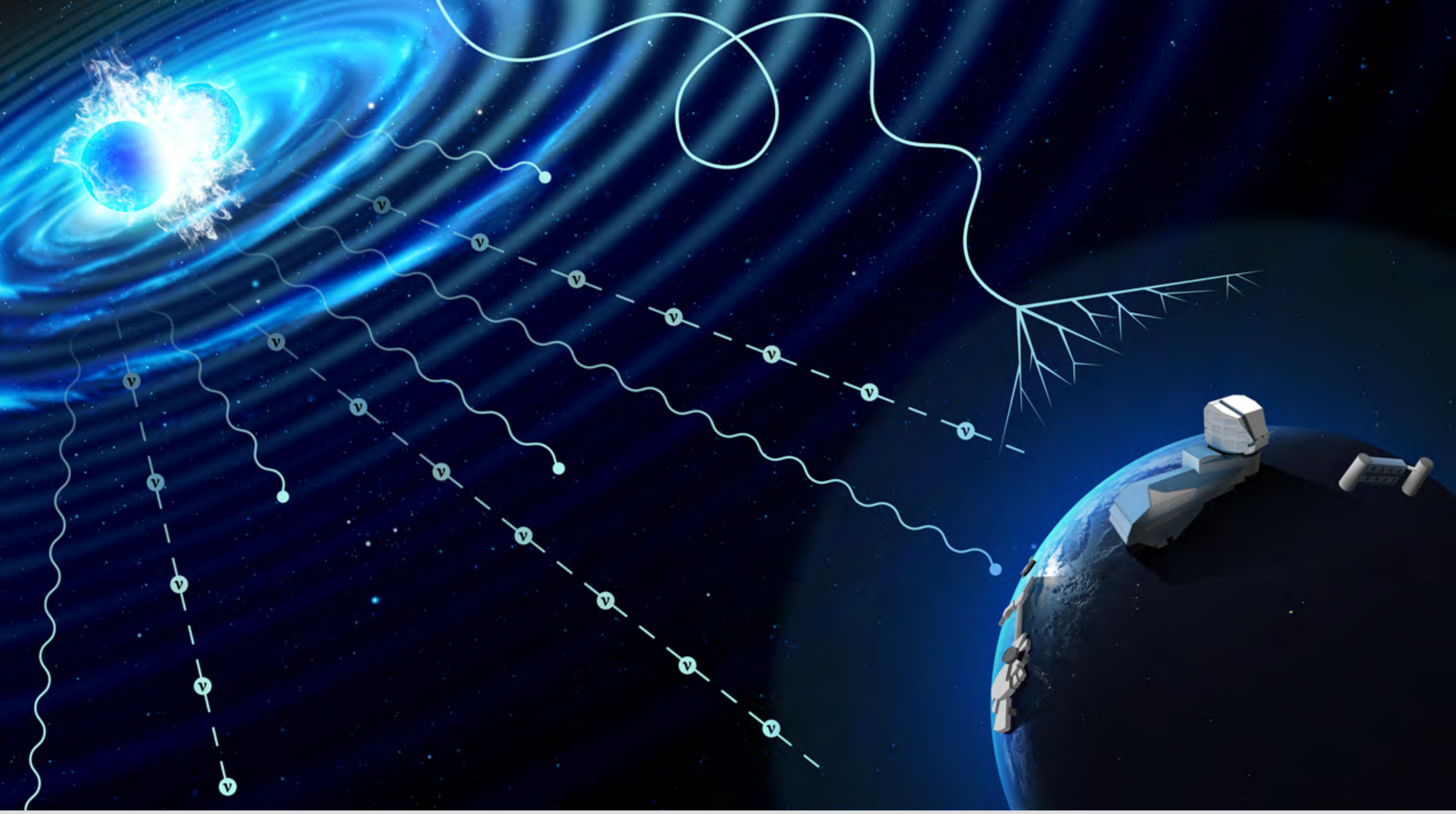
Messengers of Time and Space

Educator Resource Guide

Messengers of Time and Space is a stunning visual and educational experience that leads you on a journey through the dynamic Universe during a night of observing at the International Gemini Observatory. The show reflects on Gemini's unique rapid-response abilities as it joins forces with cutting-edge observatories like NSF–DOE Vera C. Rubin Observatory and LIGO (Laser Interferometer Gravitational-wave Observatory) to bring forth a new era of astronomy.

Messengers of Time and Space was made possible through a grant from the NSF called Gemini in the Era of Multi-Messenger Astronomy (GEMMA).



What is Multi–Messenger Astronomy?

Photons, neutrinos, cosmic rays, and gravitational waves all carry information about the Universe. Multi-messenger astronomy brings these detections together to investigate astronomical events from multiple cosmic perspectives. For example, some of the most energetic events in the Universe produce signals such as gravitational waves (ripples in spacetime) and cosmic rays (extremely fast, high-energy particles). Combining the information from each of these different detectors allows astronomers to build a more complete understanding of cosmic events.

Next Generation Science Standards Supported by *Messengers of Time and Space*

Performance Expectations

HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

- *The wavelengths and frequencies of photons and gravitational waves provide information about their astronomical source.*

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.

- *Observatories like Gemini and Rubin capture energy from light traveling vast distances, providing detailed images and spectra of objects in space.*

- *LIGO analyzes the effect gravitational waves have on spacetime as light travels through it. These minuscule effects on spacetime come from cataclysmic astronomical events like the collision of stellar-mass black holes.*
- *Rubin Observatory will study dark matter by analyzing the lens-like distortion of light from distant galaxies.*

HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the Universe.

- *Multi-messenger astronomy provides a broad set of observational tools to study the early Universe and its structure.*
- *Rubin Observatory will use distant galaxy observations to study the large-scale structure of the Universe.*

Connections to the Nature of Science

Science is a Human Endeavor
Scientists and engineers from around the world collaborate to build observatories and push the boundaries of innovation. As technology evolves, new scientific discoveries unfold, and in turn, these new discoveries inspire further technological advancement.

Scientific Investigations Use a Variety of Methods
Multi-messenger astronomy has advanced with the development of new observatories and technology. This allows scientists to use different types of signals to understand the Universe.

Messengers of Time and Space Learning Objectives

- By combining signals such as photons with other messengers like gravitational waves, neutrinos, and cosmic rays, we unlock deeper insights into the dynamic and mysterious nature of the Universe.
- Astronomy is a vibrant and evolving science that continually shapes our understanding of the Universe and our place within it.
- Combining the power of world-class facilities such as Gemini, Rubin, and LIGO will transform astronomy and redefine how we explore the Universe.
- Rubin Observatory will collect a massive amount of data every night, generating a flood of discoveries and revealing answers to questions we have yet to imagine.

The International Gemini Observatory

The International Gemini Observatory, a Program of NSF NOIRLab, consists of twin 8.1-meter diameter optical/infrared telescopes. From their locations on Maunakea in Hawai'i and Cerro Pachón in Chile, two of the best observing sites on the planet, the Gemini telescopes can collectively access the entire sky. With wide-field, high-resolution imaging and the capability for rapid-response operations, Gemini is ideal for time-critical observations of multi-messenger events.

Unraveling the Secrets of 'Oumuamua
In 2017, Gemini's unique abilities were essential in characterizing an unusual extrasolar object called 'Oumuamua. Both telescopes dropped everything to observe the object for three nights before it sped away and faded from view. Read more about Gemini's role in observing the interstellar visitor here.

Explore the 'Omuamua classroom activity to learn about the interstellar object's journey through the Solar System, the meaning behind its name, and how Gemini data was used to determine the object's shape.

NSF–DOE Vera C. Rubin Observatory

Rubin Observatory, located on Cerro Pachón in Chile, will scan the sky for a decade, creating an ultra-wide, ultra-high definition movie of the Universe using the largest camera ever built. This unique movie will bring the night sky to life, yielding a treasure trove of discoveries. With its sensitive camera and suite of filters, Rubin will increase the population of known multi-messenger sources by obtaining crucial color information and localizing events for follow-up observations by other telescopes.

Capture the Cosmos in Space Surveyors

As the fastest-slewing large telescope in the world, Rubin can point to targets in as little as three minutes. Figure out the best way to capture the most stars, galaxies, and asteroids as you operate a simulated version of Rubin Observatory's telescope in Space Surveyors.

How do Rubin's Filters Work?

Rubin's filters help scientists study various properties of astronomical objects using different wavelengths of light, including the visible, near-infrared, and ultraviolet ranges. Using multiple filters helps track changes in an object's brightness and apparent size, which is essential for studying transient events such as supernovae and comets. Learn more about how Rubin's filters work and how color images are made using Rubin's Coloring the Universe investigation.

Detecting Cosmic Explosions

Rubin's ability to rapidly detect cosmic explosions such as supernovae and provide detailed data to identify and characterize them is essential for advancing multi-messenger astronomy. Learn more about different types of supernovae and analyze data in Rubin's Exploding Stars investigation.

NSF LIGO

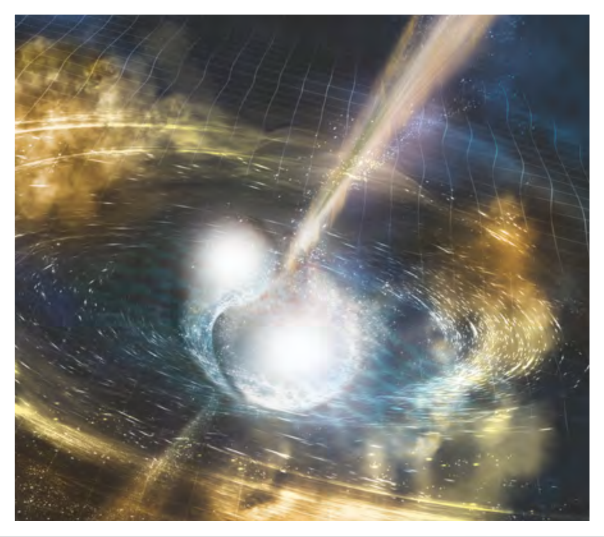
The Laser Interferometer Gravitational-wave Observatory (LIGO), operated by Caltech and MIT for the U.S. National Science Foundation (NSF), detects gravitational waves by measuring the minute ripples in spacetime emitted by cataclysmic cosmic events such as colliding neutron stars. NSF LIGO comprises two widely separated interferometers in the United States: one in Hanford, Washington, and the other in Livingston, Louisiana. These facilities operate in unison to detect gravitational waves.

Detecting the First Gravitational Wave Signals

In 2015, LIGO captured the first direct detection of gravitational waves formed from two stellar-mass black holes colliding. This Educator's Guide provides a brief introduction to LIGO and to gravitational waves, along with two simple demonstration activities that you can do in your classroom to engage your students in understanding LIGO's discovery.

First Event Observed in Both Gravitational Waves and Light

In 2017, scientists directly detected both gravitational waves and gamma-ray bursts from the collision of two neutron stars. The gravitational waves were first detected by LIGO, and the European detector Virgo helped narrow down the location of the cosmic event. At nearly the same time, NASA's Fermi space telescope had detected a burst of gamma rays. The LIGO-Virgo gravitational wave detection, coupled with Fermi's gamma ray detection, enabled some 70 ground- and space-based observatories to follow up with this kilonova explosion. Bring activities into your classroom to model how multi-messenger astronomy relies on collaboration to build a more complete picture of cosmic phenomena.



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