Online Modules from The University of Chicago

Multiwavelength Astronomy: Gamma Ray Tools, by NASA Scientist Dr. Neil Gehrels
http://ecuip.lib.uchicago.edu/multiwavelength-astronomy/gamma-ray/tools/index.html

Subject(s): Astronomy/Space Science

Grade(s) Level: 9-12

Duration: Two Class Periods

Objectives:

Students will

- Learn about advances in detector technologies that have allowed us to study high-energy phenomena;
- Analyze the advantages and disadvantages of various methods for detecting high-energy phenomena;
- Become familiar with the instruments on the Swift Gamma-Ray Burst Explorer;
- Find out about various activities and possible careers in science.

Materials: Internet connection and browser for displaying the lesson; student journal.

Pre-requisites: This lesson could be used after units on telescopes and image processing. It should come at the end of a unit on the Electromagnetic Spectrum. Before using the lesson, students should have the following:

- Knowledge of a reflecting telescope and how it focuses light;
- Knowledge of a CCD camera and its job as a detector;
- Understanding that a telescope has 2 basic parts – the focusing system and the detector;
- Basic understanding of the Electromagnetic Spectrum – different wavelengths (wavebands) with different energy.

Procedures: Students will read through the Gamma-Ray Tools lesson and answer questions using the reading guide below.

Introduction:

Dr. Neil Gehrels has been working with gamma-rays for a long time and has been instrumental in the development of new tools to explore this part of the electromagnetic spectrum. He is the Principal Investigator (PI) for the Swift Gamma-Ray Burst Explorer Mission that is currently in space. As you read through his story think about the questions listed below. Write an answer or reflection for each question.

Reading Guide:

Growing Up with Stars – From Music to Physics

- As you read about Neil's life as a child, what did you feel about his exposure to astronomy? What do you think about his foray into music?

Watching the Detectors – Counting Photons with Well-Detectors

- What kind of things caused problems for the early detectors?
- Which of the detectors do you find interesting or surprising? Explain why.

Imaging with CCDs – Focusing with Optics

- Getting the gamma-ray light to the CZT, or the detector plane, is tough. There is so much energy in a gamma-ray photon, it can go right through the mirrors we use to focus visible light. How does Neil and other gamma-ray astronomers get around this problem?

Swift Gamma-Ray Burst Explorer Mission – How Swift Works

- Neil explains why it's important to study GRBs. What do you think? Do you agree with him?
- How does Swift help with detecting and locating sources of gamma-ray bursts?
- Swift has three instruments on it. Which one actually detects the gamma-ray light? What do the other two do? Why do you think they are even on the spacecraft?

13 Billion Light Years and Counting…

- As you read Neil's last words, what are the big ideas he has left with you about gamma-ray astronomy?

Adaptations:

Have students read portions (or all) of the lesson in small groups and answer questions together. The small groups report back to the class as a whole with their responses. Or, the teacher can lead the whole class in reading through the lesson and use the questions from the reading guide as discussion prompts.

Additional Discussion Questions:

- Scientific instruments need to be calibrated. Why is this important? How is this done?
- What are the advantages and disadvantages of the three detector technologies? Consider the size, resolution, and the range of energies they detect.
- How does the Burst Alert Telescope technology work?

- What is the value of these technologies to our understanding of the universe? To our everyday lives?

Evaluation: Formative assessment of student understanding based on answers to questions in the reading guide. Follow up with extensions and/or suggested readings.

Extensions: Additional activities can be found on the Swift Site for educators at http://swift.sonoma.edu/education/index.html. Students can be prompted to chose one or two activities to explore independently, reporting back to the whole class on the following: 1) name and description of the activity; 2) what the student did or what happened in this activity?; and 3) what did the student learn from this activity?

Suggested Readings: The lessons on the history, science, and impact of Gamma Ray Astronomy from the Multiwavelength Astronomy website.

Links: These websites are recommended for providing background and supplemental information:

Tour of the Electromagnetic Spectrum http://missionscience.nasa.gov/ems/
The Swift Education and Public Outreach Website http://swift.sonoma.edu/
Swift Gamma-Ray Burst Mission https://heasarc.gsfc.nasa.gov/docs/swift/swiftsc.html
Fermi Gamma-ray Space Telescope http://fermi.gsfc.nasa.gov/

Vocabulary: The following terms are used and defined in the lesson. Teachers may want to review these in advance of using the lesson with students.

afterglows
astrophysics
Bell Labs
Big Bang
black hole
Burst Alert Telescope
calibrate
Caltech
cosmic rays
electrons
Fiona Harrison
gamma radiation
gamma-ray bursts
Gamma-Ray Imaging Spectrometer (GRIS)
Geiger counters
germanium
Goddard Space Flight Center
gondola
hard X-rays
McDonald Observatory
NASA Jet Propulsion Laboratory
neutron star
nuclei
NuSTAR
optics
particle accelerator
payload
photons
Principal Investigator
redshift
shield
spectra
spectroscopy
supernovae
Swift Gamma-Ray Burst Explorer
University of Arizona
Voyager
Yerkes Observatory

Standards: This lesson addresses NSES Content Standard E: Science and Technology and Content Standard F: Science in Personal and Social Perspectives; AAAS Project 2061 Benchmark The Nature of Technology/Technology and Science; and Common Core Common Core standards W.9-10.7, RI.9-10.1, and W.9-10.9(b).