Author: Mollie Irvine

Black holes

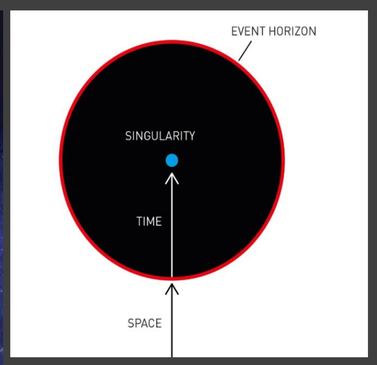
Formation of a black hole

..occurs when gravity becomes so immense that not even light can escape! This is due to a concept known as escape velocity: the speed required to escape the gravity of a body and enter its orbit. For Earth, this is 11km/s; for the sun, it is 600km/s; for a neutron star, that reaches a whopping $\frac{1}{2}$ the speed of light. And in case you haven't guessed, for a black hole, this figure equates to or exceeds the speed of light!

There are a number of ways gravity can become so immense, including…

- The death of supermassive stars
- The collision of two or more stars in a binary system, causing gravitational collapse.

An artists impression of two stars colliding.



A diagram stating the basic features of a black hole

Death of a black hole

- Black holes do not last forever.
- We can forecast into the distant future an era in the universe where black holes exist as the only 'normal matter'- *Black Hole Era*.
- We can calculate the remaining lifespan of a blackhole, using an ingenious equation known as the Hawking radiation equation.
- 'Virtual particles' 'pop' into empty space all the time and then immediately annihilate each other. When this happens on the outside of black holes, due to the intense gravity, rather than coming together and destroying each other, they get pulled apart, one entering into the black hole and the other into space to become a 'real particle', taking with it its energy (Hawking radiation). This eventually adds up to mean the black hole loses mass in a very slow and gradual process.
- It takes a supermassive black hole 10^{100} years to fully end!

$$S=\frac{\prod Ak c^3}{2hG}$$

Hawking radiation equation

Crazy facts

- It is hypothesised that there can be 'micro blackholes'- smaller than one stellar mass and sometimes even the size of an atom!
- If you were to be travelling inside of a black hole feet-first, as you neared the event horizon, the gravity acting on your feet would be billions of time greater than the gravity acting on your head. Because of this, your body would be stretched to kilometres long, albeit you would only be the width of a single hair: a process known as **spaghettification**.
- The closer you move to a black hole's event horizon, the slower time passes. This means, if you were to be travelling inside a black hole, to an outside 'observer' (obviously they wouldn't be able to see you since even light cannot escape), you would appear to stop, however, for you, you would watch time speed up and see **all** of time play out before you.
- Ton 618 has been classified as an 'ultramassive black hole', at 100 billion stellar masses!

Types of black hole

There are quite possibly an infinite number of black holes in the observable universe. Scientists assign three main label to blackholes, each based on their 'massiveness'.

Stellar black holes: 3-10 stellar masses.

Intermediate black holes: 100-1000 stellar masses.

Supermassive black holes: millions of billions stellar masses.

Timeline of black hole discovery

1783- British scientist Reverend John Michell proposed the idea of objects with such extreme gravity that even light could not escape.

1916- a friend of Albert Einstein, Karl Schwarzschild, used Einstein's Theory of Relativity to progress understanding of blackholes (Schwarzschild radius for the size of the event horizon for non-rotating black holes) via finding the solution's to Einstein's field equations.

1965- Roger Penrose proves the existence of blackholes and describes their properties.

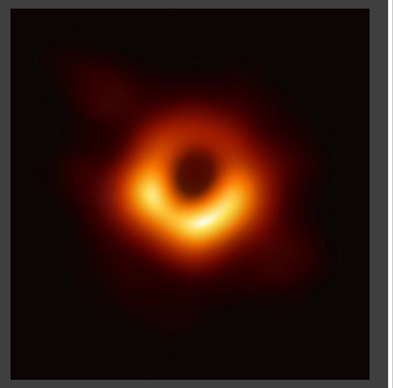
1967- the term 'black hole' coined by John Wheeler (American astronomer)

1971 - first black hole spotted.

1974- Hawking releases his paper describing Hawking radiation and how black holes can slowly shrink and end.

1990's- Reinhard Genzel and Andre Ghez map out star orbital paths to prove the existence of a supermassive black hole at the centre of our galaxy.

2019- the first imaging of a black hole.



Websites and further material

The Man Who Discovered Cosmic Black Holes: Karl Schwarzschild (astronomy.com)

What Stephen Hawking taught us about black holes (discover.com)

The Nobel Prize in Physics 2020 - Popular science background - Nobelprize.org

10 Facts About Stephen Hawking, the greatest scientist of our time ★ | hrs.ng

The Beginning to the End of the Universe: How Black Holes Die | Astronomy.com