SS433: A Journey with the Scientific Method

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Subject(s):
STEM
Astronomy
Earth and Space
Physical Science

Grade(s):
7-12

Time:
1 class period

Standard(s): *These performance expectations have been directly taken from the Next Generation Science Standards website at https://www.nextgenscience.org/.*

HS-PS4-3: Evaluate the claims, evidence, and the reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Connections to Prior Learning:
- Electromagnetic Spectrum (See Multiwavelength Astronomy: Lesson Plan)
- Objects in Space (See Star Evolution and Gamma Ray Sources)
- Observing Radiation (See Multiwavelength Astronomy: Lesson Plan)

Concept/Topic to Teach:
- History of Astronomy
- Scientific Method
- Real life examples of an astrophysics discovery

Specific Objectives: Student will be able to…
- Understand and explain the Scientific Method.
- Correlate SS-433 as evidence of the progression of the Scientific Method.
- Justify the importance of applying different instruments and perspectives to problem solving.

Lesson Relevance:

- Demonstrate the Scientific Method using a real world example.
- Compare and Contrast the tools of modern astronomy.
- Punctuate the importance of communication for scientific progression.
- Identify the time scale associated with scientific discoveries.

Cross Curriculum Connections:

- Math: Reading and interpreting graphs.
- STEM: Scientific Method/Scientific Inquiry.

Required Materials:

- Computer with Attached Projector
- "SS 433: A Journey with the Scientific Method" Google Slide

Technology:

- Telescopes, observatories, spectrometer, and data analysis software.

Modification/Accommodation*(ELL/IEP students)***:**

- Guided notes/Printed Google Slides Presentation.
- Additional time for the assignment.
- Reduction of Assignment (choose one EM spectra).
- Provide list of useful Vocabulary.
- Pairing with strong anchor student for project work.

Reteach/Extensions*(struggling/advanced students)***:**

- Reteach: Grouping with strong Anchor student to aid in classroom discussions
- Extension: A more in depth analysis of SS 433, possible report on Nature article in resources

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Instructional Procedure:

Heading: SS 433 and the Scientific Method

Goal of the Day:

- Student will be able to understand and explain the Microquasar SS 433.
- Student will be able to explain the Scientific Method and how it was applied to identify SS 433.

Advance Preparation:

- Prepare computer and projector
- Print guided notes/slides as needed

Background Information *(Lesson Introduction)***:**

"The compact central object of SS 433 is consuming the companion star which rapidly loses mass into an accretion disc formed around the central object. The accretion disc is subject to extreme heating as it spirals into the primary Black Hole or Neutron Star and this heating causes the accretion disc to give off intense X-rays and opposing jets of hot hydrogen along the axis of rotation, above and below the plane of the accretion disc. The material in the jets travels at 26% of the speed of light."

"The companion star presumably had lower mass than the original primary object and was therefore longer lived. Estimates for its mass range from 3 to 30 solar masses. The primary and secondary orbit each other at a very close distance in stellar terms, with an orbital period of 13.1 days."

See notes and links in the presentation for more information on the instruments and techniques used.

Procedure and Strategies: Explain

Direct instruction (55 min): Present 'SS 433: A Journey with the Scientific Method'

Key Vocabulary and Academic Vocabulary:

- Doppler Effect: the change in frequency or wavelength of a wave in relation to an observer who is moving relative to the wave source.
- Microquasar: the smaller version of a quasar. A compact region surrounding a black hole with a mass several times that of our Sun, and its companion star
- Quasar: 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.
- Spectral Analysis: Spectroscopy, primarily in the electromagnetic spectrum, is a fundamental exploratory tool in the fields of physics, chemistry, and astronomy, allowing the composition, physical structure and electronic structure of matter to be investigated at atomic scale, molecular scale, macro scale, and over astronomical distances.

Assessment Format:

Formative assessment question answer session.

Resources:

Abeysekara, A. U., et al. "Very-High-Energy Particle Acceleration Powered by the Jets of the Microquasar SS 433." *Nature News*, Nature Publishing Group, 3 Oct. 2018, www.nature.com/articles/s41586-018-0565-5.

EurekAlert. "HAWC: Microquasar SS 433 Reveals the Nature of the Brightest Lanterns of the Universe." *EurekAlert!*, www.eurekalert.org/pub_releases/2018-10/thni-hms100318.php.

Helfer, H. L., and M. P. Savedoff. "On the Bizarre Gamma-Ray Spectrum of SS 433." *The Astrophysical Journal*, vol. 283, 1984, doi:10.1086/184331.

Margon, Bruce. “The Bizarre Spectrum of SS 433.” *Scientific American*, vol. 243, no. 4, Oct. 1980, pp. 54–65. *Jstor*.

“SS 433.” *Wikipedia*, Wikimedia Foundation, 3 July 2019, en.wikipedia.org/wiki/SS_433.

“The Mystery of SS433.” *The Mystery of SS433 - StarDate's Black Hole Encyclopedia*, blackholes.stardate.org/resources/article-mystery-of-ss443.html.

“VLBA ‘Movie’ Gives Scientists New Insights On Workings of Mysterious Microquasars.” *VLBA 'Movie' Gives Scientists New Insights on Microquasars*, www.nrao.edu/pr/2004/ss433/.

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