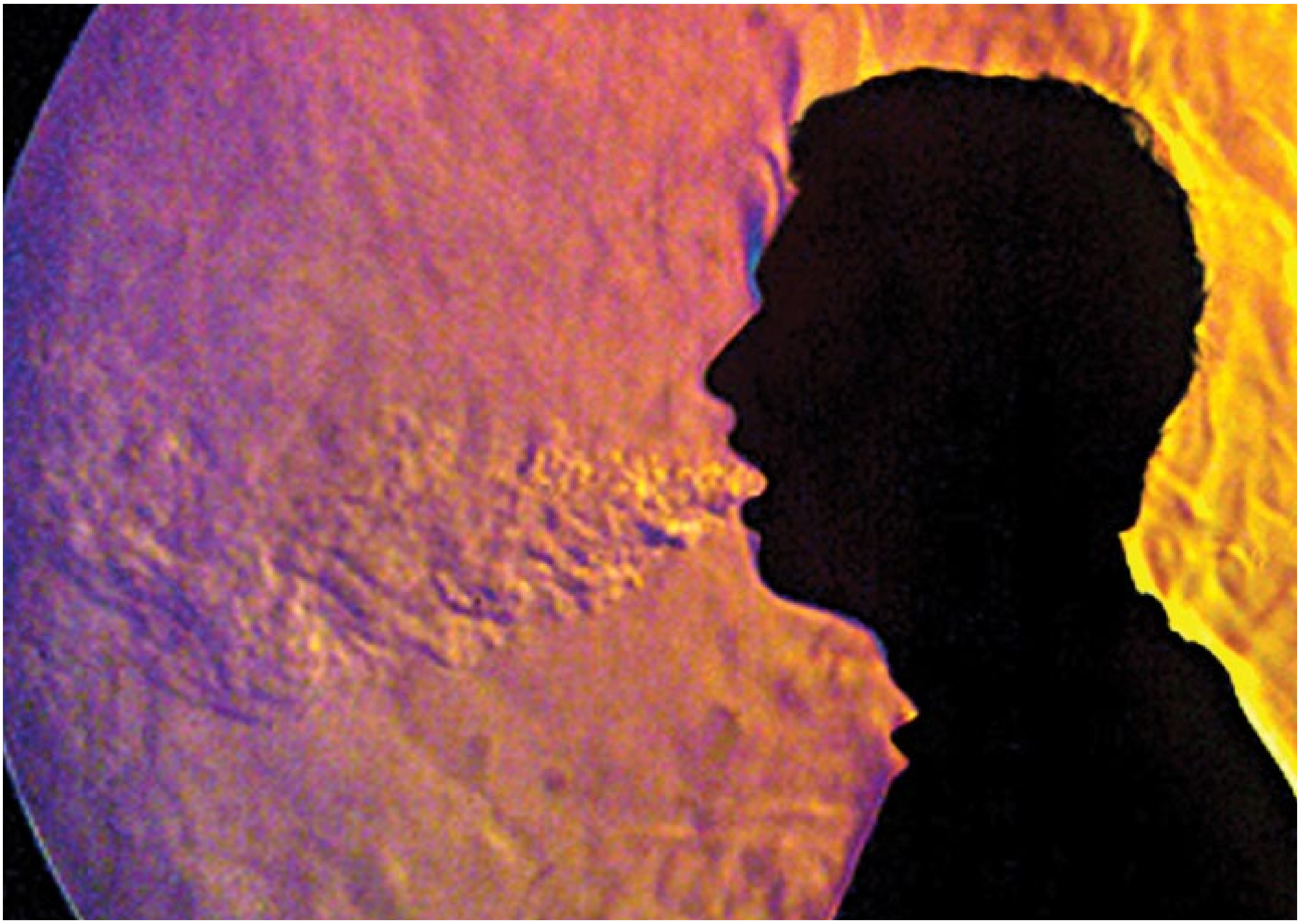
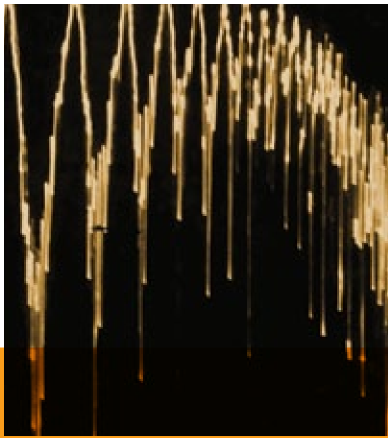




ACOUSTICS

The Acoustical Society of America

OSA
The Optical Society

THE ACOUSTICAL SOCIETY OF AMERICA (ASA)

The Acoustical Society of America is dedicated to increasing and advancing the knowledge of acoustics – the science of sound. ASA includes physicists, engineers, biologists, psychologists, geophysicists and scientists who work in music, speech, architecture, medicine, bioacoustics, noise control and oceanography. This diversity of topics, along with the opportunities provided for the exchange of knowledge and points of view, is one of the Society's strongest assets. Whether it is the study of humpback whale songs, the design of concert halls, the study of music and musical instruments or a wide range of sound-related studies, they will be investigated by ASA members.

THE OPTICAL SOCIETY (OSA)

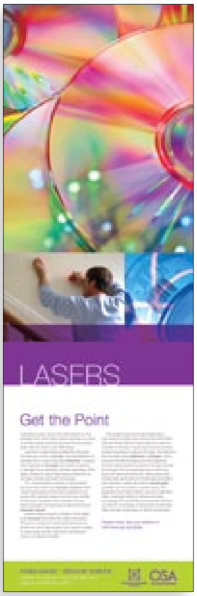
Founded in 1916, OSA brings together optics and photonics scientists, engineers, educators and business leaders. OSA is dedicated to providing its members and the scientific community with educational resources that support technical and professional development. OSA's publications, events and services help to advance the science of light by addressing the ongoing need for shared knowledge and innovation. The Society's commitment to excellence and continuing education is the driving force behind all its initiatives.

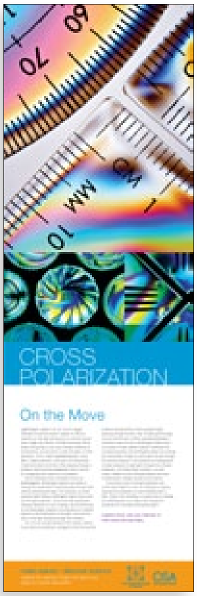
THE OSA FOUNDATION

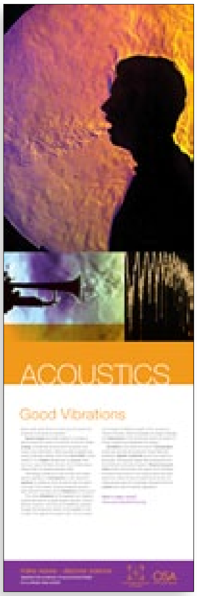
Inspiring the next generation of scientists and engineers

The future's great scientists are among the children of today and tomorrow. These children live and study around the world. Some have the resources and support needed to succeed, but many others do not. The OSA Foundation believes all students should have access to quality education resources and everyone should have the opportunity to explore scientific studies and career paths.

The Foundation focuses on advancing youth science education by providing students with access to science educators and learning materials through interactive classroom and extracurricular activities. To learn more about the Foundation and its funded programs or to request support for your program, please visit www.OSA-Foundation.org, e-mail foundation@osa. org or call +1.202.416.1421.







This poster series was created by the Acoustical Society of America and The Optical Society.

Special thanks to the following volunteers for donating their time and expertise to this poster and guidebook:

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Geoffrey Edelmann, United States Naval Research Laboratory
Pamela Harght, BAi, LLC
Dan Ludwigsen, Kettering University
Thomas Moore, Rollins College
Cynthia Moss, University of Maryland
Charles Schmid, Acoustical Society of America
Victor Sparrow, Pennsylvania State University

Good Vibrations

MUSIC REALLY DOES FILL THE AIR WHEN SOUND TRAVELS FROM A SOURCE TO THE EARS OF A LISTENER!

Sound waves are small variations in pressure, which travel from source to receiver. All sound carries **energy**, and familiar sounds such as speech and music carry information. Many sounds of speech (as well as singing) originate when the vocal folds ("vocal cords") in our **larynx** vibrate due to passage of air from our lungs. Similarly, the lips of a trumpet player vibrate when air passes between them.

The energy carried by a sound wave can create electric signals in a **microphone** or can cause the **eardrum** to vibrate so that the sound can be heard in the ear. The number of sound waves that arrive each second is known as the **frequency** of the sound.

The noisy **vibrations** of the speaker's (or singer's) vocal folds and the trumpet player's lips don't sound familiar, however, until they are modified by passing through the throat and mouth of the speaker or the trumpet held against the player's lips. The trumpeter can change the effective length of the trumpet by means of valves, while the speaker (or singer) changes the **resonances** of the throat and mouth by means of throat muscles and especially the tongue.

Acoustics is the science of sound. Acousticians study how sounds are produced, transmitted and perceived. Speech scientists study how speech is produced, the acoustic signal that is produced, and how listeners understand speech. Musical acousticians study instruments of all types, from orchestra and band instruments to the singing voice and even electronic means of sound creation and **control**. All these sources give the composer and performer the control they need for artistic expression.

Definitions

SOUND WAVES
Vibrations of air molecules that travel through air carrying energy with them. Sound waves can also travel through water and solids, but cannot travel in space where there are no molecules to vibrate.

ENERGY
The ability to do work (to move an object a distance.)

VOCAL FOLDS
Often called the 'vocal cords', are made up of two membranes on the sides of our larynx (voice box). We talk by squeezing them close together as the lungs push air between them causing them to vibrate.

LARYNX
Often called the 'voice box,' it is located at the top of the windpipe at the lower end of the throat. It is made up of muscles, membranes and cartilages, and contains the vocal folds (vocal cords).

EARDRUM
A thin membrane that separates the external ear from the internal part of the ear. Sound waves make it vibrate; this vibration is transferred to three bones of the middle ear.

MICROPHONE
Changes sound waves into electric signals.

FREQUENCY
The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low.

VIBRATIONS
Oscillations (back and forth movements)

RESONANCES
A natural frequency of vibration determined by the size and shape of an object. For example, shorter guitar strings resonate at a higher frequency than longer guitar strings.

CONTROL
A way for a musician to modify the musical instrument to affect the sound it produces. Musical instruments, including the voice, allow musicians to change pitch, loudness, even the tone color to some degree. For example, a trumpet can play the same note loud, brassy, and bright, or softer with a mellow tone.

Making Music

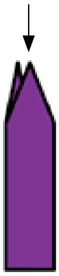
STRAW INSTRUMENT

WHAT YOU NEED

- Straws (fat, skinny and normal)
- Scissors

Here's what you do:

- Take the scissors and cut off the tip of the straw to create a point, like so. (Try to get both sides to be the same.)
- Now, *gently* chew on the straw to soften the tip, and to get the edges to be smushed together. You would like the straw just below the two tips to *almost* be touching.



- Now, put the pointy end in your mouth, and *blow really hard*. If you do it right (it might take some practice), you will get a very loud sound from the straw instrument!

Now try this:

- Take a second, slightly bigger straw and slide it over the first. This makes a sort of straw trombone!
- Try cutting some holes in your straw and play it while covering different holes. This makes a sort of straw clarinet!

Other things to try:

- How do different size straws work? Does it make a difference?
- You might also try different designs for the tip. Which works best?
- Does it make a difference how hard you blow?

CUP INSTRUMENT

Here's what you do:

- Take the cup and poke a hole in the bottom. Put the string through the hole, tie the end of the string that is inside the cup to the paper clip and then pull the string tight so the paper clip is on the bottom of the cup.
- Tie the end of the string to the table leg. Pull the cup *very tight* and pluck the string. This makes a sort of cup banjo!

Now try this:

- Find someone to help you (or if you're flexible, you can use your toes). Have the other person hold the string at different positions from the cup, making the string longer or shorter, as you pluck it. Now you can change tones!

Continued on next page

WHAT YOU NEED

- Plastic cup
- String
- Paper clip

SPECIAL THANKS TO BRIAN JONES FROM THE LITTLE SHOP OF PHYSICS AT COLORADO STATE UNIVERSITY
HTTP://LITTLESHOP.PHYSICS.COLOSTATE.EDU FOR THE IDEA OF THE "STRAW INSTRUMENT".

CUP INSTRUMENT (Continued)

Other things to try:

- Does it make a difference how tight the string is?
- Now pinch the string very tight with wet fingers or a wet paper towel and pull along the string. If you do it right, you should make a *very loud* sound! This is a sort of cup violin!
- How do different sizes and types of cups work? Do some cups make louder sounds? Is the pitch different?
- Try different types of string. Cotton, nylon, fishing line or thread.

Making Speech

YOUR VOICE

WHAT YOU NEED

- Yourself

Here's what you do:

- Hold your fingers against the front of your throat and say *Aaaaah*. Notice the vibration against your fingers.
- Change the sound to an *Oooooh*. Then to an *Eeeeee*. What do you notice with your fingers as you listen? How about your mouth?
- Would you say the different vowels are made differently by your throat or your mouth?

Now try this:

- Try *Ssssss*, not *Esssss*. Does your throat vibrate? What is vibrating?
- How about *Ffffff* or *Zzzzzz*? What is vibrating?

Other things to try:

- Vary the tone of the *Aaaaah* sound from low to high and back again. How do the vibrations change in your throat?
- Hold your hand to your throat while speaking. Pitch varies with the emphasis given to different words. The last words of a question, for example is at a higher pitch.

TEACHERS: find lesson plan details for these and other activities at http://www.exploresound.org

FAST FACT Musical instruments and our voices use the same basic principles: A source of vibration (straw tip, plucking or your vocal chords) and a resonance chamber (straw tube, cup or your throat & mouth).

SPECIAL THANKS TO DISCOVERY OF SOUND IN THE SEA - WWW.DOSITS.ORG FOR ALLOWING US TO MODIFY THEIR TEACHER RESOURCE "A CUP OF SOUND".

Pamela Harght

PAMELA HARGHT IS AN ACOUSTICAL CONSULTANT IN AUSTIN, TEXAS. She uses acoustics in her job every day in a variety of ways. Today, Pamela's consulting projects include all kinds of building environments for room acoustics and noise control. Churches, college music departments, high school music suites, HVAC (heating and air conditioning) noise control, courtroom acoustics, drama theaters, apartments/condos and performing arts centers are a small sample of the kinds of jobs she handles. Her firm also designs audio and visual systems for venues like football stadiums, baseball parks, conference rooms and convention centers. Each project is unique, which keeps the job exciting as well as a constant learning experience. "I've been to football stadiums to equalize a sound system and helped a local grocery store solve a rooftop mechanical equipment noise problem with the neighbors for community service, dealt with gymnasiums on top of classrooms and a personal training facility below an accountant's office. We see it all."

Pamela began her career after graduating from the University of Kansas in the Fall of 2008 with a Master of Arts in Architecture. She attended Berklee College of Music for undergraduate work and had the privilege of working at Tanglewood for a few summers recording and providing sound reinforcement for artists such as Yo-yo Ma, John Williams, James Levine and the Boston Symphony Orchestra, as well as several other notable guests.

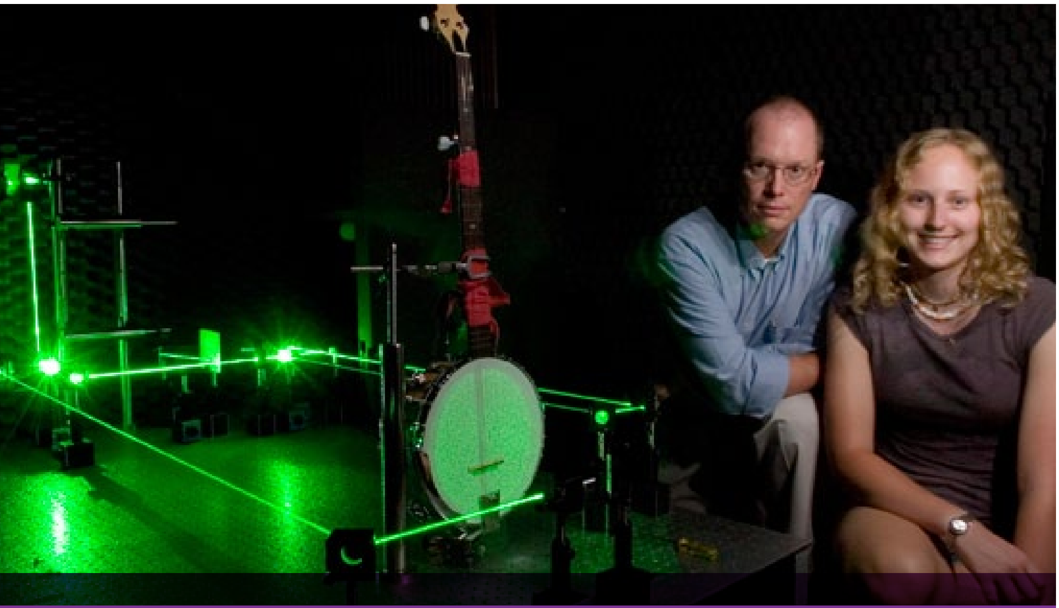
Pamela was the first member of her family to attend College and Graduate School. She has won several awards from the Acoustical Society of America, Berklee College of Music and the Greenguard Institute for her research and work throughout her college years.

As a child, Pamela studied flute and enjoyed attending concerts at Symphony Hall in Boston with her aunt. "As a child, I was always more interested in the architecture of the hall and how the symphony sounded within the space than the actual musicians, even though my aunt always made sure we had the best seats to view the flute section!" A few years later, while studying audio engineering at Berklee, Pamela also started studying--on her own--room acoustics and the influence rooms have on the recording process. "I felt the space in which the recording is done is, was the second most important part of a process, the first being the musicianship in the room."

At the time, there was no formal Acoustics major at Berklee, so her mentor and professor, Tony Hoover, guided her through research projects on the side and introduced her to the Acoustical Society of America (ASA). "Within ten minutes of talking to Professor Hoover one day during a break in class, I was chair of the ASA Student Chapter at Berklee and I was presenting a paper at the San Diego ASA meeting the following fall. That was a very productive ten minutes." From that point on, opportunities, connections and an entire career came to fruition.

Pamela runs ultra-marathons and marathons when she's not designing rooms to make the perfect sound for churches, courtrooms, drama theaters, apartments/condos and performing arts centers to name just a few!

Thomas Moore



Thomas Moore uses lasers to measure how musical instruments move when they make music.

THOMAS MOORE WAS NEVER A VERY GOOD STUDENT. Not at first. As a child, his father, who was a physicist, taught him to be inquisitive—to think through things as a scientist would and to always ask questions. But while Thom liked this approach, it did not fit into the educational philosophy of the school system. Therefore, he was not very good at his schoolwork and was always just an average student. Now that he is a teacher, he thinks that inquisitiveness is often driven out of students through "too much homework and too little thinking."

Thom eventually received his Bachelors in Physics from Stetson University, and after graduation he joined the Army. He served in the Army for 21 years, during which time he did many of the usual things an Army officer would do, but he also earned a Master's Degree in Nuclear Physics, a Ph.D. in Optics, worked at Lawrence Livermore National Laboratory, and taught physics at West Point. Thom really liked teaching at West Point, and while he was there he began thinking about how science is taught and how students learn. After he retired from the Army he took a job teaching undergraduate physics at Rollins College, where he concentrated on involving his students in original scientific research, because he thinks that a laboratory is a better place for learning than a classroom.

While at Rollins, Thom realized he could not continue his research in the field of nonlinear optics if he wanted to deeply involve his undergraduate students. So he began studying the physics of musical instruments, because he knew that his students would be interested in asking questions about music. Although he eventually became an acoustician, Thom did not stop using optics. Thanks to his background in optics, he has developed new techniques for looking at the vibrations of drum heads, pianos, trumpets, steel drums and more. Most of his experimental equipment is optical, like his electronic speckle-pattern interferometer, and he has developed new and inexpensive techniques to view the vibrations of many musical instruments. These vibrations, which can be smaller than the diameter of a human hair, are what make the music we hear. Thom conducts his research in a laboratory with a special chamber that is isolated from noise, and uses the light from a high power laser to image and measure these small vibrations.

Thom has found his work as an acoustician rewarding, and counts his published articles with undergraduate coauthors as his most important successes. He got even greater satisfaction by publishing an article with both an undergraduate student and a high school teacher as co-authors.

As an active member of both the Optical Society of America and the Acoustical Society of America, Thom has enjoyed getting to meet the people who are making history as scientists. "Anyone, even a student, can go to an OSA or ASA conference and be accepted," he noted. He remembers speaking with many renowned optical scientists when he was still a student, and now he tries to always be accessible to young acousticians in the same way.

One important reason Thom is a good teacher is that he himself was not a great student, so he understands his students' frustrations. Thom spent most of his time as a student trying to memorize answers instead of asking questions. But once he became a teacher, and had to anticipate his students' questions, Thom found that asking questions about the material was the best way for him to learn it. Now he asks simple questions, like "why do I hear bass but not treble from car stereos as they drive by?" In order to learn, you have to stop and listen, and ask a question. Often it is the simple questions have the most interesting and important answers. Even questions as simple as "why is the sky blue?" need to be asked. Thomas Moore knows the answer. Do you?

ANSWERS:

Treble (higher pitched tones) does not travel through solids, like the car, as well as bass (lower pitched tones). So the bass gets to you but not the treble – unless the windows are down.

The sky is blue because gas particles in the air scatter the blue light from the sun but not much of the other colors. The scattered blue light bounces around the atmosphere and comes to you from all directions making the sky look blue. See www.optics4kids.org/tutorials/whyskyblue.html for more detail.

JOBS IN ACOUSTICS

Acousticians include engineers, physicists, speech and hearing scientists, architects, biologists, psychologists, linguists, mathematicians, oceanographers, computer scientists, and musicians.

SPEECH SCIENTISTS

People who study how speech is made, travels and is heard.

MUSICAL ACOUSTICIANS

People who study the science of how music is made, travels and is heard. Including architects, musicians and instrument designers.

Additional Resources

For Students, Teachers and Parents

EXPLORING THE SCIENCE OF SOUND
www.exploresound.org

This fun educational website contains resources for teachers, parents and kids.

- Classroom materials,
- games for kids, and
- career profiles of acousticians.
- Aimed at kids of all ages.

New materials are being added weekly. Keep checking back for new ideas!

WORLD ACCESS FOR THE BLIND
www.worldaccessfortheblind.org

Resources and information for the blind. Daniel Kish trains blind individuals how to use echolocation to navigate the world – including mountain biking!

DALLAS SYMPHONY ORCHESTRA FOR KIDS
www.dsokids.com

Contains resources about musical instruments

- Listen to a large range of instruments.
- Nicely put together, straightforward inquiry activities for teachers
- Elementary level.

DISCOVERY OF SOUND IN THE SEA
www.dosits.org

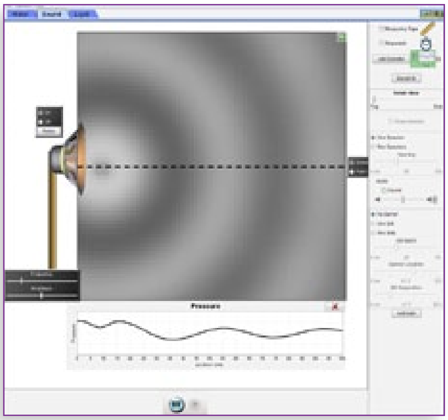
This is a very rich website with a range of education materials.

- Appropriate for all ages.
- Recordings of animal sounds and video.
- Teacher materials with extensions for all grade levels.
- Scientist profiles, and
- Lots of information about studying sounds in the sea.

PhET INTERACTIVE SIMULATIONS
http://PhET.colorado.edu

Suite of over 100, high quality, educationally effective, simulations about science.

- Appropriate for all ages.
- Includes activities for teachers.
- Simulations that relate to acoustics include:
  - » Sound,
  - » Wave on a String,
  - » Wave Interference, and
  - » Fourier: Making Waves



ACOUSTICS EDUCATION/OUTREACH
http://AcousticalSociety.org

The Acoustical Society's website has Education and Outreach resources including:

- Listen to Sounds
- Information on the science of acoustics
- Info on scholarships, prizes and grants
- Directory of graduate education in acoustics
- Career information on acoustics

FOR MORE RESOURCES INCLUDING ONLINE AND IN PRINT ORGANIZED BY TOPIC PLEASE SEE
WWW.EXPLORESOUND.ORG/ADDITIONALRESOURCES

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(United States and Canada)

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www.edmundoptics.com

The Optics Discovery Kit was created by volunteer members of the Optical Society of America. The kit is part of the Society's youth education outreach programming. To request more information about OSA and other educational materials, please contact the OSA Education programming staff at: opticseducation@osa.org.

OSA Educational Resources … *Exploring the Science of Light*

—Image courtesy of Ryan Gallagher: www.kineticphotography

OSA Optical Society of America
OSA Foundation

OSA

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