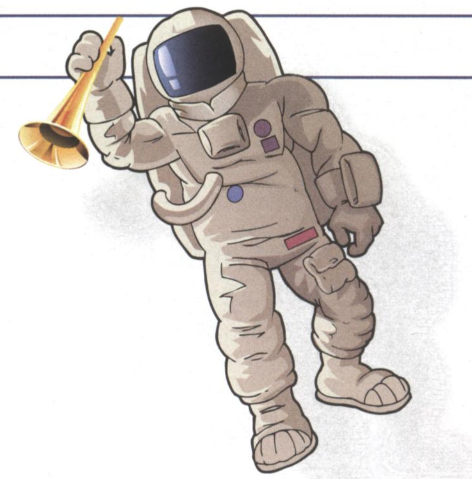


The sound of sound

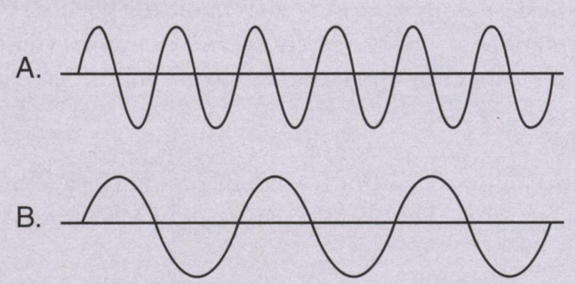
by Bob Riddle

We have all probably heard that "in space no one can hear you scream"—but are there really no sounds in space? The answer is both yes and no, depending on what you mean by *sound*. Sounds that we hear with our ears, acoustical sounds, are a result of vibrations. However, celestial objects, such as stars and planets, emit different forms of electromagnetic (EM) radiation that may be received by radio antenna, for example, and converted into acoustical sounds we can hear.

Acoustical sound happens when something vibrates and the vibrating of the object causes the air or water it is within, or an adjacent solid, to vibrate. The vibrations radiate outward in all directions from the vibrating source, and these vibrations travel as pressure waves of alternating compressions and rarefactions within the medium the waves are traveling through. We are able to hear that sound because our eardrum serves as a receiver and vibrates as a result of the traveling pressure waves. The vibrations from the eardrum are then converted from mechanical energy into electrical impulses, which are sent to the brain for interpretation and sensed as a sound we hear.

EM radiation, such as light, also travels as a wave; however, EM radiation does not require a medium for waves to propagate as a series of compressions and rarefactions. On the other hand, acoustical sound can only happen when something vibrates; that vibration is transmitted through a medium such as air, water, or a solid. Finally, there is a receiver able to sense the vibrations. Waves for both EM radiation and sound are described using the terms *frequency* and *wavelength*. Also, the frequency of a wave is equal to the frequency of the vibrating source.

FIGURE 1 Wavelength comparison of (A) a high-frequency wave and (B) a low-frequency wave



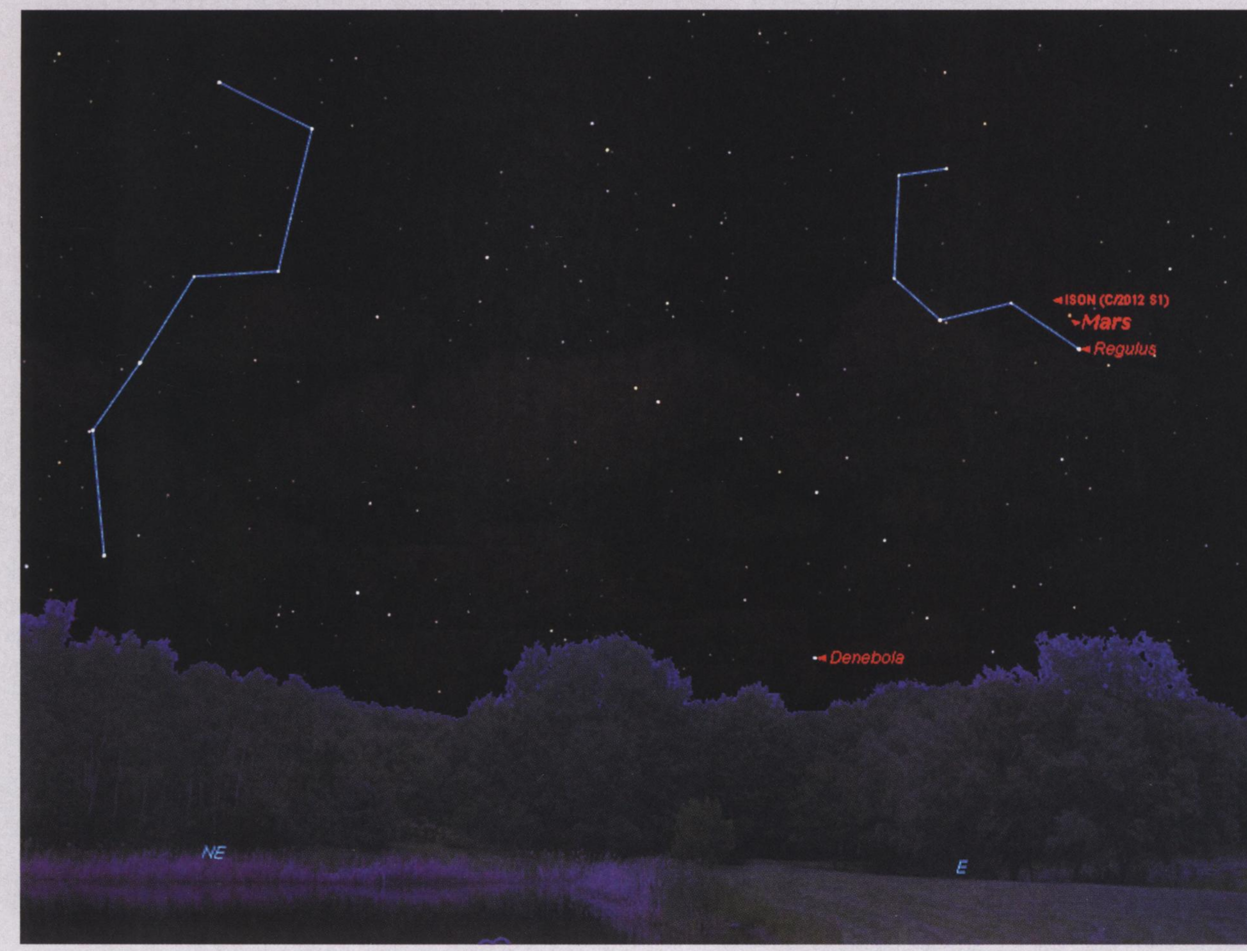
What do we hear?

Before answering this question, we need to establish what is meant by *frequency* and *wavelength* (see Figure 1). *Wavelength* is measured from one point, usually the top or crest of a wave, to the same point on the next wave. *Frequency* is a measure of how many waves pass by in a given amount of time, per second, for example. The unit for frequency is the hertz (Hz) and is defined as the number of cycles or vibrations per second. Waves are described by their frequency as being a high-frequency wave or as a low-frequency wave. High-frequency waves have shorter wavelengths compared with the longer wavelengths of low-frequency waves; more of these high-frequency, shorter waves pass by per second than would a wave with a longer wavelength. Sounds we are able to hear will have a frequency between 20 and 20,000 Hz, but as we age we start losing the ability to hear sounds at the higher frequencies.

Sounds in space

Because sound requires a medium to propagate and space is essentially a vacuum with virtually no particles within which sound can propagate, one might assume that there are truly no sounds in space. Yet this column is about sounds in space, and the sounds in space are not acoustical (i.e., based on the propagation of sound or pressure waves), but are acoustic sounds scientists have created by using waves of EM radiation received by different types of instruments. For

FIGURE 2 Mars, Regulus, and Comet ISON C/2012 S1, 6 a.m. EST



example, instruments aboard the *Cassini* spacecraft have recorded lightning strikes in the atmosphere of Saturn that are, in effect, the same sort of static crackling noise you get on an AM radio during a lightning storm. Using a Michelson Doppler imaging instrument, the Sun-orbiting Solar and Heliospheric Observatory orbiter has recorded acoustical waves moving across the Sun's photosphere. Artificially speeding up the frequency brought these waves within a frequency range audible to us.

Using the links in Resources, students may visit the European Space Agency website for a sampling of sounds from space. Students may also explore space-inspired sounds, musical compositions, and songs using "Music Inspired by Astronomy," an article written by Andrew Fraknoi. Many examples of space-inspired musical videos may be found on the Internet at sites such as YouTube, Google, or Vimeo, for example. With our solar system and our exploration of the solar system as the background context, I worked with a group of musicians a couple of years ago to produce a live musical performance accompanied by full-dome planetarium videos (see "Dark Matter presents *Orbit*" link in Resources).

International Observe the Moon Night

On the evening of October 12, the one-day-past-first-quarter Moon will be over the southwestern horizon at sunset, offering students the opportunity to observe our closest neighbor—the Moon. October 12 is also the official date for the International Observe the Moon Night and Astronomy Day. Use the websites in Resources to find out how to participate in any local events or to perhaps host your own event. In class, your students could use the online simulation game called Selene to learn about the geology of the Moon. The use of this simulation is part of research into the use of interactive games for teaching. Teachers must register to have access to this award-winning, National Science Foundation–funded simulation; be sure to read the FAQ at the Selene website (see Resources).

For students: Explore wavelengths and the spectra

Two resources, Project Spectra! and the European Space Agency's (ESA's) Sounds From Space, offer an opportunity to explore sound and EM radiation wavelengths. At the ESA website, there are some sound files of several objects at various frequencies, but remember that these are acoustical sounds produced from EM radiation signals.

At the Project Spectra! website (developed by the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics), there are several activities available for students (grades 6–12), including Using Spectral Data to Explore Saturn and Titan and Goldilocks and the Three Planets. These are easy-to-use, Flash-based simulations that may be completed online or downloaded for offline use in both PC and Mac versions. In Using Spectral Data to Explore Saturn and Titan, students follow the mission to Saturn and the release of the Huygens probe that landed on the surface of the moon Titan. Then, using data from the mission, students analyze the spectra from the rings and the atmosphere of Titan for the presence of certain gases. In a similar manner with Goldilocks and the Three Planets, students learn about Earth, Venus, and Mars and use spectral data to determine some of the gases making up the atmospheres of the three planets.

At the Space Telescope Science Institute website, students learn about the electromagnetic spectrum while using the Catch the Waves interactive simulation.

Hybrid solar eclipse

On November 3, the rising Sun and new Moon as we see them from Earth will intersect or be aligned so that the Moon will pass in front of the Sun briefly, giving us a solar eclipse. However, the circumstances for this solar eclipse are such that the eclipse will start as an annular eclipse where the Moon's disk silhouetted against the Sun will not completely cover the Sun at the moment of mid-eclipse. This type of eclipse, a combination annular and total, can happen at either sunrise or sunset when the Moon's umbral shadow does not quite reach the Earth's surface. For this eclipse, less than one minute after sunrise, the Moon's disk will cover the Sun, giving rise to a total solar eclipse for the duration of the eclipse.

At sunrise along the northeast coast of the United States, the eclipse will already be in progress and may be visible. (Use the NASA-prepared eclipse map for more information on local viewing.) The Moon's shadow will follow a path that began in the North Atlantic Ocean and ends on the east coast of Africa. Using the maps and other data provided at the NASA eclipse website, students can follow the path of totality and perhaps research any islands and African countries the eclipse path traverses.

Comet ISON C/2012 S1

This month, the comet ISON C/2012 S1 will be passing the planet Mars. Both the comet and Mars are located between Regulus and Denebola, the two brightest stars in the constellation Leo the Lion. This part of the sky rises a couple of hours before the Sun rises (see Figure 2). At its distance from the Sun in October, the comet is predicted to be around ninth magnitude, still too dim for the naked eye's sixth-magnitude limit, however it will be visible with a telescope. During October, Comet ISON C/2012 S1 will cross Mars's orbit as it moves inbound toward its November 28 perihelion passage around the Sun. Learn more about the comet in next month's column. ■

Visible planets

Mercury will be visible over the western horizon for the first half of the month but will be setting earlier each evening.

Venus will be very visible over the southwestern horizon at sunset as it moves eastward through the pincers of Scorpius the Scorpion toward the reddish star Antares, the heart of the scorpion.

Connections to the *Next Generation Science Standards* (Achieve Inc. 2013)

Standard MS-PS4-2: Waves and their applications in technologies for information transfer		
Performance expectation MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various material. MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.		
Science and engineering practice Developing and using models	**Disciplinary core idea** PS4.A: Wave properties • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude (MS-PS4-1). • A sound wave needs a medium through which it is transmitted (MS-PS4-2).	**Crosscutting concept** Structure and function Connections to engineering, technolonology, and applications of science • Influence of science, engineering, and technology on society and the natural world • Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations (MS-PS4-3).

Mars will rise two hours before sunrise near the star Regulus in Leo and will be within a few degrees from Comet ISON C/2012 S1.

Jupiter will rise shortly after midnight and will be visible all night near the Gemini twin stars of Pollux and Castor.

Saturn will be visible but low over the western horizon and will set earlier each day and too close to the Sun to view mid-month.

October

3	Uranus at opposition
4	New Moon
6	Thin waxing crescent Moon near Mercury and Saturn
8	Waxing crescent Moon near Venus
9	Mercury at eastern elongation
10	Moon perigee: 369,813 km (229,783 mi.)
11	First quarter Moon
12	International Observe the Moon Night Astronomy Day
14	Mars very near Regulus
16	Venus passes Antares
18	Full Moon
	Penumbral lunar eclipse
20	Waning gibbous Moon near Pleiades
21	Waning gibbous Moon near Aldebaran
23	Sun enters astrological sign of Scorpio
25	Moon at apogee: 404,557 km (251,406 mi.)
	Waning gibbous Moon near Jupiter
26	Last quarter Moon
29	Waning crescent Moon near Mars and Regulus
30	Sun enters astronomical sign of Libra

Reference

Achieve Inc. 2013. *Next generation science standards.* Washington, DC: National Academies Press.

Resources

Astronomy Day events, October 2013—*www.astroleague.org/content/astronomy-day-events-oct-2013*

Cassini at Saturn—*http://saturn.jpl.nasa.gov*

Catch the waves—*http://amazing-space.stsci.edu/resources/explorations/light/CatchWaves_activation-frames.html*

Dark Matter presents *Orbit*—*http://currentsky.com/dm.html*

European Space Agency: Sounds from space—*www.esa.int/Our_Activities/Space_Science/Sounds_from_space*

Franknoi, A. 2012. Music inspired by astronomy: A resource guide organized by topic. *Astronomy Education Review* 11 (1). *http://aer.aas.org/resource/1/aerscz/v11/i1/p010303_s1?view=fulltext.*

The golden record—*http://voyager.jpl.nasa.gov/spacecraft/goldenrec.html*

Hybrid solar eclipse of 2013 Nov 03— *http://eclipse.gsfc.nasa.gov/SEgoogle/SEgoogle2001/SE2013Nov03Hgoogle.html*

International Observe the Moon Night—*http://observethemoonnight.org*

Penumbral lunar eclipse of October 18—*http://eclipse.gsfc.nasa.gov/OH/OH2013.html#LE2013Oct18N*

Project Spectra!—*http://lasp.colorado.edu/home/education/k-12/project-spectra*

Selene—*http://selene.cet.edu*

Solar and Heliospheric Observatory (SOHO)—*http://sohowww.nascom.nasa.gov*

Voyager termination shock—*www-pw.physics.uiowa.edu/space-audio/voyager/termination-shock*

Bob Riddle (*bob-riddle@currentsky.com*) is a science educator in Lee's Summit, Missouri. Visit his astronomy website at *www.currentsky.com*.