COSMIC QUARRY

MID TERM EVAL

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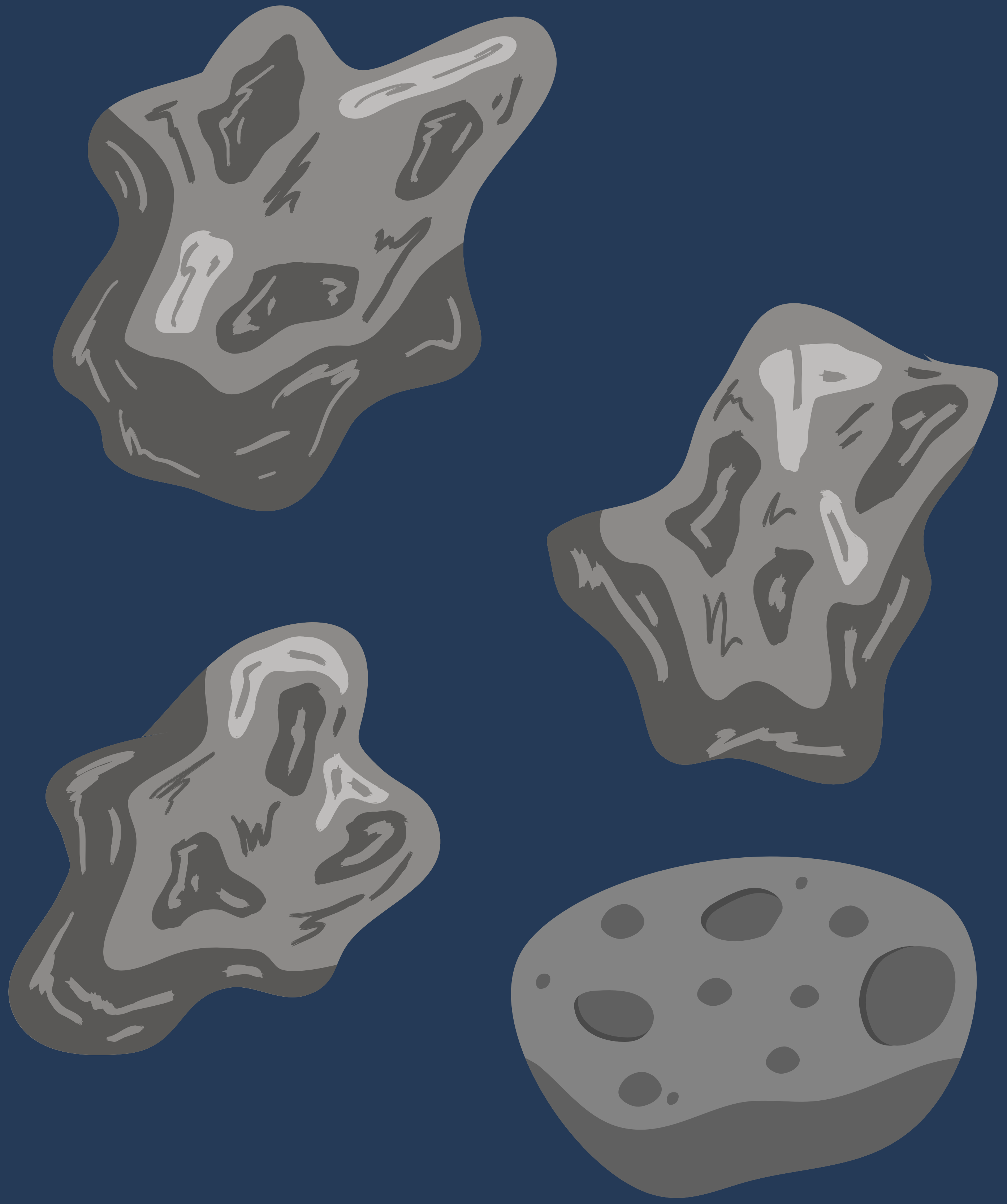
ASTEROIDS

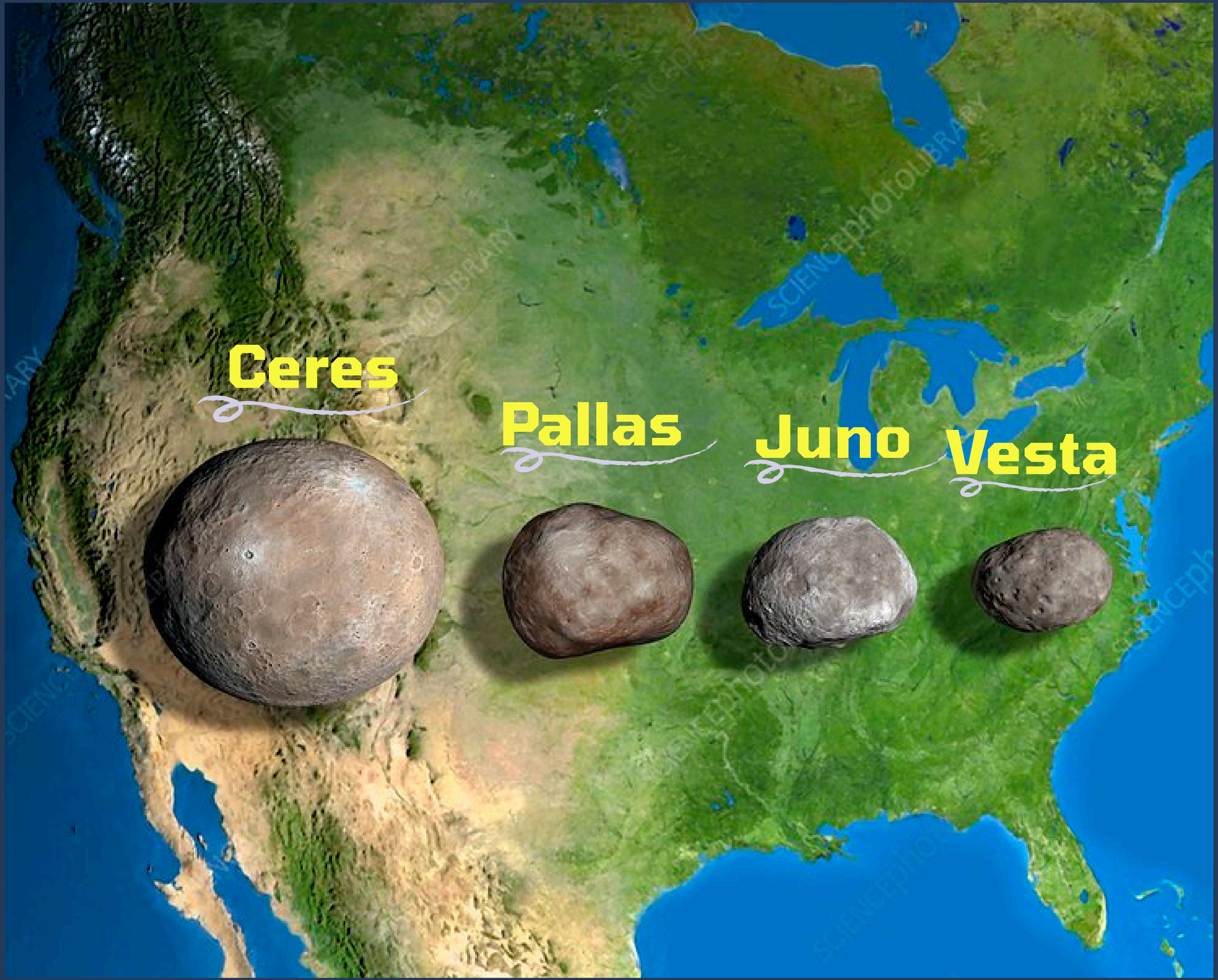
WHAT IS AN ASTEROID?

- Asteroids are solar system bodies that orbit the sun, larger than meteorites but smaller than planets.
- The term "asteroid" typically refers to objects within Jupiter's orbit, though similar objects are found throughout the solar system
- Asteroids are formed from remnants of the solar nebula, similar to planets.



SOME HISTORY TIME

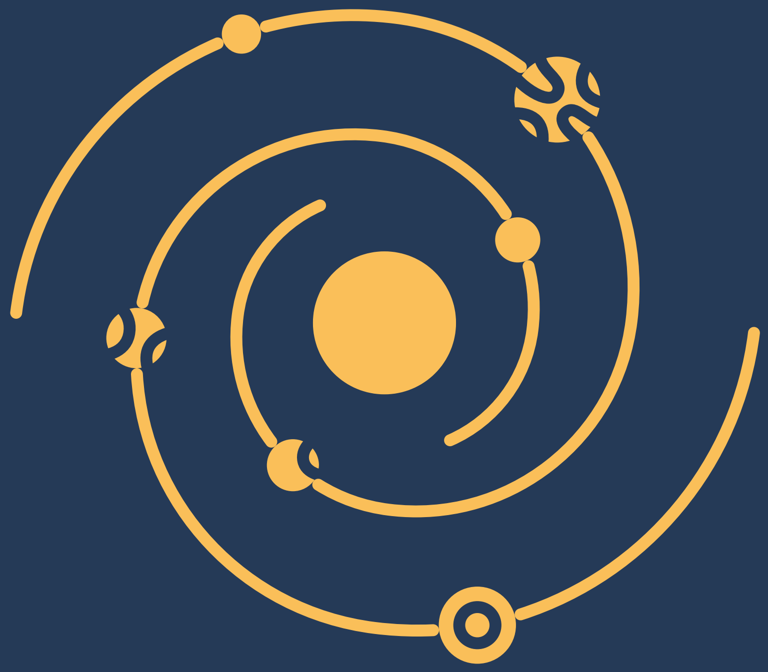
- The first asteroid, Ceres, was discovered in 1801 by G. Piazzi.
- Since 1847, at least one new asteroid has been discovered each year.
- Early discoveries include Ceres, Pallas, Juno, and Vesta, known as “The Big Four.”
- Asteroids are initially named by year and order of discovery; discoverers can later name them



TYPES OF ASTEROID

C Type

- It comprises of 75% of all asteroids.
- Reflects about 3% of sunlight falling on it.
- It is carbaneous in nature



S Type

- It accounts for 17% of all asteroids.
- Stony in nature and consists of nickel-iron and silicates.
- Reflects about 20% of sunlight falling on it

P and D Type

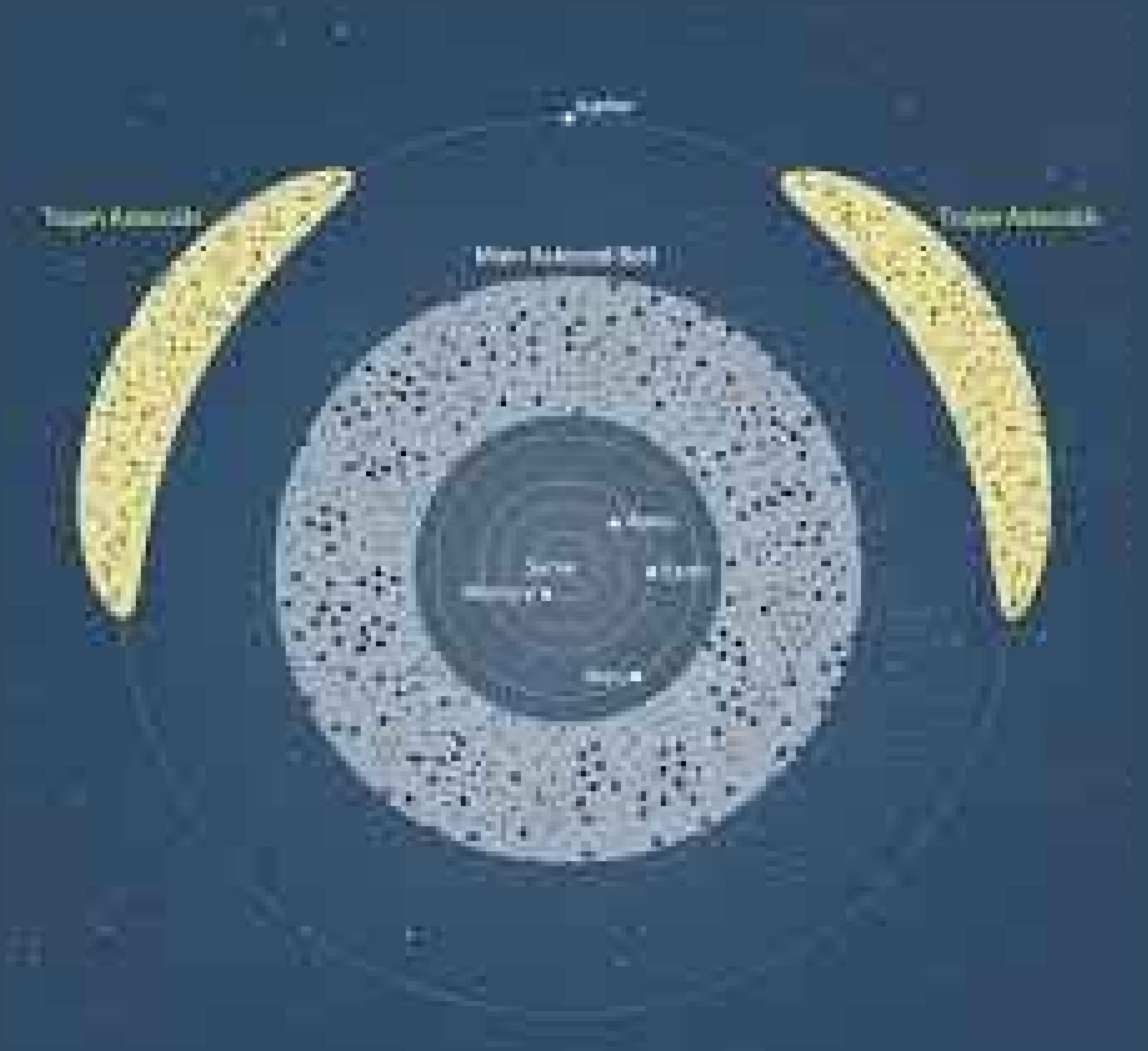
- Made up of organic matter and opaque minerals
- Reflects very little sunlight and are darkest of all asteroids

ASTEROID BELT

The asteroid belt is a torus shaped region in the solar system, centered on the sun. It roughly spans between the orbits of mars and jupiter. The asteroid belt is the smallest and innermost circumstellar disc in the solar system.

Formed about 4.6 billion years ago

- These are leftover building blocks of a planet that never formed due to Jupiter's gravity
- Gravitational interactions prevented the material from coalescing into a planet



ORIGIN THEORIES

1. Planetary Destruction Theory (Rejected)
   - Early belief: a planet between Mars & Jupiter exploded or was shattered.
   - Now disproven:
     - Total mass of belt is too small (~4% of Moon).
     - Orbits and compositions are too diverse.

2. Planet Formation Inhibition Theory (Accepted)
   - Asteroids are primordial debris from the solar system's formation.
   - Jupiter’s gravitational pull:
     - Stirred up the region,
     - Increased collision speeds,
     - Prevented accretion into a planet.

Why It's Important

- Offers clues about the early Solar System's formation
- Some asteroids contain water and organic materials
- Potential for space mining in the future
- Studying them helps us understand Earth's history and planetary defense

Discovery & History

- The first asteroid discovered was Ceres in 1801 by Giuseppe Piazzi.
- Followed by discoveries of Pallas (1802), Juno (1804), and Vesta (1807).

Composition

- Made up of rocky and metallic objects (nickel, iron, silicates).
- Some asteroids are rich in carbon (C-type), others in silicates (S-type) or metallic (M-type) elements.
- Surface is often dark and dusty.
- No atmosphere, but surface might contain ice, regolith (dust), and organic compounds.

ASTEROID MINING

Asteroid Mining is the process of extracting valuable materials from asteroids. It's a growing field in space exploration and economics with potential to revolutionize resource supply for Earth and future space missions.

HOW IT WORKS

1.**Prospecting**
Identify target asteroid (using telescopes ,spectrometers)

2.Travel and Landing
Launch mining spacecraft (robotic or crewed)

3.Extraction
Methods: drilling, heating, scraping, or using robotic arms

4.Processing
On-site refining or return to Earth

5.Transport
Deliver materials to Earth or space stations

Benifits to asteriod mining

Reduces Earth’s envoirmental strain.
Supplies ressources for space colonies.
Enables deep-space mission(fuel depots in space).

Challenges

Due to Earth's strong gravitational pull, launches from space or low-gravity bodies like the Moon, Mars, or Titan are more energy-efficient.

Cost of launch, travel, and operations

Tech limitations (robotics, autonomy)

Legal issues (ownership & international treaties)

Risk: unknown asteroid compositions, technical failure

EFFECTS ON EARTH

- Market Disruption: The influx of rare metals like platinum and gold from space could oversaturate global markets, drastically devaluing Earth’s raw material industries.
- Impact on Developing Countries: Nations that rely heavily on mineral exports—such as South Africa, Zimbabwe, and the Democratic Republic of the Congo (DRC)—face potential economic collapse due to plummeting resource values.

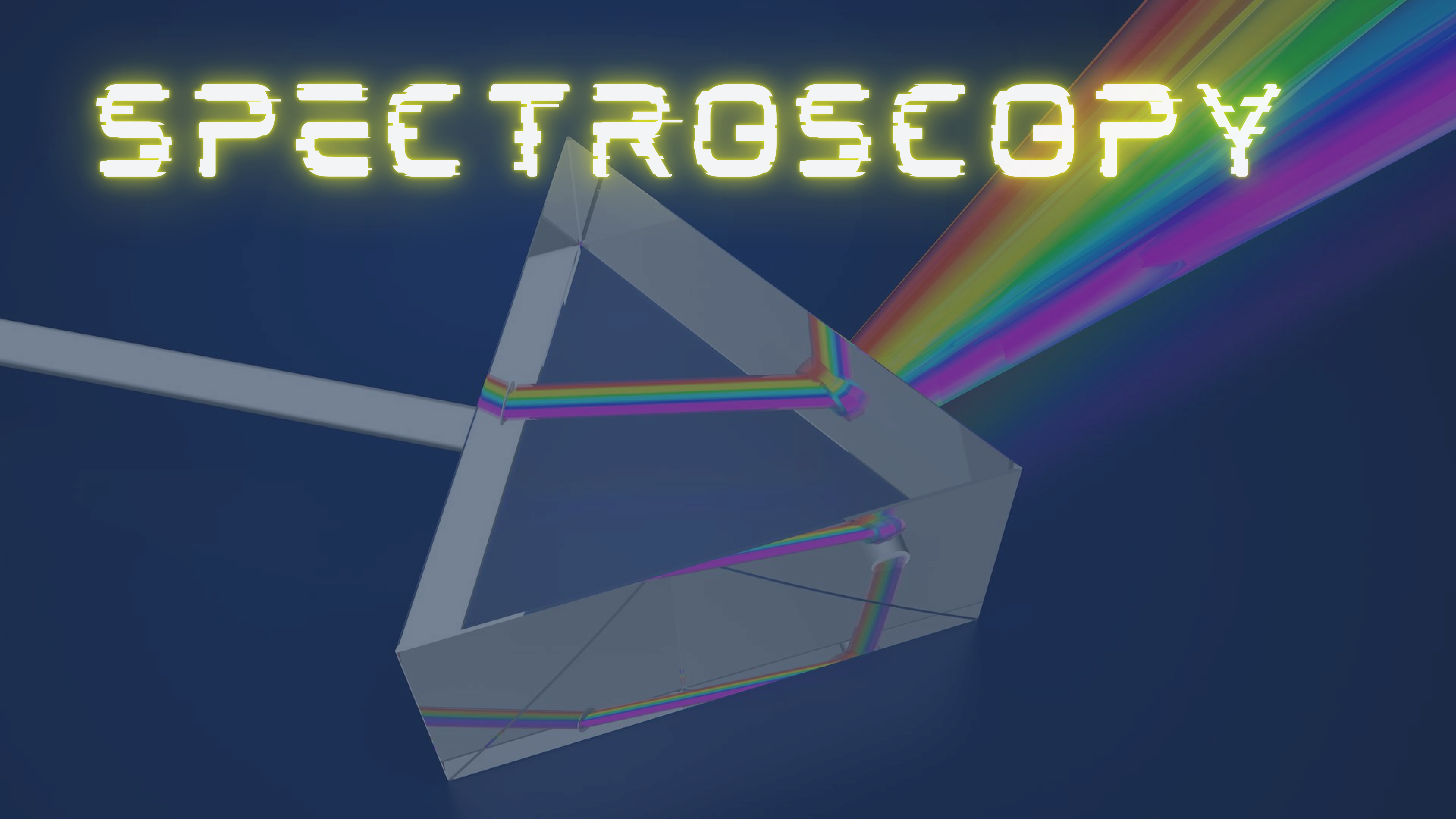
Access to rare and valuable metals (like platinum, gold, cobalt)

Could hurt Earth-based mining economies and jobs

Development of new tech and jobs in aerospace, robotics, and AI

Only wealthy nations/companies may benefit

Preserves forests, ecosystems, and reduces pollution


SPECTROSCOPY

WHAT IS SPECTROSCOPY?

Study of the absorption and emission of light and other radiation by matter as related to the dependence of these processes on the wavelength of the radiation. Further it also includes the study of interaction between particles like electrons, protons, ions etc both intra and interparticle.

APPLICATIONS

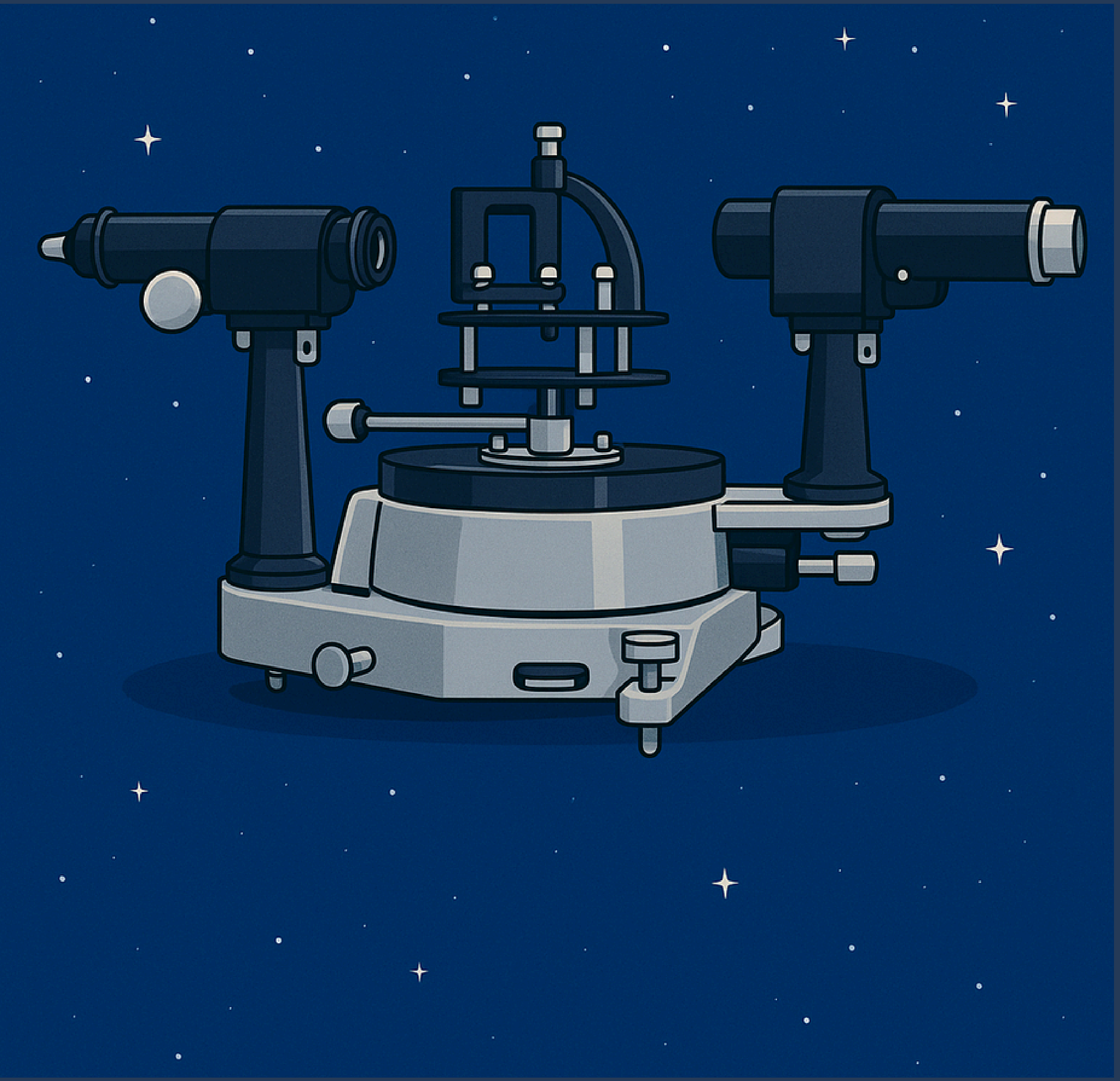
Studying Exoplanet Atmospheres
During a planet's transit (when it passes in front of its star), the
spectrometer can detect gases like oxygen, carbon dioxide, or methane in the planet's atmosphere.

Analyzing Star Composition
By studying a star's spectrum, scientists can identify what elements
(like hydrogen, helium, sodium) are present in the star.

Measuring Redshift
When galaxies move away from us, their light shifts to the red side of the
spectrum. Spectrometers detect this shift to measure how fast the universe is expanding.

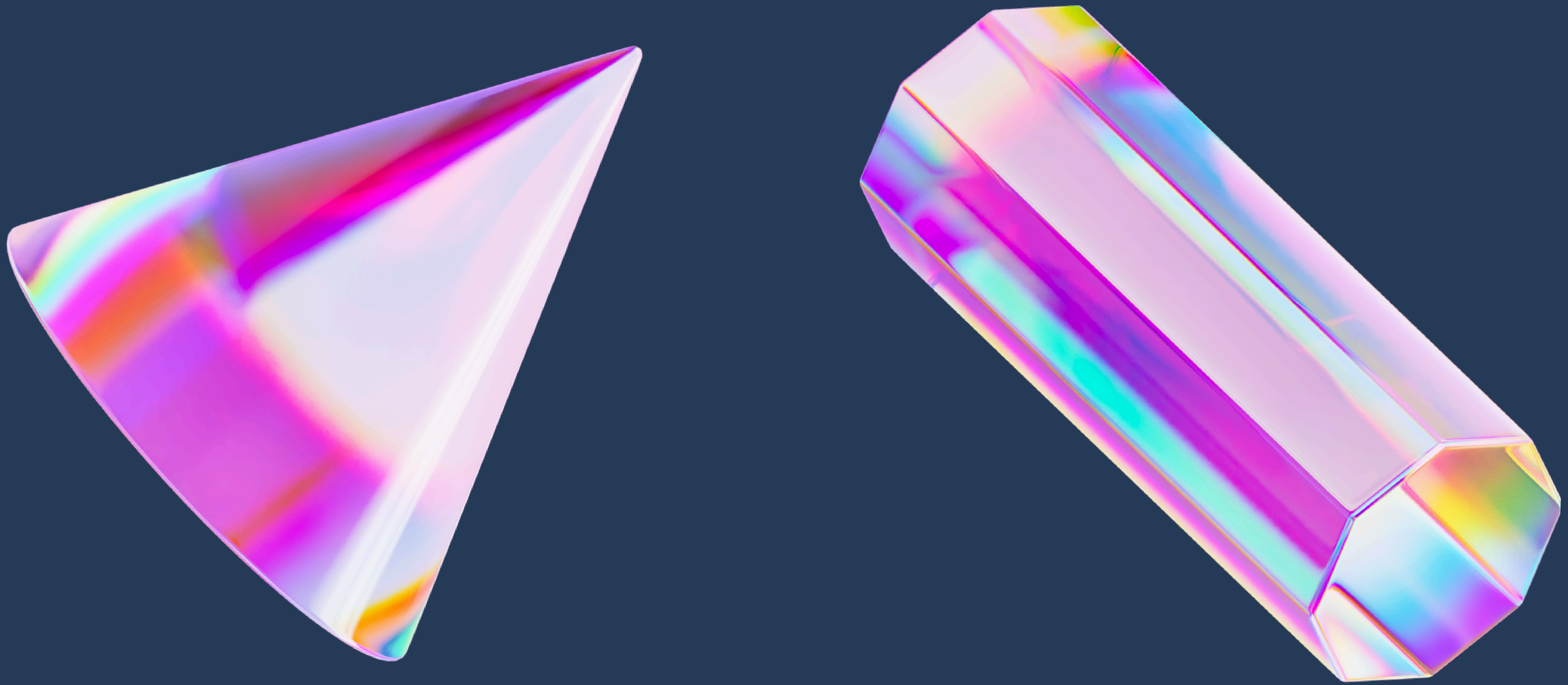
Determining Star Temperature
By analyzing the color and spectral lines of a star, we can
estimate its surface temperature.

PARTS OF SPECTROMETER



- Light source
- Collimator
- Dispersive Element
- Focusing Lens
- Detector

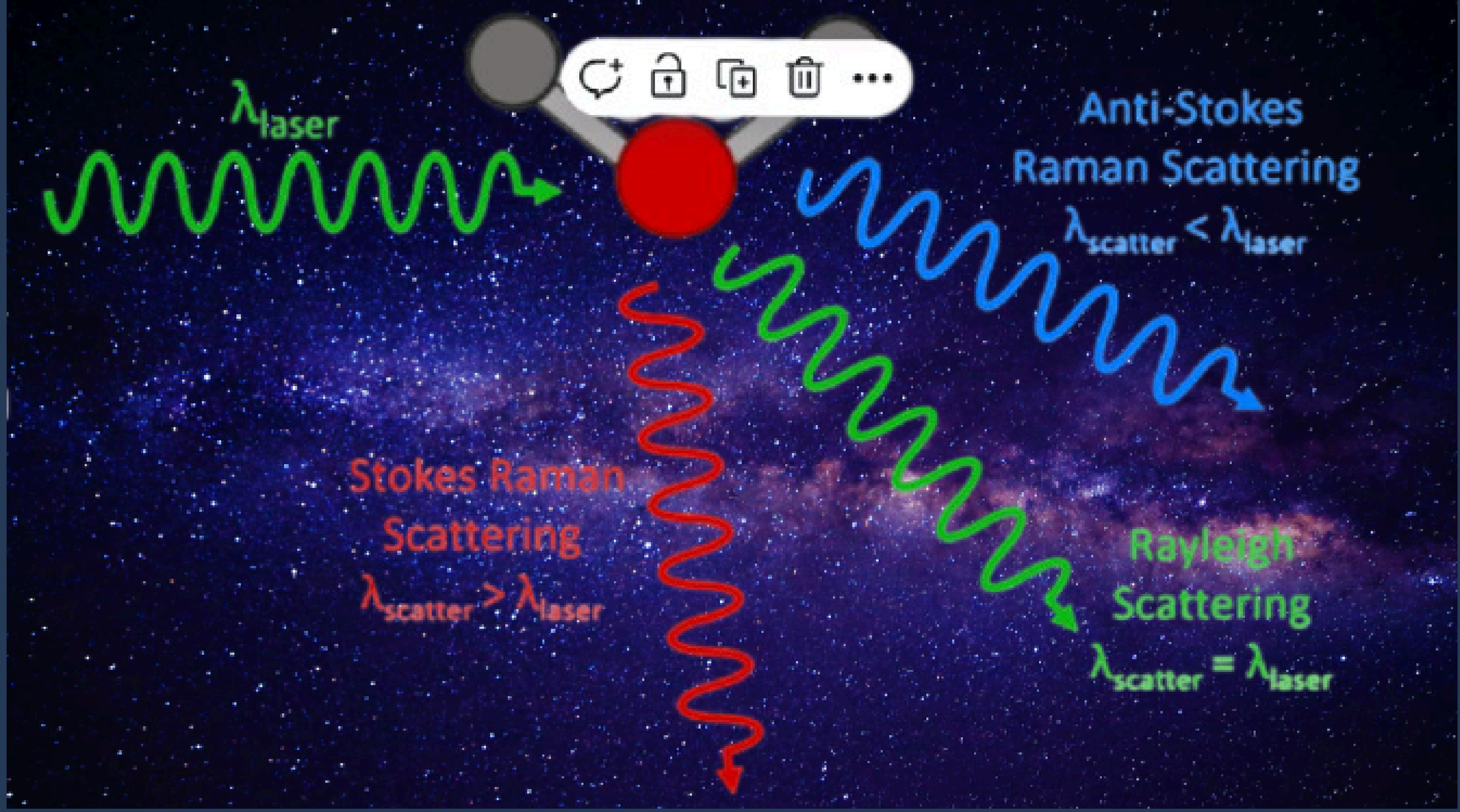
OPTICAL SPECTROMETER



DEFINITION

An Optical Spectrometer measures light intensity across different wavelengths in the visible, UV, or near-infrared range. It splits light using a prism or diffraction grating and detects the spectrum to analyze material properties. Common components include a slit, collimator, dispersive element, and detector. It’s used in physics, chemistry and astronomy for identifying substances and studying their structure.

RAMAN SPECTROSCOPY



Raman spectroscopy is a way to study what a material is made of without damaging it. It works by shining a laser on the material and looking at how the light bounces back.

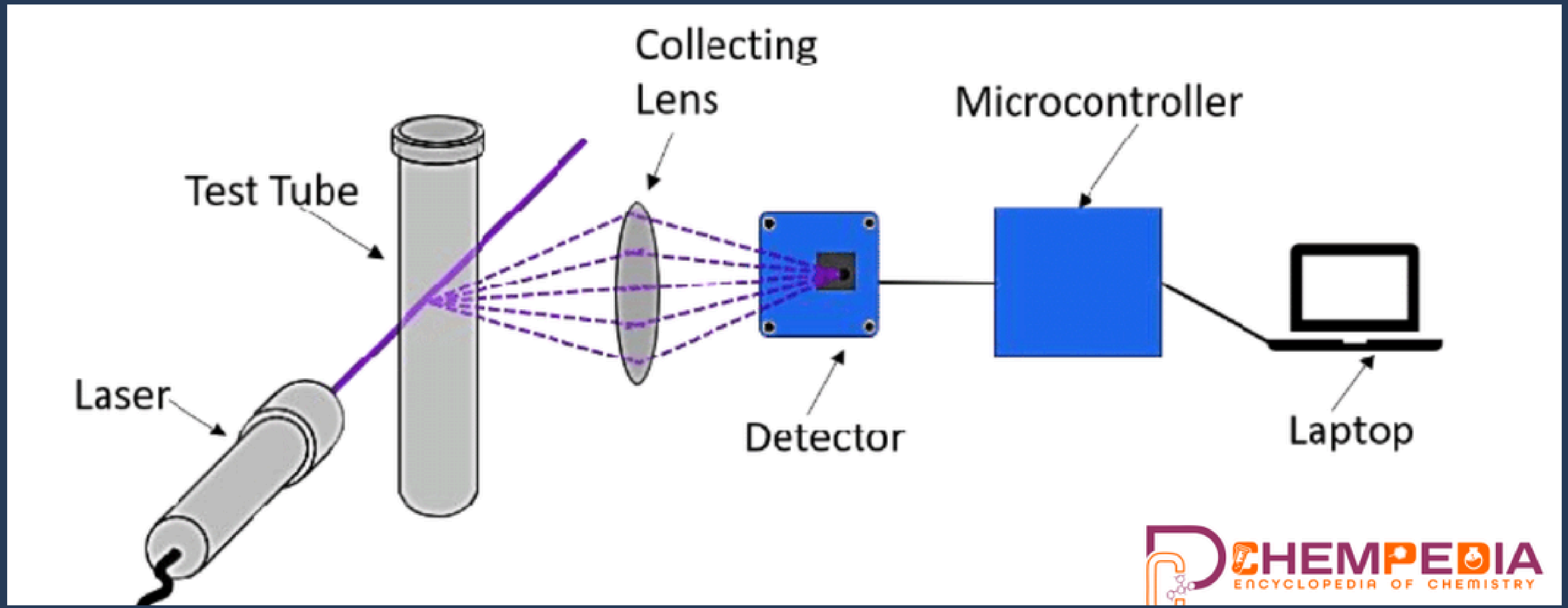
By measuring these energy changes, Raman spectroscopy creates a spectrum that is a molecular fingerprint which helps us learn what kinds of chemical bonds are in the sample and how the molecules are arranged.

KEY PRINCIPLE

The fundamental principle behind Raman spectroscopy is the Raman effect, which involves inelastic scattering of light.

MECHANISM

Step-by-step....



1. Excitation to Virtual State: The incoming photon temporarily excites the molecule to a short-lived, unstable energy level called a virtual state. This is not a real energy level but a temporary state during the interaction.

2. Energy Exchange: The molecule then relaxes back, but it may end up in a different vibrational energy state than before. This causes the scattered photon to lose or gain energy.

3. Types of Raman Scattering:

- Stokes Scattering: If the molecule gains vibrational energy, the scattered photon loses that energy and has lower frequency (longer wavelength) than the original light.
- Anti-Stokes Scattering: If the molecule loses vibrational energy, the scattered photon gains energy and has higher frequency (shorter wavelength).

4. Polarizability Change: For Raman scattering to occur, the molecule's electron cloud must change shape (polarizability) during vibration. The greater this change, the stronger the Raman signal.

5. Raman Spectrum: The scattered light is collected and analyzed. The shifts in light frequency correspond to specific molecular vibrations (like C-C or C-H bonds), creating a unique "fingerprint" for identifying molecules.

APPLICATIONS OF RAMAN SPECTROSCOPY

Pharmaceuticals

Identifying drug components, checking purity, studying drug stability.

Life Sciences

Studying cells, tissues, proteins without damage, even in water.

Forensics and Art

Detecting substances, authenticating artworks non-destructively.

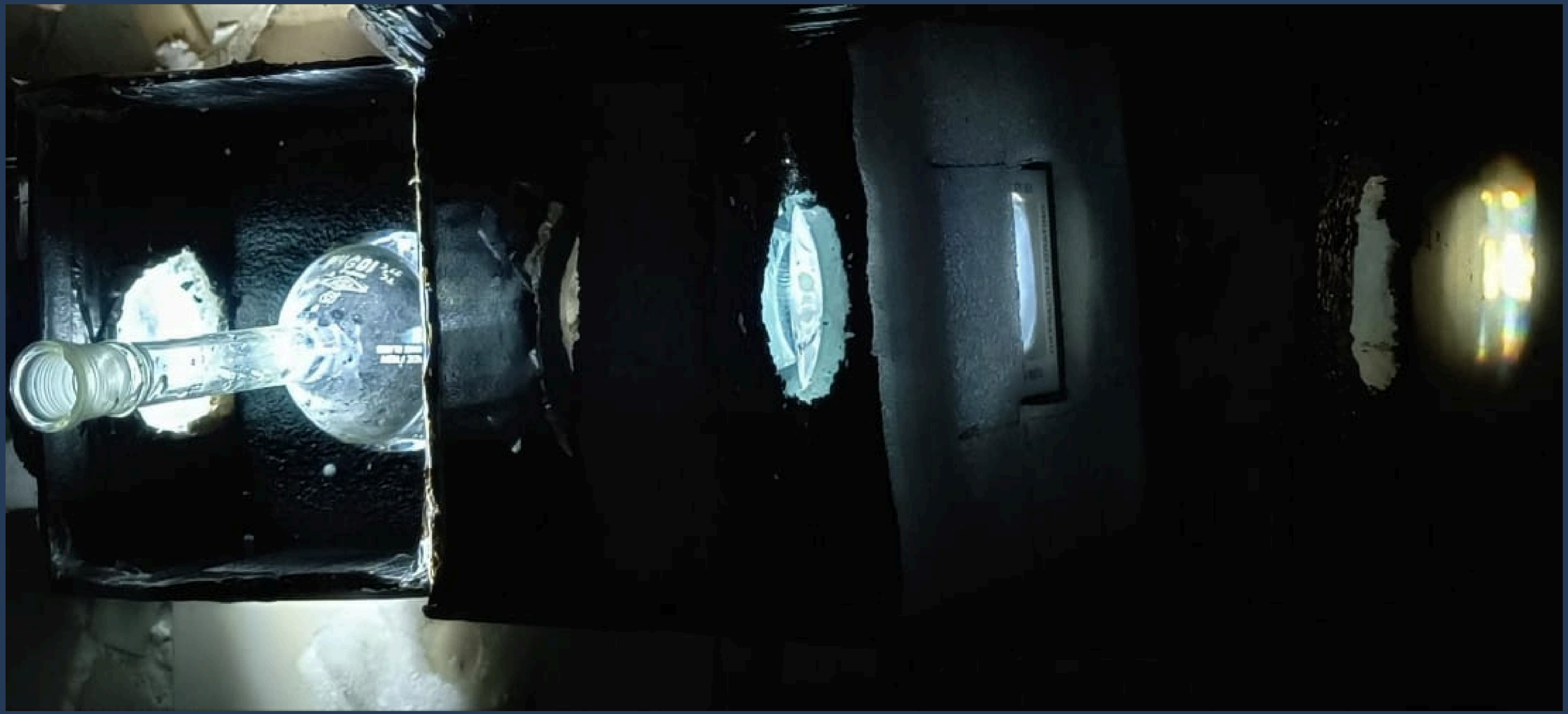
Material Science

Analyzing polymers, ceramics, semiconductors, and detecting stresses.

Environmental Monitoring

Detecting pollutants and chemical changes in the environment.

OUR DIY SPECTROMETER



MODEL

We made our model of spectrometer that uses light to analyze the composition of the minerals.We used basic tools
available to us to make a working spectrometer that can perform the spectroscopy of the liquid sample and then
analyzing the spectrum to understand the mineral composition

COMPONENTS

Torch:We used torch to act as a light source to provide the white light to illuminate the sample. We haven't
used laser as it is monochromatic source of light which can't be used to generate spectrum.

- Convex Lens:We used three convex lenses in total in our model.It helps to focus the scattered light to a
single point which helps in getting the concentrated source of light.
- Glass tube:We used glass tube to hold the liquid sample which act as a cuvette in our model.
- Diffraction Grating:We used diffraction grating of 600 nm lines to generate the spectrum of light obtained
after passing through the solution.
- Raspberry Pi Camera:To obtain the image of the spectrum obatined we used the raspberry pi camera.

Design

1. First there is a torch on the holder to which provides the parallel beam of light which is attached to the
opening hole of the cardboard box conatining the sample.
2. Further there is a carboard box holding the glass tube containing the sample whose inner walls are painted
black in order to absorb the stray light.
3. On the other side of the box there is another hole which act as a joint for the second part.This joint is
detachable which makes the two parts independent yet connected.
4. After that there is a system of lens,diffraction grating,lens in a cardboard box which forms the spectrum of
light coming from the source.
5. At the end of the box Raspberry Pi Camera is installed which takes the image of the pattern obtained from
the final lens. The camera is further attached to the Rasberry Pi circuit and then to the screen.

WORKING

1. Light from the torch falls on the glass tube containg sample solution and scattered.
2. This scattered light is passed through the lens to make it concentrated at a point.
3. Light coming from the lens is passed through the difffraction grating which forms the pattern.
4. This light is again passed through another lens which forms the spectral paatern on the screen.
5. This light is then captured by the pi camera which takes the image of the pattern and forms the spectral
pattern on the screen.
6. From the pattern obtained we analyze the composition of the mineral.

FUTURE PLANS

We would use the data obtained from our DIY spectrometer. Apply ML Algortihtm and use this to find mineral composition of planets and asteroids.
In the second half we would be doing mineral mapping of the asteroid belt and if possible we will extend our spectrometer to planet spectroscopy.

CONCLUSION

In the first part of the project we studied about the spectroscopy and made the DIY spectrometer for studying the mineral composition. This spectrometer is basically a liquid type spectrometer that uses light to determine the composition of the sample dissolved in the liquid. We further aim to use the ML algorithms to do the spectroscopy of the asteroids.