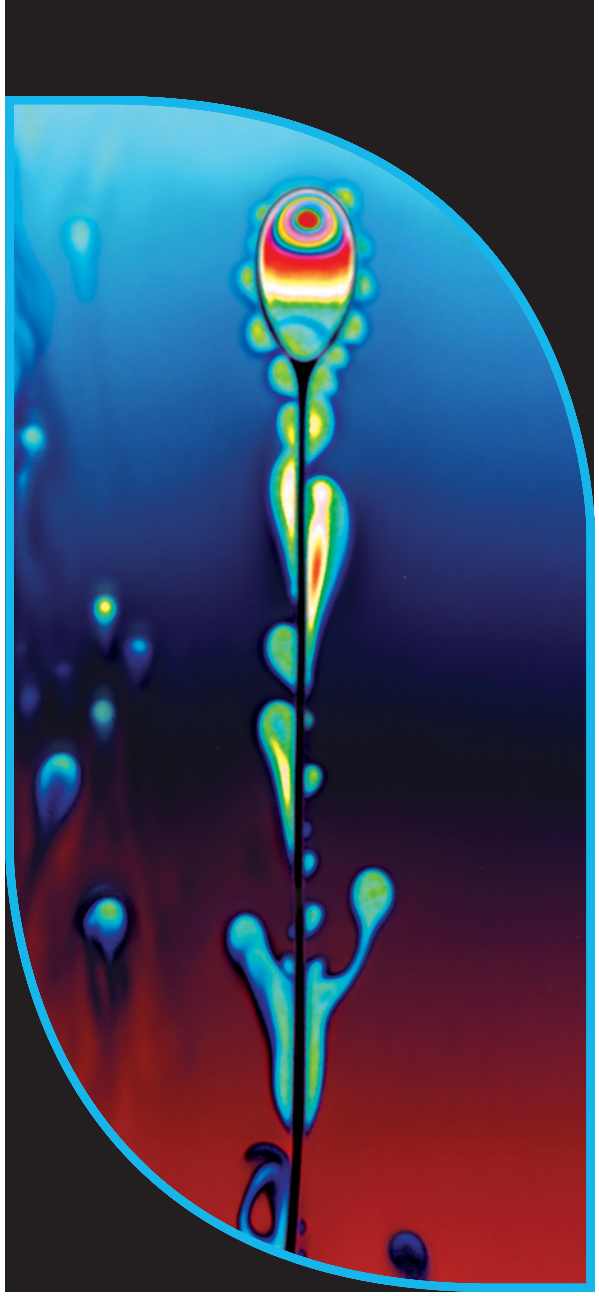
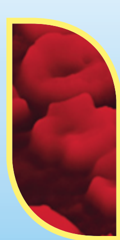


SPECTROSCOPY

OSA Educational Resources … *Exploring the Science of Light*



OSA®
Optical Society of America

Optical Society of America (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.

OSA's Education Outreach

Education outreach is one the most important and significant ways OSA supports and inspires young scientists. A variety of materials and programs have been developed to address the needs of students from elementary school through 12th grade. We invite you to explore the education resource pages at www.osa.org and welcome your comments and suggestions. Contact OSA's educational programming staff at opticseducation@osa.org.

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.

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OSA would like to thank the following volunteers for donating their time and expertise to this project:
Daniel Eversole, Univ. of Texas at Austin, USA; Irene Georgakoudi, Tufts Univ., USA; Halina Rubinsztein-Dunlop, Univ. of Queensland, Australia, and Ali Serpenguzel, Koç Univ., Turkey.

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The American Institute of Physics, www.aip.org

OP-TEC National Center for Optics and Photonics Education   AMERICAN INSTITUTE OF PHYSICS Information that matters®

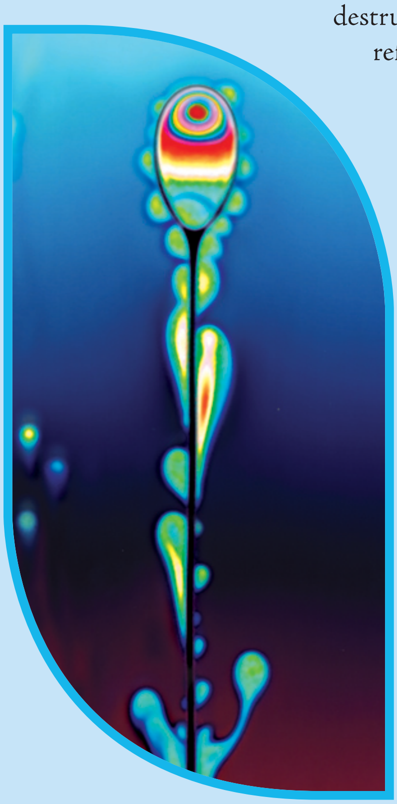
SPECTROSCOPY

Have you ever noticed the colors reflected off a simple bubble? How are these colors created? It all has to do with the thickness of the liquid used to create the bubble and the light bouncing off it. Light waves interact with one another in fascinating and stunning ways. Using a powerful optical microscope and specialized cameras, scientists captured the light waves bouncing off a film of liquid soap (like the wall of a bubble) to create this beautiful image.

Visible light travels in waves containing seven colors: red, orange, yellow, green, blue, indigo and violet or ROY G BIV for short. These waves vary in size (amplitude) and distance (wavelength). Think about waves in the ocean; the distance from the crest (top) of one wave to the crest of the next is one wavelength. Red light has the longest wavelength and violet light the shortest.

When two light waves combine, the waves can meet each other crest-to-crest. This adds the color of the two waves together, resulting in bright colors – known as constructive interference. If the light waves meet crest-to-trough (bottom) they cancel each other or produce the color black – this is known as destructive interference.

The colors in this image are actually a map of the thickness of the soap film in various areas. The thickness determines whether or not the waves collide constructively or destructively. The thicker part of the liquid reflects the longer waves, the thinner part reflects the shorter waves; the red areas in this image represent the thickest portions of the liquid.



By understanding how light waves travel through substances and interact with one another to produce color, scientists are able to measure even the smallest differences in thickness. How small? Think about this. If you could split a hair from your head (100 micrometers) into five thousand different slices (20 nanometers), the colors reflected would allow scientists to determine the differences in slices down to one ten-thousandth (100 nanometers) of a millimeter.

Definitions

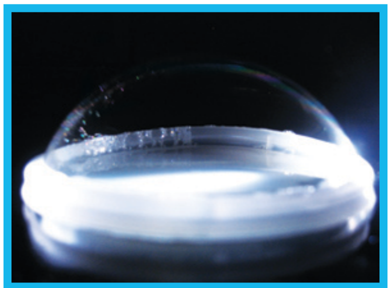
Light Waves
Light is an electromagnetic wave that is visible to the eye. The elementary particle that defines light is the photon.

Wavelength
The distance from the peak of a wave crest to the peak of the subsequent wave crest, or from one trough to the next trough, expressed in units of distance (e.g. km, m, cm, micron, nm).

Interference
The result of waves impinging on one another. Constructive interference occurs when the waves are nearly in phase, or when their "peaks" combine; destructive interference occurs when the waves are nearly 180° out of phase, or when the "peaks" cancel out the "troughs" of the waves.

EXPERIMENTS Want to explore the amazing world of color and light for yourself?

1. Bubbularium



Fast Fact

Right before your bubble popped, the skin of the soap bubble was only one-millionth of an inch thick!

This experiment and others can be found by visiting www.exploratorium.edu.

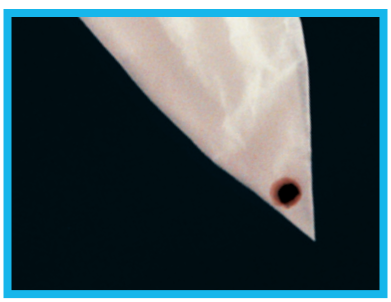
What You Need

- Small clear plastic lid from a butter container
- Clear tape
- Flashlight
- Bubble juice
- Spoon
- Drinking straw
- Room you can darken

What To Do

1) Tape the plastic lid over the end of the flashlight the light shines from.
2) Turn the flashlight on and hold it so the light shines straight up.
3) Dip your finger in the bubble juice and wet the lid. Next, put a spoonful of bubble juice on the lid.
4) With the straw, blow one big bubble to make a bubble dome that covers the whole lid.
5) Turn off the room lights and hold the flashlight so that the bottom of the bubble dome is just above your eyebrows.
6) Look up at the bubble – what do you see? Do you see a variety of colors like those in the poster? What colors do you see right before the bubble pops?

2. Black is Black or Is It?



What You Need

- 1 white basket-style coffee filter
- Paper clip
- Water
- Clear plastic cup
- Ruler
- Black felt-tip pen or marker (nonpermanent)

Fast Fact

You eyes determine color based on reflection, scattering and absorbtion. When a color is absorbed, you do not "see" that color. Because black absorbs all colors, it reflects nothing and you see only black. When a color is reflected off an object, you see the reflected color.

This experiment and others can be found by downloading the "Lighten Up!" booklet from the "Education" section at www.osa.org.

What To Do

1) Fold the coffee filter in half three times to form a triangle. Use a paper clip to hold it together, if necessary.
2) Make a 1/4 inch dot with the black marker about a 1/2 inch above the point of the triangle. Allow the black dot to dry.
3) Put 1/2 inch of water in the bottom of the cup.
4) Place the tip of the coffee filter in the cup, making sure the dot does not enter the water.
5) Watch what happens as the filter absorbs the water.
6) What did you discover about the color black?
7) Experiment with other marker colors.

CAREERS CHANGING OUR WORLD

Mark Miles, CEO,
Mark Miles Consulting

Laid up with a broken leg after a motorcycle accident in 1984, Mark Miles had plenty of free time to catch up on his reading. An electrical engineer by training, he spent his convalescence poring through scientific journals, reading about nanotechnology and the burgeoning field of microelectromechanical systems, or MEMS. At some point during his rehab, Miles began to wonder whether a network of tiny electronic sensors could be programmed not just to activate switches but to reflect light.

He hadn't studied the idea very long before he discovered that a variety of natural creatures had already managed a similar trick. The intense colors that flash off the wings of butterflies like the blue morpho, for instance, are not created through bright pigment. Instead, nanoscale structures on the wings cause incoming light waves to interfere with one another, reflecting only specific wavelengths of brilliant color. (It's one way that butterflies communicate with one another, particularly during mating season.) Beetle wings and the nacreous layer in seashells possess the same property, creating colors that increase in brightness in direct proportion to the light in the environment.

Miles eventually turned what butterflies do naturally into a new type of glare-proof electronic display. Called the interferometric modulator, or iMod, it flashes brilliant colors while drawing only a fraction of the electricity required to power a typical LCD.

Its "pixels" are fashioned from microscopic plates of coated glass laid between reflective membranes. Electrical impulses force the surfaces to move together or apart, modulating the color that is reflected back to the eye. The wavelength of the reflected light can be tuned all the way into the ultraviolet spectrum, which appears black to the naked eye. The brighter the ambient light, the brighter the colors displayed on the screen.

Mark Miles is CEO of Mark Miles Consulting Inc. a San Francisco-based consultancy that was established to promote and support the development of innovative display-centric concepts and products. He is also a strategic technology development consultant for Qualcomm MEMS Technologies (QMT). Originally from Atlanta, Ga., he received his BS in Electrical Engineering from MIT in 1985. He has over six years of experience in micro electromechanical and materials processing, and is the inventor of the Interferometric Modulator (IMod) technology.

The excerpts used to profile Mark Miles are from Product Design, Nature's Way, by Ethan Watters, June 12, 2007.

Jesse Colt, Infrared Sensor
Manufacturing Technician,
Infrared Associates, USA

Jesse Colt graduated in 2006 from Indian River Community College in Ft. Pierce, Fla., with an Associate of Applied Science in Electronics Engineering Technology specializing in photonics.

He is employed full time at Infrared Associates of Stuart, Fla, a photonics company that produces high quality infrared sensors. Jesse has a challenging job where he manages the manufacturing of mercury cadmium telluride (HgCdTe) infrared sensors used in medical thermography, thermal imaging, spectroscopy, analytical instruments, pollution monitoring, and research. Jesse really enjoys the challenge of finding ways to improve the manufacturing process for the sensors and to increase the yield and quality of the product.

His job is also very interesting and exciting because he works with cutting-edge equipment and produces advanced products used to improve the health of people and the environment. An extra benefit is his job pays very well and Jesse has received several pay raises since he started with his company.

Additional OSA Resources for Students, Teachers and Parents

OPTICS: Light at Work

This 15 minute DVD is geared toward 12 and 13 year old students, and is a great resource for raising awareness of optical science, along with its applications and many career opportunities. In addition to introductory information about the science of optics, the video highlights real world applications of optical technology, from everyday items like remote controls, cell phones and bar code scanners, to space exploration, innovations in solar energy and new frontiers in medicine. A variety of career options are highlighted through clips from a diverse group of scientists currently working in the field. Helpful advice and encouragement to students is included throughout.

Laser Technology: Changing Daily Life, Forging New Opportunities

This 42-minute CD-ROM traces the fast-paced history of the laser and includes exciting visual depictions of laser applications. Targeted to high school and post-secondary students, the CD focuses on the characteristics of diode, solid-state and gas lasers and the properties that make them useful in a variety of applications including telecommunications, entertainment, biomedicine and the military.

Optics Discovery Kit

The Optics Discovery Kit provides educators with classroom tools and optics lessons. The kit features 11 experiments that demonstrate basic principles of optics. Components include: lenses, color filters, polarizers, optical fibers, a mirror, a hologram, a diffraction grating and an anamorph. Also included are teacher and student guides. The new updated version will be available January 2008.

Terrific Telescopes Kit

Terrific Telescopes is an education packet based upon the Hands-On Optics (HOO) program. The kit's activities give students the opportunity to learn about the properties of lenses such as the focal length and the "flippoint". The lessons and materials also demonstrate how to use a single lens and other household objects as magnifiers. Students are encouraged to discover how to combine two lenses together to create a simple refracting telescope. The educator-led activities include demonstrations of how light bends and how lenses are used to create colorful images. A teacher's guide with step-by-step instructions is included with the kit.

Optics Suitcases

Developed by the OSA Rochester Local Section, the Optics Suitcase is an innovative, interactive presentation package designed to introduce middle school students to a variety of science concepts. The suitcase provides students with packets of materials that can be taken home to show to friends and family members as a reinforcement of the classroom lessons. To view the Suitcase Teaching Guide, and to read articles about outreach programs that have successfully used these materials, visit: www.opticsexcellence.org.

Educational Website

OSA hosts an educational website for students, teachers and parents. All material is designed to spark students' interest in science. The site features optics experiments, tutorials, demonstrations, games, optical illusions, career profiles, reference materials and more. Visit www.opticsforkids.org to continue your exploration of optics.

For more information about ordering any of these products please contact opticseducation@osa.org.