

## Article-Based Observation on Gravitational Waves

**Directions:** Read the article "[Gravitational waves offer new view of dynamic cosmos](#)," as well as the earlier article "[Physicists detect gravitational waves](#)," which gives important background information. Then answer these questions:

1. What is the main topic of the articles?
2. What is spacetime?
3. What are gravitational waves?
4. How were gravitational waves detected?

5. How were the detected gravitational waves created?
6. Why is the first direct detection of gravitational waves so significant?
7. What can scientists find out from studying gravitational waves?
8. How do scientists plan to tell which direction gravitational waves are coming from?

## Responses to Article-Based Observation on Gravitational Waves

- 1. What is the main topic of the articles?** Possible student response: Scientists directly detected gravitational waves for the first time.
- 2. What is spacetime?** Possible student response: Spacetime combines the three dimensions of space plus the fourth dimension of time into a single continuum.
- 3. What are gravitational waves?** Possible student response: Gravitational waves are ripples in space-time, like ripples produced on a rubber sheet when a massive object is moved on it.
- 4. How were gravitational waves detected?** Possible student response: Gravitational waves were detected by the Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO uses interference between laser beams traveling up and down the arms of its L-shaped detectors to look for signs of the waves. Gravitational waves stretch and compress empty space itself, ever so slightly changing the lengths of the detector arms and thus changing how the laser beams interfere.
- 5. How were the detected gravitational waves created?** Possible student response: The gravitational waves were created by two massive black holes spiraling around each other and merging together.
- 6. Why is the first direct detection of gravitational waves so significant?** Possible student response: Gravitational waves were predicted by Albert Einstein's theory of general relativity a century ago, so this discovery confirms Einstein's predictions. Gravitational waves tend to be very weak when they reach Earth (with spacetime only expanding and contracting by a minute amount, like a fraction of the width of a proton), so detecting them required both a very strong source (massive colliding black holes) and a very large and very sensitive detector (which was not possible until recently). The detection also creates a new field of astronomy through which scientists can understand the universe.
- 7. What can scientists find out from studying gravitational waves?** Possible student response: By observing gravitational waves, scientists can study the properties of black holes as they collide, compare the gravitational waves and visible light produced by neutron star collisions or star explosions, and check Einstein's theory of general relativity to see if its predictions are very accurate or need to be corrected for certain circumstances.
- 8. How do scientists plan to tell which direction gravitational waves are coming from?** Possible student response: With three gravitational wave detectors (Virgo plus LIGO detectors in two locations), scientists can compare the timing of the gravitational wave signals arriving at each detector to determine which direction the waves are coming from.