THE UNIVERSE IN THE CLASSROOM

www.astrosociety.org/uitc

No. 55 - Summer 2001

AstroCappella — A Musical Exploration of the Universe

Singing about Science

Songs about solar fusion? Doppler shifting ditties? While the idea of upbeat pop songs that are rich in science content might seem incongruous, a rocking band of techies with deep roots in the space science and education communities has melded music and science into the classroom-friendly AstroCappella Project. The Chromatics, an a cappella vocal band made up of astrophysicists, aerospace engineers, and other high-techers, has just released their 13-song CD/CD-ROM AstroCappella 2.0, which is the culmination of more than three years of collaborations with teachers, students, and fellow scientists.

The AstroCappella songs take the listener on a journey which starts in our own solar system ("Nine Planets", "Sun Song", "Habitable Zone"), and ends up at the edges of space, time and gravity ("High Energy Groove", "Swift Song"). Along the way, listeners get tuneful introductions to the concept of light as electromagnetic radiation, spectroscopy, the Doppler shift, and the expansion of the Universe.

Each song has extensive background and supporting materials, accessible through a computer's CD-ROM drive. These include self-guided activities, complete lesson plans, slide shows, science rock videos, beautifully illustrated background articles, and a glossary, as well as games and puzzles based on the content. A NAS (National Science Standards) map is included to make integrating the songs into the science curriculum a snap. The CD is packaged with a visually stunning 16-page illustrated lyrics booklet. The first pressing of AstroCappella 2.0 has already sold out; the second pressing has just arrived in the Chromatics' offices.

What drives scientists with a beat to croon about the heavens?

It all began when serendipity and geography conspired in the makings of a DC-area contemporary a cappella group. Co-founded by an engineer and a comet researcher, the Chromatics drew its members from the science and technology fields. By 1997, the group included several astronomers, engineers, computer systems administrators and a NASA budget analyst. The seeds for spacey science songs had been planted.

Alan Smale, Business Manager for the Chromatics is a NASA astronomer

An equal commitment to a career in astrophysics and a desire to communicate the wonders of science to the general public led Padi Boyd to the NASA IDEA (Initiative to Develop Education through Astronomy) program in 1997. "When I was researching grants, I came upon IDEA — a small program that gives seed money to innovative astronomy educational programs," recalls Boyd. "In a conversation with fellow Chromatic Alan Smale, I brought up, almost as a joke, the idea of writing songs about astronomy and going for one of these grants. It was very tongue in cheek at the time, but once we started talking about it, we all started recalling entire Schoolhouse Rock songs from 15 years ago." The two X-ray astronomers did a little research and confirmed what they suspected already: that music is an incredibly powerful way into a person's mind and memory.

Padi Boyd, astrophysicist, soprano, and originator of the AstroCapella concept

"It was one of those golden ideas that seems so obvious in hindsight," Smale adds. "Everywhere we looked, we saw how kids respond instantly to music, and how easy it is for Schoolhouse Rock (on one end of the spectrum) and advertisers (on the other) to get their message across in exciting and memorable ways using song. And we saw in adults how often an interest in music and an interest in science go hand in hand."

Harmonizing with Science Educators

Boyd and Smale, who are both astrophysicists at NASA's Goddard Space Flight Center Laboratory for High Energy Astrophysics, joined forces with middle school math teacher Kara Granger, who was already working on educational projects within their lab. Together they came up with the concept of a short CD with five or so songs, and an activity to go along with each song, to be used in the middle school math or science classroom. In May of 1998, a modest six-song CD with minimal packaging and a six-activity booklet were distributed to teachers free of charge. The songs covered radio astronomy, the Sun, the Doppler Shift, the Hubble Space Telescope, the nearest stars, and X-ray and gamma-ray astronomy. Web designer and Chromatics member Karen Smale designed a content-rich Web site (www.astrocappella.com) as a companion to the CD where visitors can download audio files, lesson plans and more. The concept took off. To date, the group has distributed 10,000 copies of the original AstroCappella CD and booklet to educators around the world. Supplies of the first AstroCappella CD ran out in the middle of 2000.

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Beyond the original grant

While the original grant has run out, enthusiasm within the Chromatics has not. Their many interactions with teachers encouraged them to expand on the AstroCappella concept. Specifically, teachers repeatedly asked for new songs about the solar system. AstroCappella 2.0 is chock-full of solar system information, from the largest gas giant to the smallest meteor. Background information on the CD-ROM includes images, multi-media materials, and unconventional but accessible lesson plans. Karen Smale took the lead on developing the materials for the CD-ROM according to her own educational vision. "Computers and the visual media have advanced our access to a wide variety of resources for education and entertainment," she notes. "Students expect multi-sensory input — they get it in their video games — so why not take a multi-sensory or multi-media approach to science? Images grab the public's attention — our most visited outreach Web site in the Laboratory for High Energy Astrophysics is the Astronomy Picture of the Day. So we've combined images and music, videos and hands-on activities like puzzles, games, and creative projects to let students use as many senses as possible and help them to actively participate in the learning process."

Many of the lesson plans revolve around food. Miso soup is used to demonstrate solar convection. Students can take an edible tour of the solar system with common supermarket items standing in as scale models of the planets. Chocolate fondue and ice cream are made and tied to ideas of temperature, and the habitable zone around the Sun. "The teachers we work with encouraged us to use food as a motivator for kids of all ages," Boyd says. "This past summer, in a week-long workshop, we tested many of the lesson plans. By far the most popular were those involving food!"

Within the songs themselves, as well as the background information, new discoveries are highlighted throughout. "I'm committed to the idea that students and the general public have a right to learn about and enjoy our modern picture of the universe," Boyd says. "For centuries, people have been fascinated with the universe, and Earth's and humanity's place in it. We've learned so much about our solar system, our Galaxy, and the universe, but many times the most exciting, most thought-provoking ideas don't make their way to students and the taxpayers who are footing the bill. Even in my lifetime, we've made such enormous strides in our knowledge of the Solar System. Starting with the lunar landings, we've been exploring our neighbor planets with ever-increasing technology, and finding out all kinds of new things, big and small. We've tried to get this sense of awe, and of continuous learning, into the AstroCappella project: the Pluto (planet or Kuiper Belt object?) controversy makes an appearance in the song Nine Planets. The expanding universe is mentioned in several songs."

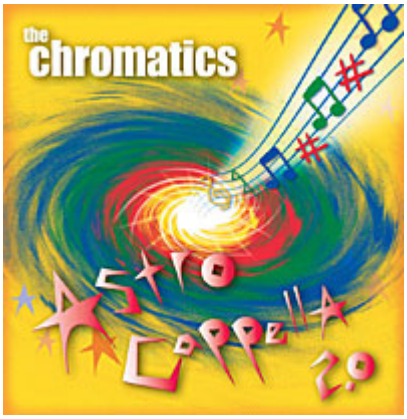
Getting the Word Out

Members of the Chromatics, and other educators, develop and present teacher workshops that include a harmonic dose of AstroCappella. The singers have traveled as far afield as Orlando, FL, and Honolulu, HI to bring their musical view of the universe to local educators. AstroCappella songs make frequent appearances in the educator workshops developed by Laura Whitlock, former head of Goddard's High Energy Astrophysics outreach program, and honorary master teacher. "The music of AstroCappella serves as a great hook to gain the attention of students and, perhaps, even to invade their minds with choruses of science," says Whitlock. "The activities included can then follow up on the concepts embedded in the songs. At a recent workshop in Palm Springs, CA, one teacher came up to me to say that she had been teaching the electromagnetic spectrum to her class. Their response was 'less than enthusiastic'. This teacher had heard the Chromatics perform some of the AstroCappella songs several years ago and thought the music might help engage her students. She played 'Cosmic Radio Show' for the class and had them try the activity to create a radio

antenna out of an umbrella. She was thrilled at the response of the students and reported that for days afterward she heard 'Hey, ho, did you know there's a Universe in the radio?' coming out of her students."

The Chromatics now routinely sneak an AstroCappella song or two into their regular concerts as a way of turning their audiences on to science. They have been banquet entertainers for science and technology conferences, and have appeared on PBS and CNN while performing AstroCappella songs. In November 2001 they performed at the Smithsonian Air and Space Museum and the Maryland Science Center. "Music and science are both about passion," notes Boyd. "We've created music that lets us share our joy about discovery and our wonder about the universe around us with others. Some people feel afraid of science, others feel science has nothing in it for them. If our music awakens in them the realization that we've just found planets around other stars, or that the early moments of the birth of the universe are imprinted in some of the photons all around us, then I think we've done those people a service. If they're further inspired to dig deeper into the science behind these marvelous realizations, then we've helped their teachers as well."

How can I get a copy?



The Chromatics — Padi Boyd, Alan Smale, Karen Smale, Lisa Kelleher, Deb Nixon, John Meyer, and Paul Kolb — would like to reach the widest possible audience of teachers, informal educators, and the general public with AstroCappella 2.0. Visit their Web site at www.astrocappella.com to order copies. The CDs are also distributed through the Primarily A Cappella Catalog, the Mainely A Cappella Catalog and the Science Songwriters' Association.

Praise for the Chromatics received directly via their Web site:

"I just wanted to let you know how much I have enjoyed your AstroCappella CD. I have had it playing in my office to learn the songs for a class and the reaction I get from people coming in is priceless. I will notice them humming or keeping beat with the music then the words sink in and they can not believe it is an educational song that is also fun to listen to. The touch of having a Web page with activities that go with the song is outstanding. If you do any more Educational CDs I would like to be first in line."
— Ann McCartney, Georgia State U., GA

"If science at school had been this interesting, I wouldn't have always slept through it."
— Anonymous South Carolina 4-H Member, SC

"I am a junior high science teacher working with students on a science Olympiad team. One of our events is astronomy and we stumbled across a snippet of the Doppler song in our search for information. We were so excited about the song that we had to know the words. We called in our surfing the net expert and quickly discovered more fun songs!!!!!!! WE MUST HAVE THAT CD!!! We have spent over an hour listening and singing along."
— Krisi Williams, Paulding Middle School, Paulding, OH

"Your music is fantastic!!! Thank you very, very much!"
— Cindy Langelier, Novelty, OH

"My students could always remember the lyrics to commercials or TV sitcoms — Gilligan's Island, Brady Bunch, Burger King — but never the parts of a cell. Using music to teach and to learn is effective but teachers just don't have the time to create lyrics to songs (some of us just don't have the talent). Your CD is one of the most innovative uses of music for science education. The information in the songs elevates the level of understanding for some very complicated concepts in astronomy for middle school students. The activities are also outstanding that accompany the songs. Thank you for giving me an effective tool to use in the classroom."
— Cheryl Wood, Orlando science teacher, FL

"I was in Las Vegas and heard you perform. I received a copy of your CD and book. Thank you very much. You are excellent educational entertainment ... I have used it with my own high school astronomies and they think you are really "cool." They like the beat and the tune, irrespective of the words (or story, as in the Doppler shift song)."
— Jeanne Bishop, Westlake High School, Westlake, OH

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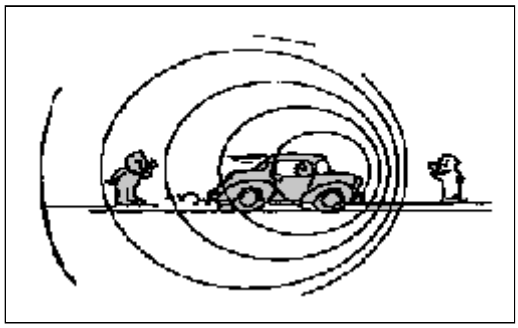
Related Activity

Editor's note: This activity is both on the Astrocappella web site and the CD-ROM featured in this article. You can read the lyrics to "Doppler Shifting" and hear it performed by the Chromatics at the same site.



Here It Comes, There It Goes!

An activity by Kara C. Granger related to: 'Doppler Shifting'

Activity Summary:

Every student can demonstrate the Doppler effect! During this interactive outdoor procedure, students will use an ordinary toy to reveal the Doppler effect. The connection is also made to moving cars, and to the shifting of the lines in the absorption or emission spectrum when the distance between a star and Earth is increasing or decreasing.

Objective:

Students will perform an experiment in which they will demonstrate the Doppler effect. They will also understand the connection to everyday-life examples.

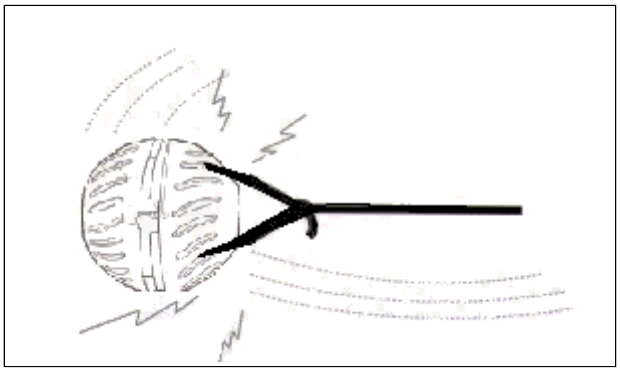
Materials for each group of students:

- 'splash out' ball**
- electronic noise making mechanism with pure tone (from Radio Shack, or other electronics store)
- 9 volt battery
- 9 volt battery clip
- jump rope
- masking tape

Procedure:

1. Twist the 'splash out' ball open.

2. Thread one end of the jump rope through the holes of the 'splash out' ball and tie the end back to the rope. Next, twist the wires of the electronic noise making mechanism together with the wires of the battery clip. Plug the battery into the battery clip, and tape this assembly to the inside of the 'splash out' ball. You now have a 'Doppler ball assembly'. See the illustration below.



3. The teacher should stand about 5 meters away from the students twirling the Doppler ball assembly in a circle above his or her head. In order to gain enough speed, let out about 1.5 meters of jump rope as you twirl it.

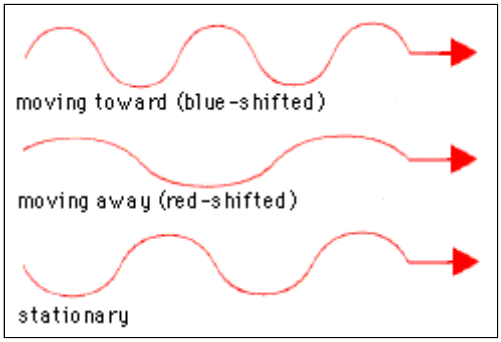
4. Students should observe, record and describe what they hear as the Doppler ball approaches, passes, and goes away from them.

5. Let different students try twirling the Doppler ball. Ask them to describe what they hear.

Discussion:

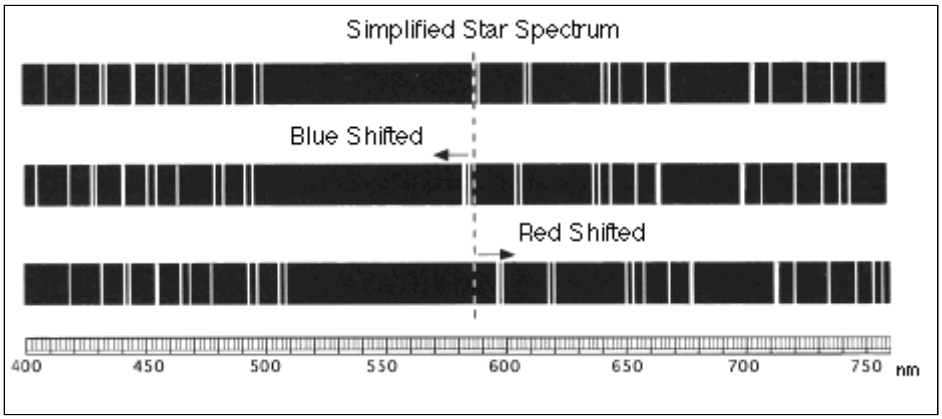
This is a demonstration of a phenomenon called the Doppler effect. It results from the motion of a source coming towards, and going away from an observer. This effect can occur with both sound and light, because both sound and light reveal wave- like behavior. For instance, if a source of light was a moving star relative to an observer on Earth, this would cause the star's spectra to be shifted toward the red (going away) or toward the blue (coming towards) end of the spectra.

The number of waves reaching an observer in one second is called the frequency. For a given speed, frequency depends upon the length of the wave. Long waves have a lower frequency than short waves. As long as the distance between the source of the waves and the observer remains constant, the frequency remains constant. However, if the distance between the observer and the source is increasing, the frequency will decrease. If the distance is decreasing, the frequency will increase. The images below illustrate this effect.



Now imagine an everyday-life example such as observing and listening to an approaching car. The sound waves coming from the engine are squeezed closer together than they would be if the car were still. This happens because the car is moving in your direction. This squeezing of the waves increases the number of waves (i.e., the frequency) that reach your ear every second. But after the noise of the car's engine passes, the frequency diminishes. In actuality, the sound waves are stretched apart by the car's movement in the opposite direction. As the observer, you perceive these frequency changes as changes in the pitch of the sound. The sound's pitch is higher as the car approaches, and lower as it travels away. An image contained in this activity plan, located below the title of this activity, illustrates what happens.

A similar situation takes place with stars. If the distance between a star and Earth is increasing, the lines in the absorption or emission spectrum will shift slightly to the lower frequency, or red end of the spectrum. If the distance is decreasing, the lines will shift toward the blue end. The image below shows a simplified star spectrum with red and blue shifting. Notice how the entire spectra gets shifted to the blue (left) or red (right).



Extensions or Further Discussion:

1. Does the person swinging the Doppler ball assembly hear the Doppler shift? Why or why not?

2. Can the red/blue shift technique be used for objects other than stars? Can you tell which way an emergency vehicle is traveling by the pitch of its siren?

3. What has the Doppler shift told astronomers about the expansion of the universe?

References:

The general idea for this lesson plan was adapted from a Doppler effect lesson located within "Space-Based Astronomy: A Teacher's Guide with Activities" associated with the Office of Space Science Astrophysics division of NASA.

Thank you to John Wood for suggesting the use of the Doppler ball assembly.

**This toy is made by Galoob and can be bought at your local toy store. For more information, contact Galoob Customer Service at 1-800-442-5662.