Science Screen Report®

VOLUME 44, EPISODE 3 - 12 minutes

ASTRONOMY: *The Very Large Array (VLA) Telescope*

SYNOPSIS

The VLA, or Very Large Array was built in the 1970s by the National Radio Astronomy Observatory, but has gone through many updates in recent years to keep the instruments and technology up to date. The VLA is a multi-purpose instrument, and with an array of 27 antennas, scientist investigate a variety of astronomical objects, including radio galaxies, quasars, pulsars, remnants of supernova, gamma ray bursts, radio-emitting stars, the sun and planets, black holes, and the hydrogen gas that constitutes a large portion of the Milky Way galaxy.

CURRICULUM UNITS

- ASTRONOMY
- ENGINEERING
- PHYSICS
- PHYSICAL SCIENCE

CAREER POSSIBILITIES

- ASTRONOMER
- CHEMIST
- COMPUTER SCIENCE
- ELECTRICAL ENGINEER
- MECHANICAL ENGINEER

NEXT GENERATION SCIENCE STANDARDS & NATIONAL SCIENCE EDUCATION STANDARDS

NEXT GENERATION SCIENCE STANDARDS: www.nextgenscience.org

ESS1.A: The Universe and Its Stars
The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.

Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

Grades 9 - 12
Science & Technology
Abilities of technological design
Understandings about science and technology

Grades 9 - 12
Science in Personal & Social Perspectives
Science and technology in local, national, and global challenges

Grades 9 - 12
Earth & Space Science
Origin and evolution of the universe

CRITICAL THINKING EXERCISES

1. Discuss with students how interferometry has increased the power of telescopes, giving astronomers better tools to view distant objects.
2. Have students research the reasons for different array configurations of the VLA telescope.
3. Discuss how other branches of science, besides astronomy, may be influenced by potential discoveries of the VLA telescope.
4. Study the electromagnetic spectrum paying special attention to frequency/wavelength relationships. What are the specifics regarding radio waves?

ABET
Accreditation Board for Engineering and Technology
www.abet.org

NMOE
National Museum of Education
www.nmoe.org

BACKGROUND

The Very Large Array, or VLA, is named after scientist Karl G. Jansky to honor his discovery of radio waves from the Milky Way. The VLA consists of 27 radio antennas in a Y-shaped configuration on the Plains of San Agustin, fifty miles west of Socorro, New Mexico.

To observe the world around us, we use our eyes to detect visible light, a type of electromagnetic radiation. The full range of all radiating waves is called the electromagnetic spectrum. Some objects in space emit types of electromagnetic radiation from all over the spectrum, some of which cannot be seen by the human eye, such as radio waves.

Astronomers use telescopes such as the VLA to accurately view celestial objects that give off radio waves. Because radio waves penetrate dust, astronomers use radio astronomy techniques to study regions that cannot be seen in visible light, such as the dust-shrouded, center of our Galaxy, the Milky Way. Studying radio waves, they are capable of tracing the location, density, and motion of the hydrogen gas that constitutes three-fourths of the ordinary matter in the Universe.

ADVANCED ORGANIZERS

Prior to viewing this video, students should have some understanding of the following Benchmarks for Science Literacy, Oxford University Press, which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 4. The Physical Setting
Section A: The Universe, Grades 6-8

- The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot.
- The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years.
- Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past.

Benchmark 4. The Physical Setting
Section A: The Universe, Grades 9-12

- On the basis of scientific evidence, the universe is estimated to be over ten billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass.
- Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years.
- Eventually, some stars exploded, producing clouds containing heavy elements from which other stars and planets orbiting them could later condense. The process of star formation and destruction continues.
- Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and X-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle data and complicated computations to interpret them; space probes send back data and materials from remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed.
- Our solar system coalesced out of a giant cloud of gas and debris left in the wake of exploding stars about five billion years ago. Everything in and on the earth, including living organisms, is made of this material.

**Benchmarks can be found at www.project2061.org/tools/benchol/bolintro.htm*

VOCABULARY

Aperture synthesis: An array of radio telescopes used in radio astronomy to simulate a single large-aperture telescope. Some such instruments use movable dishes while others use fixed dishes.
Electromagnetic spectrum: The entire range of electromagnetic radiation. At one end of the spectrum are gamma rays, which have the shortest wavelengths and high frequencies. At the other end are radio waves, which have the longest wavelengths and low frequencies. Visible light is near the center of the spectrum.
Gamma ray bursts: A short-lived, extremely luminous burst of gamma radiation from an unknown astronomical source, occurring at random positions in the sky several times a day.
Pulsars: One of several hundred known celestial objects, generally believed to be rapidly rotating neutron stars, that emit pulses of radiation, especially radio waves, with a high degree of regularity.
Quasars: One of over a thousand known extragalactic objects, starlike in appearance and having spectra with characteristically large redshifts, that are thought to be the most distant and most luminous objects in the universe.
Radio waves: A very low frequency electromagnetic wave (from roughly 30 kilohertz to 100 gigahertz). Radio waves are used for the transmission of radio and television signals; the microwaves used in radar and microwave ovens are also radio waves. Many celestial objects, such as pulsars, emit radio waves.
Super-massive black hole: The largest type of black hole, on the order of hundreds of thousands to billions of solar masses. Black holes are theoretical massive objects, formed at the beginning of the universe or by the gravitational collapse of a star exploding as a supernova, whose gravitational field is so intense that no electromagnetic radiation can escape.
The Very Large Array: A set of 27 radio telescopes arranged in a Y -shaped pattern, each arm of which is approximately 13 miles (21 km) long, and located near Socorro, N.M.; computer-processed data from the set provide high-resolution images of distant astronomical objects.

SUGGESTED REFERENCES

- *The 5 most powerful telescopes and 5 that will define the future of astronomy:* **www.popularmechanics.com/science/space/telescopes/4299775**
- *National Radio Astronomy Observatory:* **www.nrao.edu/**
- *Alma Observatory Homepage:* **www.almaobservatory.org/**
- *European Southern Observatory – Alma:* **www.eso.org/public/teles-instr/alma.html**
- *How Will ALMA make images?* **www.almaobservatory.org/science_articles/05_how_will_alma_make_images.pdf**