Community in the Classroom Presentation Plan

Lesson Name Cosmic Rays and Neutrinos
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Grade Level 8 **Standards Connection(s)** Structure of Matter;

Abstract:

In this 50-min presentation, a slide show on the Sudbury Neutrino Observatory (SNO), a telescope that was built 2 km underground, will be presented. It was located deep underground in order to prevent too many cosmic rays from producing false signals in the detector. After the slide show, the students will have an opportunity to experiment with a cosmic-ray detector.

Vocabulary/Definitions:

Telescope:
A telescope is an instrument that can be used to observe distant stellar objects. There are many types: optical or radio wave. They can locate at different altitudes: ground-based (usually at mountain top) or space-based (such as the Hubble Space Telescope). Most telescopes observe "electro-magnetic" signal (such as optical light in conventional optical telescopes, or radio wave in ground-based radio-wave telescopes. This presentation will focus on telescopes that observe neutrinos and cosmic rays. The neutrino telescope (SNO) was built underground in a mine. *(The students' prior-knowledge of telescopes could serve as a springboard for introducing and highlighting the features, functions, and purposes of the Sudbury Neutrino Observatory telescope.)*

Neutrinos:
With regard to the structure of matter, eighth grade students are expected to learn that the structure of the atom is composed of protons, neutrons, and electrons. They are also expected to know that in solids the atoms are closely locked in position and can only vibrate; in liquids the atoms and molecules are more loosely connected and can collide with and move past one another; and in gases the atoms and molecules are free to move independently, colliding frequently.

We know that matters are made up of protons, neutrons and electrons. Over the last several decades, we also found out that protons and neutrons are made up of smaller constituents called quarks. As far as we know, electrons do not have any constituents. There are only fundamental particles in nature that do not have smaller constituents. The light that we see (photons) and neutrinos are examples for these fundamental particles. X-rays, radio-waves, optical light are all photons!

The Sun creates energy through a process called nuclear fusion, in which protons (the Sun is a giant ball of hydrogen or protons) are combined to form other elements. This fusion process creates a lot of energy in the core of the Sun. Light is produced in the solar core, but it takes over tens of thousands of years for the light (photons) to travel from the core to the surface of the Sun. This is because the Sun is very dense, and it is very hard for the photons to fight its way out. From the surface of the Sun, the light reaches us on Earth in merely 8 minutes. Neutrinos are a byproduct in this nuclear fusion process. But neutrinos do not interact with matter in the Sun readily, and can travel from the solar core to the solar surface almost instantaneously. So if we can see the neutrinos from the Sun, we can see directly and instantaneously the solar core. The sunlight we see are at least 10000 years old! SNO was built to see these neutrinos.

Cosmic Rays:
We know that there are "cosmic rays" impinging on the Earth's atmosphere. These cosmic rays are mostly protons. Some of them came from the Sun, some from other sources inside and outside our galaxy. But the origins of these galactic and extra-galactic cosmic rays are unknown. When these protons hit the atoms (nitrogen, oxygen) in the atmosphere, a lot of other subatomic particles are created. We will be using the cosmic-ray detector to observe one of the by-products called muons in this presentation. Muons are the heavier cousin of electrons. But muons do not make up matters as the electrons.

Materials:
The following items will be provided by the facilitator:
Cosmic-ray detectors, laptop and LCD projector (for showing the slide show), graph papers

The following items should already be available in the classroom for this presentation:
Pencil (1 per student);
Meter Stick (1 per every 4 to 5 students);
Wrist Watch or Timer with a seconds hand (1 per every 4 to 5 students).
**White Screen for slide presentation*

Classroom Visit

1. Personal Introduction: ___2_____ **Minutes**
The presenters will introduce themselves and briefly discuss their work.

Topic Introduction: **3_____ Minutes**

- *What is physics?*
- *How does the Sun create its energy? – Nuclear Fusion (see above)*
- *How do we know it is nuclear fusion? – if neutrinos are observed, then we know it is nuclear fusion.*
- *What is the importance of nuclear fusion? – Can provide clean energy! Operation nuclear reactors use nuclear fission for energy production, and can pose environmental hazards, but fusion is clean. In fact there are researches around the world to create a fusion reactor (but not successful yet).*
- *Why do physicist like myself have to become a miner in order to study neutrinos?*

2. Learning Experience(s): **40 Minutes**

The following topics will be introduced and discussed with the students via a slideshow (20 min).
- Different types of telescopes
- Neutrino telescopes
- Why are neutrino telescopes built underground?
- What do I do as a neutrino physicist?
- What do we know about neutrinos now?
+ topics in the intro section above.

The following sequence of events will facilitate students' experimentation with cosmic-ray detectors after the slideshow (20 min).
The class will be divided into four to five groups.
Each group will be given a cosmic-ray detector for experimentation.
The operational characteristics of the detectors will be presented to the students.
The students will then try to tilt the detector at different angles to determine the amount of cosmic rays at different "zenith angle".
The tilt will be measured by the meter stick (or ruler).
Results will be plotted on the provided graph papers.

The process will reinforce the grade-level standards for Investigation and Experimentation. In the eighth grade, students are expected to learn how to ask meaningful questions and to conduct careful investigations. Students are expected to practice how to: construct appropriate graphs from data and develop quantitative statements about the relationships between variables.

3. Wrap-up: Sharing Experiences and Building Connections **3_____ Minutes**

Q and A will be done while the students are experimenting with the cosmic-ray detector

Cosmic rays can damage cells in human body (similar to other forms of radioactivity such as X-rays). The higher the altitude, the higher the cosmic ray flux (since at lower altitude, there is more air to shield you from the cosmic rays). But the radiological effects are negligible on Earth's surface. As a wrap-up, the class will brainstorm ideas about some of the challenges that need to be addressed in working in the cosmic ray flux:

Increased cosmic ray exposure occurs when flying.
How about astronauts? What are the challenges to building a lunar or Martian station for human habitat?

4. Close: **2 Minutes**
How can kids learn more? Thanks and good-bye! Clean-up.

*Space, telescopes and astronomy: http://**www.nasa.gov***
SNO: http://sno.phy.queensu.ca
ICECUBE (neutrino telescope at the South Pole): http://icecube.wisc.edu/

TOTAL 50 – 60 Minutes

Follow-up – After Presentation

In the eighth grade, students are expected to read and respond to historically or culturally significant works of literature. –The use of Updike's 1960 poem, "Cosmic Gall" could serve as a follow-up to address how scientists' knowledge about neutrinos has changed over the years.

Cosmic Gall
Neutrinos, they are very small.
They have no charge and have no mass
And do not interact at all.
The earth is just a silly ball
To them, through which they simply pass,
Like dustmaids down a drafty hall
Or photons through a sheet of glass.
They snub the most exquisite gas,
Ignore the most substantial wall,
Cold-shoulder steel and sounding brass,
Insult the stallion in his stall,
And, scorning barriers of class,
Infiltrate you and me! Like tall
And painless guillotines, they fall
Down through our heads into the grass.
At night, they enter at Nepal
And pierce the lover and his lass
From underneath the bed - you call
It wonderful; I call it crass.

Up until about a decade ago, scientists thought that neutrinos do not have mass, similar to photons. But this has since been proved to be wrong. Neutrinos can pass through matters easily, and very rarely do they interact with matter. This is different from photons, which can trigger your retina easily.