The Expansion of the Universe

Document Overview

Teacher background information and instructions

SmartBoard class teaching aids

Student activity instructions (2)

- How Fast Do Galaxies Move?
- The Expanding Universe

Minnesota Science Standards

9.1.1.1   Science is a way of knowing about the natural word and is characterized by empirical criteria, logical argument and skeptical review.

9.1.3.3.2   Communicate, justify, and defend the procedures and results of a scientific inquiry or project using verbal, graphic, quantitative, virtual, or written means.

9.3.3.3.1   Explain how evidence, including the Doppler shift of light from distant stars and cosmic background radiation issued to understand the composition, early history and expansion of the Universe.

Objectives

- Students will interpret a line emission spectrum of galaxies of different distances from Earth for redshift.
- Students will use the percent change in redshift to calculate the speed of galaxies.
- Students will illustrate the expansion of the universe using a model.
- Students will explain the use of Cephied variables in the application of Hubble's Law (redshift velocity = distance x Hubble constant)
- Students will make inferences from the data collected and calculations in support of Hubble's Law.

Type of Activity

These two Earth & Space Science activities are supported and prefaced by two SmartBoard discussion presentations. The first activity requires use of computers to access a virtual spectroscope lab and then complete calculations using redshift change percent and the speed of light. The second activity has students make a model of the expanding universe using Slinkies. Collected data is then used in calculations with Hubble's Law. Guiding questions for students are included in both activities.

Duration
Three 50 minute periods

Connection to Nobel Conference Speakers

Dr. Alex Filippenko
One of the world's most highly cited astronomers, Alex Filippenko was a member of the Supernova Cosmology Project and the High-2 supernova Search Team that used observations of extragalactic supernova to prove the accelerating expansion of the Universe and thus imply the existence of dark energy. The discovery earned the teams' leaders the 2011 Nobel Prize in physics. This video, www.nasonline.org/programs/distinctive-voices/video-gallery/dark-energy.html may provide background information for teachers.

Dr. George Smoot
2006 Nobel Prize winner—experimental astrophysicist, George Smoot is an active researcher in observational astrophysics and cosmology. His group at Lawrence Berkeley National Laboratory and the University of California at Berkeley is observing our galaxy and the cosmic background radiation that is a remnant from the (Big Bang) beginning of our Universe. The Galactic Emission Mapping (GEM) is aimed at measuring and modeling Galactic millimeter to meter wavelength emission and Galactic structure. Satellites, such as COBE and ground-based observations are used in this research.

Teacher Tips
These activities and supporting presentation discussions notes (SmartBoard) were chosen and consolidated for a required senior high general Earth & Space course.

Concepts
Big Bang Theory
Cephied Variables
Doppler Effect
EMR
Hubble Law
line emission spectrum
redshift
spectroscope

Materials

Activity 1	Activity 2
student activity sheet	student activity sheet
computers	Slinky
calculator	8 pieces of string
pen/pencil	metric ruler
	calculator
	pen/pencil

Description of Activities

The two activities that comprise this lesson on the expansion of the Universe were collected and generated for use with an 11th grade Earth & Space course. The level of difficulty is considered appropriate for the general population of high school students. Two SmartBoard concepts discussion presentations are included for use. It is suggested that these maybe beneficial preceding each activity providing background information (or review) and introducing new concepts relating to the corresponding activity. Besides embedded links to activities and demonstrations, short videos introducing Dr. Alex Filippenko and Dr. George Smoot are also linked.

The first activity, "How Fast Do Galaxies Move?" utilizes an online virtual program designed for NASA. It's well organized—leading students through introductory materials, practice with spectroscope line emission spectrums showing redshift, to calculations of the speed of receding galaxies. Questions in the activity follow the organization of the virtual spectroscope program. Unfortunately, this program is not yet support by pads or notebooks.

In Activity 2, "The Expanding Universe" has students interpreting the Hubble graph, modeling the expanding Universe, plotting their own graph and calculating the Hubble constant and its inverse to estimate the age of the universe—or time of the Big Bang. Students are also asked to draw inferences from their collected data and calculations in support of the Big Bang theory and the expansion of the Universe.

Resources

http://zeus.as.arizona.edu/~dmccarthy/GSUSA/Activities/Cosmology/Hubble.pdf
http://www.cfa.harvard.edu/seuforum/galSpeed/
http://btc.montana.edu/ceres/html/Universe/uni1.html
http://sac.csic.es/astrosecundaria/book/workshops/T8%20The%20expansion%20of%20the%20Universe%20final.pdf
http://www.grb.sonoma.edu/materials/lesson_plan/hubble.html
www.youtube.com/watch?v=KfAs2hztDtl
www.youtube.com/watch?v=mcBV-cXVWFw
www.youtube.com/watch?v=gniDHWqOR_Q
www.ted.com/talks/george_smoot_on_the_design_of_the_universe.html