to be pushing out the surrounding interstellar medium.

HISTORICAL GUESTS

According to one surviving Islamic record, SN 1054 was the cause of the lowering of the Nile river that occurred in the year of its observation. This event was said to have caused an epidemic within the Capital of Egypt.

Although European records of SN 1054 are less direct, with multiple possible interpretations, surviving records of SN 1054 and a supernova appearing in 1006 suggests that such events were considered to be signs of impending plague and famine.

From the Old world to the New, we look at a surviving piece of rock art in Chaco Canyon, New Mexico. Dating has put human activity in the region between the 9th and 13th Century, reaching its height in the 11th century. Within the wealth of diagrams in the region is one placed high above the ground along a cliff.

A crescent moon is placed squarely next to a pictograph of a shining star. A crescent moon would not be able to form if the star depicted the Sun. However, for the first few days of SN 1054's appearance, a crescent moon would have been located next to this new star.

The hand print next to the map shows that the diagram depicted was of great importance to the people staying there. A series of concentric circles with iridescent rays may also allude to an observation of Halley's comet, which would have been visible in the same region just 12 years after SN 1054 first appeared.

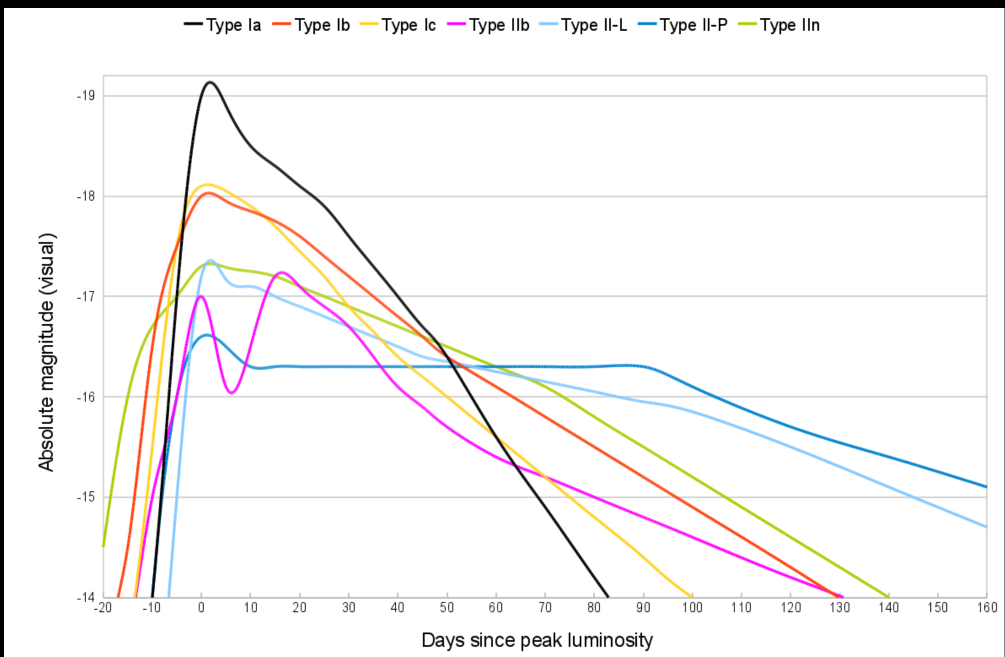
CHACO CANYON ROCK ART.
SOURCE: ROB PETTENGILL (HTTP://BADASTROPHOTOS.COM/)

Rock art depicting various pictograms above a colourful set of concentric rings

HISTORICAL GUESTS

Signs of guest stars have also been observed in records of Aboriginal Oral Traditions. One example is a story regarding the appearance of a new bright star on the night of a funeral procession for a community member, following his sacrifice at sea to save his brother. Myths surrounding constellations are also often found in many records, one of which includes a character that is mentioned to be moving around the sky. Given that characters in such myths are often represented by bright stars around the region, a transient star like SN 1054 fits the criteria for a moving star.

With each culture, we see a different interpretation of changes to the sky. From omens of the future to signs of great people or periods. We can see each culture's perception of the lights in the night. Each interpretation is a reflection of their culture, but standing on the shoulders of these giants, we see a clearer picture of the reality of these guest stars; we know better than to scream of impending plague and famine when a new star appears in our skies. Like a tower, our perception of knowledge stabilises as we add to its foundation; this is the value of inquiry into our reality. Who knows what aspects of our universe will change when our decendants look back with better eyes? We stand on the shoulders of giants, climb on!



SUPERNOVAE LIGHT CURVES.
SOURCE: WIKIMEDIA
Light curves, showing the light intensity of different types of supernovae as a function of time, highlighting their transient nature.

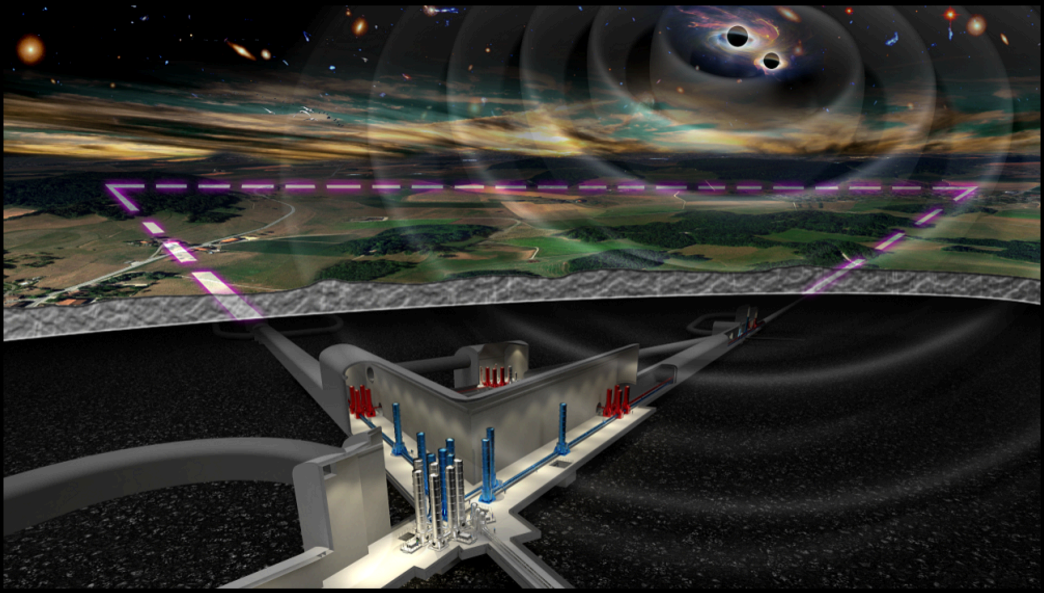
EINSTEIN TELESCOPE

In two locations in Europe, scientists and engineers are studying the possibilities of building a new detector for gravitational waves, which should be placed some 250 metres below the Earth's surface. A triangle with edges of 10 km, the Einstein Telescope will have a size similar to that of the circular particle accelerator CERN in Geneva.

The Einstein Telescope (ET) will expand a young area in the science of astronomy, that of the gravitational waves. For millennia, we have watched the stars. We have, however, mostly done this using only different types of light: fist visible, then infrared and ultraviolet light, and finally observing radio waves and gamma rays.

Gravitational waves are not light waves, but waves created by moving mass. We were unable to “hear” those waves, until the American LIGO facilities detected the collapse of two black holes in 2015. Just like the observations of light were expanded into other wavelength regimes, ET will expand our view of the gravitational-wave universe into lower frequencies.

The costs of building ET are estimated to be over 2.2 billion euros, a number that is only going up as everything is getting more expensive. This is a huge amount – and we do not even know what we are going to find. But as Faraday allegedly responded to a query about the practical use of his experiment: “Why, sir, there is every probability that you will soon be able to tax it!” After all, intrinsic curiosity is always the source for new technology.

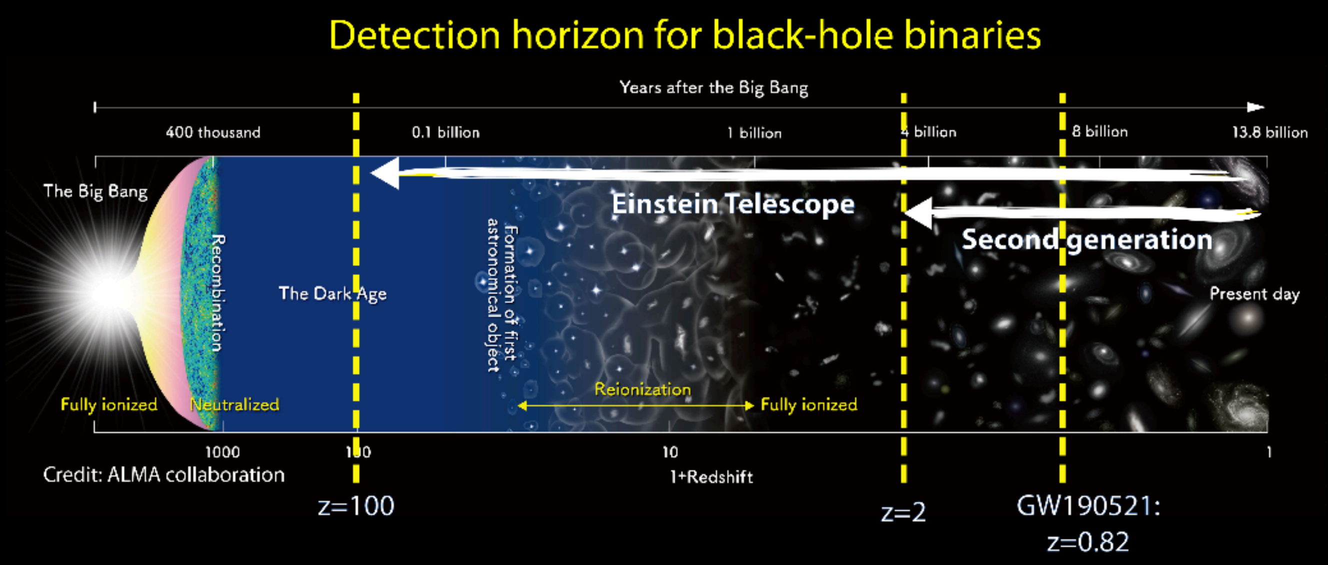


ET PICTORIAL. SOURCE: ET | EINSTEIN TELESCOPE

EINSTEIN TELESCOPE

Fundamental research requires a lot of patience. In 1919, nobody had any clue what use Einstein's Theory of General Relativity would have. However, without it, we would not have GPS systems today, and we would not be able to find our way. Similarly, the CERN facility has as a goal to find out the smallest structures of matter, by smashing particles into each other. As some spin-offs, the internet and touchscreens were invented there, as well medical applications such as proton treatment. Hardly anybody goes without LEDs or microchips these days, but nobody was thinking about LEDs or microchips when they were developing quantum mechanics in the early 20th century.

Where CERN looks as the tiniest parts of matter, the Einstein Telescope addresses larger events in the Universe: collisions between black holes or neutron stars. These events took place billions of years ago, so the ripples they created have become incredibly weak, and we require extraordinarily sensitive apparatus to detect them. Picture the South China Sea, which covers an area of around 3,500,000 square kilometres. If you add one drop of water to that, you are on the scale of a detection of gravitational waves. Einstein himself thought: forget it, we will never be able to measure this!



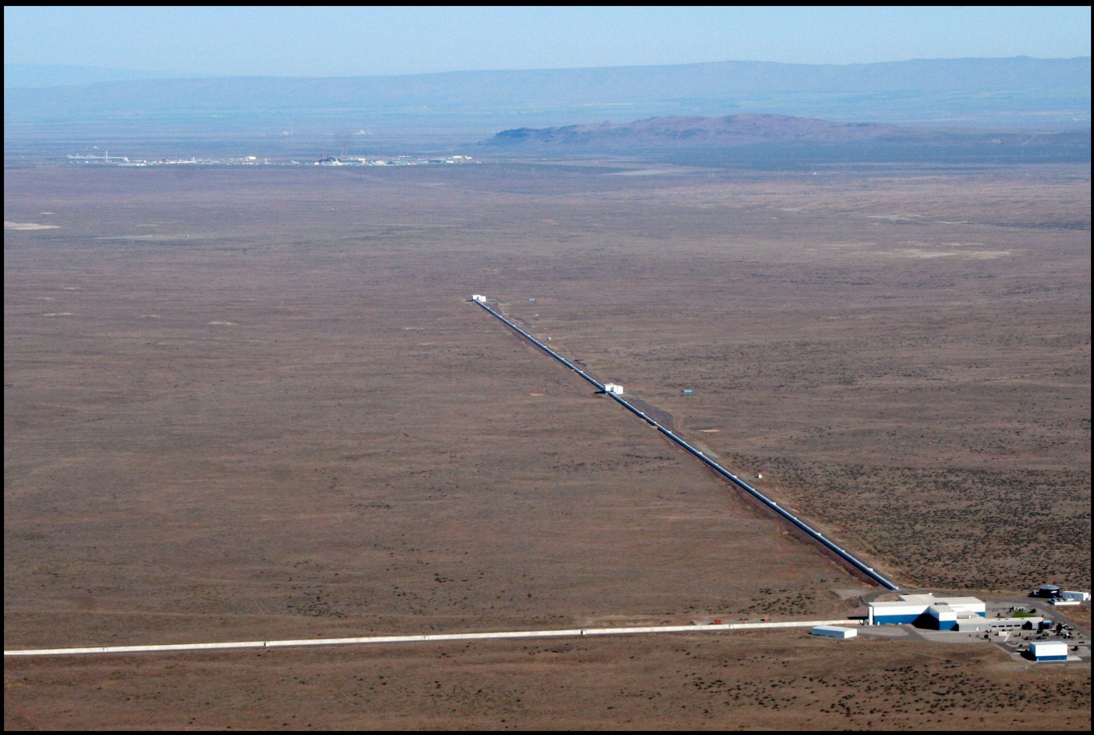
ET UNIVERSE. Source: ESO/NAOJ
The Einstein Telescope (ET) is a proposed underground infrastructure to host a third-generation gravitational-wave observatory. It builds on the success of current, second-generation laser-interferometric detectors Advanced Virgo and Advanced LIGO, whose breakthrough discoveries of merging black holes (BHs) and neutron stars over the past 10 years have ushered scientists into the new era of gravitational-wave astronomy.

EINSTEIN TELESCOPE

In 2015, it was achieved after all. The detectors of LIGO in the US and Virgo in Italy caught gravitational waves, a discovery that was rewarded with the Nobel Prize. Einstein Telescope will make everything even more precise. This requires the development of a system that can cool a vibration-free environment to -262 degrees Celsius.

Scientists and engineers have to be creative to come up with this technology: it is not only the theoreticians that are sitting in some attic calculating the behaviour of gravitational waves that use their creativity on a daily basis to push science forwards.

One may wonder why governments are willing to sponsor a scientific endeavour that costs billions of dollars. The reason is that similar large projects have seen a return of investment of some three or four euros for every euro that is put in them: Switzerland and France are still making a disproportionate amount of money off of CERN. Perhaps Singapore can also boost its economy, just by investing a couple of billion in projects that do “nothing more” than expanding our knowledge of the workings of the Universe.



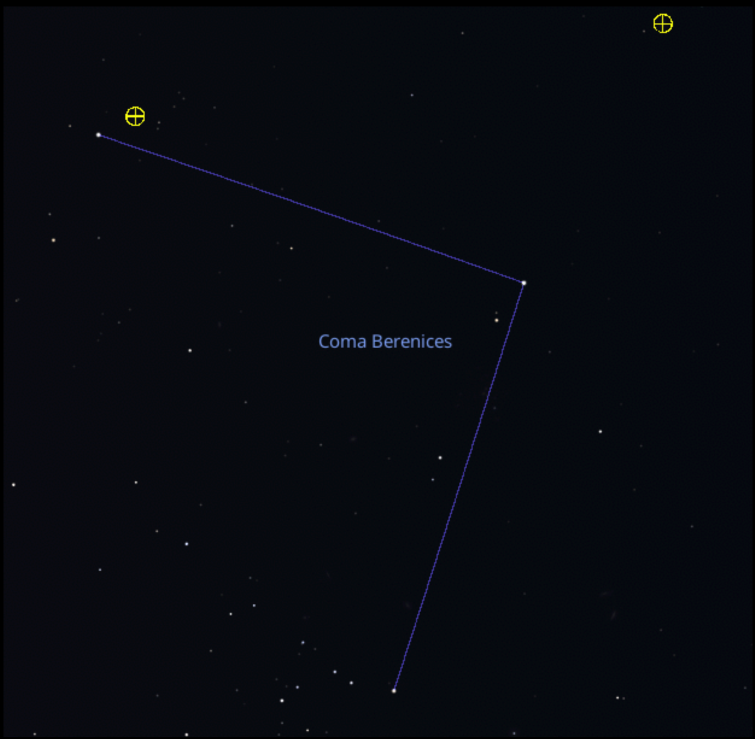
LIGO HANFORD OBSERVATORY. SOURCE: WIKIMEDIA
The two 4km long arms of the LIGO Hanford observatory are seen in the picture above.

TRIVIA

Welcome to the Trivia! Here, we will include interesting facts and problems that we have curated for you, the reader.

The answers to the problems can be found in the next newsletter, but for now, we hope you'll enjoy this new segment!

Problem I
Identify both the Messier objects in the following photo.



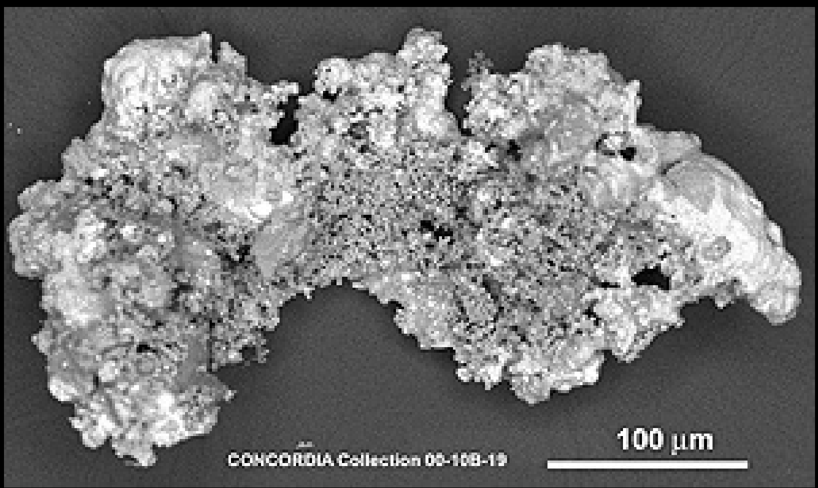
Problem II

Roughly how long does it take for a massive main sequence star to fuse all the silicon in its core to iron i.e. before it goes supernova?

TRIVIA

Fun Fact of the Month

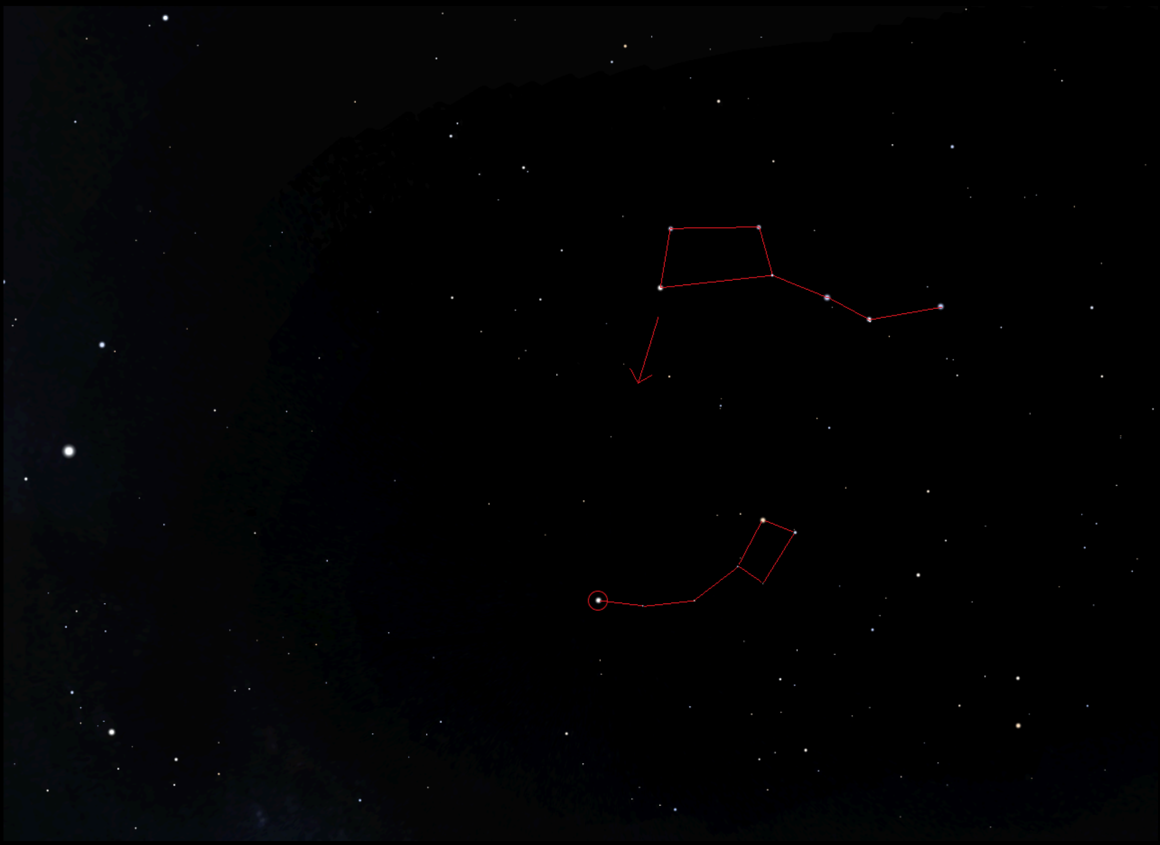
Believe it or not, you might be carrying a tiny piece of space on your head right now. Those dazzling streaks across the night sky? Some of them—micrometeorites—actually make it all the way to Earth. According to Dr. Alastair Gunn in BBC Science Focus Magazine, if you stood in the same outdoor spot all day every day, you'd be hit by one roughly once every 13 years. So, if you spend about half your time outside, chances are you've already been gently "kissed" by space dust at least once by the time you're 26!



Source: NASA
This and other micrometeorites teeter on the edge of what our eyes can see. This particular one was collected from Antarctic snow, from where pristine samples are often collected.

ANSWERS FOR THE PREVIOUS NEWSLETTER

Problem I



Problem II

Standard Candles are celestial objects or phenomena that have a known brightness and can thus help us accurately measure the distance to them by measuring their observed flux. A prominent example of this is Type Ia supernovae, which have a peakness absolute magnitude of -19.3, or equivalently 4.13 billion times the sun's current power output! Another example of this is are Cepheid Variables, which are stars which experience extremely periodic pulsations that are directly tied to their maximum and minimum brightness during said pulsations.

EVENTS AND STARGAZING

Featured Stargazing Location: Changi Beach Park

Source: NParks

One of our more hidden spaces, Changi Beach park's elusiveness is precisely what makes it one of the best stargazing spots in Singapore. With its pristine shoreline, panoramic views of the Johor Straits, and Malaysia's lush landscape as a distant backdrop, this location gives an idyllic energy which provides the ideal ambience for laying back and losing yourself in the stars. I mean, who doesn't love the sound of waves crashing against sand as they stare up into the pearly, speckled night sky?

To make the experience even more scenic, the Changi Bay Park Connector links the area to the larger Park Connector Network, giving cyclists and walkers a beautiful, uninterrupted stretch to explore. Not far off, the Changi Boardwalk meanders along the coastline with sea breezes and uninterrupted views—ideal for a pre-stargazing stroll or a quiet moment before night falls.

Changi Beach Park is also a lot more accessible than it might seem. From Tanah Merah, take Exit B and hop onto Bus 9, alighting at Changi Beach CP4. There is also the option of taking Bus 89 from Pasir Ris Station Exit B.

Food is also not a worry, as numerous eateries that are less than 15 minutes by walking from the beach, and within the iconic Changi Village complex.

So, what are you waiting for? Grab as many of your astronomy enthusiasts friends as you can and head on down to Changi Beach Park for an unforgettable night filled with stargazing, sea breeze, and maybe a few soulful conversations too.

EVENTS AND STARGAZING

Event Showcase: On the Moon Again

Source: https://www.onthemoonagain.org

Ever find yourself staring at our pearly celestial companion wanting to share the joy of it with others? Well, wait no longer, as the world gathers to celebrate the joy of the Moon with their fellow humans from 6-8 June 2025, with the event titled “On the Moon Again”. This date is in honour of the French astronomer and science populariser Camille Flammarion, whose 100th year death anniversary falls in this month. This event also seeks to carry forward the momentum from 2019, when this festival was first incepted in celebration of the Moon Landing’s 50th anniversary.

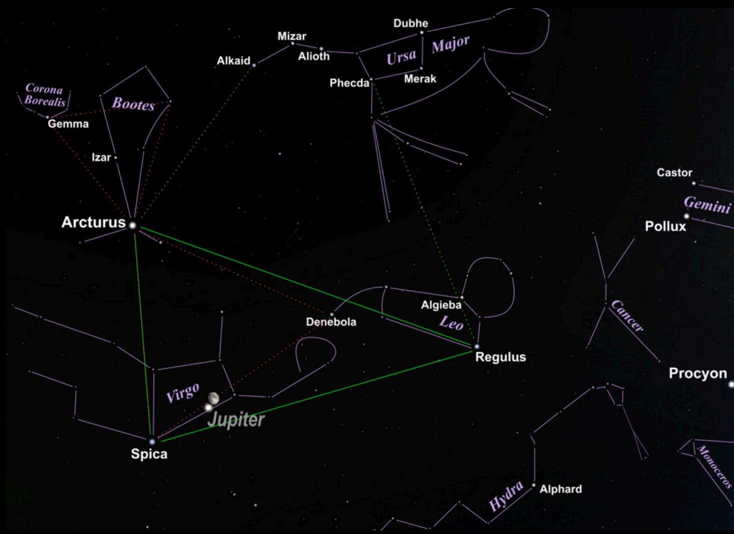
To participate, you may set up your telescope or other viewing apparatus in public spaces–with due permission, of course–and offer passersby a chance to to view the Moon’s beautiful surface firsthand. This event aims to make the joy of lunar observation more accessible to common people, with the hope of fostering a collective sense of wonder and curiosity about our closest celestial neighbour.

If you’re already in a part of a local astronomy group, then all the better! This is a perfect opportunity to extend outreach to interested members of the public.

Ultimately, whether you're an experienced astronomer or a casual stargazer, your participation can inspire others to look up and explore the night sky. For more details on how to get involved, visit onthemoonagain.org.

EVENTS AND STARGAZING

June's skies offer a new chapter of the celestial sphere.



The Spring Triangle highlighted
Source: Stellarium

Free-hand stargazing

- **The Spring Triangle -** This asterism consists of the bright Spring stars: Arcturus, Regulus and Spica. A smaller Spring triangle is formed replacing Regulus with Denebola

The False Cross within Carina
Source: Stellarium

- **The False Cross -** Commonly mistaken for the Southern Cross, this asterism has a similar declination to the real deal. If you ever land on this while finding Crux, head east.

- **Mars - Regulus visual binary -** Contrasting Regulus' blue glow, the red planet will be spotted near this bright star in Leo, reaching their closest approach on 18th June.

Mars and Regulus forming a visual binary in Leo
Source: Stellarium

EVENTS AND STARGAZING

The Southern Pleiades
Source: Stellarium

Binoculars

- **Southern Pleiades (IC2602) -** To locate the Southern Pleiades (Theta Carinae Cluster) , look low in the southern sky during late summer to early autumn evenings, near the bright star Canopus in the constellation Carina. It appears as a small, loose star cluster best seen with binoculars or a telescope due to light pollution.

- **Beehive Cluster (M44) -** Look west in the early evening skies, in the constellation Cancer between the bright stars Castor and Regulus. It's visible to the naked eye in dark skies but best viewed with binoculars.

- **Butterfly Cluster (M6) -** Look low in the south-western sky on clear evenings, near the tail of the Scorpius constellation. It's best seen with binoculars just above the bright star Shaula.

The Beehive Cluster
Source: Stellarium

The Butterfly Cluster
Source: Stellarium

EVENTS AND STARGAZING

Telescope

- **Ptolemy's cluster (M7) -** This open cluster was first recorded in the 2nd century by the Greek astronomer Ptolemy, who had incorrectly labelled it as a nebula. It can be easily located by taking the 2 nearby stars, Shaula and Lesath, at the end of Scorpius' hook. The cluster can be found by extending a the line between the 2 stars away from Scorpius.

Ptolemy's Cluster
Source: Stellarium

- **Jewel Box Cluster(NGC 4755) -** To spot the Jewel Box Cluster (NGC 4755), look low in the southern sky around 9 pm, which is when it will be around its highest point. It is near the bright star Mimosa in the Southern Cross (Crux) constellation.

Jewel Box Cluster
Source: Stellarium

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Events and Stargazing

Changi beach Park
On the moon again

Trivia

Micrometeorite