Exploring the Universe with Spectroscopy

Lesson Plan, Student Version, Teacher Version and Supplemental Materials

Topic:

- Electromagnetic Spectrum
- Spectroscopy
- Space Exploration
- Astrobiology

Subject/Grade Level:

- 8th Grade Physical Science

Duration:

- 4-5 one-hour class periods

Materials:

- Spectrometer
- Laminated Reference Spectroscopy Cards
- NOVA Origins Video: Where are the Aliens? - http://video.pbs.org/video/1978745715/
- NOVA Origins: Chemical Fingerprints Reading

Supplemental Resources:

- Laboratory for Atmospheric and Space Physics - http://lasp.colorado.edu/home/education/k-12/project-spectra/
- NASA Mission: Science - http://missionscience.nasa.gov/ems/index.html
- NOVA Origins: Where are the Aliens? - http://www.pbs.org/wgbh/nova/teachers/activities/pdf/3113_origins.pdf
- Spitzer Space Telescope - http://www.spitzer.caltech.edu/search/image_set/20?by_type=spectra&tabs=hidden

Middle School 8th Grade Physical Science Standards:

3. Structure of Matter: Each of more than 100 elements of matter has distinct properties and a distinct atomic structure. All forms of matter are composed of one or more of the elements. As a basis for understanding this concept:
    a. Students know the structure of the atom and know it is composed of protons, neutrons and electrons.
4. Earth in the Solar System: The structure and composition of the universe can be learned from studying stars and galaxies and their evolution. As a basis for understanding this concept:
    a. Students know that the Sun is one of many starts in the Milky way galaxy and that stars may differ in size, temperature and color.
    c. Students know that stars are the source of light for all bright objects in outer space and that the Moon and planets shine by reflected sunlight, not by their own light.
    d. Students know the appearance, general composition, relative position and size, and motion of objects in the solar system, including planets, planetary satellites, comets and asteroids.
9. Investigation and Experimentation: Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:
    e. Construct appropriate graphs from data and develop quantitative statements about the relationship between variables.

Inquiry Objective:

- Students will be able to compare and contrast the chemical composition of planets, moons and stars
- Students will be to articulate where NASA should search for life based on biological requirements based on spectral analysis of the solar system

Learning Objectives:

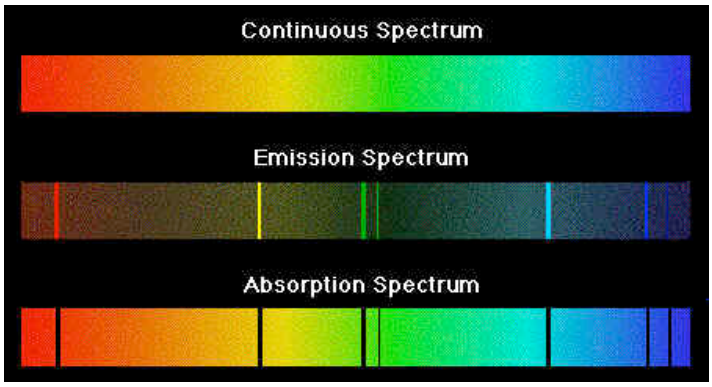
- Students will be able to explain the properties of different types of electromagnetic radiation
- Students will be able to identify different types of solar radiation and how each impacts Earth
- Students will be able to identify the atmospheric composition of different planets and moons by comparing infrared and ultraviolet absorption spectra
- Students will be able to explain how spectroscopy is used to explore the universe

Background Information: Astronomical Spectroscopy

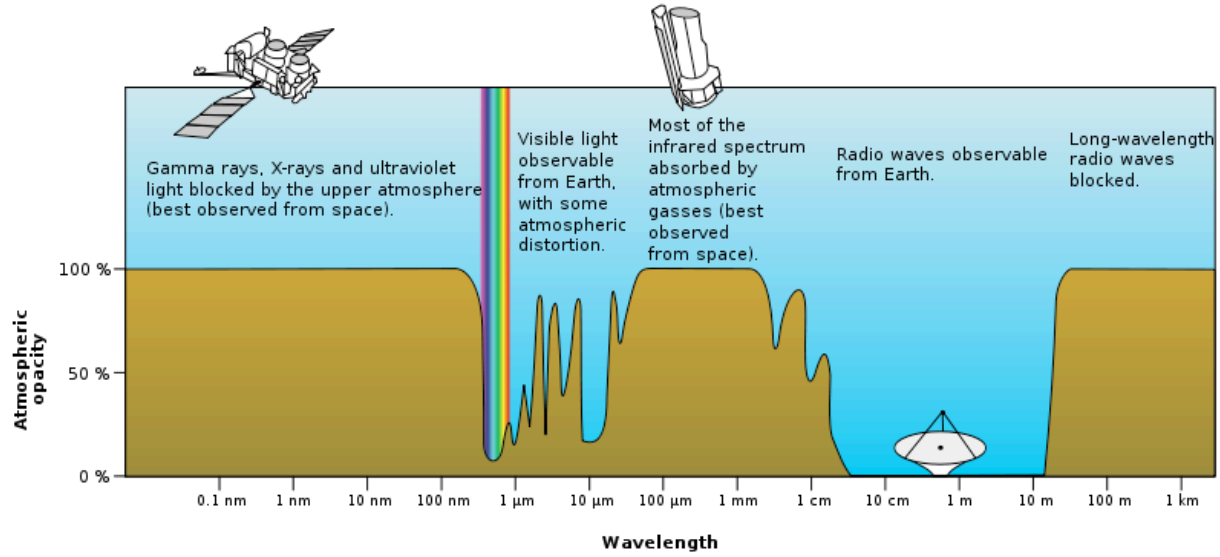
- **Spectroscopy:** The general study of how electromagnetic waves interact with matter, including the absorption and emission of radiation.

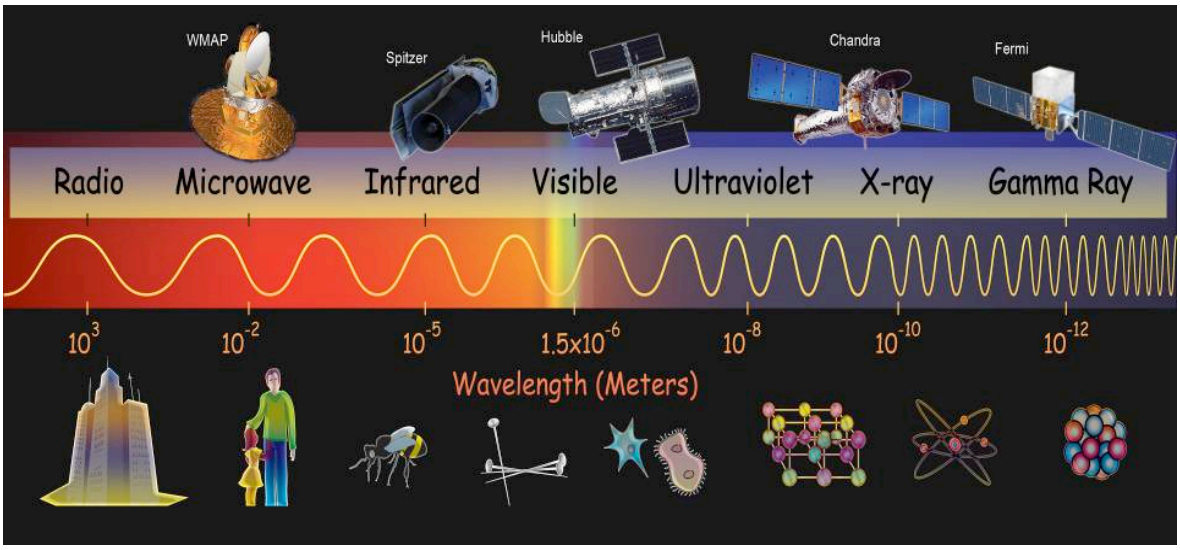
- **Emission:** Emission indicates that radiation is being released by an object.

- **Absorption:** Absorption occurs when radiated energy is absorbed by an object. Absorption spectra are produced when the light emitted from a hot, dense material passes through a cooler, less dense gas. Atoms in the cooler gas absorb certain wavelengths of light, producing dark lines superimposed on the continuous spectrum. These lines correspond to energy states of atoms in the gas and provide a unique fingerprint of the composition of the gas.

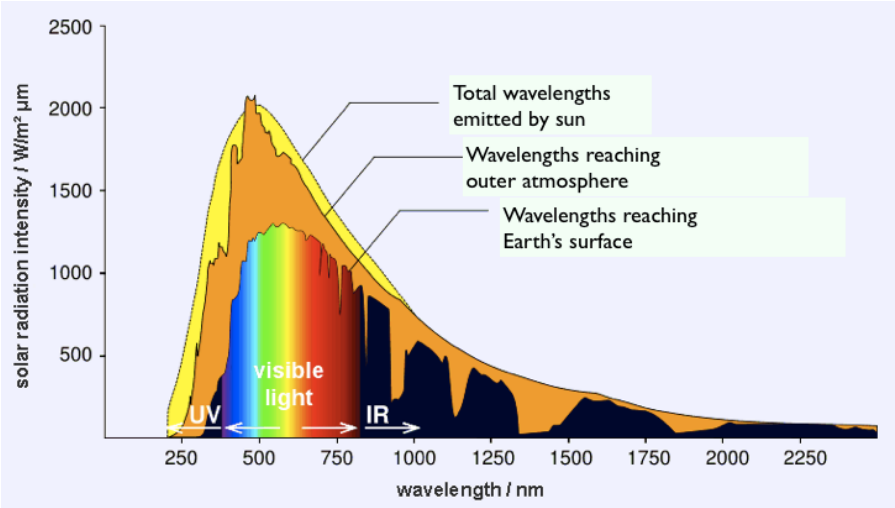


- **Astronomical Spectroscopy:** The study of electromagnetic emission and absorptions of stars, planets and other celestial objects to determine the chemical composition and motion of such objects.
    - **Radio Astronomy:** Radio waves can be studied from Earth, since they are not absorbed by the atmosphere. These waves consist of extremely low energy waves which can be used to to study distant pulsars, star-forming regions, quasars and supernova remnants.
    - **Wilkinson Microwave Anisotropy Probe:** Currently measuring differences in temperature across the universe left over from the Big Bang.
    - **Spitzer Space Telescope:** Infrared telescope that can penetrate through dense gas and dust to see cool objects.
    - **Hubble Space Telescope:** Images objects in near infrared, visible and ultraviolet wavelengths, including how energy particles interact with solar atmospheres to determine their chemical compositions.
    - **Chandra X-Ray Observatory:** SInce Earth's atmosphere blocks x-rays, Chandra can detect and study the composition, temperature and density of higher energy objects, such as pulsars, supernovae remnants and black holes.
    - Fermi Space Telescope: This telescope can studies the hottest and most energetic objects in the universe, including neutron stars, pulsars, supernovas and black holes and can also be used to study the chemical composition of planets, moons and stars by detecting radioactive elements.





- **Solar Emission Spectrum:** The Sun's radiation almost completely falls within the ultraviolet, visible and infrared spectrum, however, nuclear fusion also produces gamma radiation. Since planets do not produce their own light, the Sun's emission spectrum in combination with absorption spectra can then be used to determine chemical composition of planets, galaxies, and nebulae.



- **Space Exploration Using Spectroscopy:** Even though we can only "see" a tiny fraction of electromagnetic radiation, scientists use electromagnetic radiation to study our solar system and the entire universe. However, most electromagnetic radiation is blocked by the atmosphere, so telescopes, balloons and satellites must be sent into space in order to study objects in our universe.

- **Astrobiology:** Astrobiology is the study of the finding life in the universe by examining the evolution of life here on Earth and potential habitats where life may exist elsewhere.
    - **Exoplanet:** Planet found outside our Solar System

Instructional Design:

- **Introduction to Radiation:** In this section, students will demonstrate their understanding of the electromagnetic spectrum and complete practice calculations about different types of radiation. This will also serve as a basic introduction to radiation since students often have a difficult time comprehending energy emission and the possibilities of harmful radiation. Students will also have an opportunity to examine spectra of different types of light.

- **Exploring Planets with Absorption Spectroscopy:** For this activity students will practice reading absorption spectra and determine and compare the atmospheric composition Earth, Mars and venus Venus, as well as Titan and Saturn.

- **Searching for Life in the Universe Using Spectroscopy:** For this section, students will determine what qualities make a Earth particularly suitable for life and compare spectral analysis of Earth, Venus and Mars in order to explain why

other terrestrial planets do not support life. Students will explore what and how scientists are currently looking for life in the universe. The final portion of this activity includes the analysis of a "mystery planet" where students apply information and skills they learned in previous sections to determine if this particular planet could sustain life.

Assessment:

- Writing in complete sentences
- Thorough reading comprehension responses
- Identification of absorption peaks
- Justification of Mystery Planet