TEACHER RESOURCE

SCIENCE CONTENT/ CURRICULUM LINK
ASTRONOMICAL SYSTEMS, PHYSICAL INQUIRY AND PHYSICS CONCEPTS, THE STRUCTURE OF MATTER.

STARDOME OBSERVATORY & PLANETARIUM
FACTS, RESOURCES AND ACTIVITIES ON...

STARS (PART 2 – BLACK HOLES, NEUTRON STARS AND WHITE DWARFS)

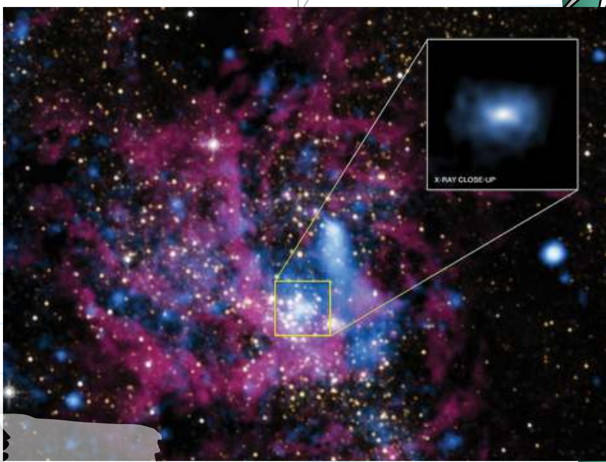
In this resource, we're revisiting the stars in the second part of our star series to learn about the life-cycle of a star. You can find part one here.

Every second the Sun converts 700 million tonnes of hydrogen into 695 million tonnes of helium. Using the equation $E=mc^2$, we can calculate that the Sun must expel about 5 million tonnes of energy every second! By comparing the size of the Sun to the energy it emits, astrophysicists have calculated it is only about halfway through its lifecycle. In another 5 billion years, when the Sun starts running out of nuclear fuel, it will grow into a red giant. As the helium core burns out, the Sun will undergo thermal pulses where the outer layers will spread out, forming a planetary nebula, and the core of the Sun will become a dense white dwarf star (about the size of Earth). The planetary nebula will disperse over thousands of years, but the white dwarf will last longer than anything we know of in the universe.

Stars that are about ten times larger than the Sun can continue nuclear fusion, creating elements all the way until they reach iron. This is the point where the star can no longer balance the pressure of gravity with the force of energy radiating outward, and the star explodes in a supernova – the largest explosion in the entire universe. The explosion sparks the creation of elements heavier than iron. The expelled outer layers of these stars are supernovae remnants. The core of the stars can collapse down into neutron stars or black holes.

Neutron stars are even smaller than white dwarf stars but contain much more mass because they form from a more massive star. The pressure in the core of these stars force individual atoms to collapse in on themselves and fuse electrons to protons. This creates neutrons, and with no electrons to force atoms apart, the neutrons squeeze together into a dense ball. As the star shrinks, angular momentum is conserved, and the rotation of the star increases to hundreds of revolutions per second.

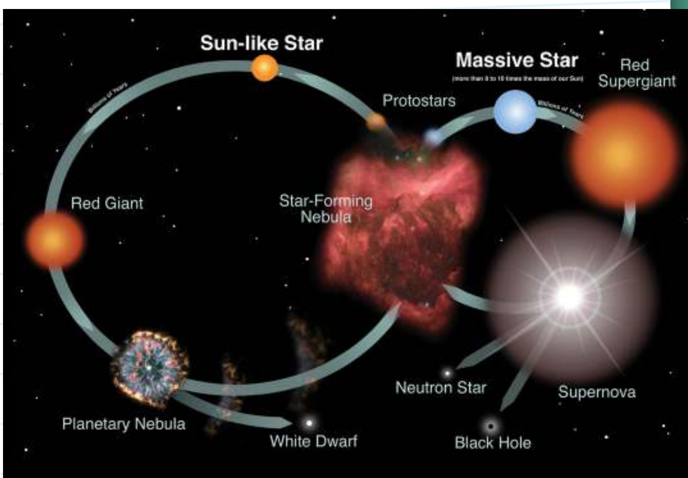
If the density of the star gets to a point where atomic structures cannot get any closer together, gravity overwhelms all other forces. This creates a singularity with infinite density, and the core becomes a black hole. Gravity is pulling objects into the core of a black hole faster than the speed of light. Therefore, anything that gets pulled in will cease to be visible from what is called the event horizon. From there nothing can escape, not even light. However, the gravity of a black hole is no stronger than the gravity of the original star. A black hole with the same mass as the Earth would be about the size of marble, but still have the same gravitational pull as the entire Earth.



Sagittarius A is the black hole at the centre of the Milky Way galaxy. Credits: NASA/UMass/ D.Wang et al., IR: NASA/STScI*

Black holes are invisible because nothing, not even light can escape.

Credit: NASA and the Night Sky Network



Check out these other resources...

- Wikipedia – Stellar Evolution: https://en.wikipedia.org/wiki/Stellar_evolution
- HubbleSite Black Holes: http://hubblesite.org/explore_astronomy/black_holes/encyc_mod3_q3.html

DISCUSSION POINT

What types of telescopes have observed black holes, and what behaviour of matter has been observed to conclude a black hole may be nearby?

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ACTIVITY

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THE FINAL STAGES OF STELLAR EVOLUTION

Objective...

To simulate the end of a star's life with a balloon and some aluminium foil. In this activity students will discover for themselves how these transformations work, and what effect they have on the gravitational pull of the once brilliant star.

You'll need...

- aluminium foil
- balloons
- pump
- scales
- tape measures

Instructions...

MASSIVE STAR → BLACK HOLE

- Blow up a balloon fully (the star) and cover it with aluminium foil (the outer layers of the star).
- Record the initial mass using the scale and circumference of "the star" using the tape measure.
- Simulate the collapse of the star by having the students squeeze the balloon until it pops.
- Allow for some of the square sheets of foil to "explode" off in the "supernova", but then squeeze the remaining foil around the popped balloon until it is a dense sphere.
- Record the mass and circumference.
- Calculate the density of "the star" from before and after the collapse (density=m/v, volume=$(4/3)\pi r^3$, radius=circumference/2π).
- By this time, it should be apparent that no matter how much pressure they add onto their sphere that the mass, and therefore gravitational pull, will not increase, only the density.
- Calculate the size of the event horizon using the equation: $R=2GM/c^2$ (R=radius of the event horizon, M=mass of the black hole, G=universal gravitational constant 6.67×10^{-8} cm^3 g^{-1} s^{-2}, c=speed of light 3×10^{10} cm/sec).

(If the mass is 30 grams, the radius it would become a black hole would be about 4×10^{-27} cm, and the density would be about 9×10^{79} g/cm^3).

Adapted from the Denver Museum of Nature and Science Black Holes Educator Guide.

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Take a photo of your activity and send it to us. We'd love to see it! education@stardome.org.nz

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