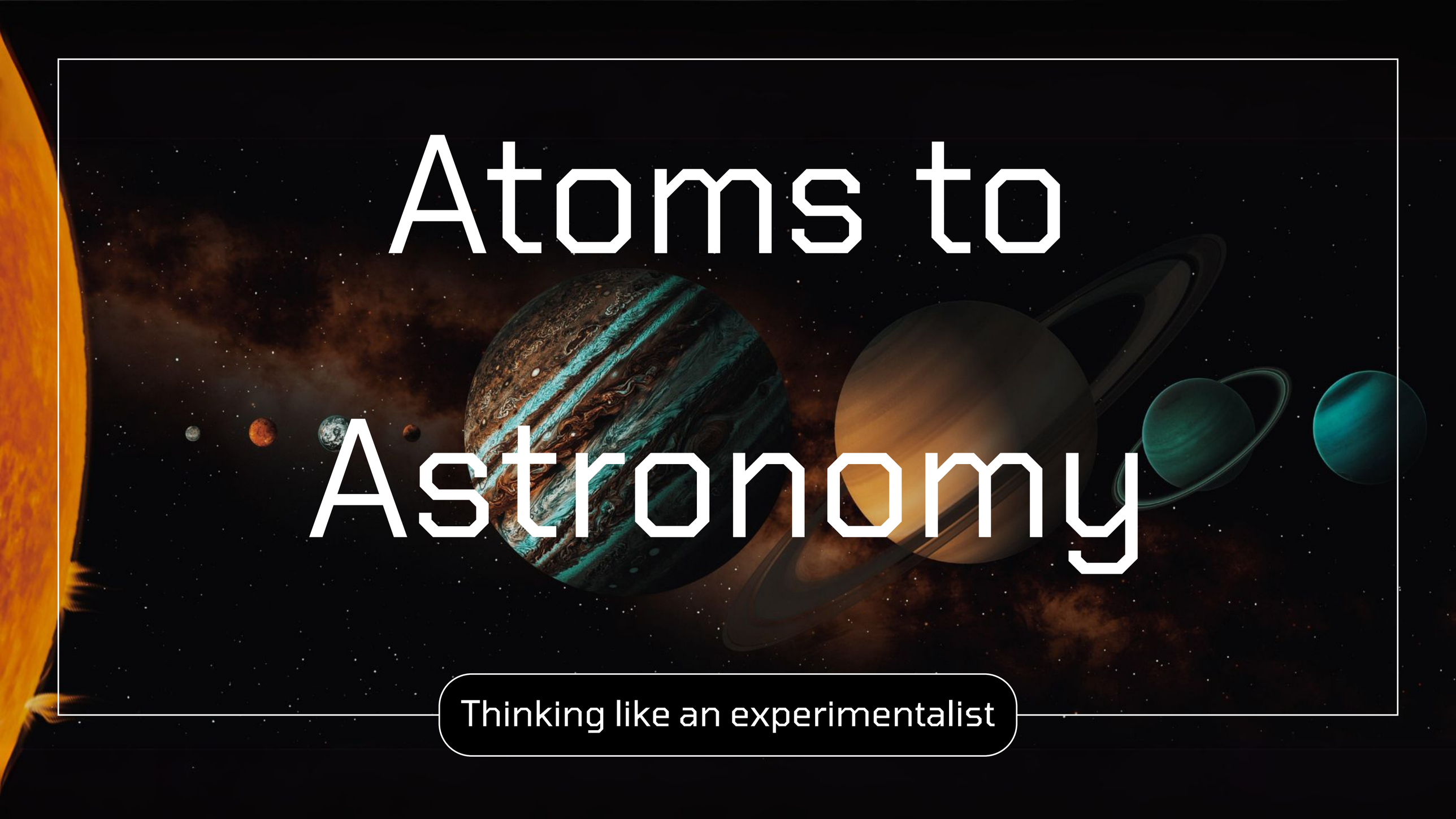

Atoms to
Astronomy
Thinking like an experimentalist

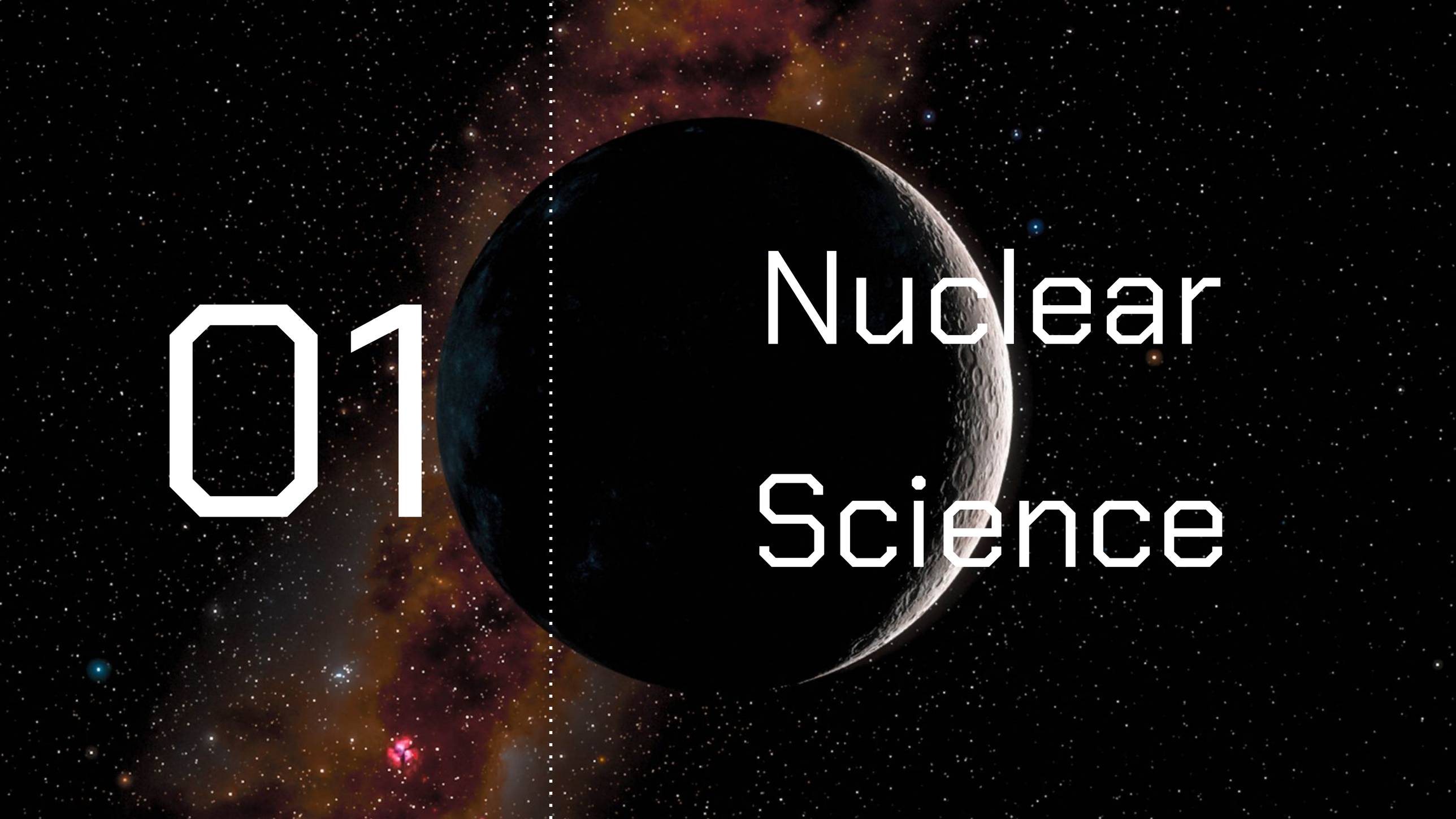
# Overview

01 Nuclear Science

02 Electricity and Magnetism

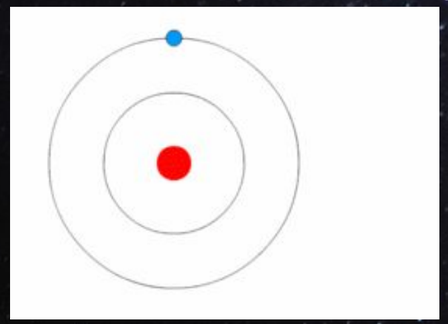
03 Gravitation

04 Afterword

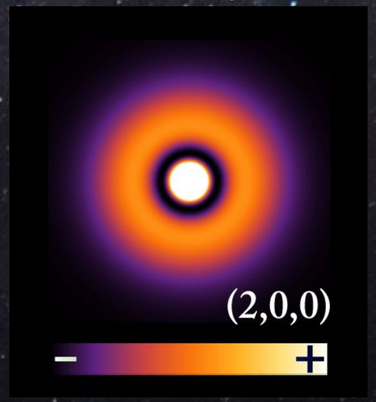

01
Nuclear
Science

# The Atom

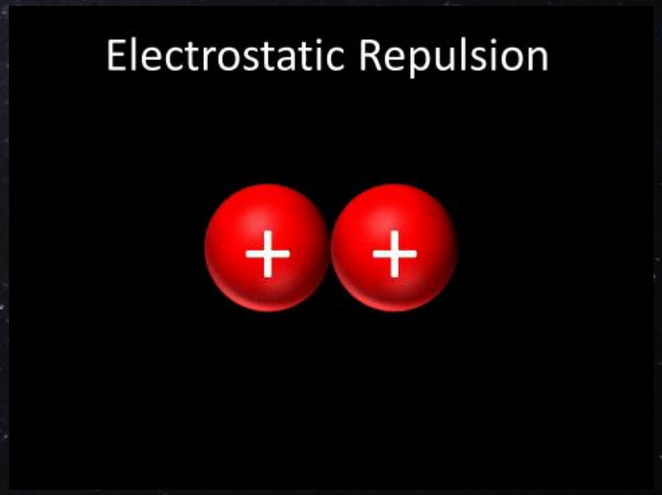
Atoms are made up of positive charge protons and negative charge electrons. All protons lie in the middle of an atom while electrons orbit in clouds.



Bohr Model



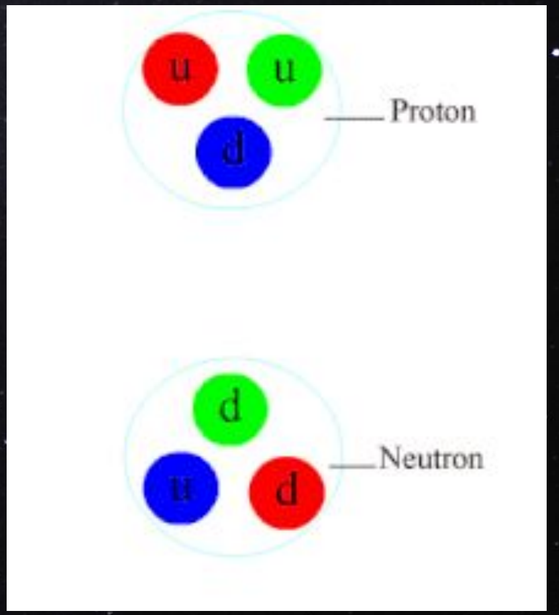

Schrodinger Model



# Strong Force

A strong force keeps the positive charge protons together in the nucleus.

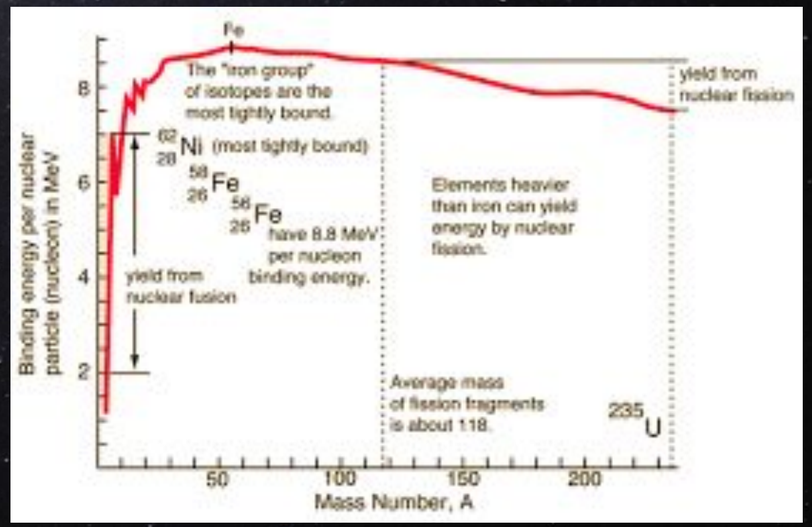
“Work” is done by the nucleons (protons and neutrons) through the strong force! Adding more nucleons does more work and thus releases more energy!



# $E=mc^2$

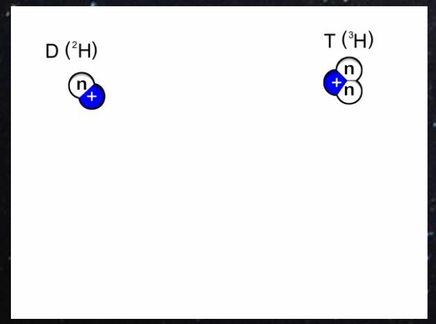
Einstein postulated that energy and mass are fundamentally related. Mass can be converted into energy and vice-versa!

Energy released by by strong-force interactions is called “binding” energy. Different atoms have different average binding energies.

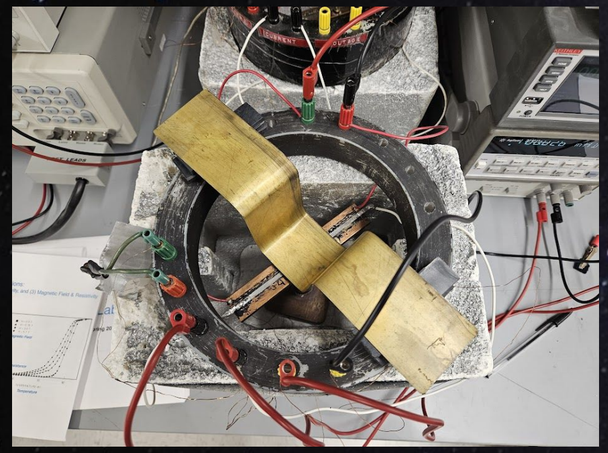


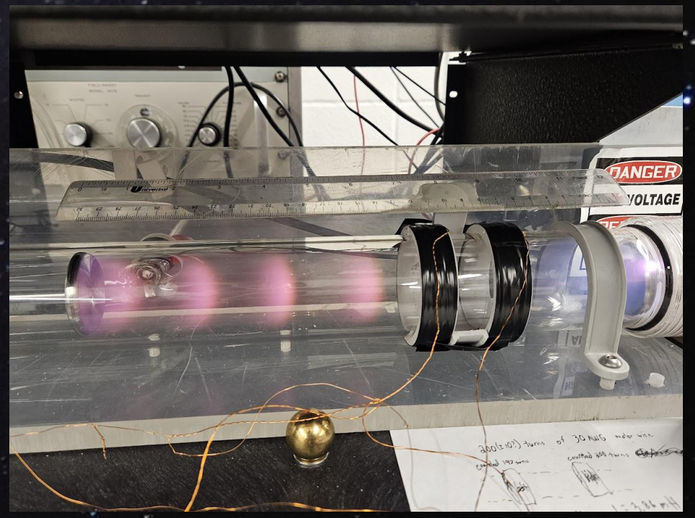
# Fusion

Light atoms can fuse together to release energy. However, it is extremely difficult to get small atoms to fuse!



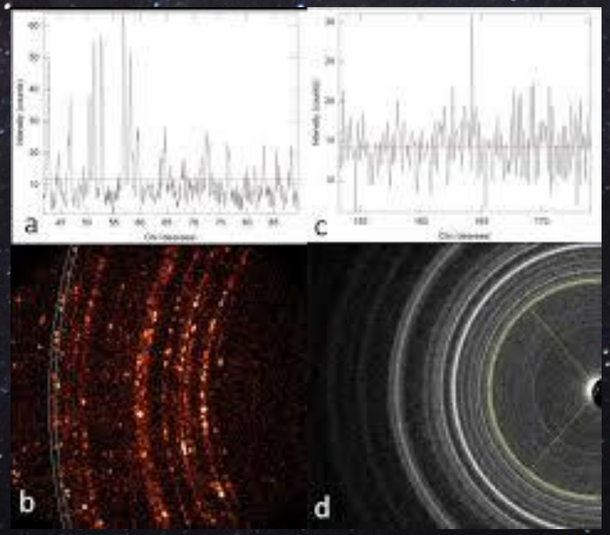

# Materials

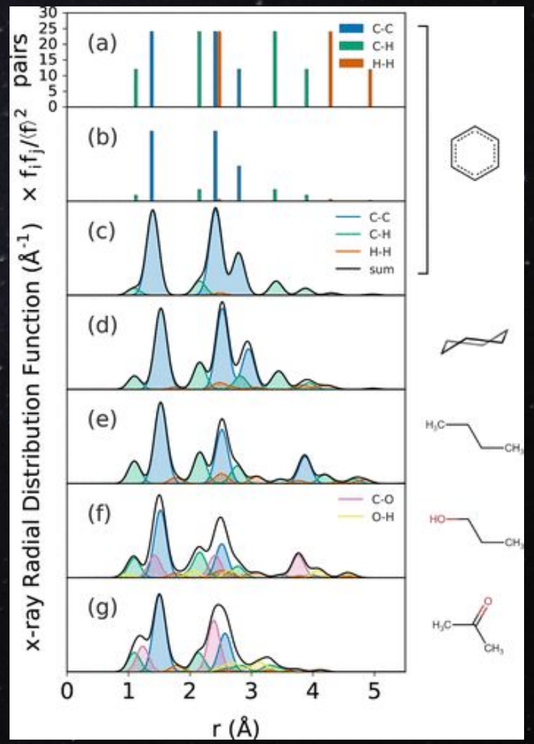


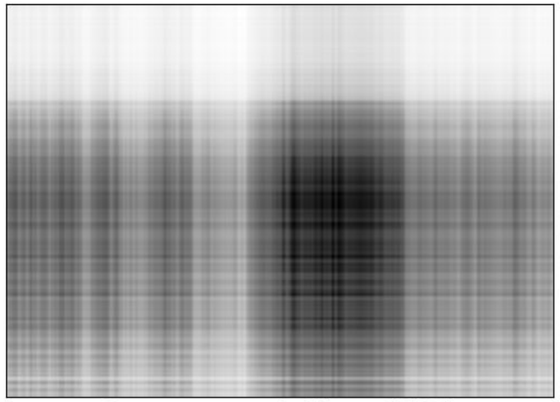


# Diffraction

Synchrotron





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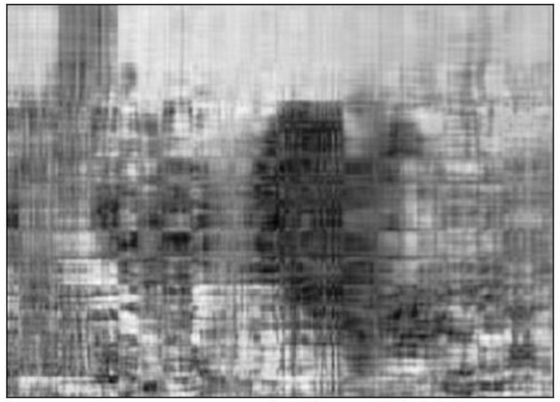

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Original Image

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# Mapping

Demo

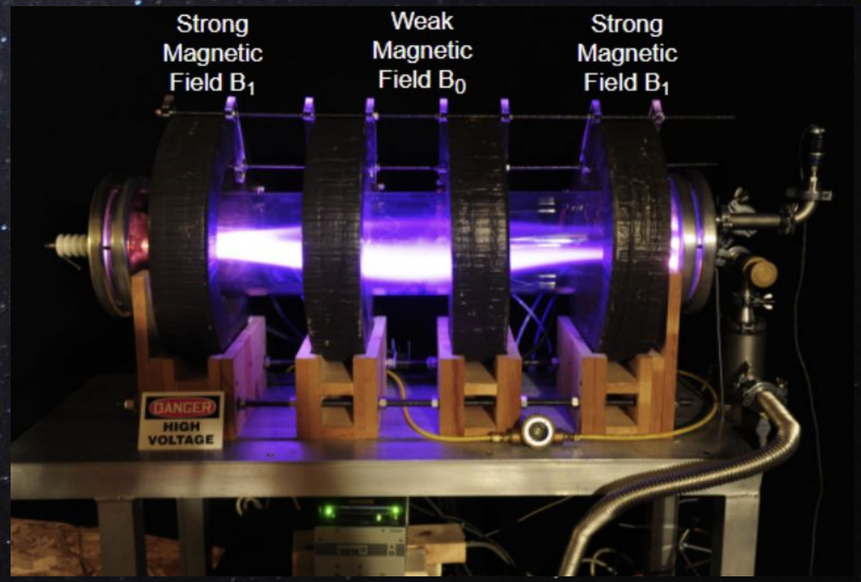
# 02

# Electricity and Magnetism

# Confinement

Light atoms can fuse together to release energy. However, it is extremely difficult to get small atoms to move the way we want!

We can use magnets to lead these atoms along different paths!



# Collision

When we have many particles together, they tend to collide.

Collisions always conserve momentum, but the initial and final velocities can vary!

Charged particle collision can be treated as elastic: no energy will be lost!

# Interactions

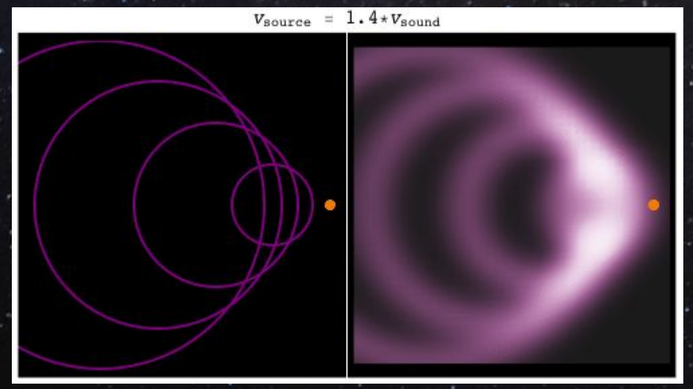
Demo

# EM Waves

Light is an electromagnetic wave.

These waves travel at the speed of light!

Nothing can travel faster than the speed of light in a vacuum.




# 03

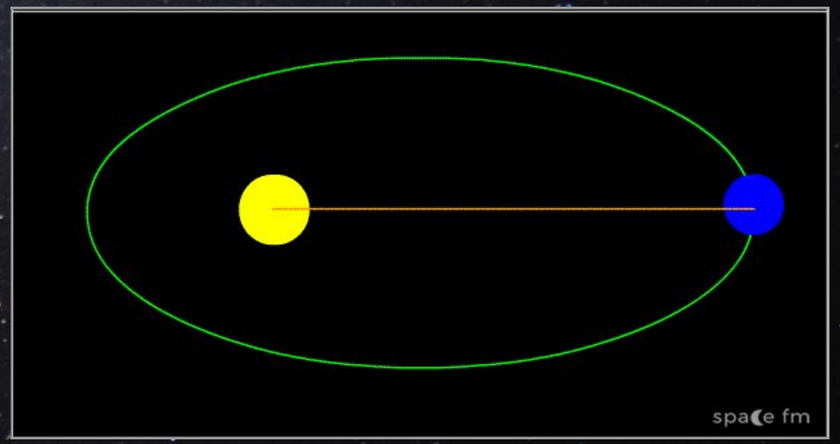
# Gravity

# Kepler's Laws

Kepler's first law: planetary orbits are elliptical.

Kepler's second law: orbits sweep out the same area for any given period of time.

Kepler's third law: the period of an orbit squared is proportional to the cube of the length of the (semi-major) axis of rotation.

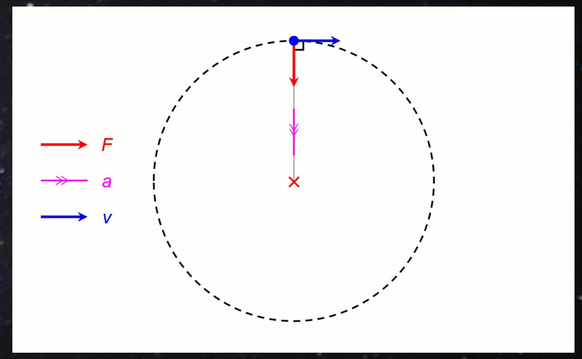


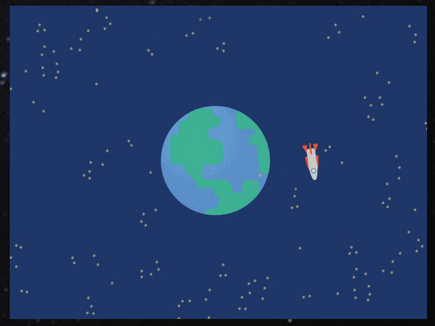
# Newton's Laws

Newton's second law: the force on a mass equals the product of its mass and acceleration.

Newton's third law: for every action (force) there is an equal and opposite reaction.

Centripetal force: $F=mv^2/r$



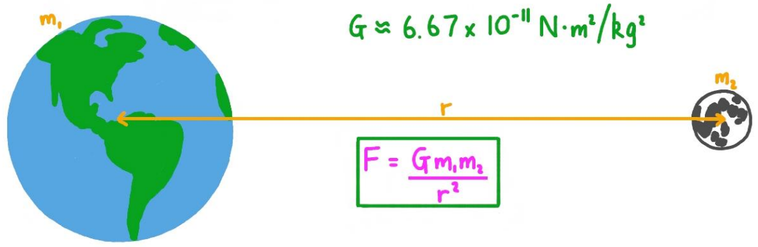
# Universal Law

## Newton's Law of Universal Gravitation

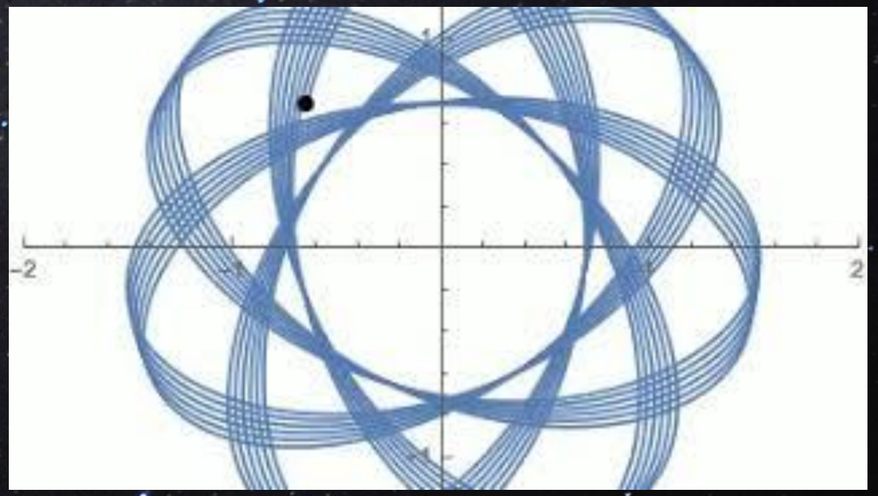
Two bodies exert gravitational forces on each other, where the direction of the force on either body is toward the center of mass of the other body.

Universal Gravitational Constant

$G \approx 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$

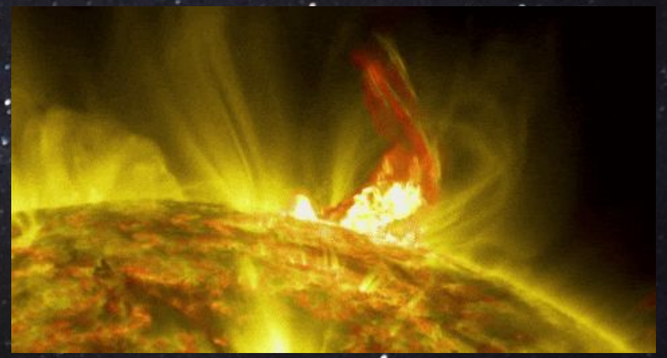


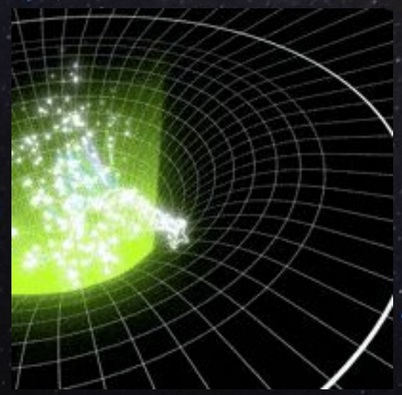

$$F = \frac{G m_1 m_2}{r^2}$$

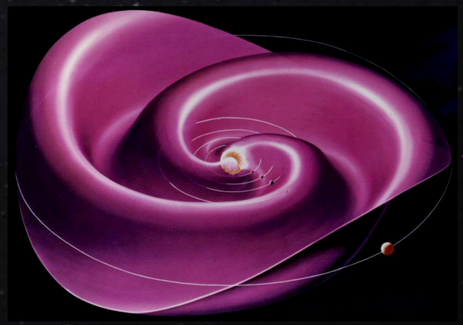


# 04 Afterword

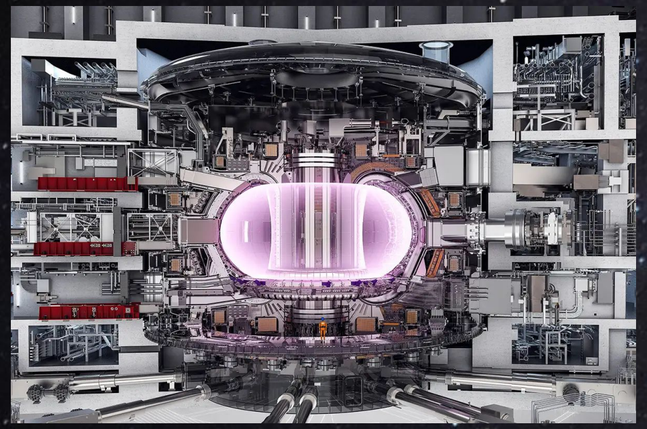
# Relativity

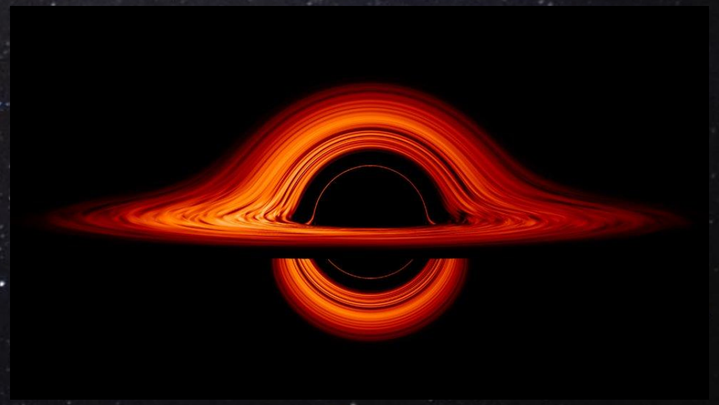






# Experiments





# Questions?