



Experimenting with UV-sensitive Beads

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Introduction

Participants experiment with ultraviolet (UV) light-sensitive plastic beads, which are generally white but turn colors when exposed to UV light.



Materials Needed:

- 5 UV-sensitive beads per participant
- 1 pipe cleaner or ribbon per participant
- 1 worksheet per participant
- Materials such as water, sunscreen, orange pill bottles, sunglasses, fabric, etc. for experimentation (*see worksheet*)
- 1 bookmark sheet per participant (*optional*)
- Heavy paper or manila folders, glue, scissors (*optional*)
- Imagery of EM spectrum and SDO (*optional*)
- UV (“black”) light or flashlight if sunlight is not available



Activity Time:

~30 minutes

Age Group:

7 - adult¹

Target audience: Public science education events, youth groups, scientists visiting classrooms, other informal science settings. Can be used to introduce the concept of UV or EUV invisible light prior to lectures on NASA missions that utilize UV light. May be adapted to classrooms 2-12.



¹ The beads are attractive to younger children, however it is difficult for them to understand the concept of invisible light. The beads should **NOT** be given to children under 3 because of the possibility of choking.



Learner Objectives:

After the activity, students/participants should understand that:

1. The Sun produces light in all wavelengths, including invisible ultraviolet (UV)
2. UV can be dangerous and can burn our skin, damage our eyes, and destroy our cells.
3. The Earth's atmosphere provides significant, but not complete, protection from UV.
4. There are both ways to detect UV and also to protect ourselves from it.

Obtaining UV beads:

You can purchase UV beads from Educational Innovations™ or a similar source:

<http://www.teachersource.com/product/ultraviolet-detecting-beads/light-color>

When gathering beads, 1 large coffee scoop holds ~75 beads. Warm temperatures help the beads change from white to colored. Cool temperatures, e.g. ice water, help the beads return quickly to white. Note: Some older sunscreens do not work with these beads, nor do they work with human skin. Newer sunscreens have corrected this deficiency.

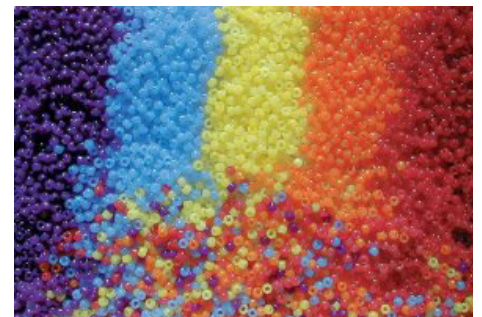
Background:

These beads contain a special chemical that changes color when exposed to ultraviolet (UV) light. UV is an invisible type of light from the Sun. It can burn our skin and cause cancer, damage our eyes, and destroy our cells. Most UV is blocked by our Earth's ozone layer and atmosphere, but some still gets through and can be detected. The beads will stay white when inside or not exposed to UV.

Incandescent and fluorescent lights will not affect them. They will only turn bright colors when exposed to UV, usually from the Sun or a UV ("black") light. The darker the color of the beads, the more UV rays they are detecting. Once you bring the beads back indoors, they will (slowly) change to white again. This process can be repeated many times. (*Further information on UV is provided with the EM spectrum image.*)

Process:

1. Paraphrase the description above and show participants the electromagnetic spectrum chart. Ask them if they understand that there are more forms of light than what we can see. Can they give examples [*X-ray, radio waves, etc.*]? Reinforce the concept that ultraviolet (UV) is a form of light that cannot be detected by our eyes but is emitted by the Sun and other stars.
2. Hand out beads and pipe cleaners, and bookmark materials if you wish to make them. Have participants assemble their bookmark, if necessary. Then have the students string their beads onto the pipe cleaner or ribbon, put it through the hole in the bookmark, and twist or tie the ends together.
3. Now, **ask the students to be the scientist and experiment with their beads!** Hand out the worksheets and have participants determine which materials keep the beads, and





hence themselves, safe from dangerous UV, and which materials don't. Have them test their beads with the various items on the worksheet – do they look white, faint, or colored? Can they think of other items to test?




Final discussion:

Ask students which of the materials tested are most effective at keeping you safe from dangerous UV light from the Sun? As a reflection closer, ask students at what times of the day are they most at risk for UV radiation from the Sun? [*mid-day*] Least at risk? [*night, sunrise, sunset*]. In which season are they most at risk? [*summer*] Do not tell students the answers. Let them go home thinking about them.

Going Farther:

Show students the images following or current images from NASA'S SDO/AIA, TRACE, IRIS, STEREO, or other missions taking imagery in UV. Ask students why the images are unusually colored. [*They were taken in UV, which is invisible to human eyes, so computers have colored the data to make them visible.*]

What wavelengths of light cause a color change in the UV beads?

Infrared 1000-700 nm	Visible 390-700 nm	UV-A 400-315 nm	UV-B 315-280 nm	UV-C 280-100 nm
Infrared light makes our skin feel warm and can be detected some animals such as snakes.	Visible light can be seen by our eyes. It includes all the colors of the visible rainbow.	Too much exposure to ultraviolet A can result in the same damage as UV-B but to a lesser degree.	Ultraviolet B light is needed for vitamin D synthesis in our bodies, but is a major cause of sunburn, skin cancer, cataracts, suppression of the immune systems, and photo-aging.	Ultraviolet C light is extremely dangerous, but completely absorbed by the ozone in the Earth's atmosphere and does not reach the Earth's surface.
				
Beads are white >360 nm		Beads are colors 360-300 nm		Beads are white 300 – 100 nm

Descriptive information from Educational Innovations



You be the scientist!

UV Bead Worksheet

	Your prediction (Do you think the beads will be white, faint, or colored?)	Actual Color of Beads (white, faint, or colored)	Safe from UV?	Notes
Under water				
In sunlight				
In shadow				
Using sunscreen				
Cloudy sky <i>(i.e. no direct sunlight)</i>				
Behind paper				
Behind sun glasses				
Behind eye glasses				
Under cloth				
Inside plastic orange medication bottle				
Behind window glass				
Behind car windshield				
Under brim of cap				
Behind plastic				
Sun at mid-day				
Sun at sunset/sunrise				
UV (black) light				
Fluorescent light				
Incandescent light				
LED light				



UV Bead Bookmarks

The Electromagnetic Spectrum

Radio	$10^4 - 10^2$ cm	
Micro-wave	1 cm	
Infrared	10^{-2} cm	
Visible	10^{-5} cm	
Ultra-violet	10^{-6} cm	
X-ray	10^{-8} cm	
Gamma Ray	$10^{-10} - 10^{-12}$ cm	

Wave Length

About the size of

Our eyes can see visible light, the colors of the rainbow, but the Sun also gives off light our eyes cannot detect. Ultraviolet light is an invisible part of the Sun's electromagnetic spectrum. The Earth's ozone layer protects us from most of the Sun's dangerous UV, but too much can burn our skin, damage our eyes, and destroy our cells. These beads contain a special pigment that changes color when exposed to UV light. You can use them to detect UV radiation and learn what best protects you from it.

LOCKHEED MARTIN
P70012_back

UV DETECTING BEADS
STANFORD SOLAR CENTER

Under fabrics • Under water • Behind dark glasses
Sunny day at noon • Sunny day at sunset
Cloudy weather • Behind glass • Under paper
Electric Light • Full sunlight • Shade

Do your beads look white, faint, or colored in these? In which of these are you best protected from dangerous UV radiation?

For more information, visit: <http://solar-center.stanford.edu/activities/uv.html>

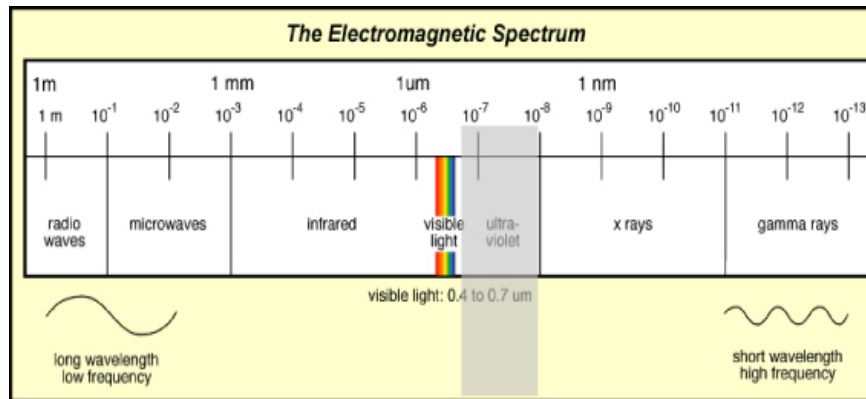
Stanford and Lockheed Martin Solar and Astrophysics Lab developed these bookmarks to support this lesson. The bookmarks briefly explain the electromagnetic spectrum and UV light.

To assemble bookmarks:

- Make copies of the patterns here.
- Have students cut them out and fold in half lengthwise.
- Cut a piece of cardstock the same size as the bookmark, fold the bookmark around the cardstock, and glue.
- Punch a hole in the top.



The Electromagnetic Spectrum and Ultraviolet Light

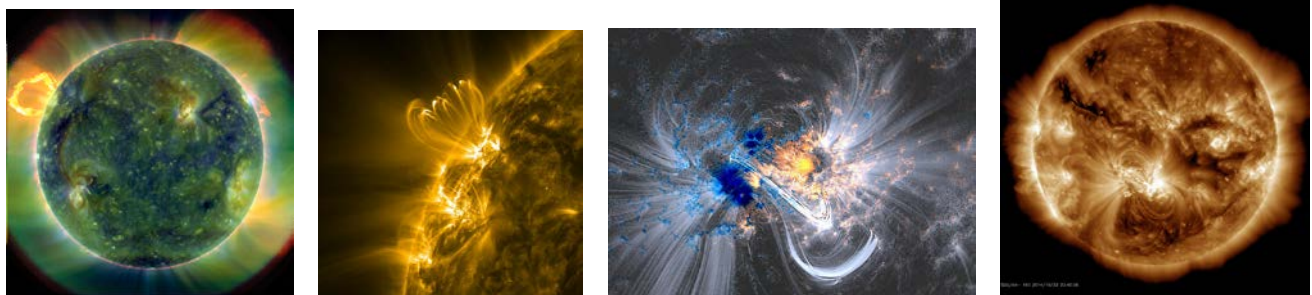


Ultraviolet (UV) light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays (in the range between 400 nm and 10 nm). It is so-named because the spectrum consists of electromagnetic waves with frequencies higher than those that humans identify as the color violet. UV frequencies are invisible to humans, but near UV is visible to a number of insects and birds.

Although ultraviolet radiation is invisible to the human eye, most people are aware of the effects of UV on the skin, like suntan and sunburn. Short-wavelength and mid-wavelength UV can cause much damage to living organisms, such that life on Earth outside of the deep oceans is possible only because the atmosphere, primarily the ozone layer, filters out nearly all short-wavelength and most mid-range UV. A small amount of UV reaches the surface and is capable of causing long-term skin damage and cancer. A smaller amount of UV reaches the surface and is responsible for sunburn and also the formation of vitamin D in humans.

Thus UV light has many effects, both beneficial and damaging, to human health.²

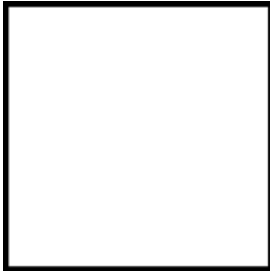
The Sun in UV light



NASA/SDO AIA instrument images taken in EUV but artificially colored because human eyes cannot detect UV light

² This, and more information, is available from Wikipedia and the web.

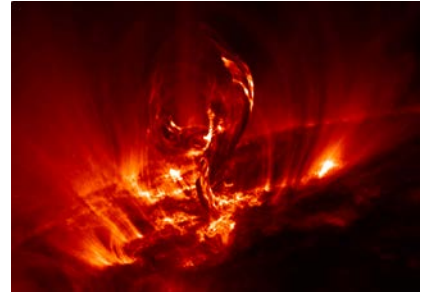
In astronomy, very hot objects preferentially emit UV radiation. Our Sun primarily emits UV in the areas above the surface and in the Sun's extremely hot atmosphere ("corona"). This area is where most intense solar activity occurs. Because the ozone layer blocks many UV frequencies from reaching telescopes on the surface of the Earth, most UV or EUV (extreme ultraviolet) observations are made from space.



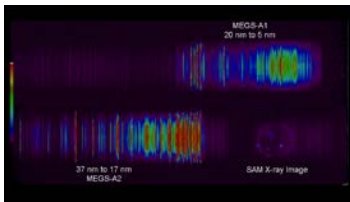
The Sun seen in UV by human eyes (it's invisible)



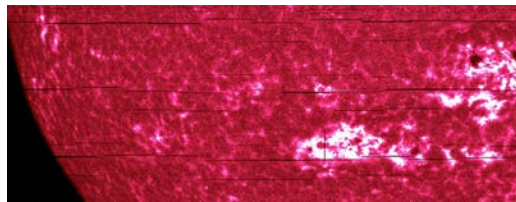
NASA's SDO/AIA instrument



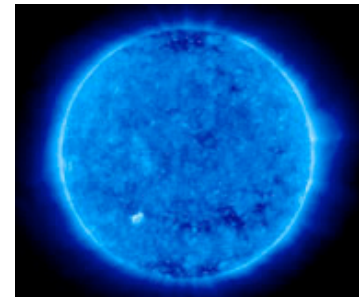
NASA's TRACE mission



NASA's SDO/EVE instrument (spectrograph images)



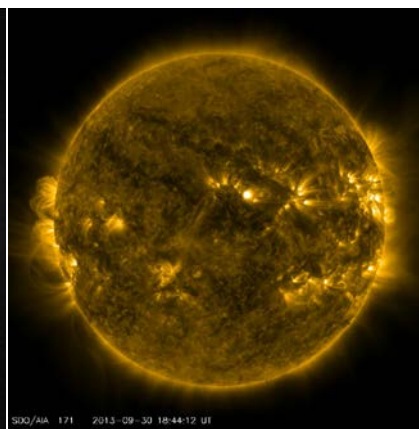
NASA's IRIS mission



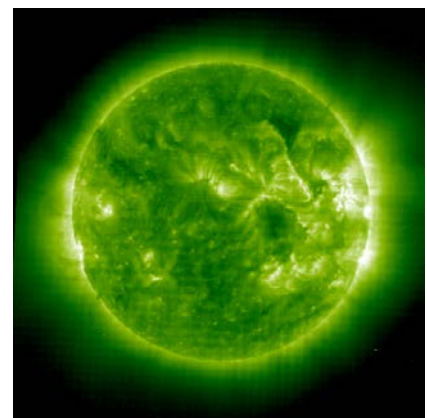
NASA's STEREO mission



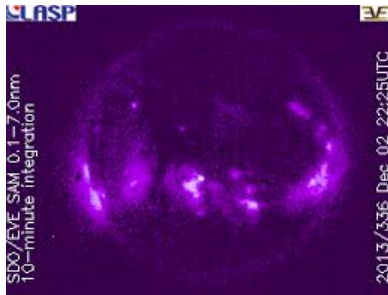
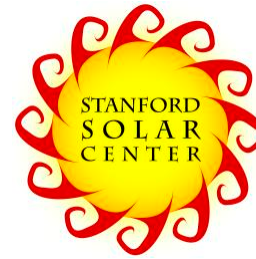
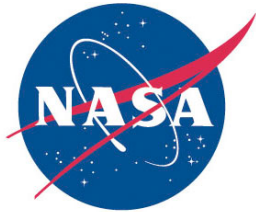
PROBA2/SWAP



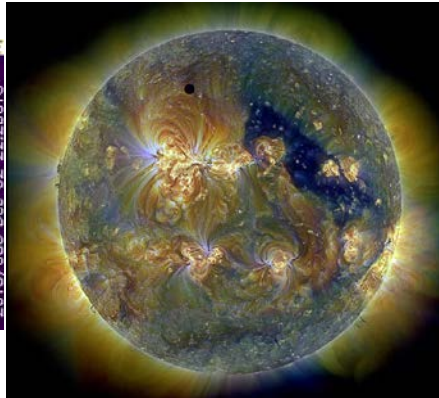
NASA's SDO/AIA instrument



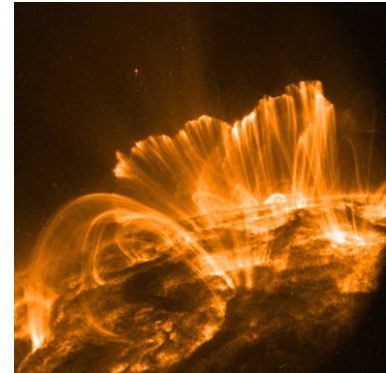
ESA/NASA's SOHO/EIT instrument



NASA's SDO/SAM instrument



*NASA's SDO/AIA instrument
(black dot is Venus transiting the Sun)*



NASA's TRACE mission

Extremely hot stars emit proportionally more UV radiation than the Sun. Our Sun's emissions peak in the visible light range, hence our eyes have evolved to see visible light. Beings on planets where their star's emission peaks in the UV would have different eyes than ours, ones sensitive to UV, and perhaps they would see their world differently than humans do. To the right is an artist's conception of what such a star and planet might look like.

