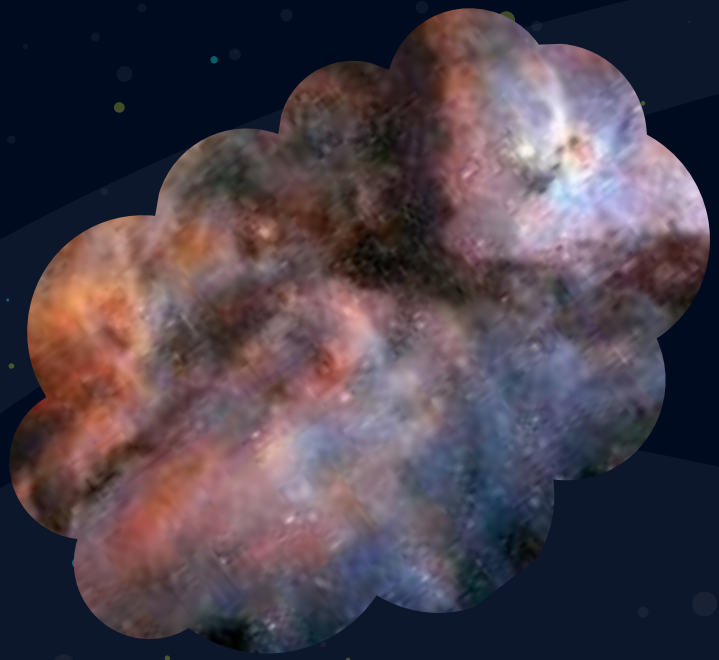
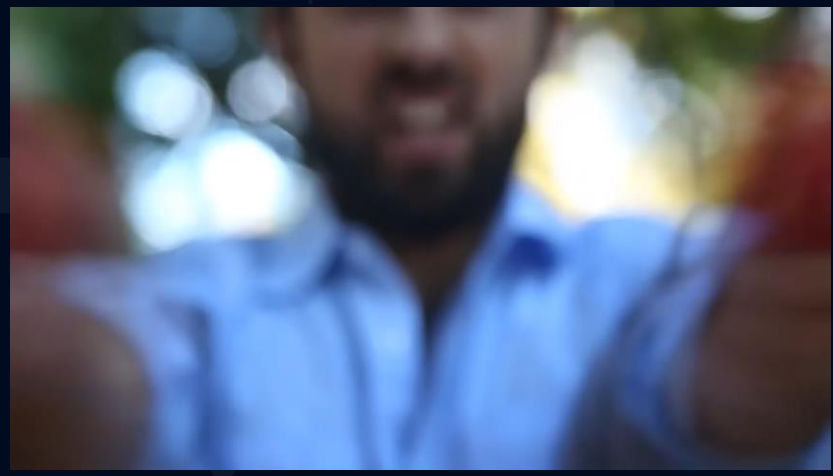
Stellar Evolution

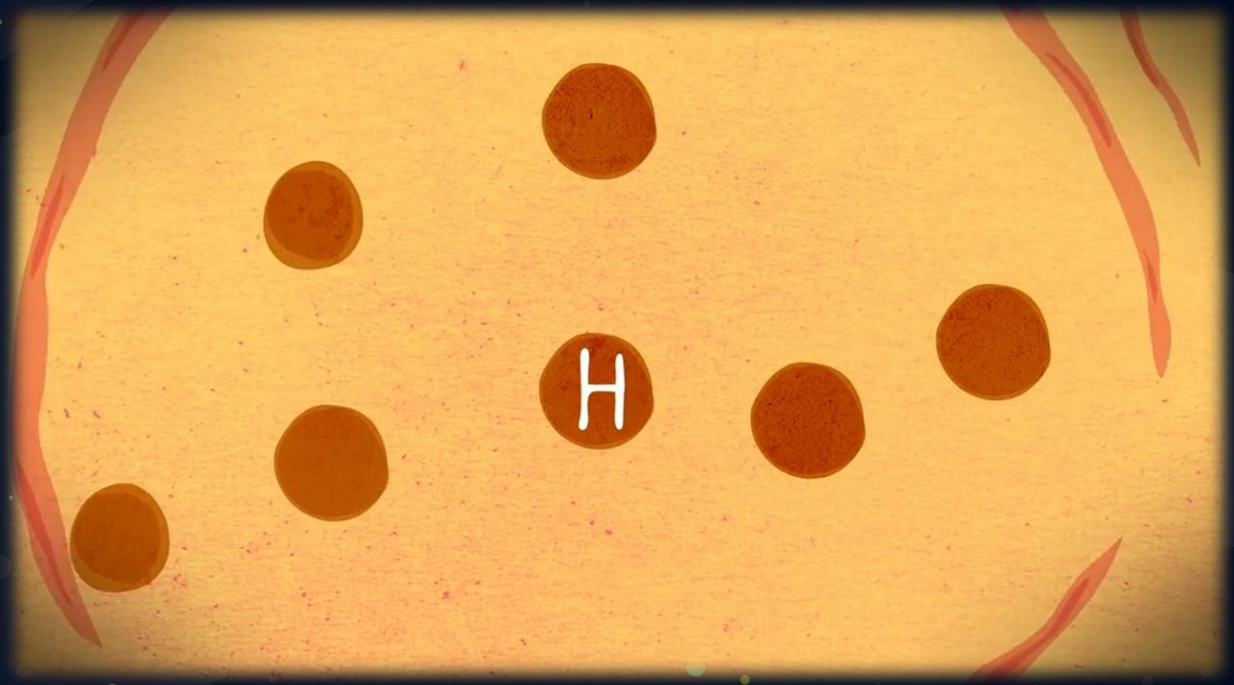


cloud under goes
gravitational collapse

As the cloud starts to contract, its energy increases and triggers nuclear fusion reaction

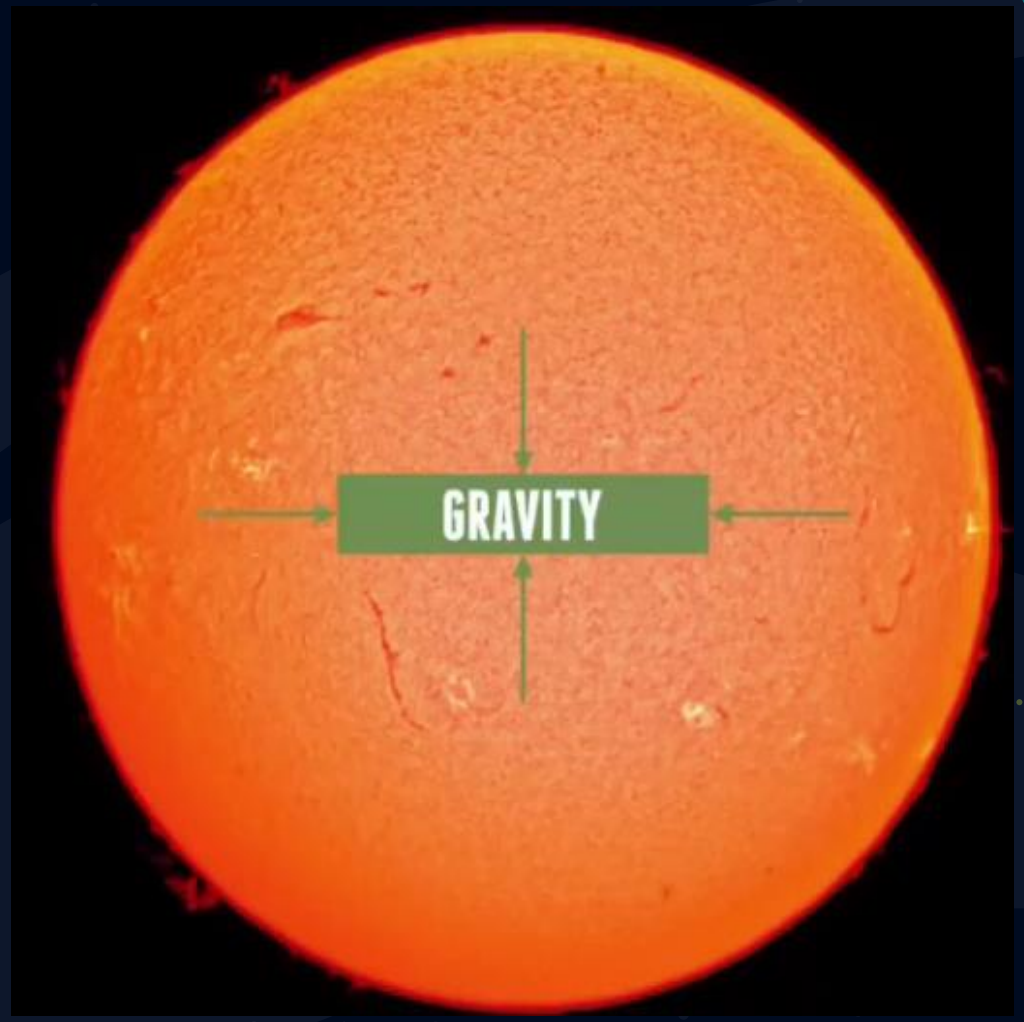


Credit - veritasium
https://www.youtube.com/watch?v=Ux33-5k8cjg&t=37s

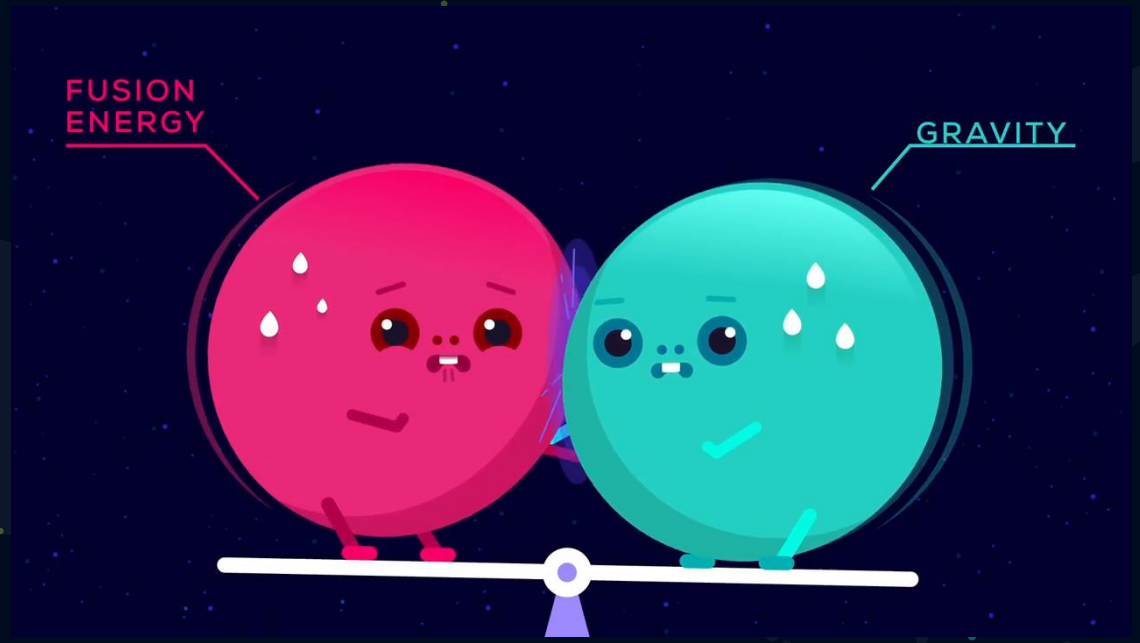


Credit – Ted Ed
https://www.youtube.com/watch?v=fFeV8WxIZLk&t=255s

Once the nuclear reaction starts the inward gravitational force is balanced by the energy released outwards during nuclear reaction.



https://www.youtube.com/watch?v=1UGBeedYuF4

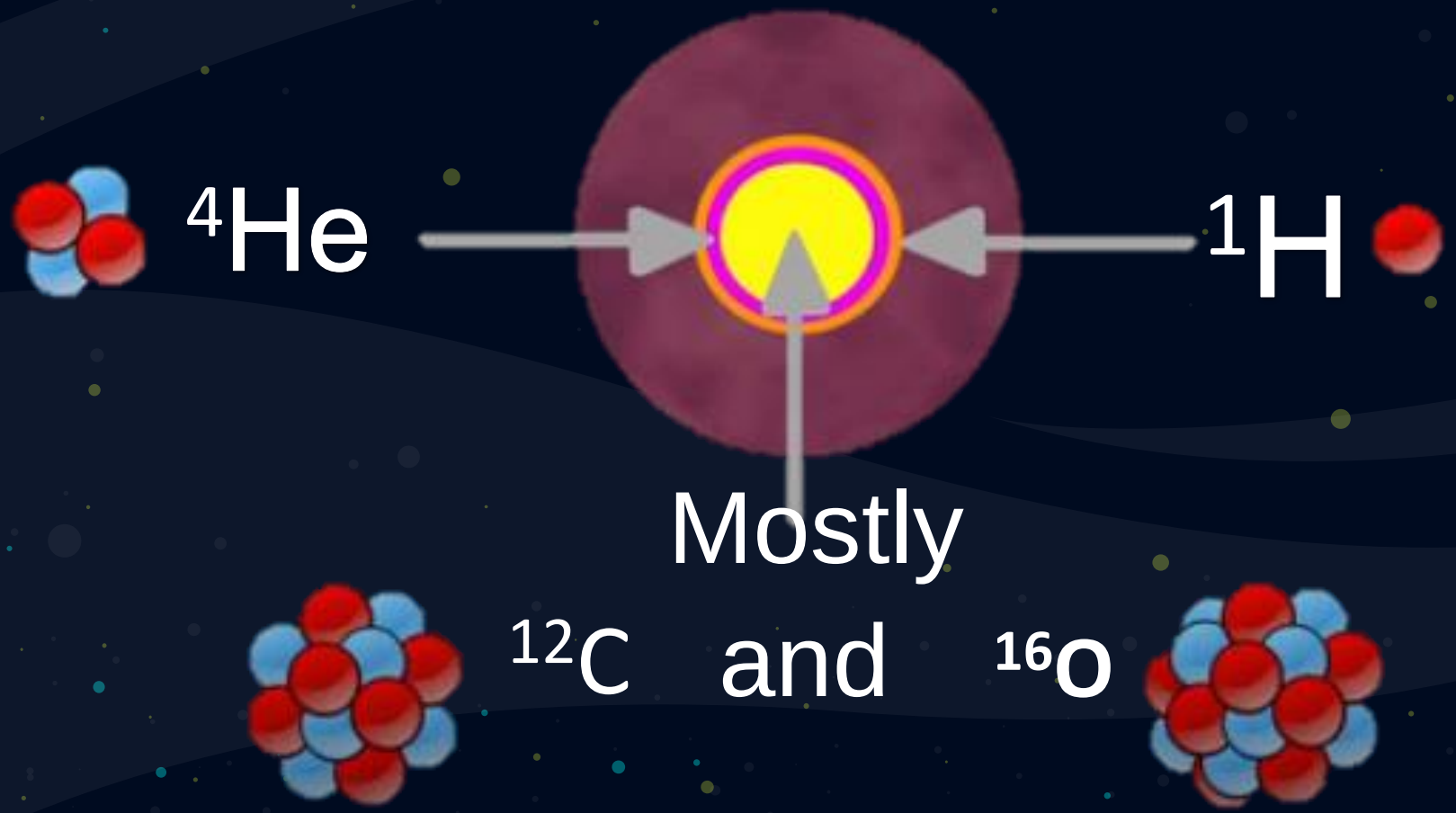


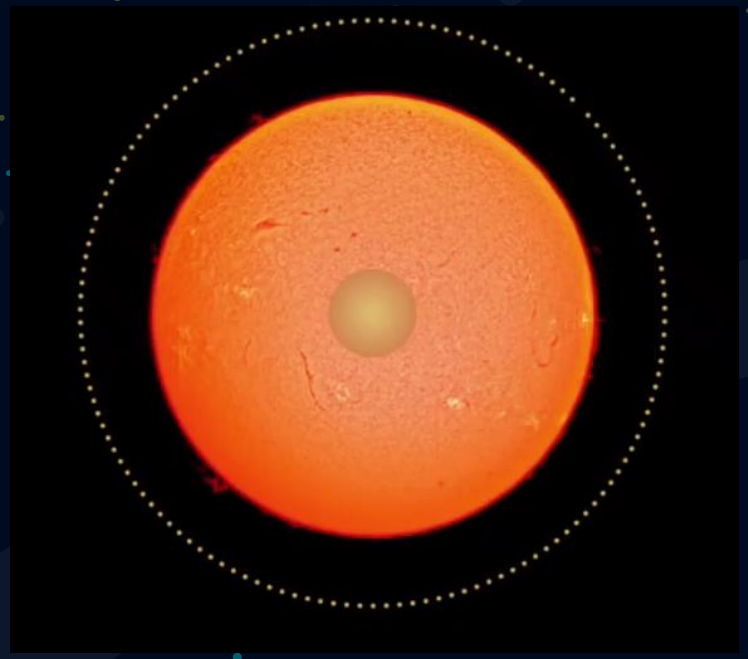
Credits – kurzgesagt.
https://www.youtube.com/watch?v=qsN1LglrX9s&t=253s

What if the stars runs out of fuel ?

Credit – Ted Ed
https://www.youtube.com/watch?v=fFeV8WxIZLk&t=255s

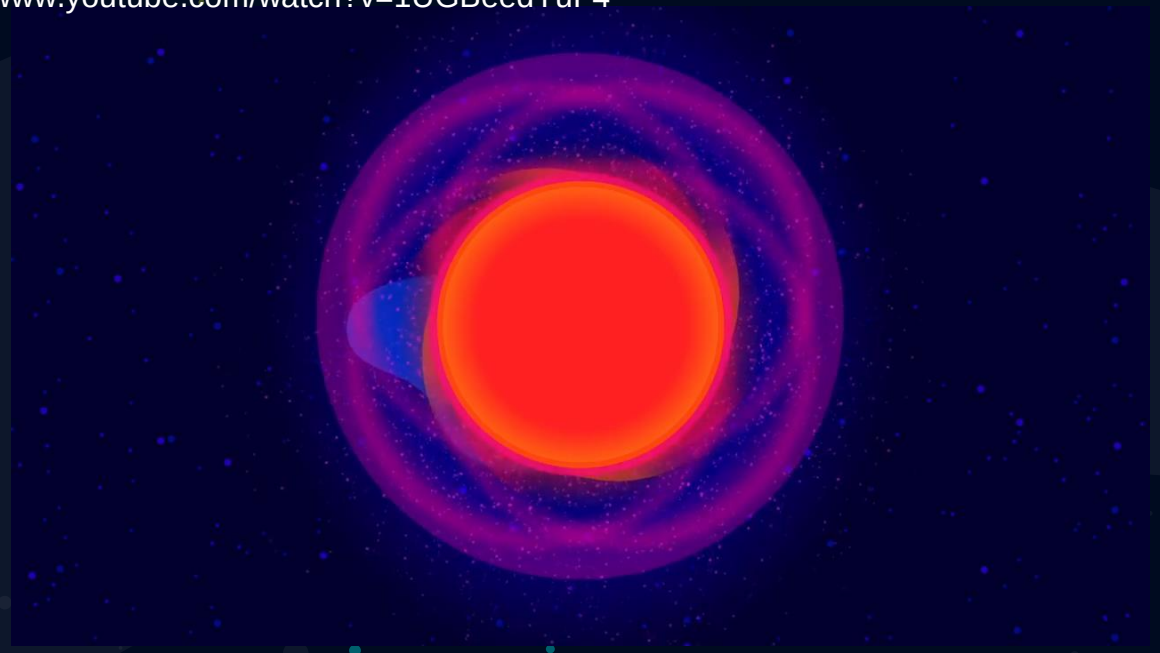
When the Core of a red giant star contains predominantly carbon and oxygen the fusion stops





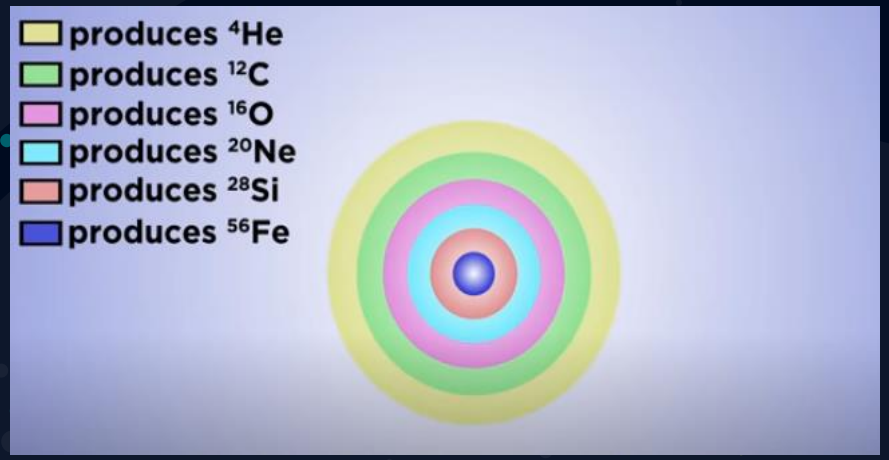
https://www.youtube.com/watch?v=1UGBeedYuF4

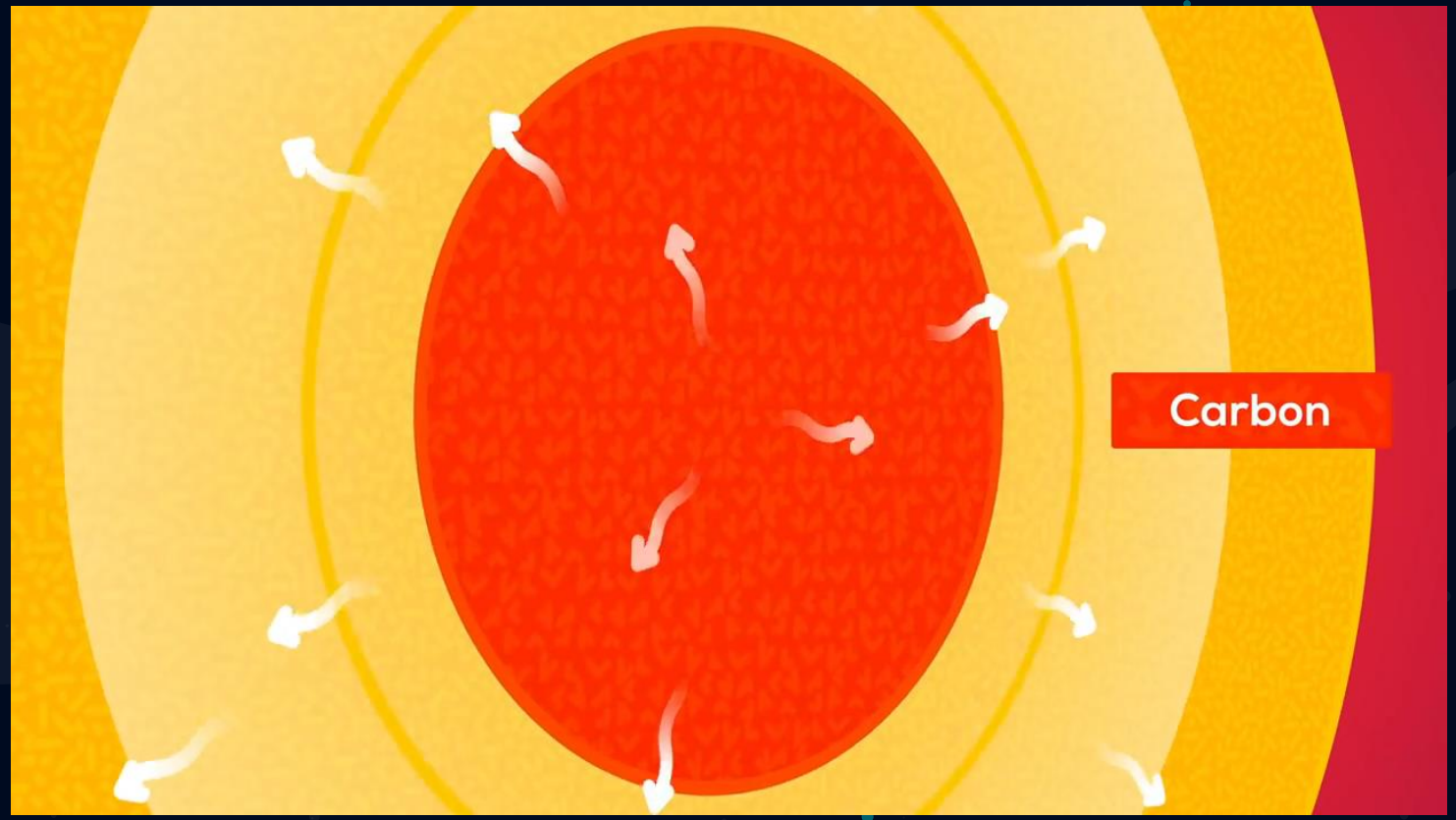
Outer layer explodes and core collapses resulting in planetary nebula and white dwarf is formed.



Credits – kurzgesagt.
https://www.youtube.com/watch?v=gsN1L

Elements up to iron can be found at the core of high mass stars (Greater than 8 solar mass)



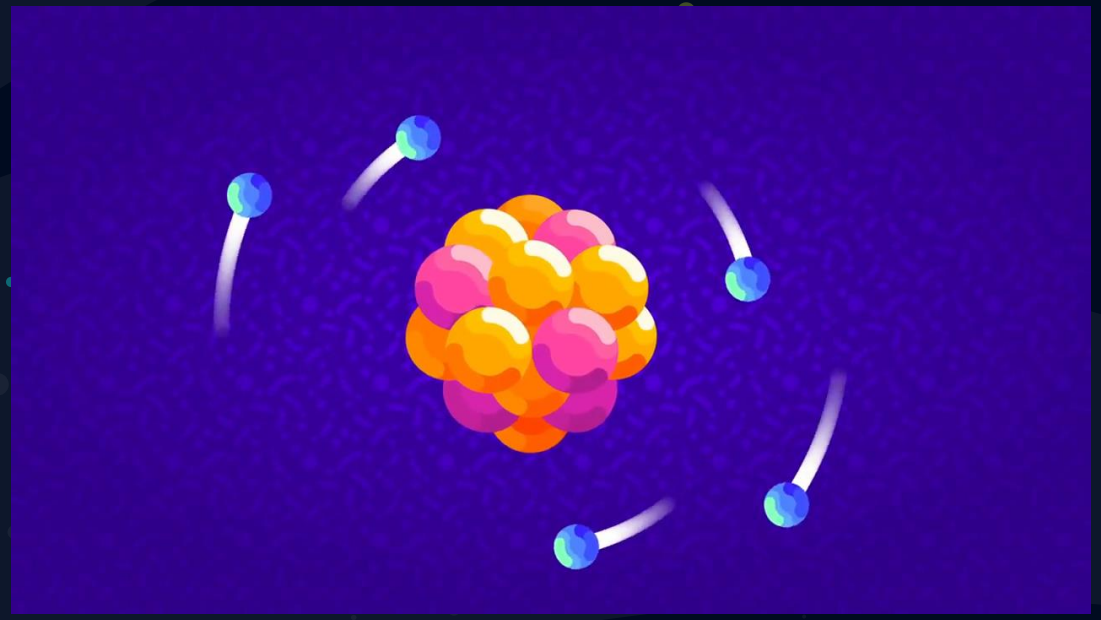


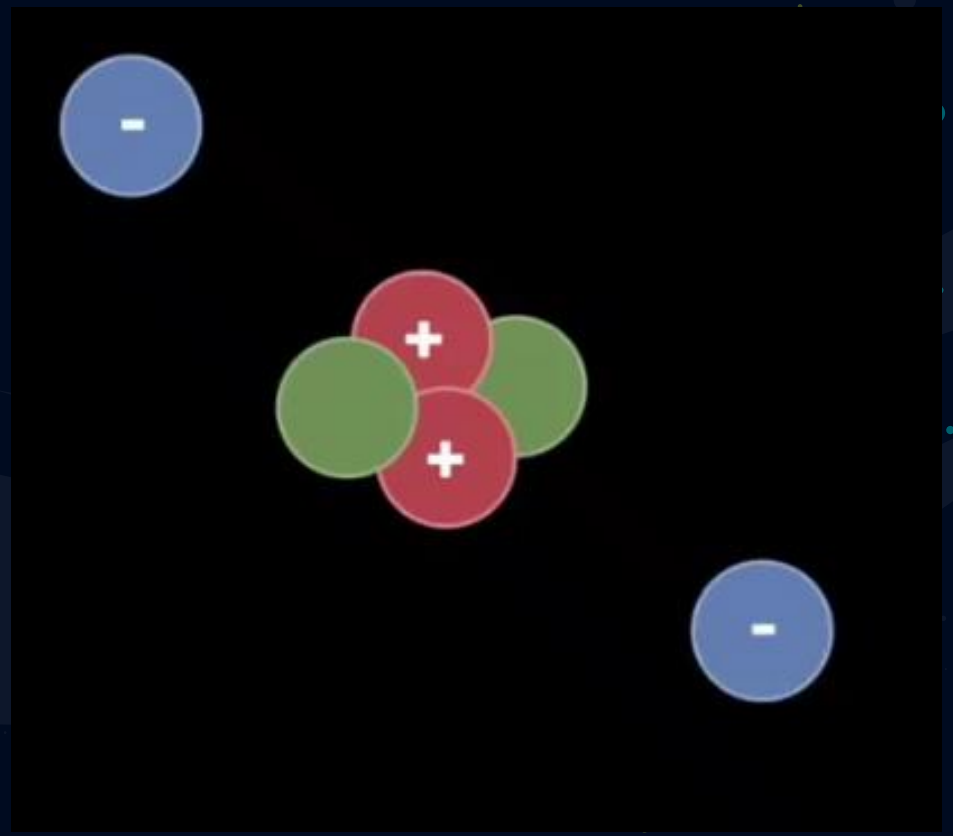
Credits – kurzgesagt.
https://www.youtube.com/watch?v=qsN1LglrX9s&t=253s

Once the core is predominately iron, star wont have further energy to fuse iron

Credits – kurzgesagt.
https://www.youtube.com/watch?v=qsN1LglrX9s&t=253s

All the electrons go fuse into nucleus with protons and forms neutrons and releases shock wave, which triggers supernova.





Credits – kurzgesagt.
https://www.youtube.com/watch?v=qsN1LglrX9s&t=253s

Supernova

https://www.youtube.com/watch?v=RrMvUL8HFlM

Carb nebula

What decides the fate of stars?

Chandrashekar's limit

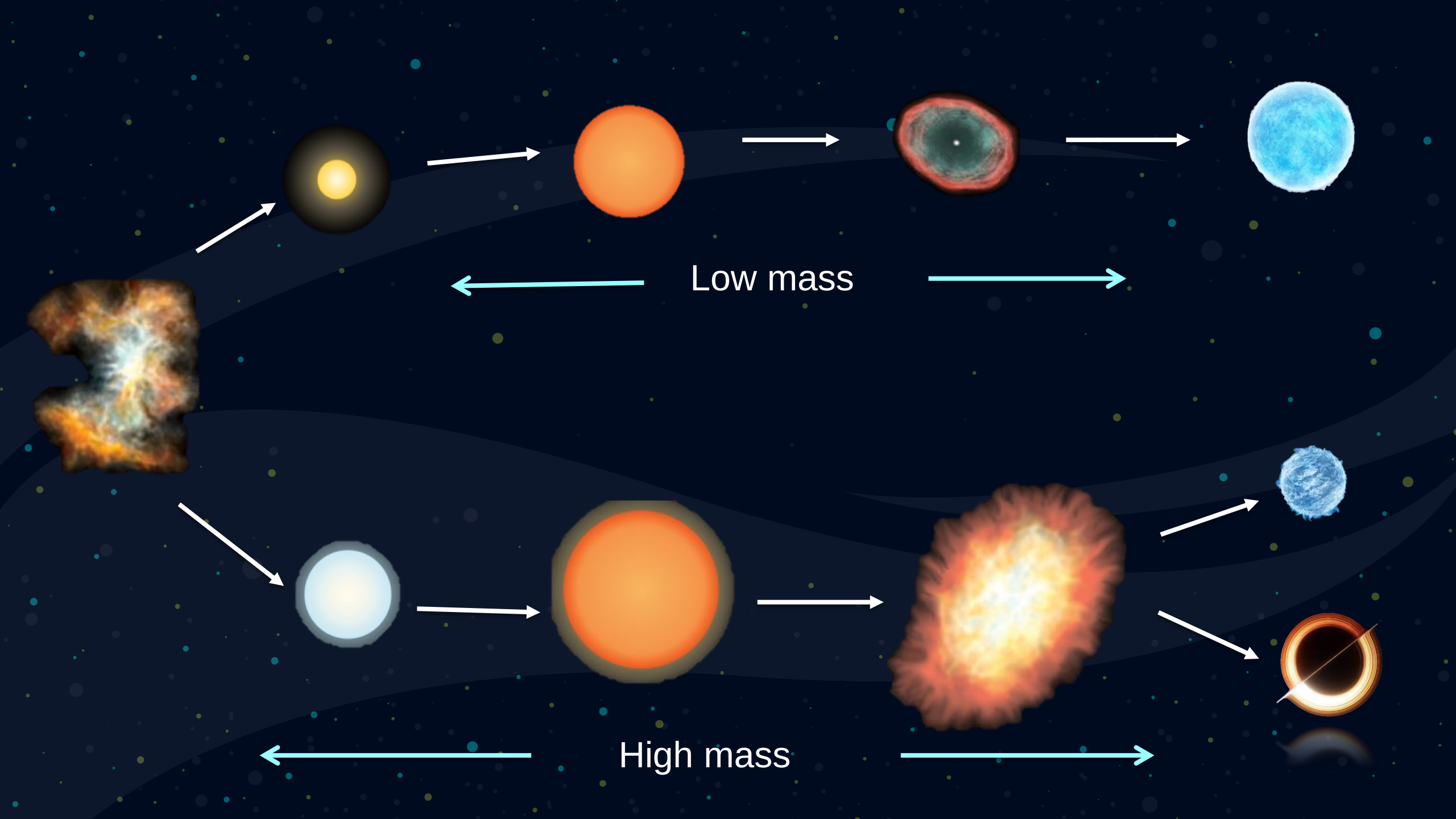
If the cores mass is < 1.4 M

White dwarf

If the cores mass is > 1.4 M

Neutron star

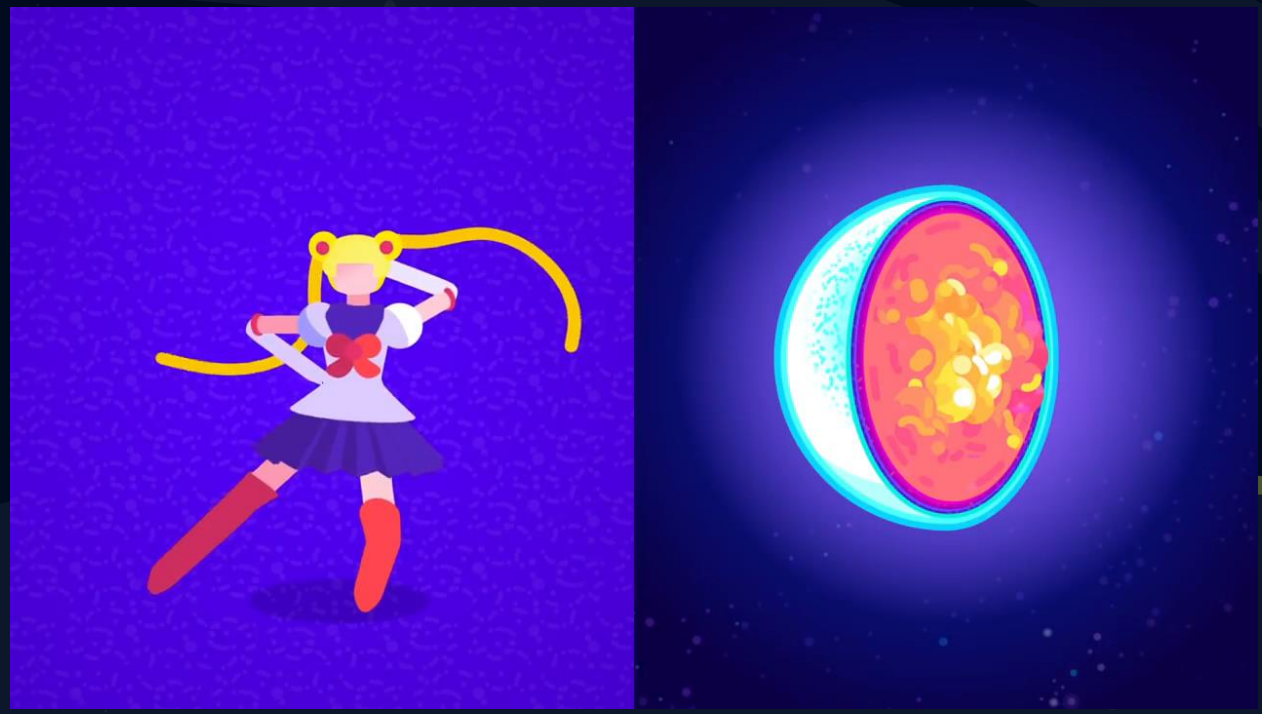
Black hole


Low mass
High mass

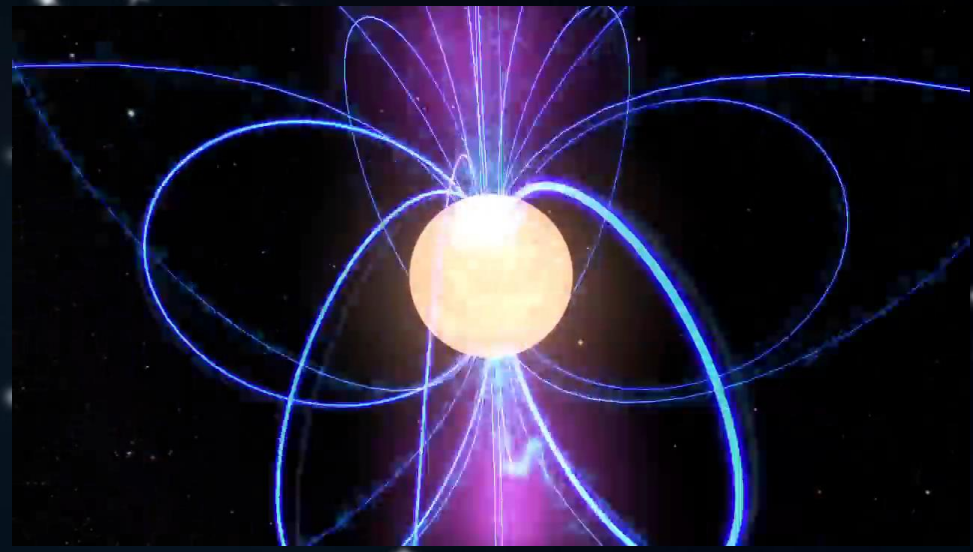
PULSAR

A **pulsar** is a highly magnetized rotating neutron star that emits beams of electromagnetic radiation out of its magnetic poles.

When a star collapses under its own gravity, all the mass are concentrated to a single point. Neutron star manages to gain the rotational energy and forms a pulsar



The events leading to the formation of a pulsar begin when the core of a massive star is compressed during a supernova, which collapses into a neutron star.



This radiation can be observed only when a beam of emission is pointing toward Earth

QUASARS

A Quasar is an extremely luminous active galactic nucleus (AGN), in which a supermassive black hole with mass ranging from millions to billions of times the mass of the Sun is surrounded by a gaseous accretion disk.

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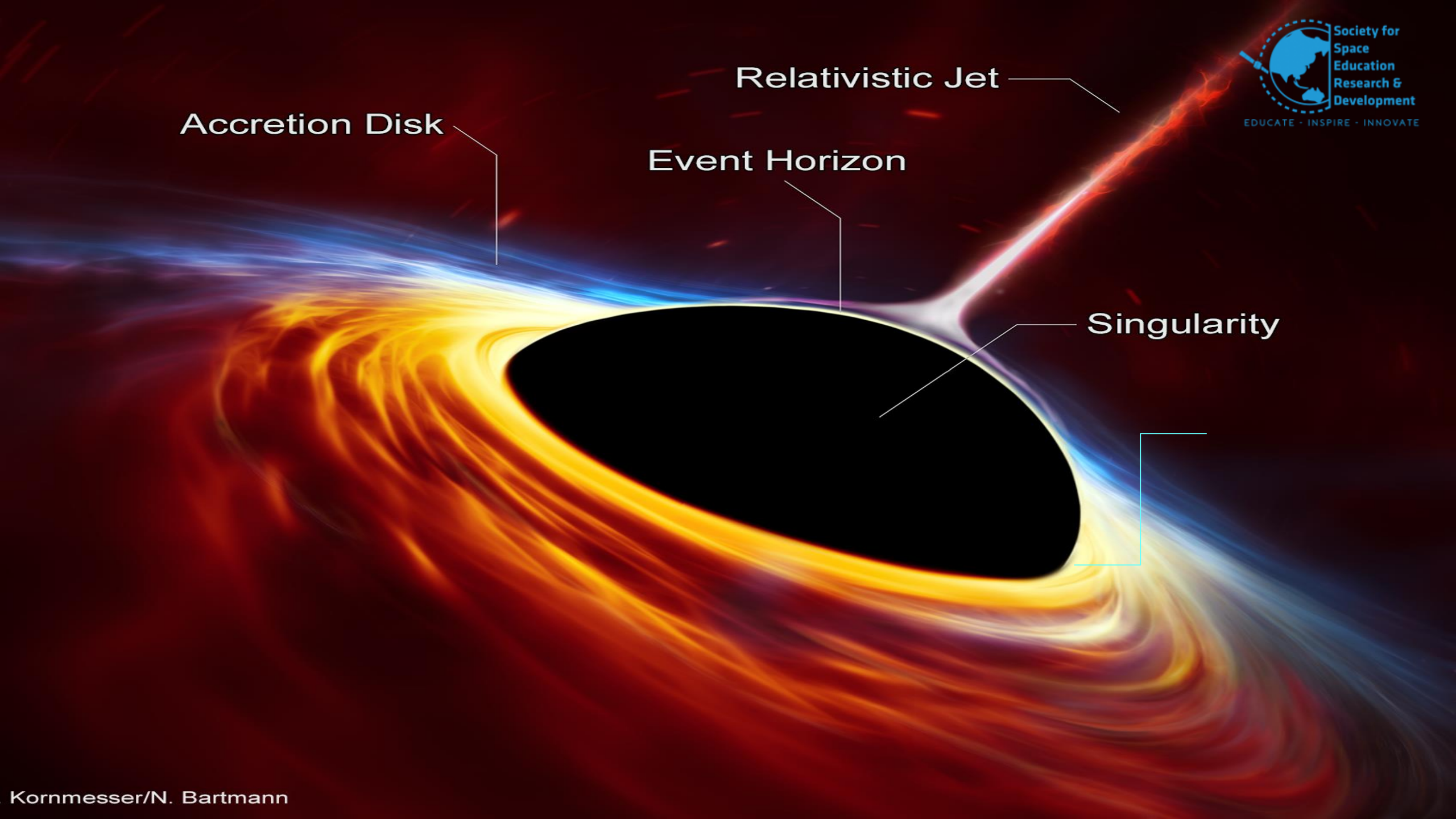
BLACK H  LES

Black Holes ?

A dens compact object with enormous gravitational pull such that even light cannot even escape from it.


Relativistic Jet
Accretion Disk
Event Horizon
Singularity
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Kornmesser/N. Bartmann

The Event Horizon:

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- This is the "point of no return". Any object, even light, that is within this radius cannot escape the gravitational pull of the black hole
- The Schwarzschild Radius: This is the event horizon's radius. It is the radius at which the escape velocity is equal to the speed of light,

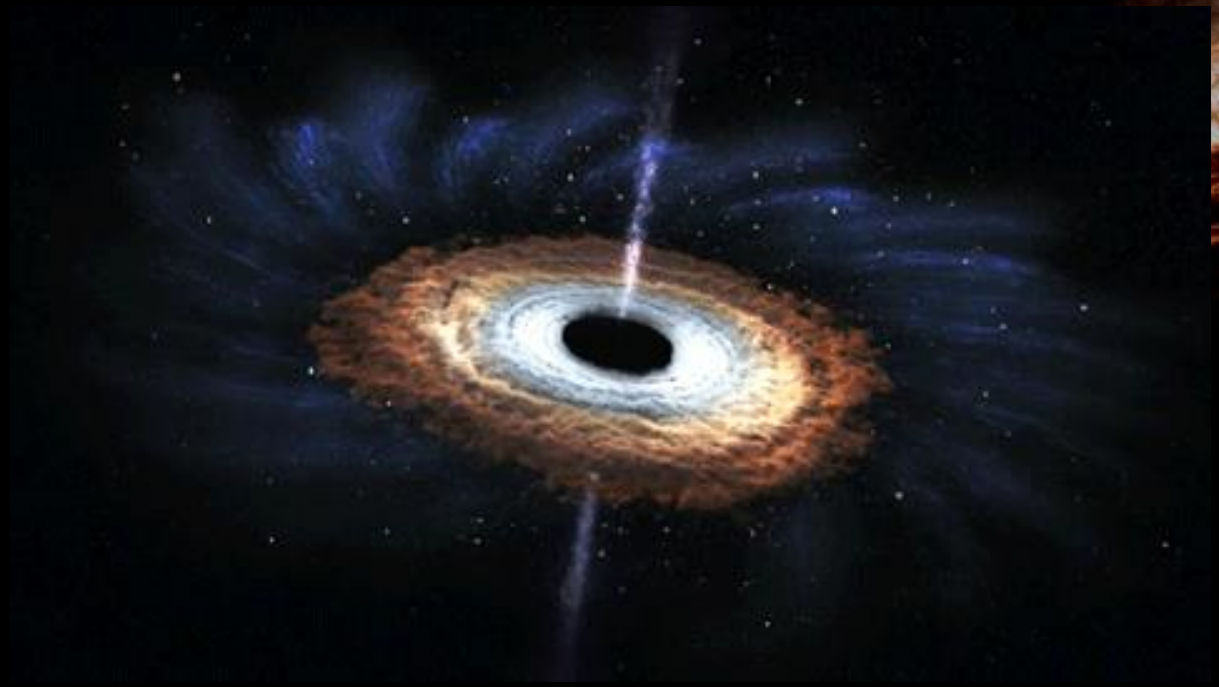
$$R = 2GM/C^2$$

The Singularity

- This is the region of the black hole where all the mass of the black hole has been compressed down to nearly zero volume. As a result the singularity has almost infinite density and creates an enormous gravitational force

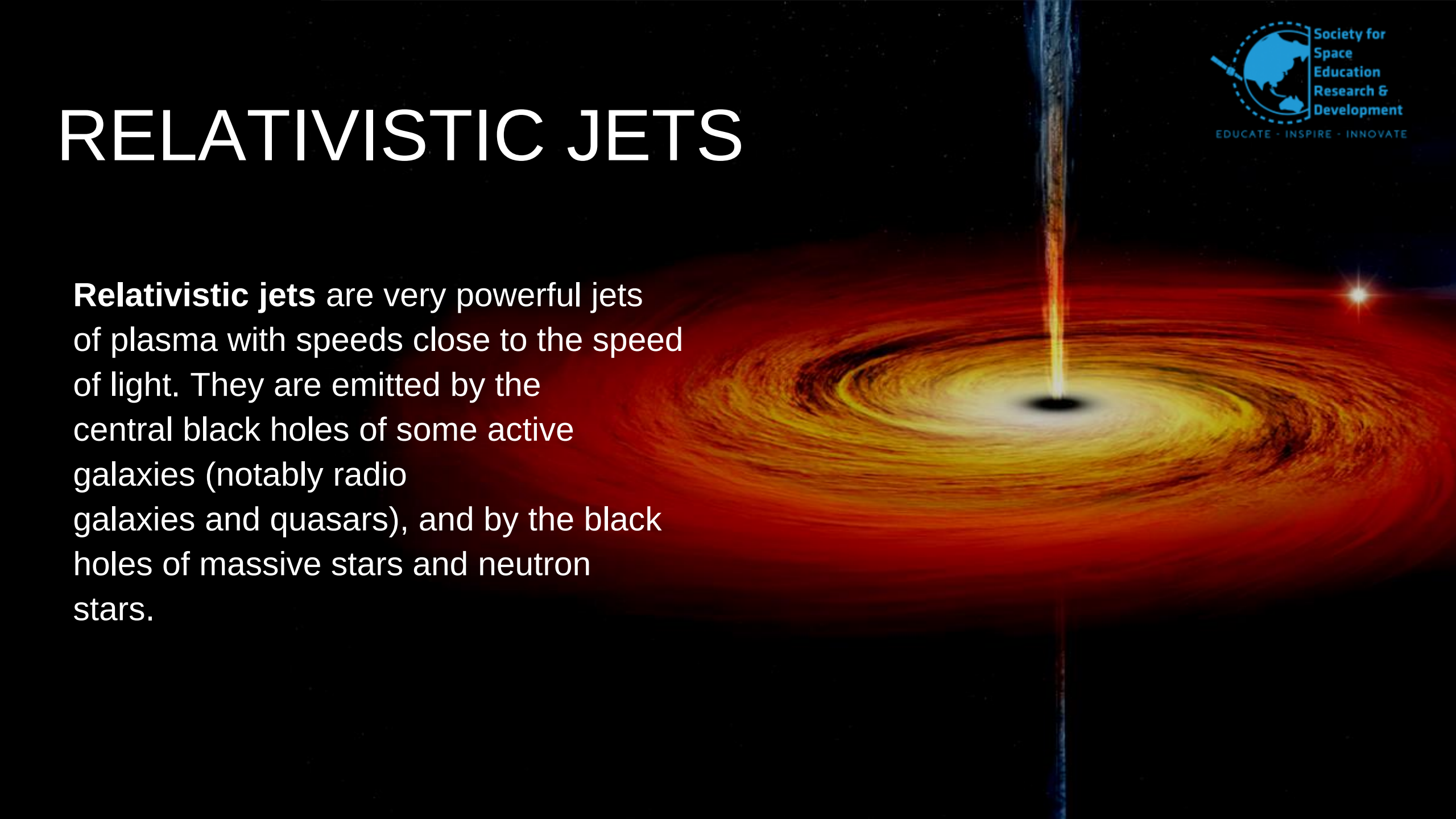
The Accretion Disk:

This is a disk composed of stellar material that is spiralling towards that black hole



RELATIVISTIC JETS

Relativistic jets are very powerful jets of plasma with speeds close to the speed of light. They are emitted by the central black holes of some active galaxies (notably radio galaxies and quasars), and by the black holes of massive stars and neutron stars.



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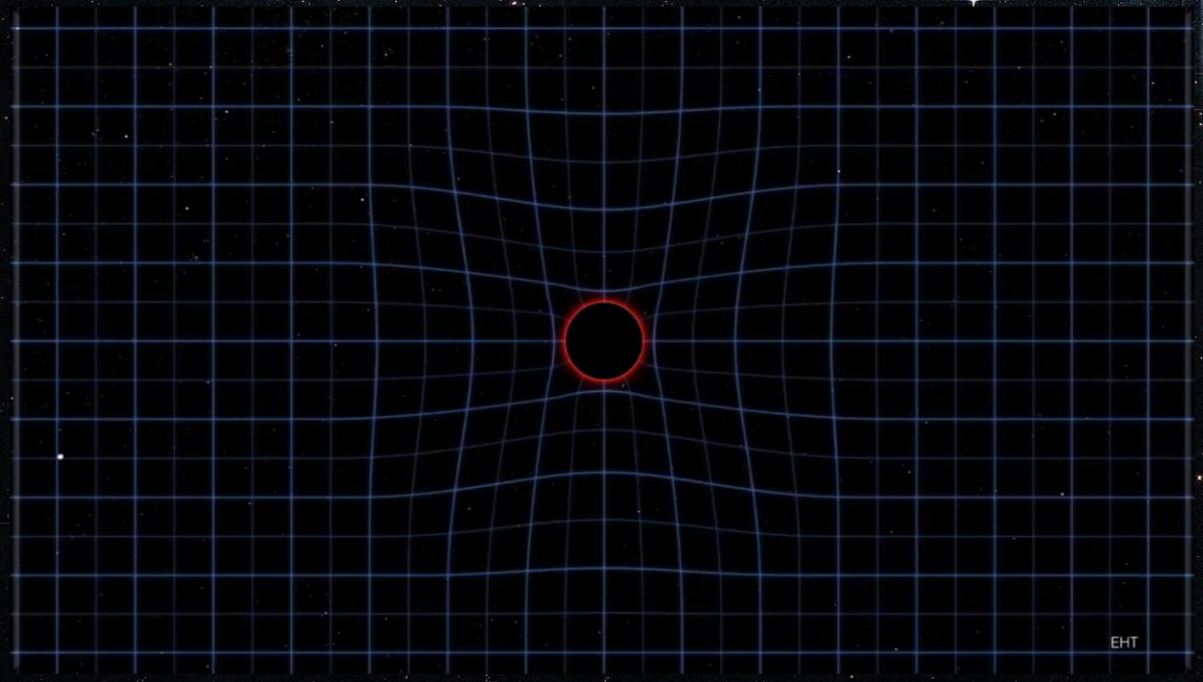
PHOTON SPHERE

The photon sphere is a spherical boundary of zero thickness in which photons would be trapped in a circular orbit about the black hole.



https://www.youtube.com/watch?v=uyMtsyzXWd4

$$\text{Radius of the photon sphere} = \frac{3}{2} \times \text{Radius of event horizon}$$

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ACTIVITY TIME

Objective:

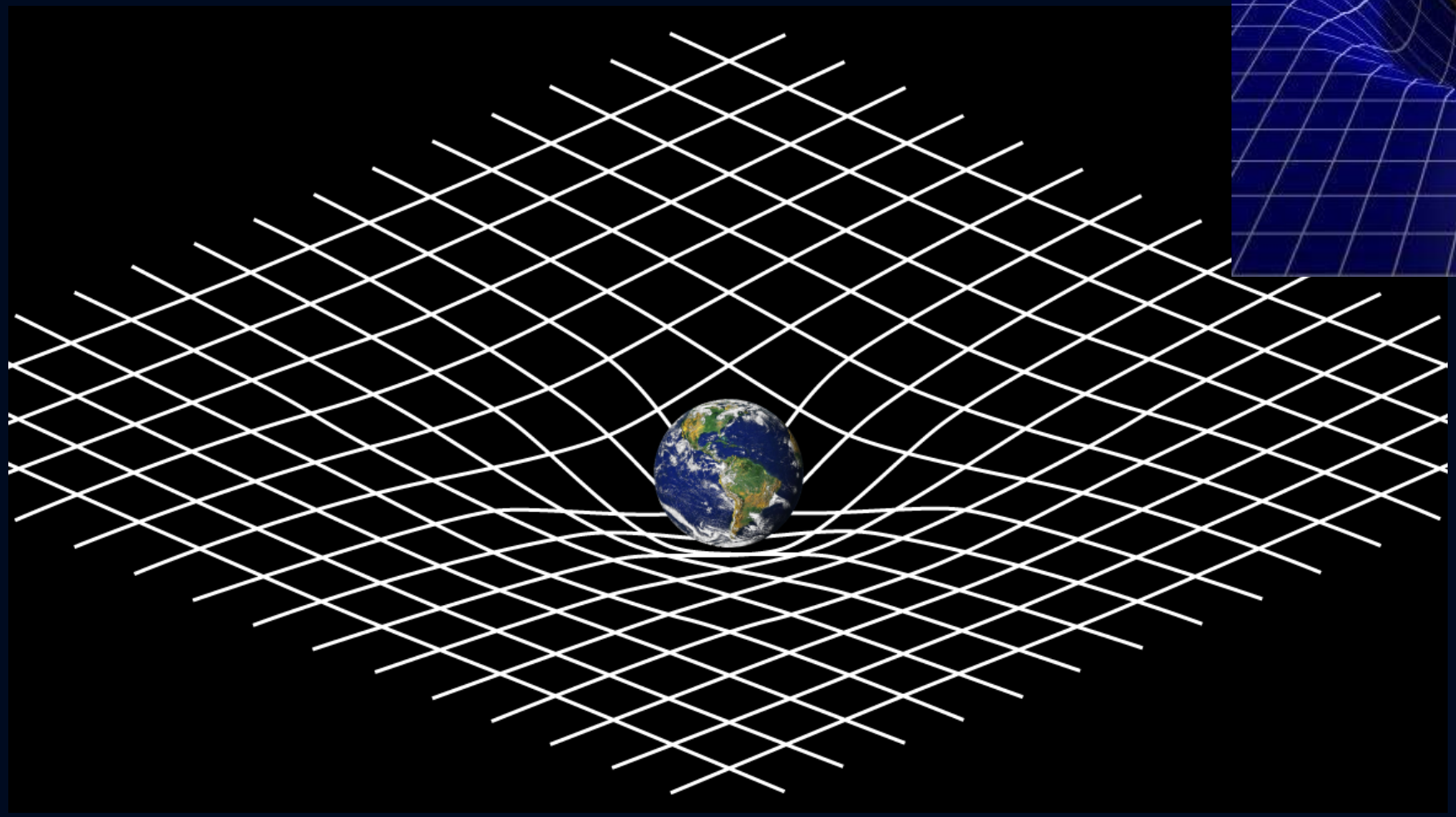
To Understand Einstein's Theory Of Gravity.

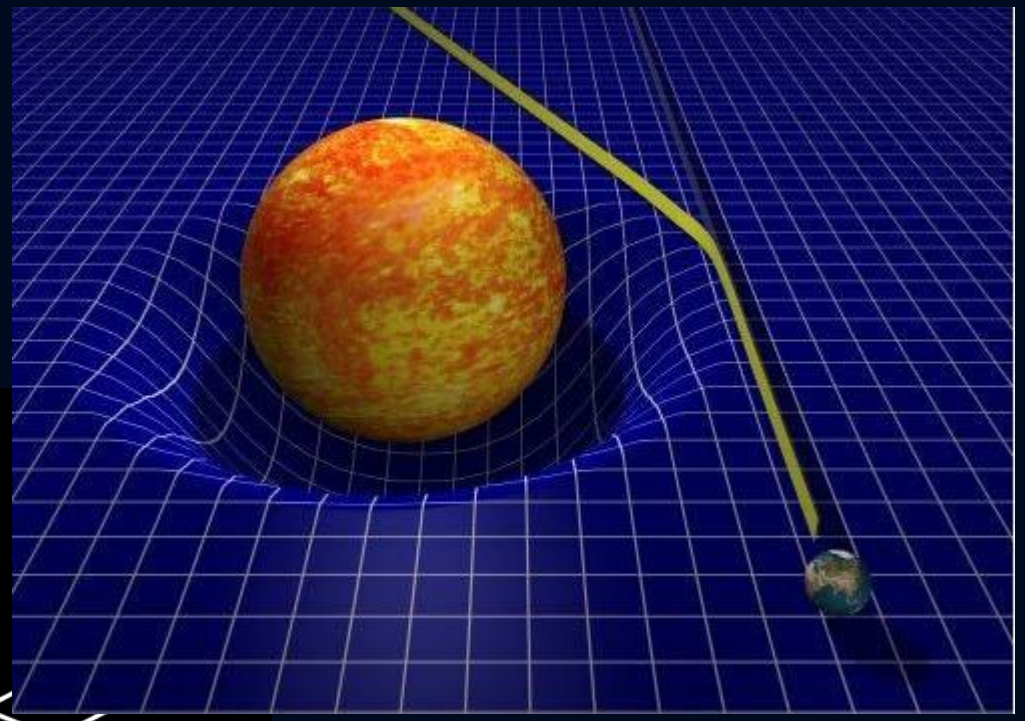
- Take a cloth, stretch and tie it around the bowl.
- Now place any object with considerable mass.
- Can you say what happens?

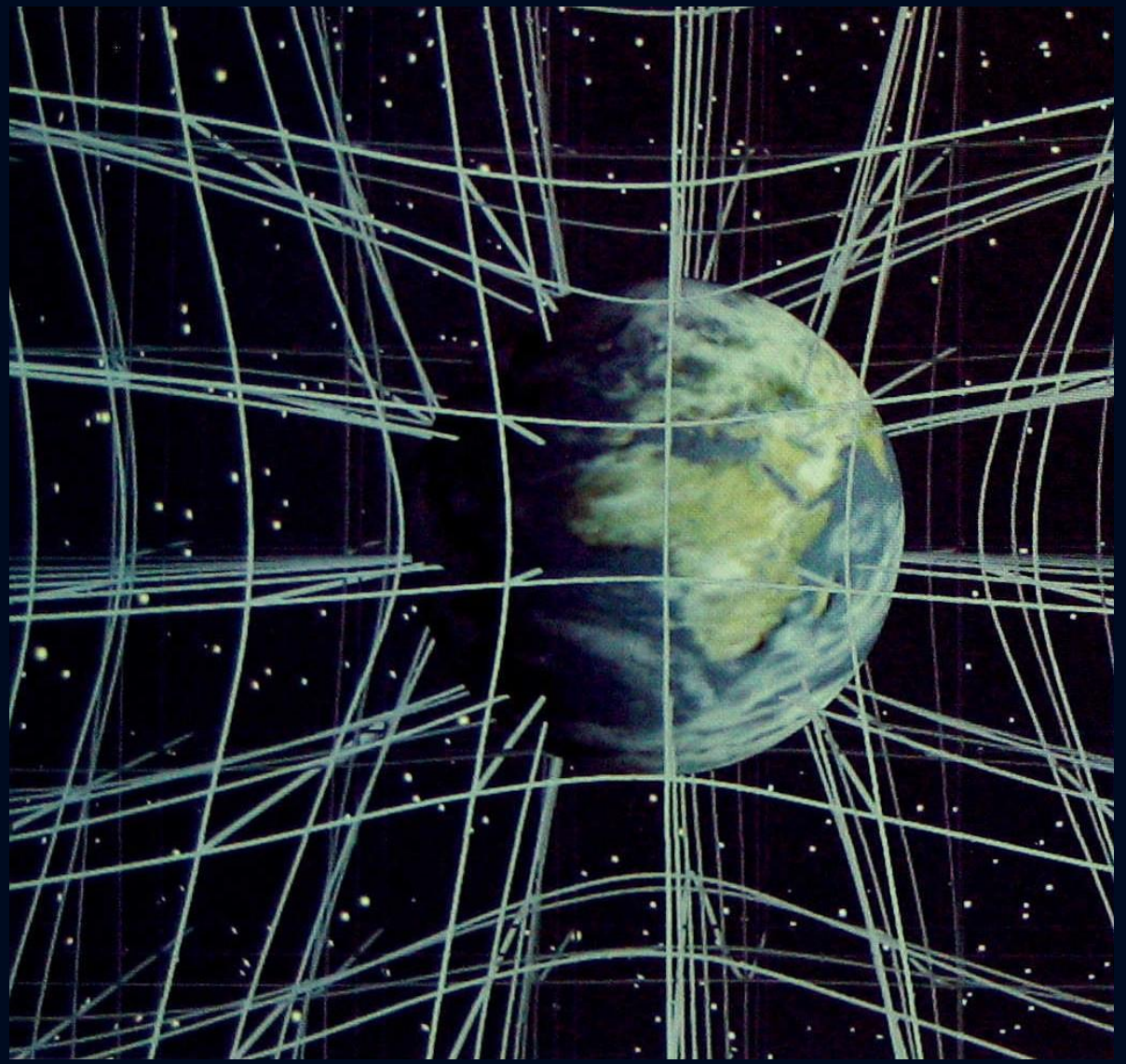
- Now lets understand what it has to do with gravity!
- Take a picture of it and upload it at as homework.

What is space - time

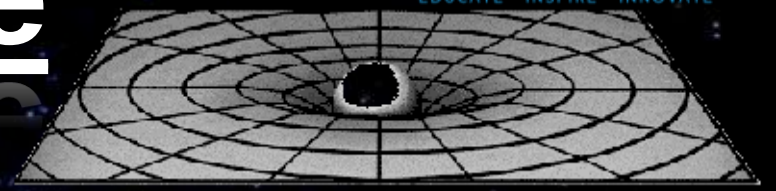
- A mathematical model which fuses 3 dimension of space and 1 dimension of time







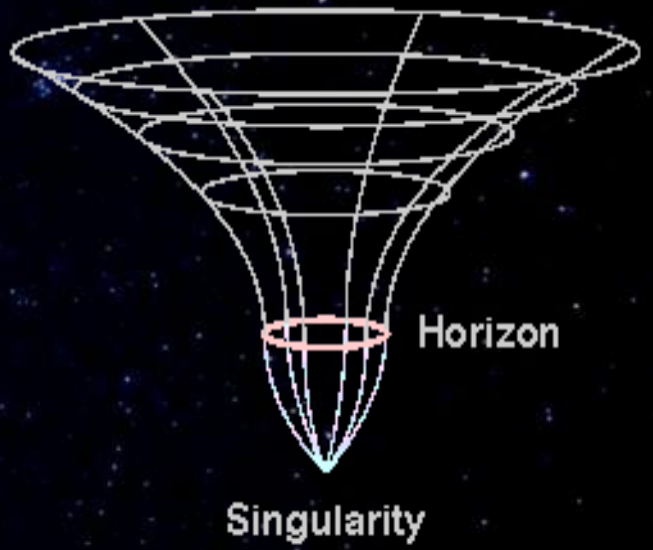
Relativity and Black Hole



The Curvature of Space caused by a Massive Object.

The principle of General Relativity is that the presence of *matter curves space*. In this view, gravity is not a force, but a curvature in the fabric of space, and objects respond to gravity by following the curvature.

One of the prediction of the theory of general relativity is the presence of black hole.



Curved Spacetime around a Black Hole. Inside the *horizon or gravitational radius* space is so strongly curved that nothing can escape.

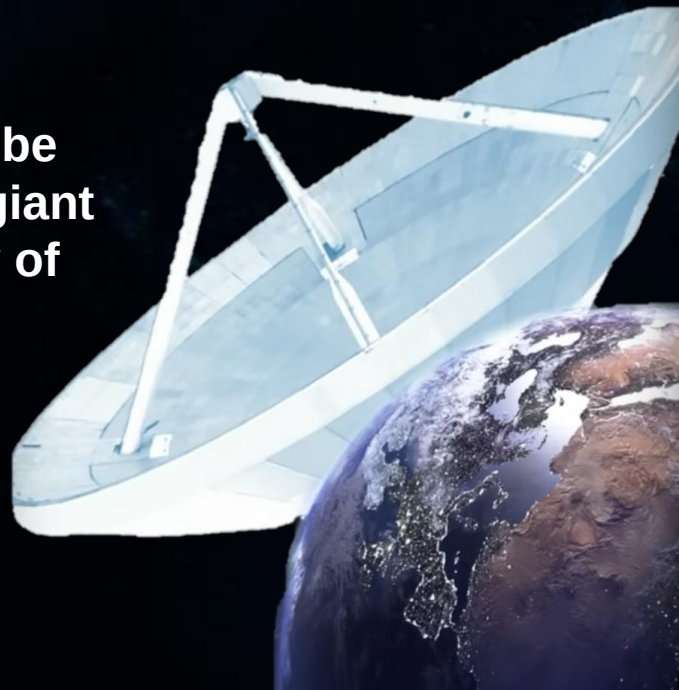
1ST IMAGE OF BLACK HOLE

- For scientists it was not an easy job to take the picture of black hole as they wanted an earth sized telescope! to obtain such a high resolution.

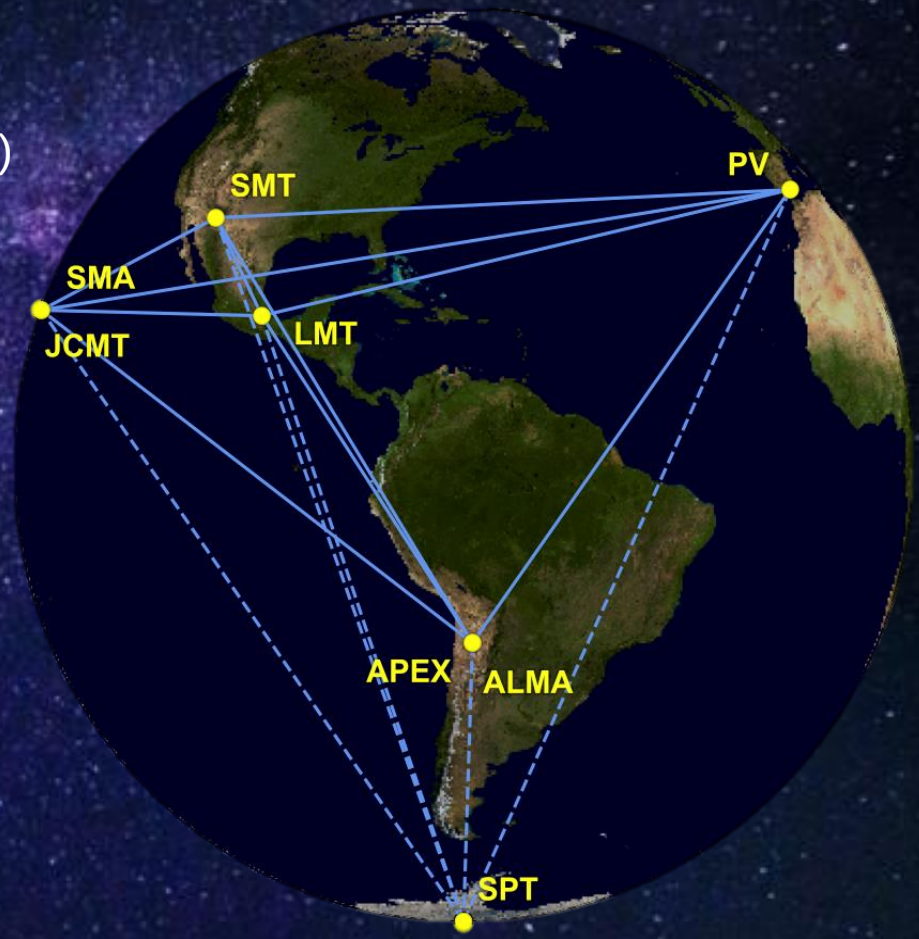
- A team formed to take on the challenge, creating a network of telescopes known as the Event Horizon Telescope, or the EHT. They used a technique , known as Very Long Baseline Interferometry, or VLBI.

- VLBI:

VLBI works by creating an array of smaller telescopes that can be synchronized to focus on the same object at the same time and act as a giant virtual telescope. In some cases, the smaller telescopes are also an array of multiple telescopes.



- Atacama Large Millimeter Array (**ALMA)**,
    - Location: Atacama Desert, northern Chile
- Atacama Pathfinder Experiment (**Apex**),
    - Location: Atacama Desert, northern Chile
- Submillimeter Telescope (**SMT**)
    - Location: Mount Graham, Arizona, US
- IRAM 30m Millimeter Radio Telescope (**IRAM 30m Telescope**)
    - Location: Sierra Nevada, Spain
- James Clerk Maxwell Telescope (**JCMT**)
    - Location: Hawaii County, US
- Submillimeter Array (**SMA**)
    - Location: Hawaii County, US
- Large Millimeter Telescope (**LMT**)
    - Location: Sierra Negra, Mexico
- South Pole Telescope (**SPT**)
    - Location: South Pole



ALMA - CHILE

SMA - HAWAII

SPT - SOUTH POLE

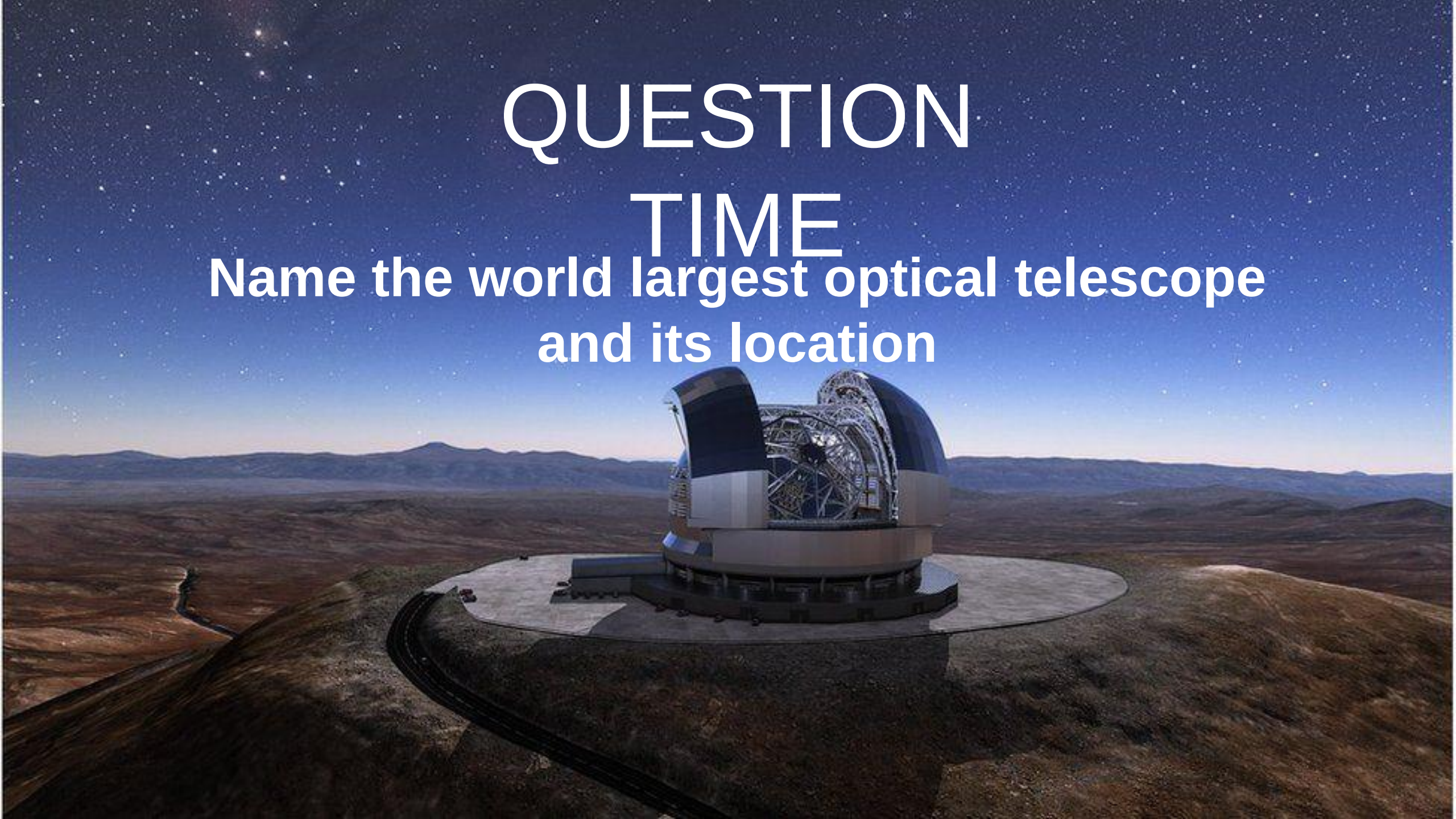
SMT - ARIZONA

PV - SPAIN

JCMT - HAWAII

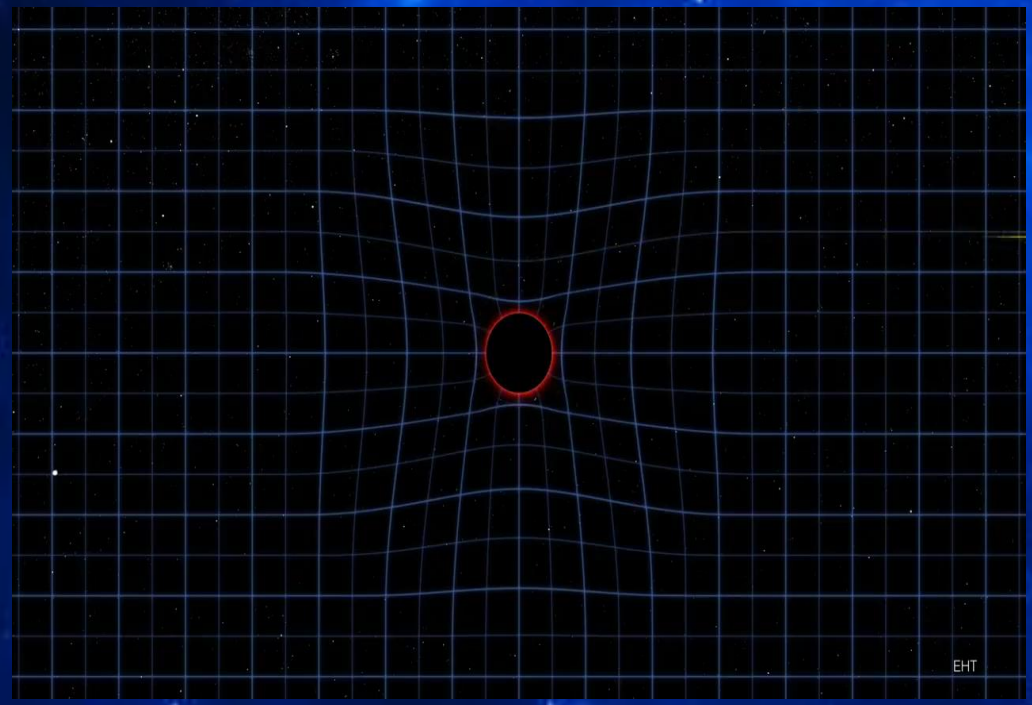
LMT - MEXICO

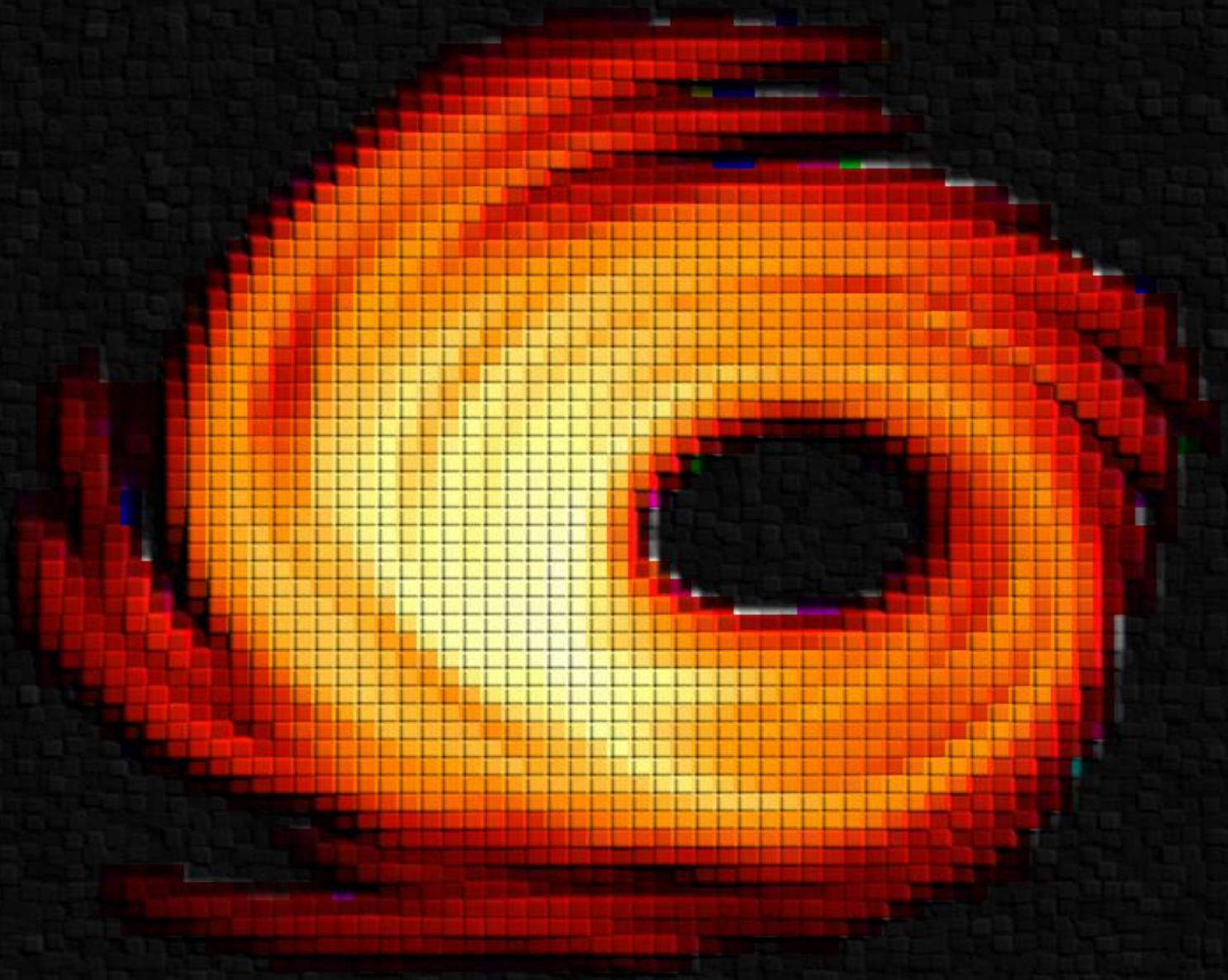
APEX - CHILE

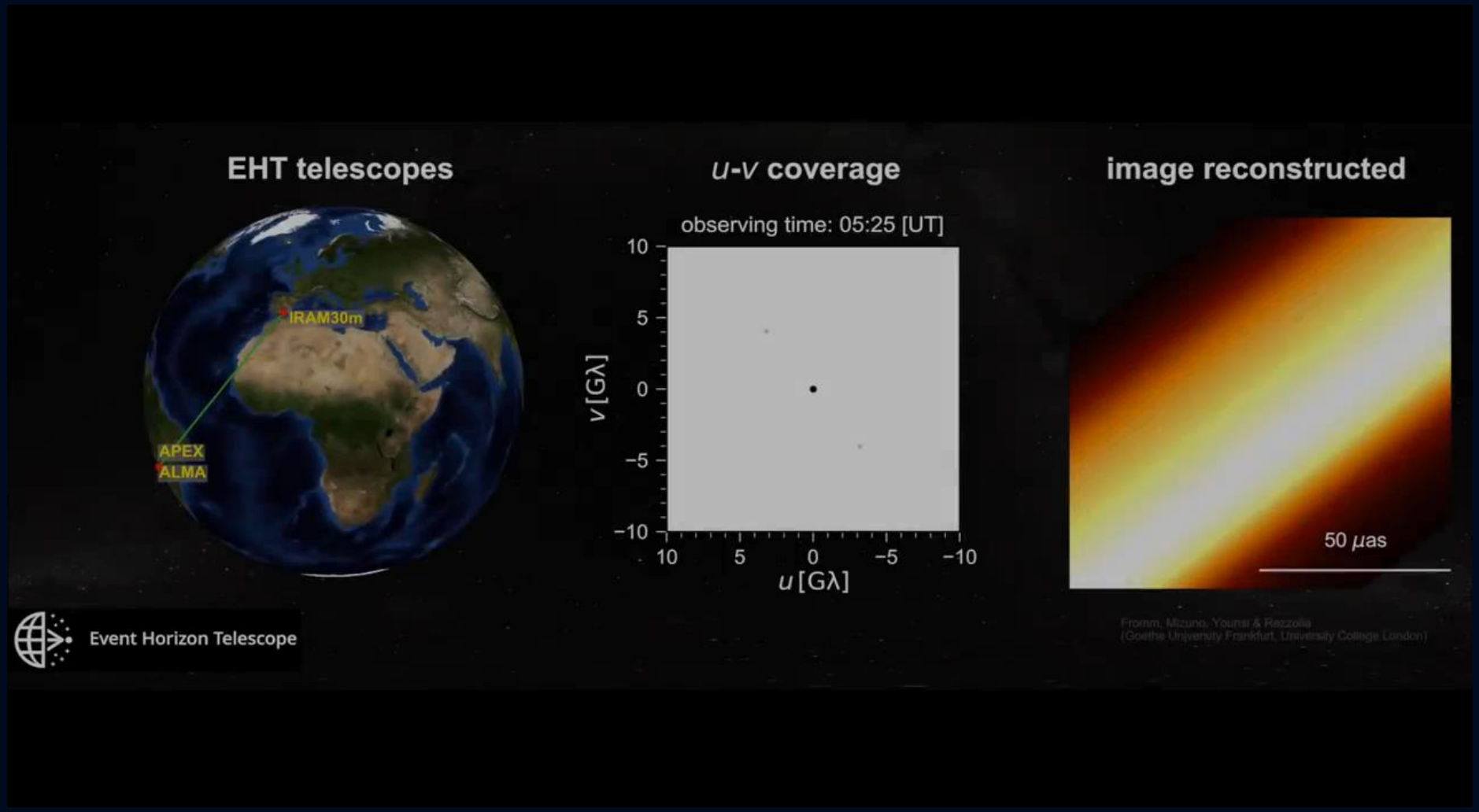

QUESTION
TIME
Name the world largest optical telescope
and its location

- The aperture if EHT was the farthest distance between two telescopes.

- Then they decided two targets –
    1. Sagittarius A
    2. M 87



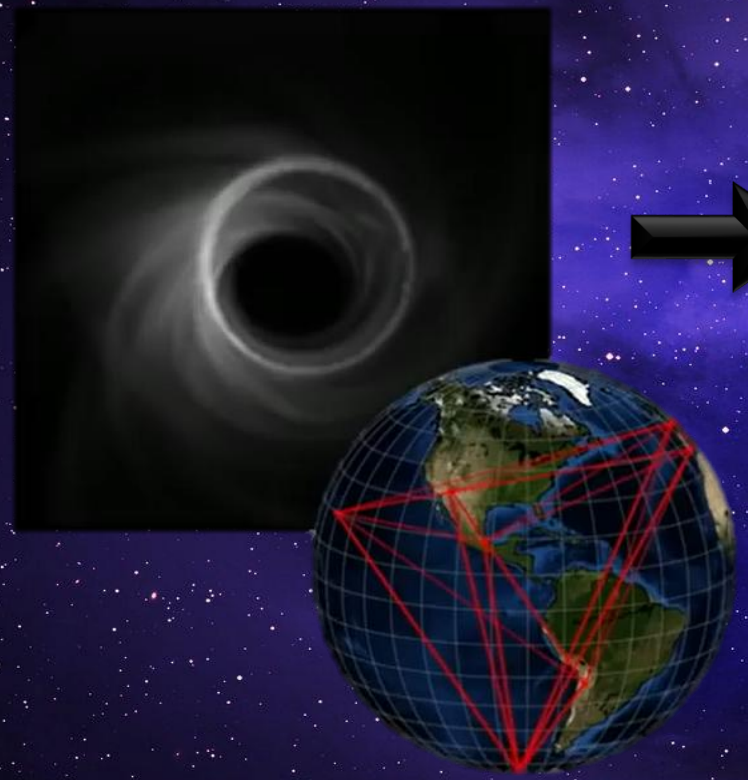


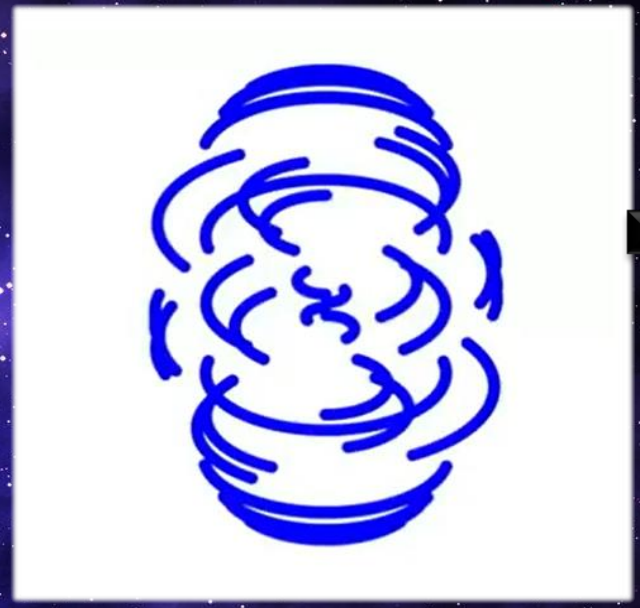


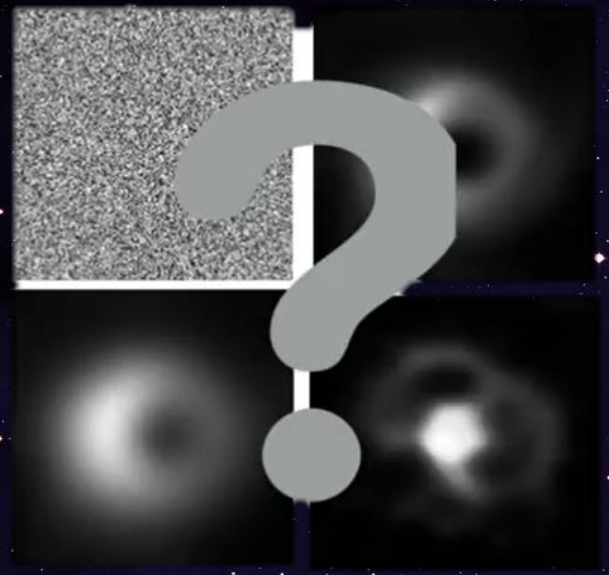
Credit - veritasium
https://www.youtube.com/watch?v=S_GVbuddri8

- Each telescopes will combine light to take a picture and then arrange them . It was more like a puzzle.

- Each telescope was synchronized with high precision atomic clocks.
- As more telescopes are added and the rotation of Earth is factored in, more of the image can be resolved, and we can expect images with higher resolution







Measurements

Infinite number if
Possible images

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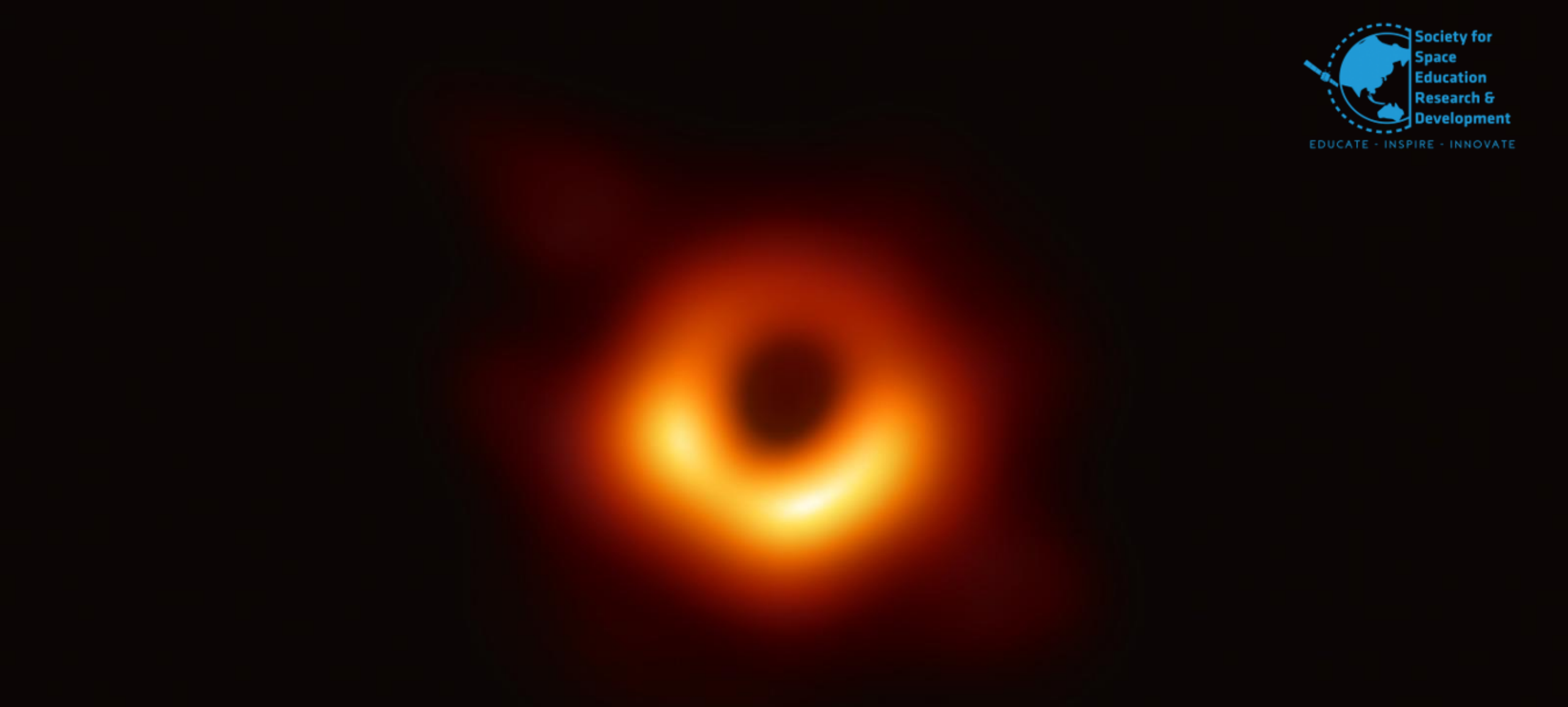

1st Image of Black Hole

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DO BLACK HOLES DIE ?

Yes they do die. Its called evaporation of black holes.

Hawking radiation reduces the mass and rotational energy of black holes and is therefore also known as black hole evaporation. Because of this, black holes that do not gain mass through other means are expected to shrink and ultimately vanish


Thank you