# Astronomical Data Science with Python

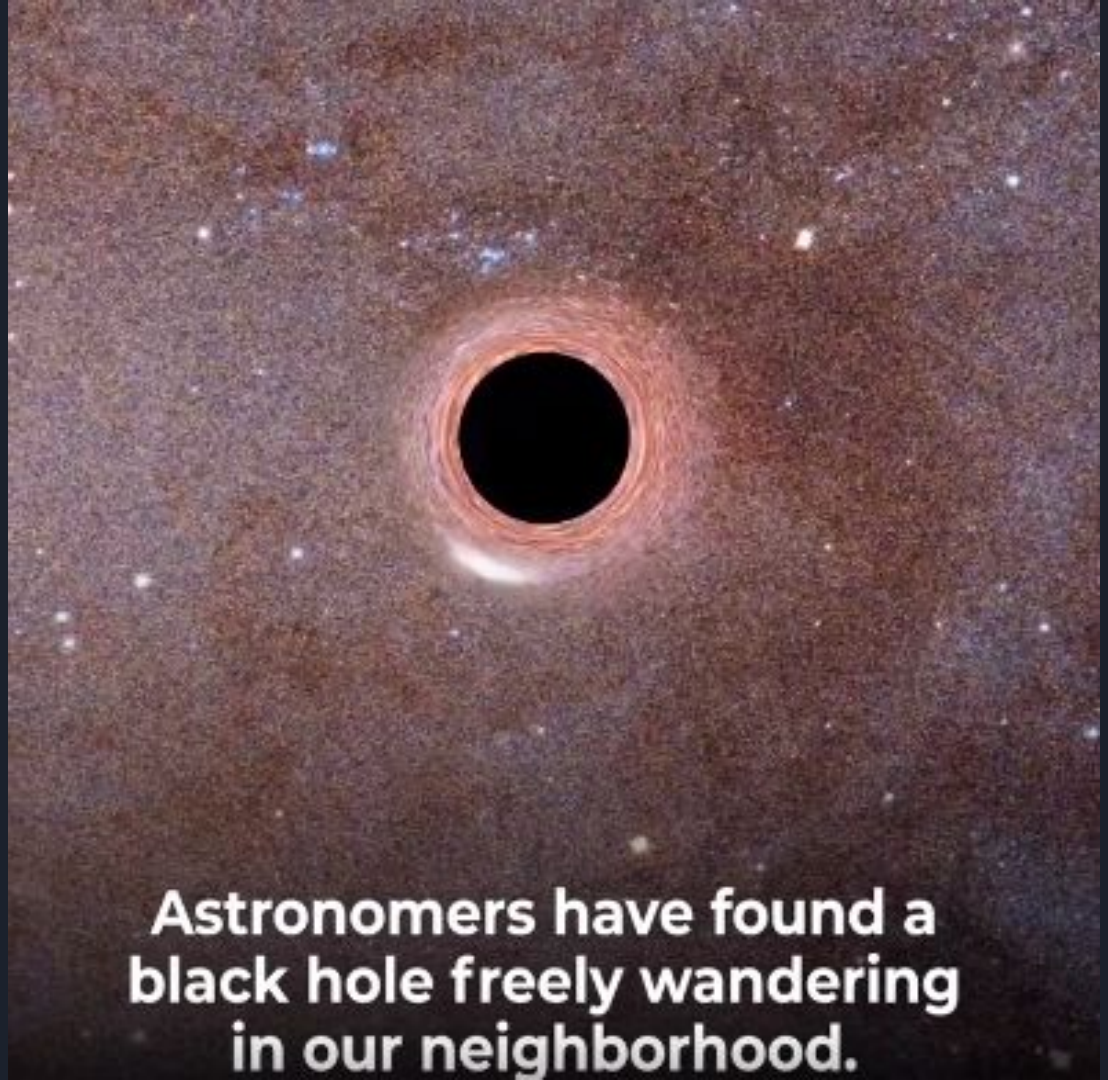
SPARTIFICIAL

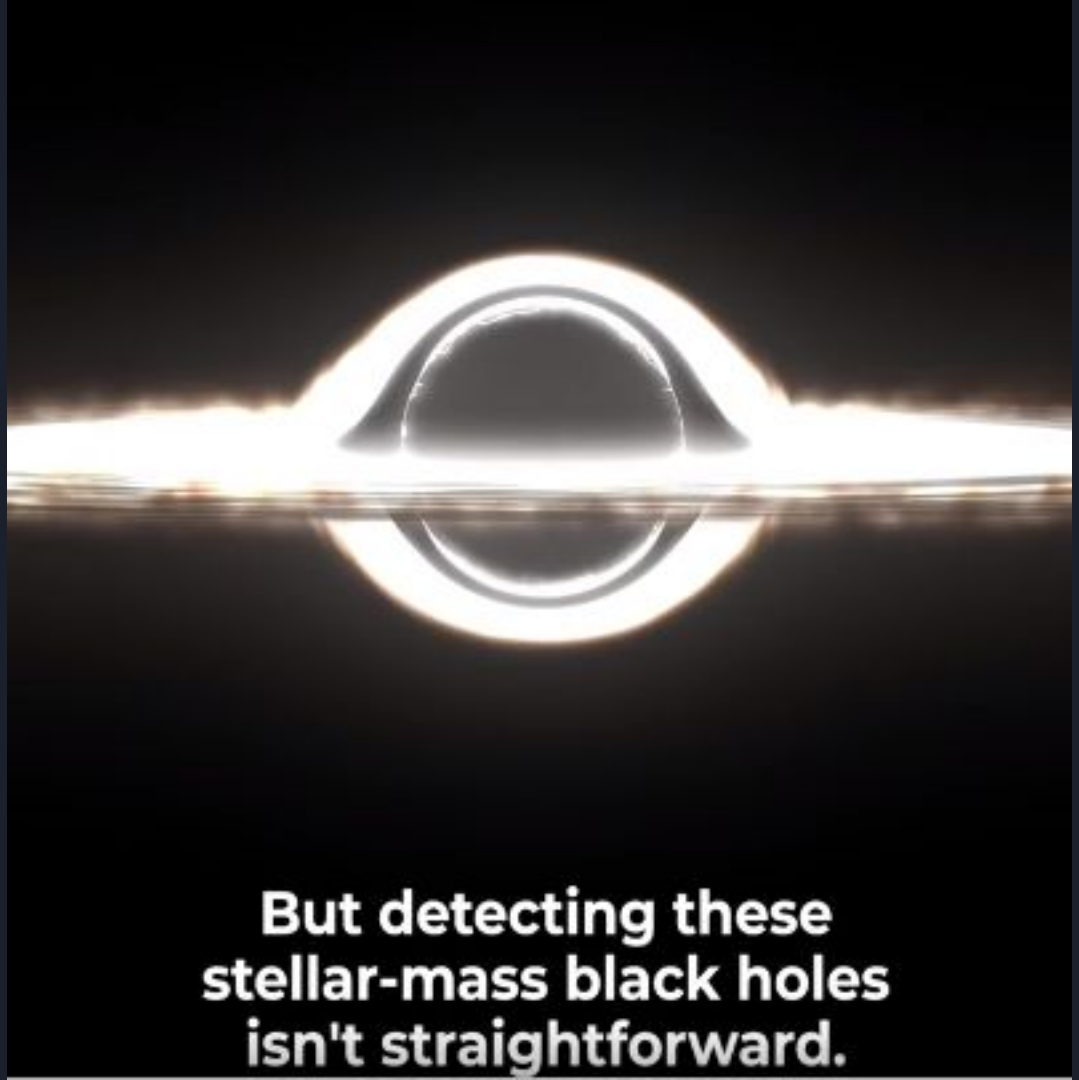
Day 1

# What’s in the course ?

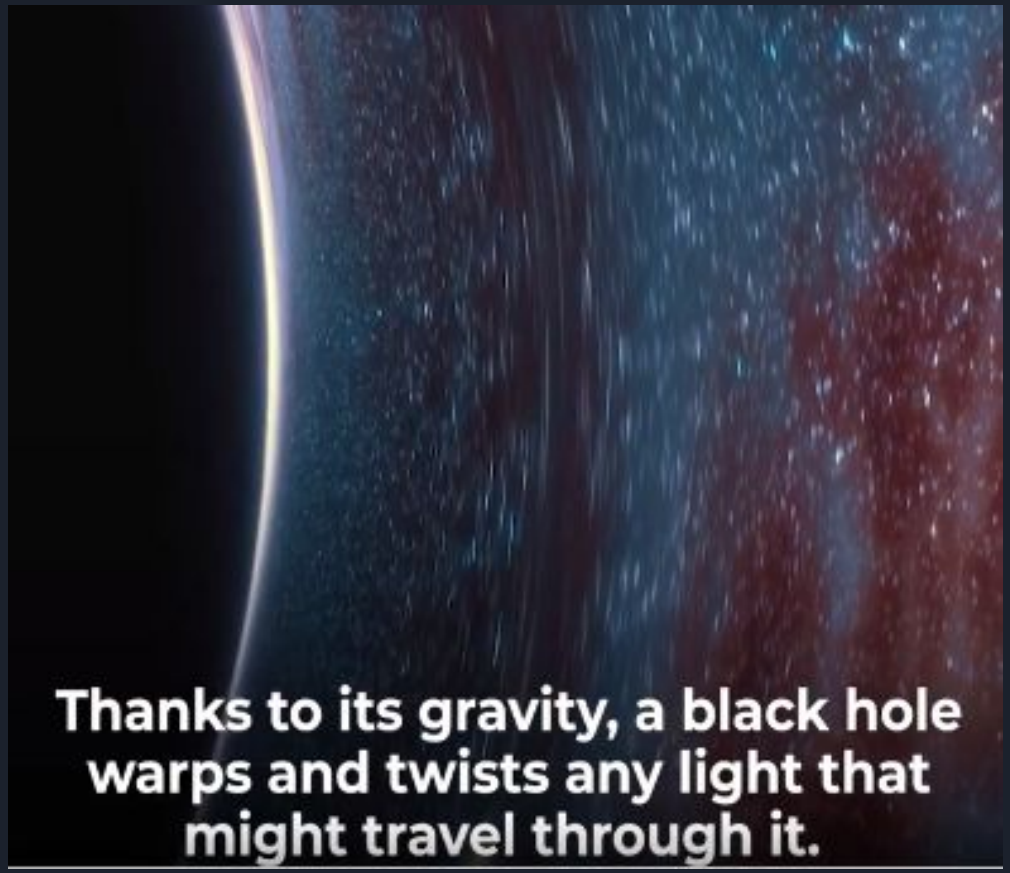
But before we dive into it ….

Let’s understand why this course


Astronomers have found a
black hole freely wandering
in our neighborhood.

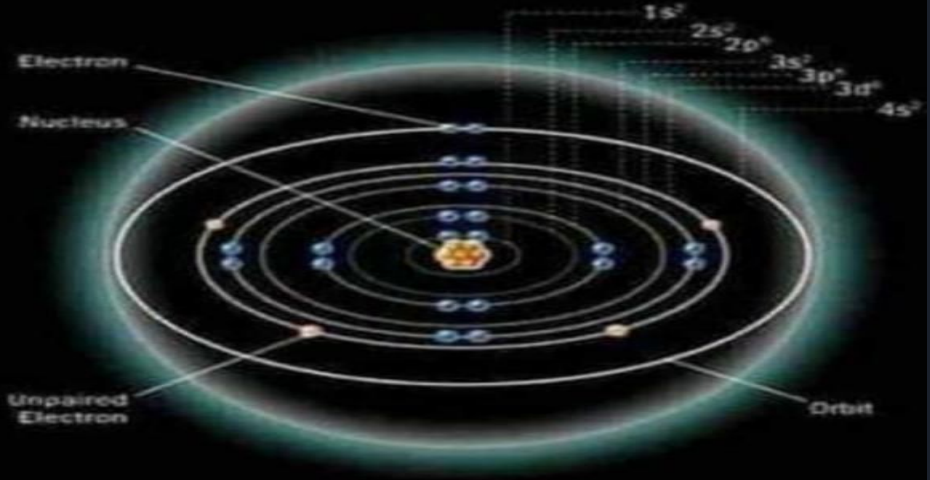

But detecting these
stellar-mass black holes
isn't straightforward.


So scientists use indirect ways
to detect the presence of a
black hole in space.


Thanks to its gravity, a black hole warps and twists any light that might travel through it.

# The Solar System

# Inside An Atom




Feynman: I, a universe of atoms,
An atom in the universe!

Have you heard the words?

# Space Telescope

Have you heard the words?

Hubble Telescope
Black hole
JWST (James Webb)

Have you heard the words?

Hubble Telescope

Galaxy

Black hole

JWST (James Webb)

Have you heard the words?

Machine learning

Hubble Telescope

Image processing

Galaxy

Black hole

JWST (James Webb)

Have you heard the words?

Hubble Telescope

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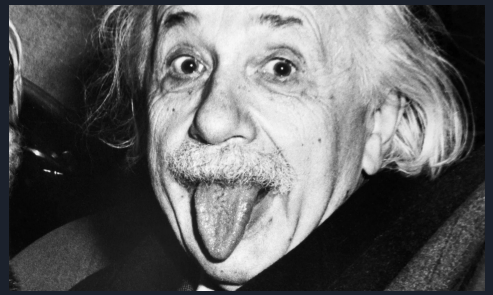
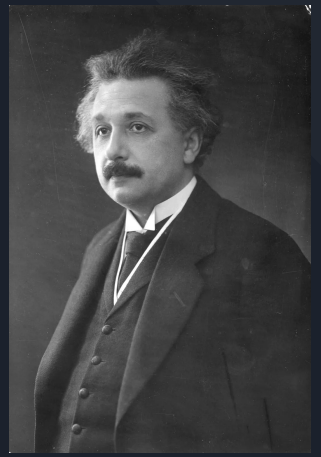
Machine learning



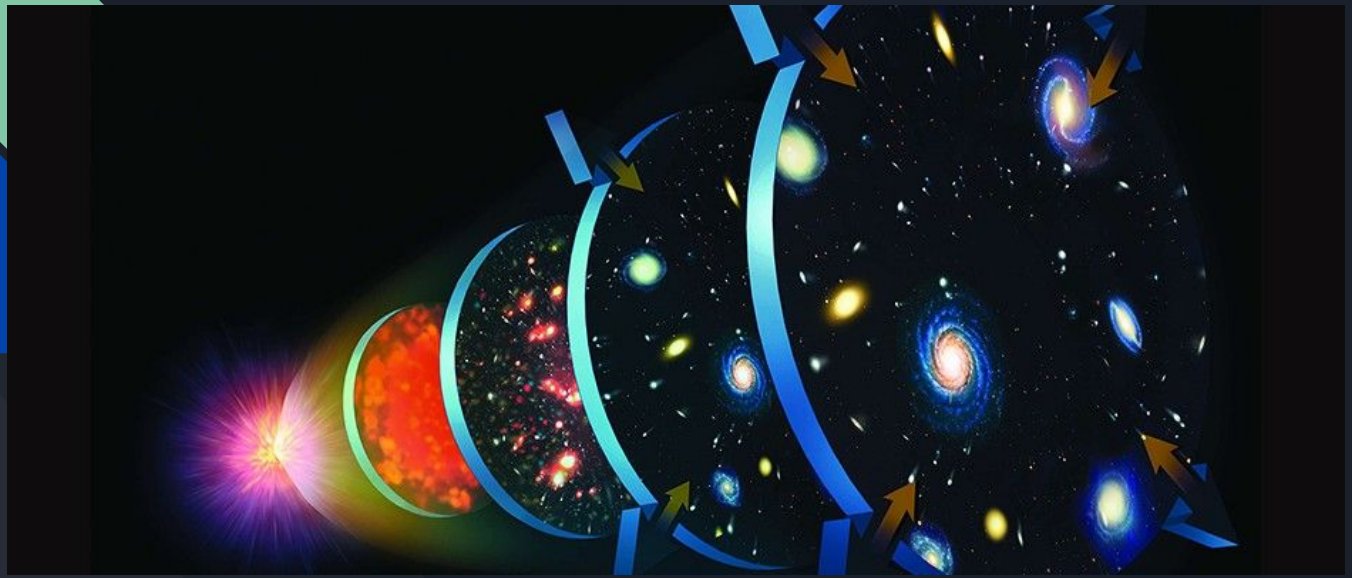


$$G_{\mu\nu}+\Lambda g_{\mu\nu}=\frac{8\pi G}{c^4}T_{\mu\nu}$$

In 1905, Einstein's ideas on Special Relativity were considered improbable and unbelievable . . .

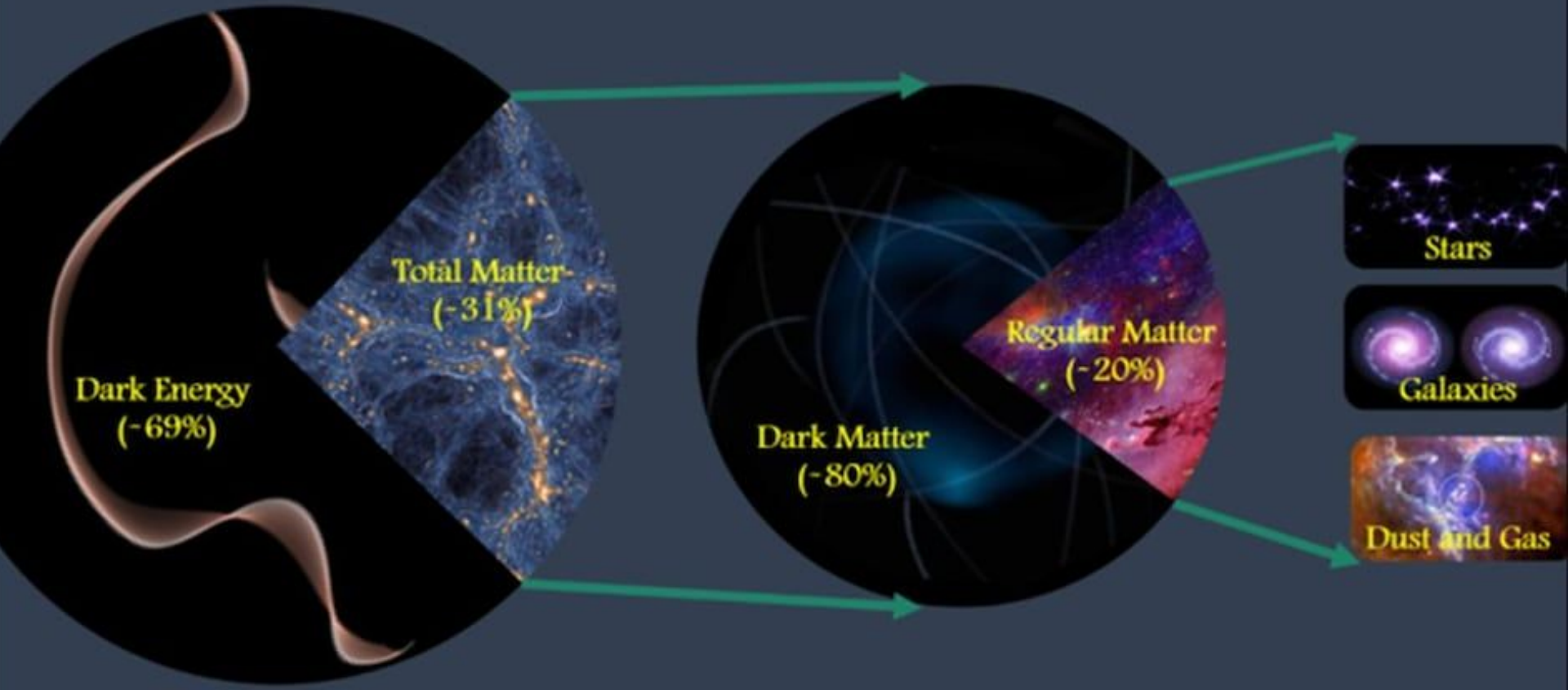
. . . and his ideas on spacetime curvature even more so in 1916 . . .

. . . and yet, GPS won't work and spacecraft will fall from the skies unless we use GR!

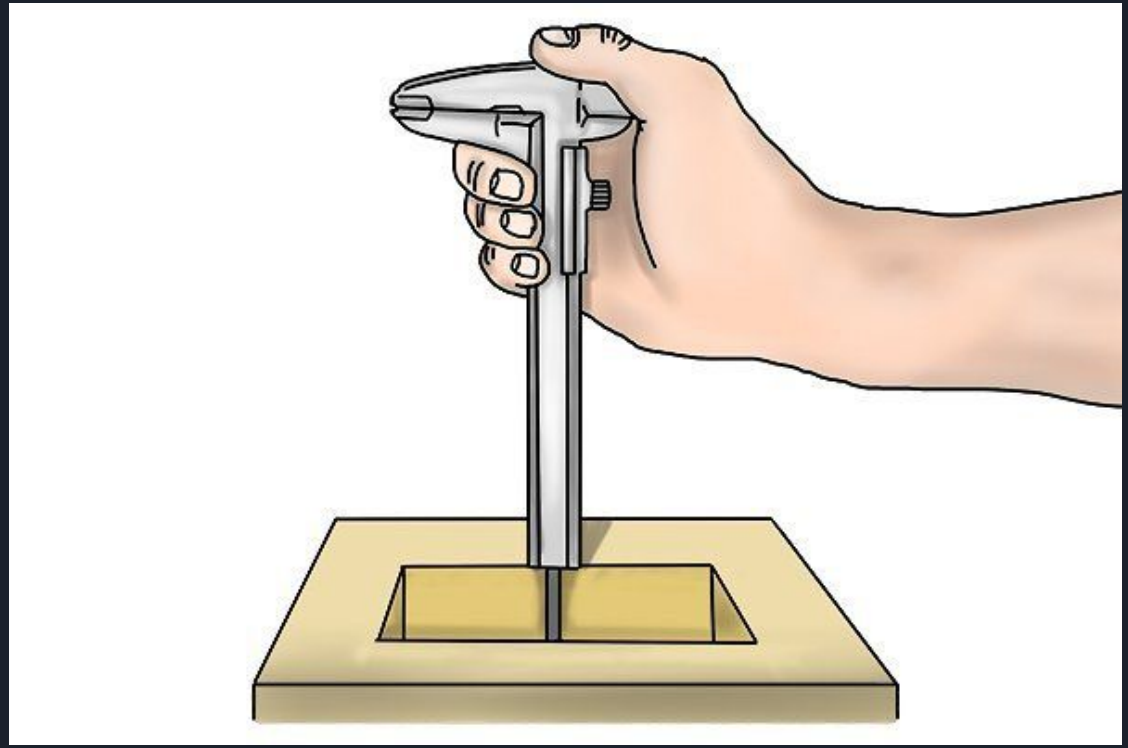


Over the last century, new technology has provided new evidence for the Big Bang, black holes, and even Dark Energy . . .
. . . and even some evidence against Dark Energy!

New technology has provided new evidence for the Big Bang, black holes, and even Dark Energy.


Dark Energy
(~69%)
Total Matter
(~31%)
Dark Matter
(~80%)
Regular Matter
(~20%)
Stars
Galaxies
Dust and Gas

# Understand the depth of this field with an example....



# Space telescope

# What is a Space Telescope?

Especially made for the purpose of observing space objects from outer space

# Hubble telescope

- Revolutionary NASA spacecraft
- To explore the limits of known universe
- Offer a pristine look at the skies without light pollution

The Hubble Space Telescope,

**Why does NASA put telescopes in space? Location, location, location!**

- Stars twinkle in our night sky due to distorting, or bending, of the starlight by the Earth's atmosphere.
- This distortion is like looking at an object through a glass of water.
- Large telescopes here on the ground—which also must peer through Earth's atmosphere—are equally vulnerable to our atmosphere's visual tricks.

# Hubble Vision

**2001** | Hubble measured the elements in the atmosphere of the **exoplanet** HD 209458b.

**2004** | The Hubble Ultra Deep Field was released allowing astronomers to look even further back in the time of the cosmos.

**2005** | Hubble photographed two previously unknown moons orbiting **Pluto**.

**2007** | Hubble observations showed that the dwarf planet Eris was bigger than **Pluto**. Hubble also assisted the production of a 3D-map showing the distribution of **dark matter** in the Universe.

**2008** | Hubble took a picture of the exoplanet Formalhaut b, the first visual image of an exoplanet. In the same year Hubble found organic molecules on an extrasolar planet and the telescope's 100 000th orbit around Earth was celebrated.

**2010** | Hubble images revealed distant **galaxies** with likely **redshifts** (a measure of distance used in cosmology) greater than 8, showing the Universe as it was when it was less than a tenth of its current age. Hubble also photographed a never-before-seen evidence of a collision between two **asteroids.**

**2011** | Hubble made its millionth observation, a spectroscopic analysis of the exoplanet HAT-P-7b. The 10,000th scientific paper using Hubble data was published.

**2012** | Images taken by Hubble showed seven primitive galaxies from a distant population that formed more than 13 billion years ago. The images showed the galaxies as they were when the Universe was less than 4 percent of its present age. Later in the year that record was broken when Hubble discovered an object from when the Universe was only 3 percent of its present age, only 470 million years after the Big Bang.

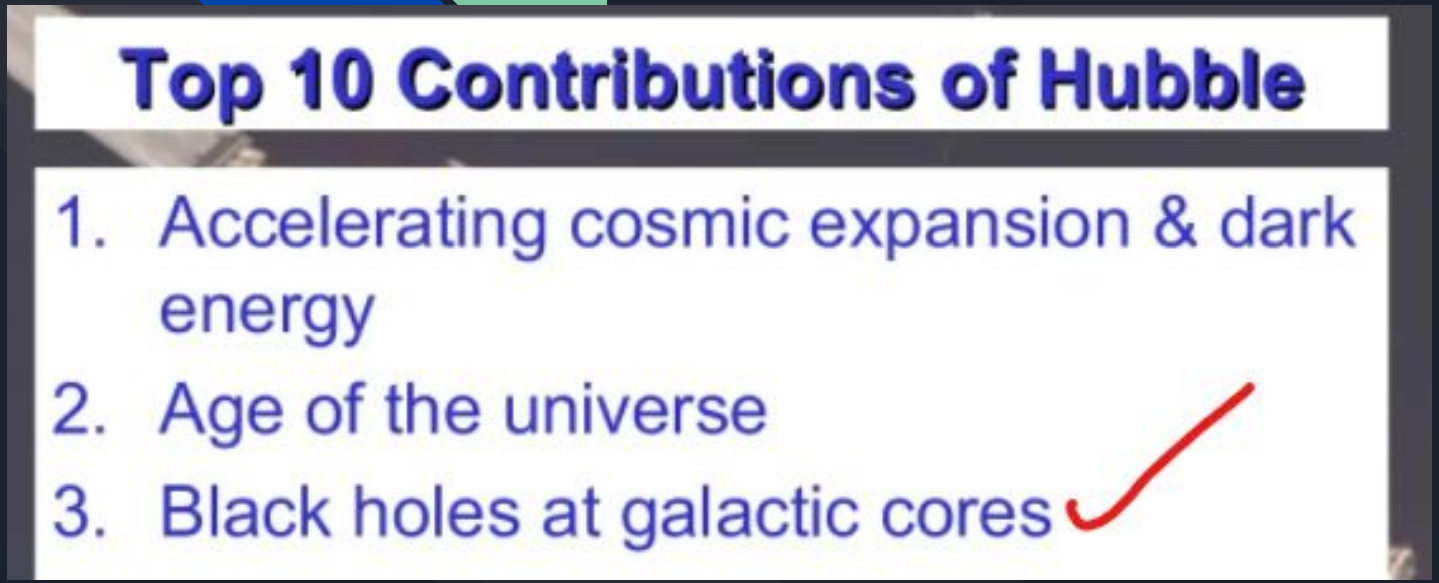
**2013** | Hubble was used to determine for the first time the true colour of a planet orbiting another star and found **water vapour** erupting off the surface of **Jupiter**'s moon **Europa.**

**2014** | Hubble became the first telescope ever to observe an asteroid disintegrating and revealed the most detailed weather map for an exoplanet ever.

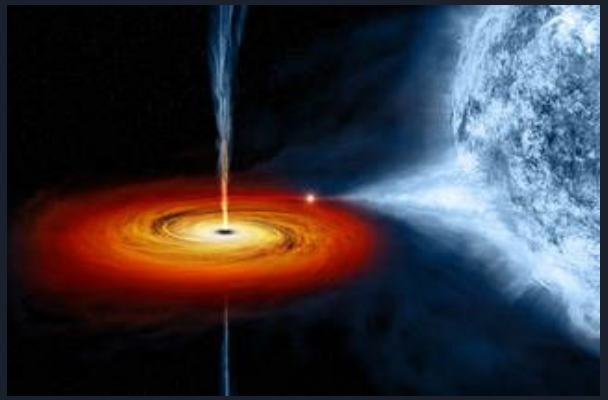
**2015** | Hubble observed, for the first time, the effect of gravitational lensing on a distant **exploding star**, where the powerful gravity of a foreground galaxy acts like a cosmic magnifying glass, enhancing and splitting the image into a cross-shaped pattern of light.

One of the contribution of hubble telescope

# Black hole detection

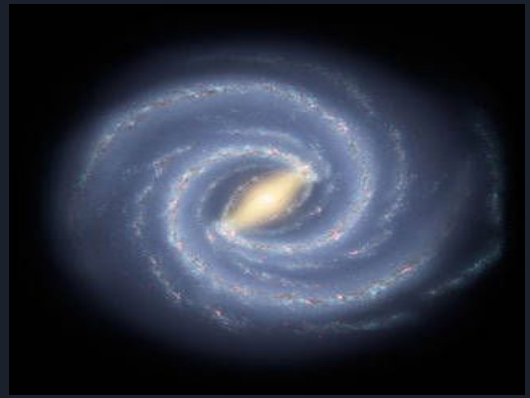


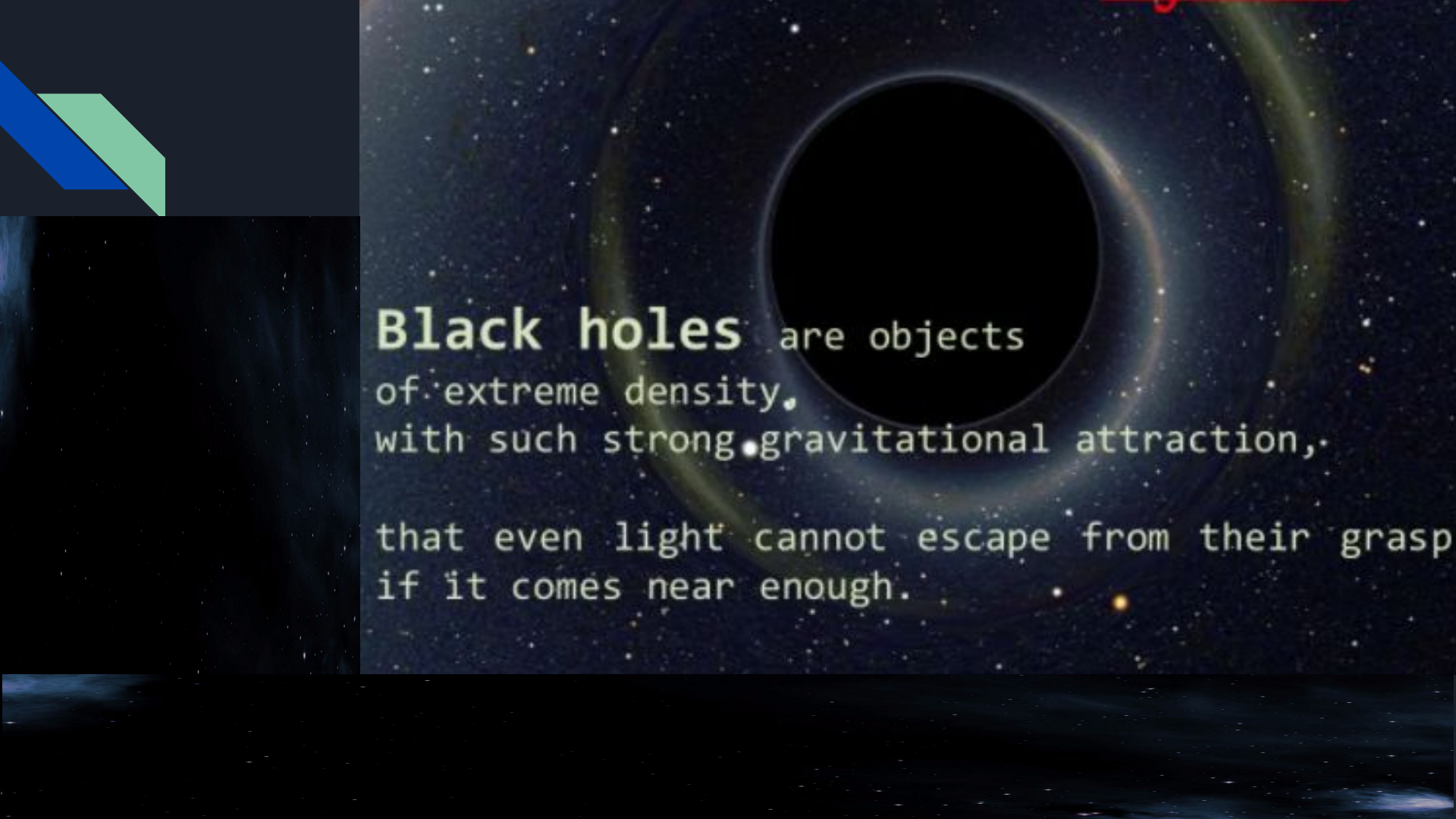
# Black hole

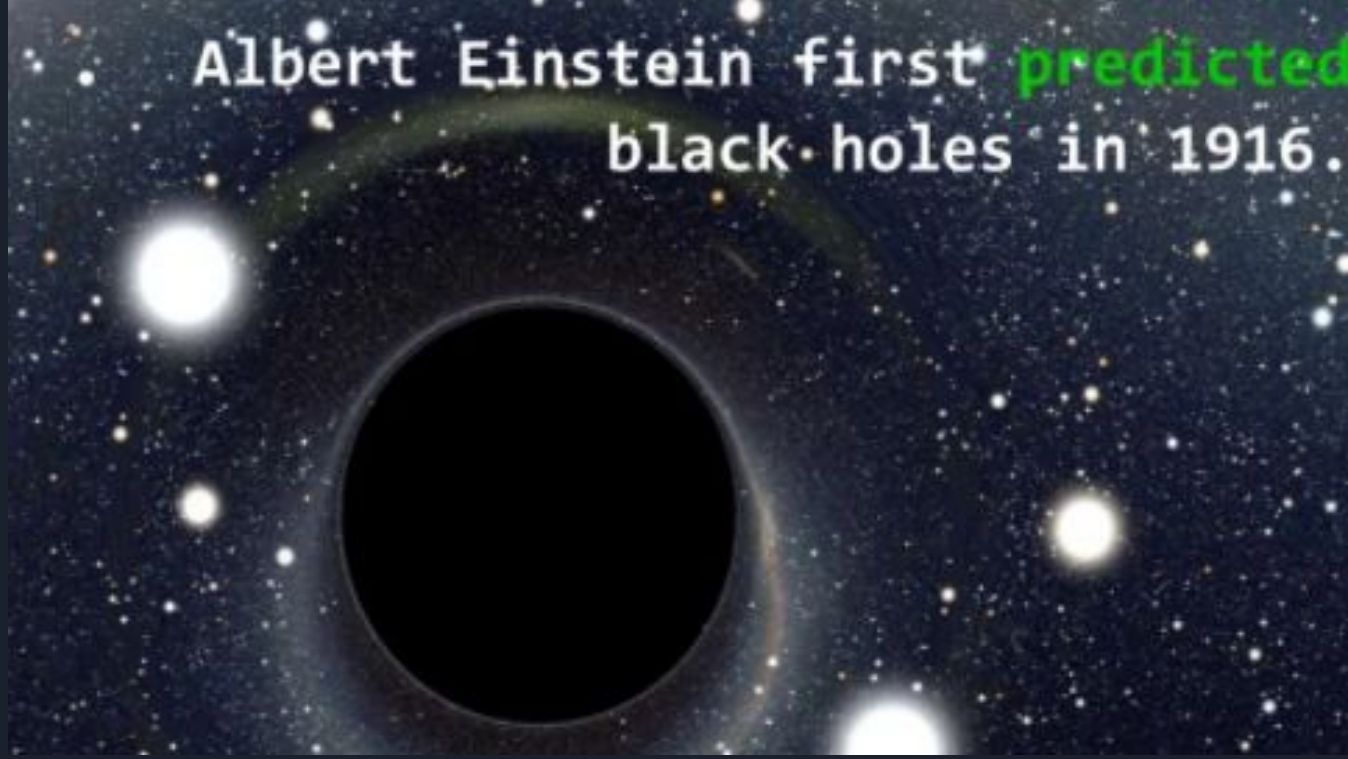


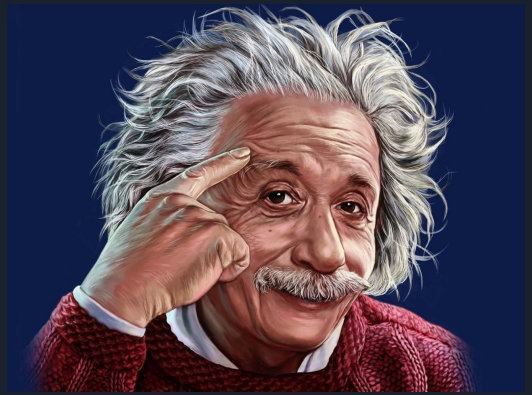
A black hole is a place in space where gravity pulls so much that even light can not get out.

The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.




**Black holes** are objects
of extreme density,
with such strong gravitational attraction,
that even light cannot escape from their grasp
if it comes near enough.


Albert Einstein first predicted
black holes in 1916.



# How does black hole look like ?

In 2019, the Event Horizon Telescope (EHT) collaboration produced the first-ever image of a black hole, which lies at the center of the M87 galaxy 55 million light-years from Earth. The image showed a bright ring with a dark center, which is the black hole's shadow.

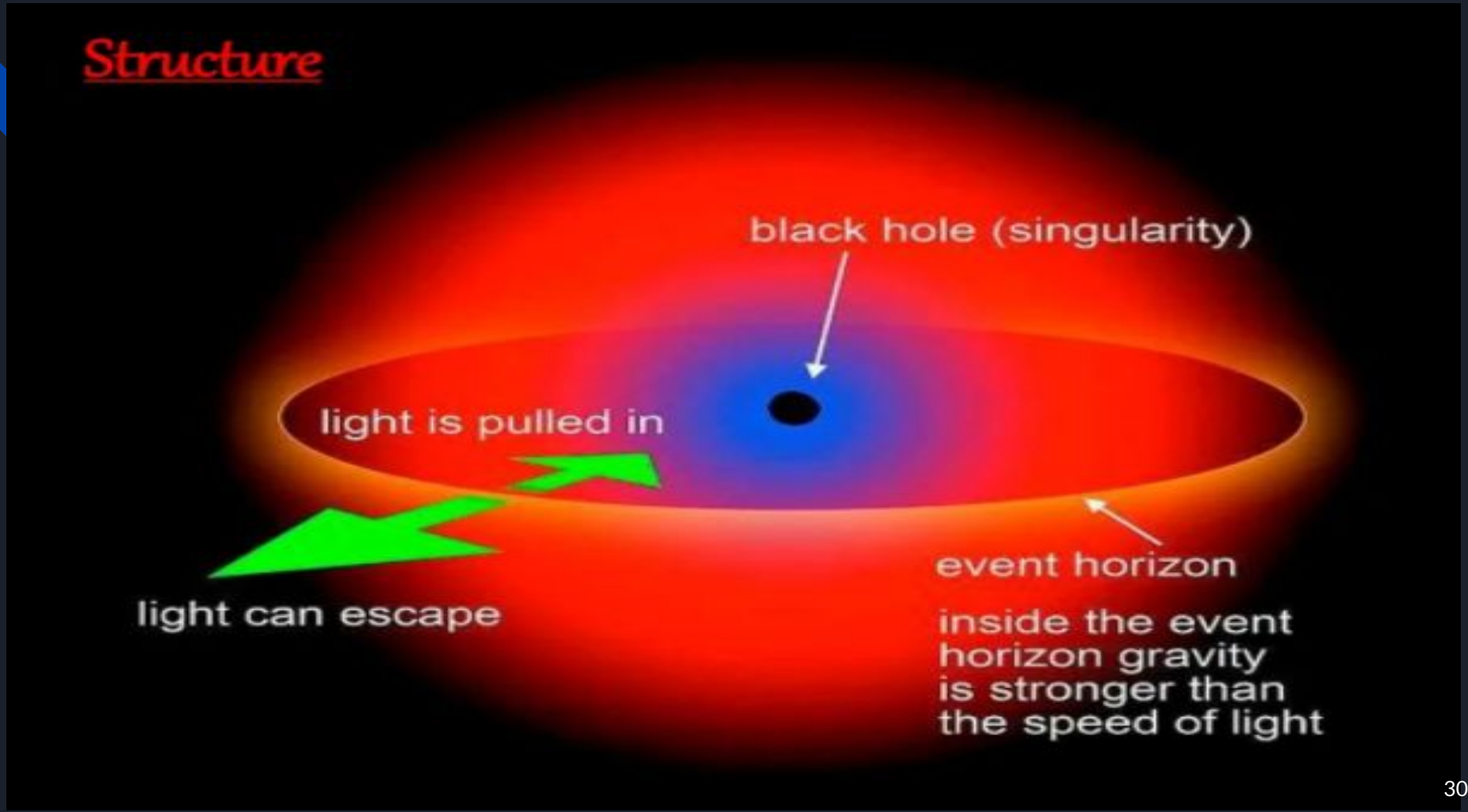
# How a star becomes a black hole?

When a star burns through the last of its fuel, it may find itself **collapsing**.

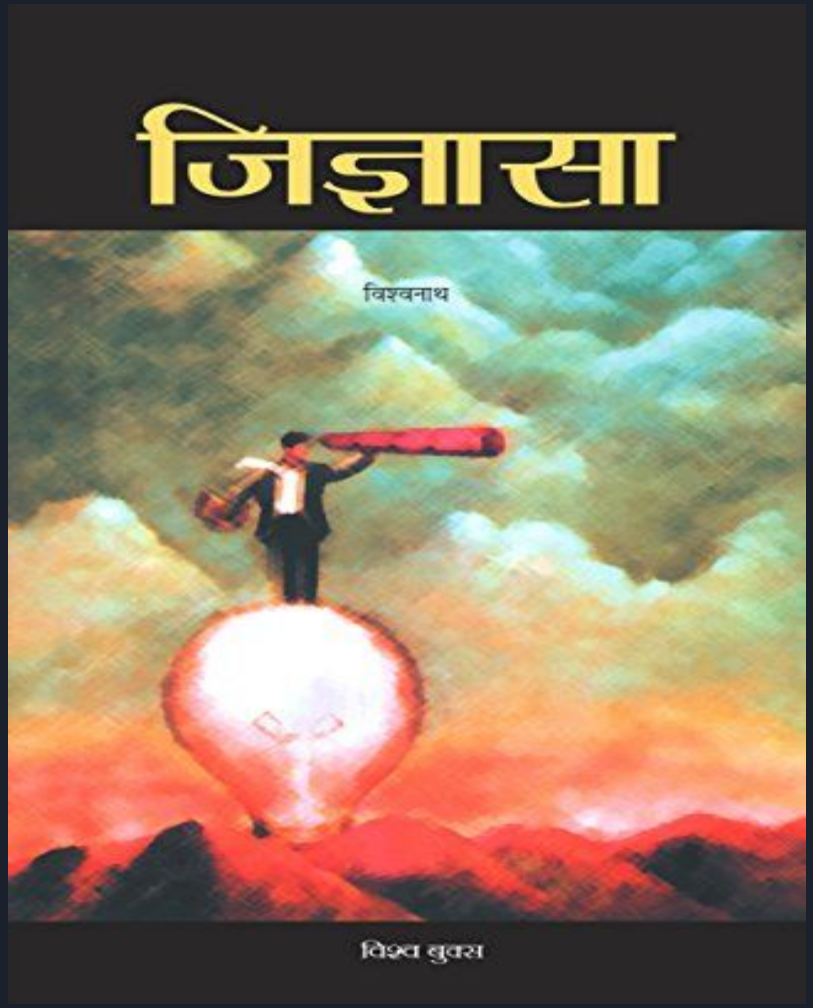
For smaller stars,
the new core will be **a neutron star or a white dwarf**.

But when a larger star collapses, it continues to fall in on itself to create **a stellar black hole**.

# Structure


black hole (singularity)
light is pulled in
light can escape
event horizon
inside the event horizon gravity is stronger than the speed of light

# But Why Is everyone researching about it???


जिज्ञासा
विश्वनाथ
विश्व बुक्स

- Not only to prove the existence of black holes, but also to understand the physics of black holes and their surrounding environments.

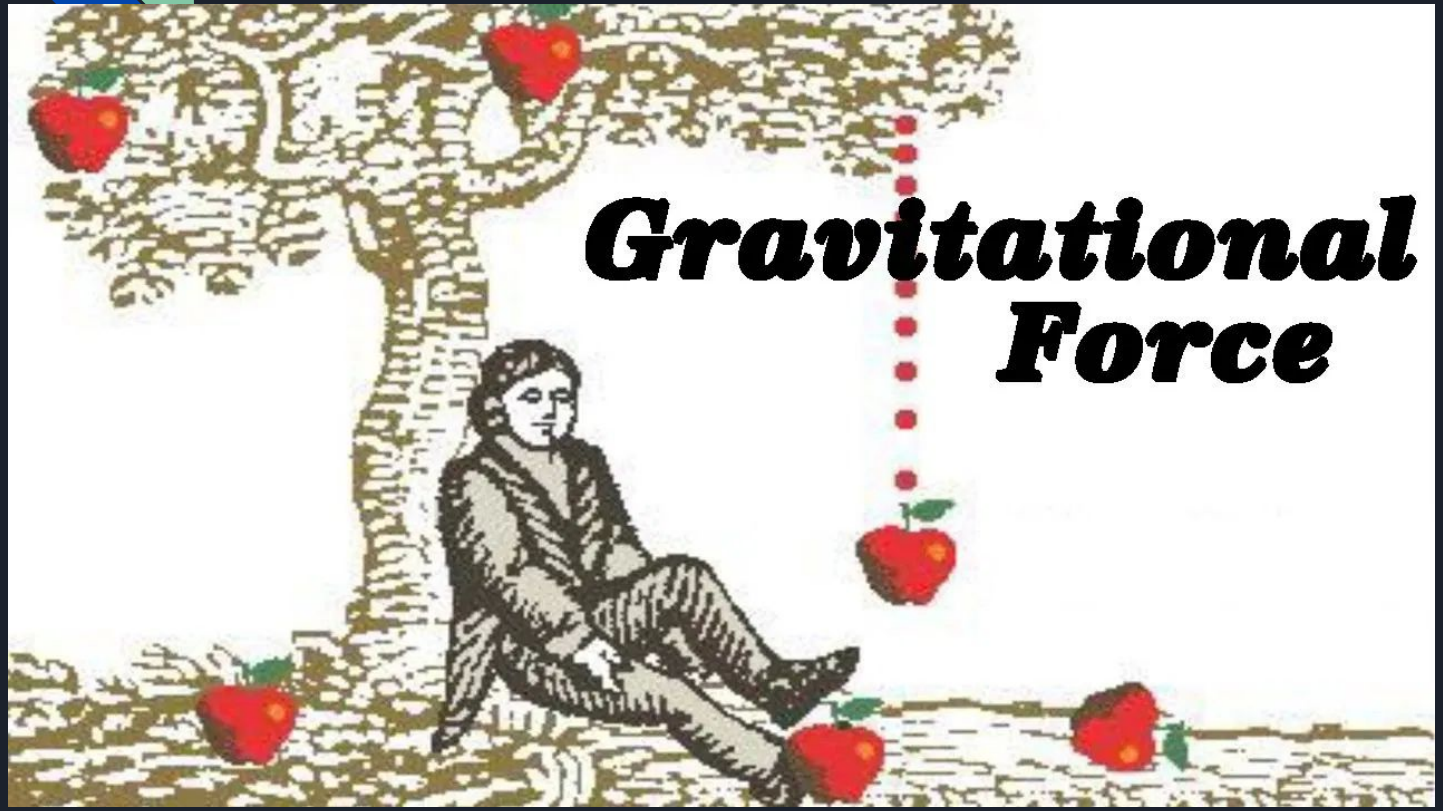
Black holes are laboratories for testing fundamental theories that explain how the Universe works on the largest and the smallest scales (e.g., GR and possible corrections to Quantum Field Theory).

- In addition to the fundamental physical theories, there are many details of plasma physics that are not completely understood.
- Properties of the hot gas surrounding and being pulled into the black hole beyond the event horizon are not fully known.

# Why is it important to understand theory.....

# To develop theory.....

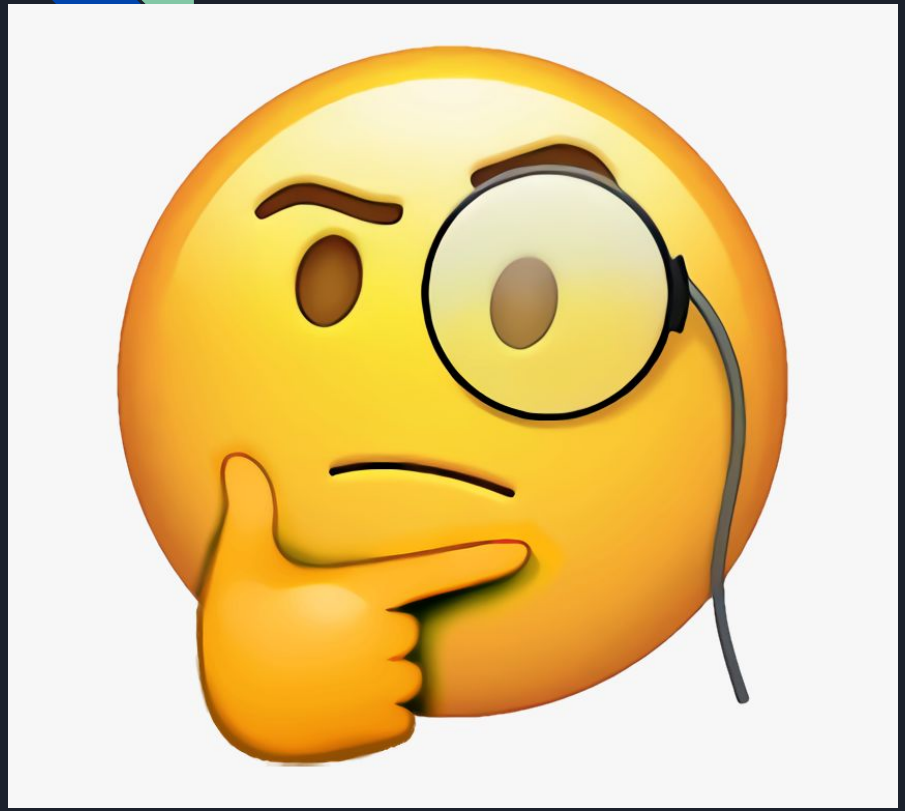
# Example



# This is just one example

# Why black holes.....

# How can we

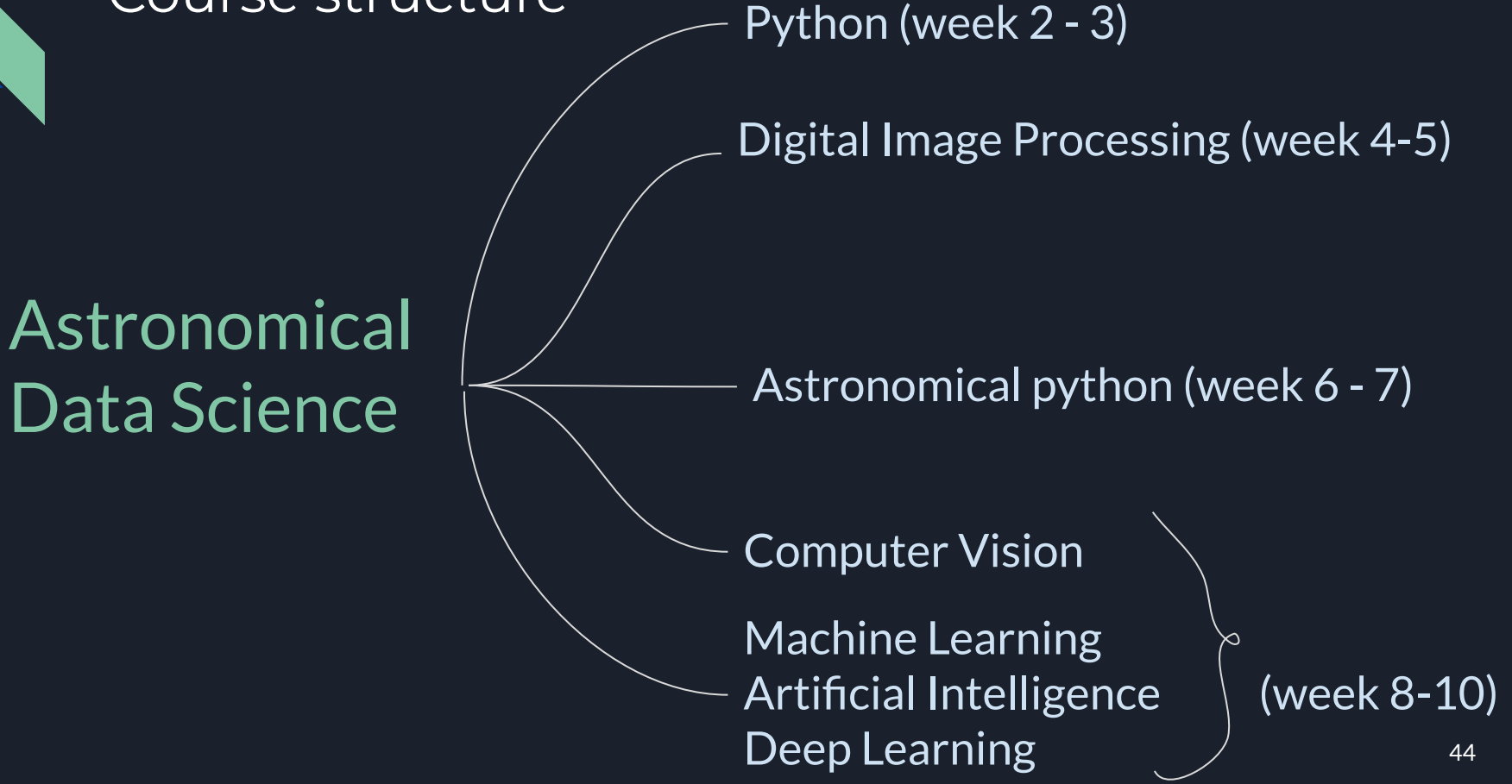



A+

Black hole was just an example

Let’s see what this course has for you

# Course structure



# HIGHLIGHTS .....

## Extensive Teaching

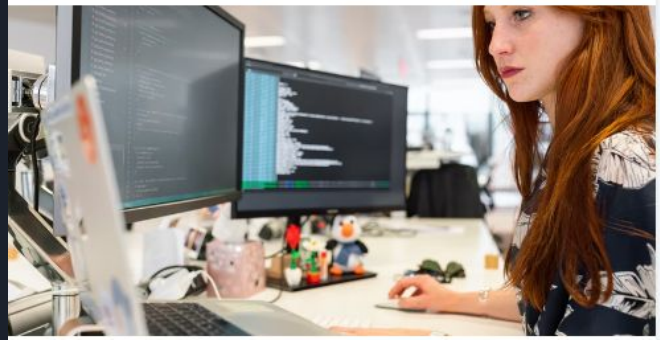
Get thoroughly trained by IITians and IISTians with complete guidance and assistance throughout the program.


- Online, interactive training sessions
- Daily doubt sessions
- In-depth study modules & resources
- Regular assignments
- Regular performance reports
- Lifetime access to recorded sessions

# HIGHLIGHTS .....

## Hands-On Training

Learn through practical implementation and hands-on training and advance from the basic to advanced concepts of AI.



- Practical coding sessions
- Learn by practical implementation
- Practice assignments
- Training completion certifcate

# Research Internship

You will get a chance to be a part of the Research Internship once the eight weeks training program gets completed. The Research Internship will be of a duration of 8 to 10 weeks after the training program.

Eligibility Criteria:

- Submit all assignments within the deadline.
- Securing at least 50%  marks in each assignment
- Clear the interview (only if required).

# Schedule of training program

Monday, Wednesday, Friday - 7:00 PM to 8:00 PM


BE PATIENT.
GOOD THINGS
TAKE TIME.
- ANONYMOUS