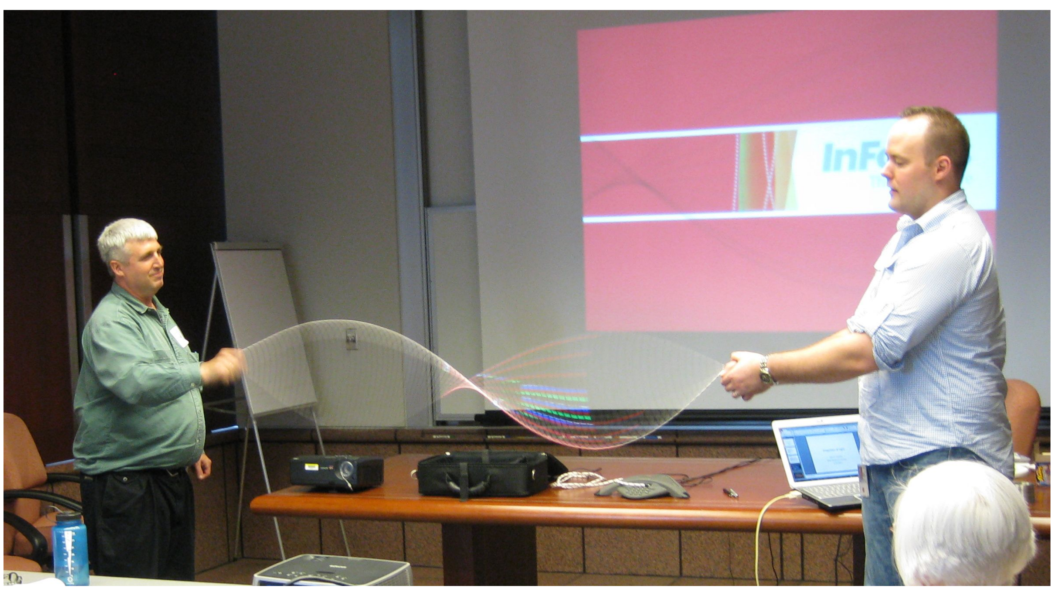
Science Afternoon at NIST with a Focus on Properties of Light
Wednesday, March 20, 2012

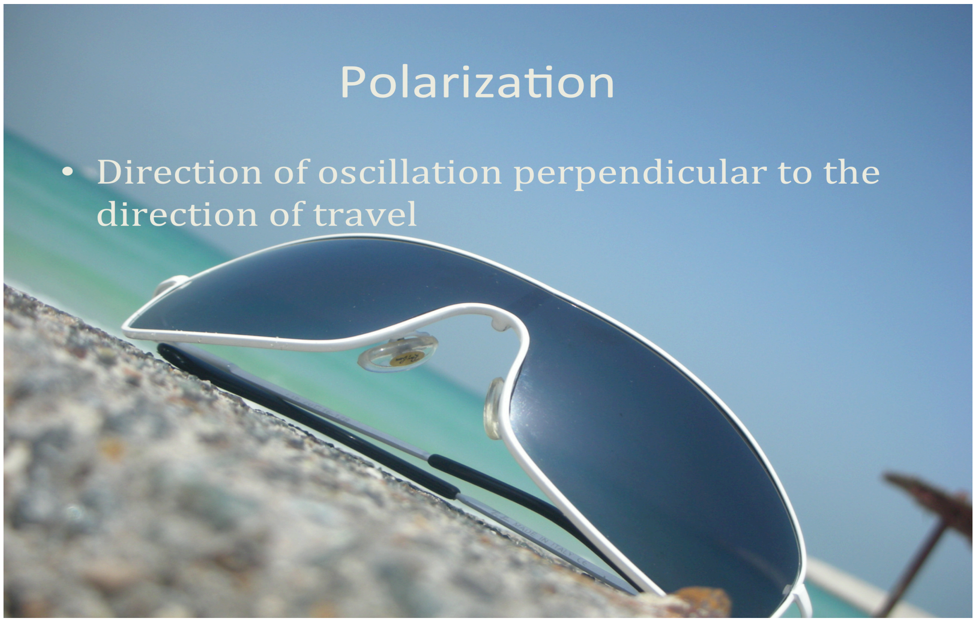
Dr. John Lesoine, a National Research Council Postdoctoral Fellow in the Radiation and Biomolecular Physics Division at NIST, has an extensive background in light and optics, and shared with teachers how he uses light to learn more about materials as well as how properties of light can be taught to students.

The Afternoon started with an "Engage" activity, the nanosecond bar, based on something seen at Educational Innovations, http://www.teachersource.com/Nanotechnology/Nanotechnology/NanosecondBar.aspx. Mary made each teacher one by taping "one nanosecond" to a ruler. Each 30 cm ruler represents the distance light travels in 1 ns. Teachers can walk students through the conversion of this 30cm/1 ns to the speed of light.

Starting with the basics, John has Carolyn Holcomb and Dana Schneider create a longitudinal wave with a slinky.



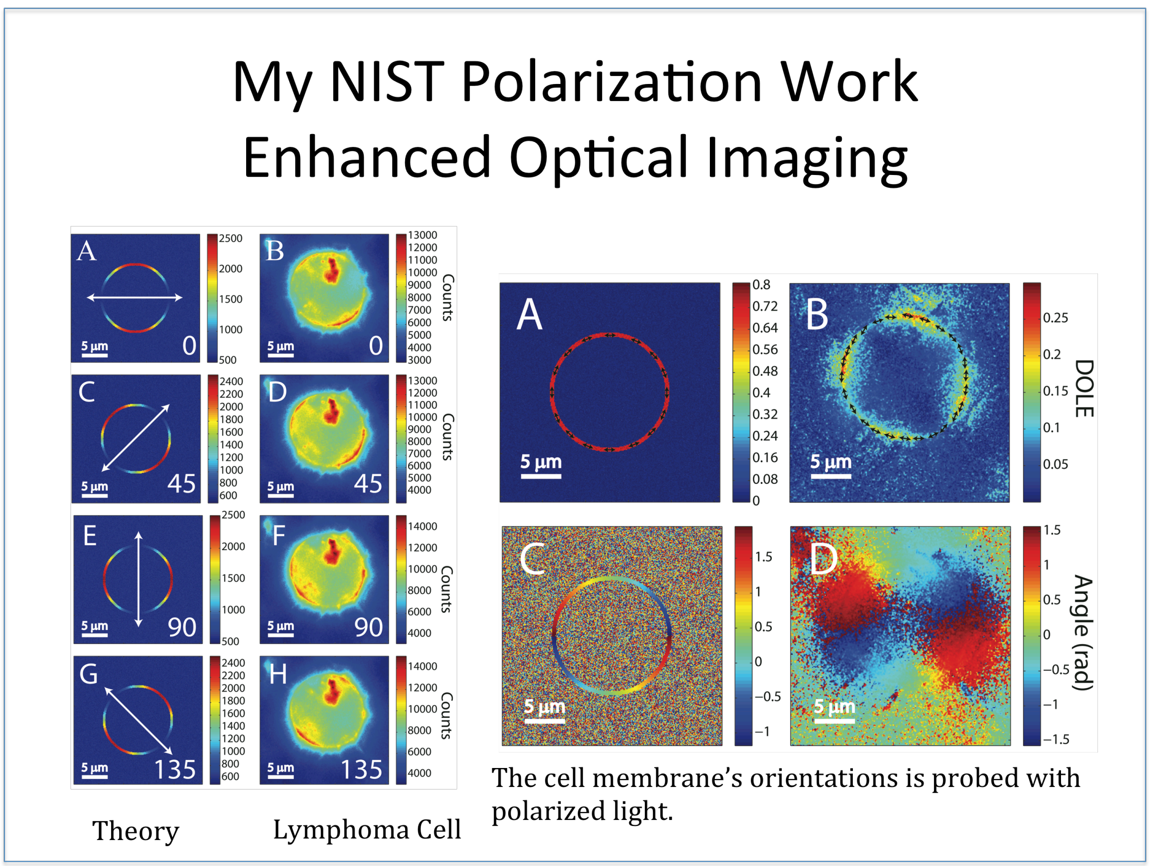
Then it's on to creation of a transverse wave by John and Dan Goldman – see the nodes at their hands and in the middle? Nodes are the spots where there is minimal movement. The node in the middle is created by the interference of reflected waves traveling along the rope and reflecting at the nodes at their hands. Twirling faster produces more reflected waves and more nodes while twirling slower would decrease the number of nodes on the rope. This is similar to the waves that are reflected by mirrors in a laser cavity.



John introduces polarization with a kit full of materials including a polarizing filter, calcite, mica, a piece of Plexiglas, and cellophane tape. Remember that clear plastic forks work just as well to show evidence of strain and stress as that fancy Plexiglas piece! Just put the fork between the polarized sheets aligned so no light appears to get through and stress the fork to see the colors change; note that the areas of stress show the greatest color changes, which is why structural engineers use this technique with bridges and buildings.

Chris Grant investigates the polarizing filters – so cool how they block light in different amounts when turned one way or the other.

Carolyn, Mary Kate Lesoine, and Dana look at mica and other materials in between the polarizing filters.



John uses polarized light in his work at NIST to provide more information about medical images. For example, he takes images of cell membranes using polarized filters at certain angles and compares those to images taken without the polarizer. Turns out that with polarized light the difference between normal and damaged or diseased skin and organs can be detected. Using these images would provide more information for physicians to make more informed treatment decisions.

And then discussion shifts from polarized light to light scattering. John creates a sunset in a glass with a small amount of milk in water and a white flashlight. The light in the glass looks blue and the light that is transmitted looks red. The milk causes the light to scatter and longer wavelength light scatters less than shorter wavelength light. (Mnemonic: remember longer less)

This is that same glass of milky water with John holding it and shining both a green (532 nm) and red (635 nm) laser through it from the bottom. Notice that since the green light is shorter wavelength it scatters more and seems to disappear in the milk sooner than the longer wavelength red light.


Scattered light is polarized so it should be able to be blocked by the polarizing filters turned a certain way. Try looking at the sunset in a glass while rotating the filter and see! Here I caught most of the teachers looking at the red and green laser light in the milky water with filters.

And since UV light is longer than visible light it's scattered even more than the green light. John reported that if we humans could see UV light that we would see it coming from everywhere, not just the sun – all because of the scattering!

We ended with a discussion of UV light properties and experiments including using beads that can detect UV light. The UV beads can be used to measure the efficacy of suntan lotions, or whether old suntan lotions really loose their effectiveness. Here's a fun idea: slather cream cheese on a piece of acetate and put it over some UV beads. On another piece of acetate, put suntan lotion. Does blocking the visible light of the sun, as the cream cheese does, also block UV rays? And what about standing in the shade? Are we safe from UV rays there?

What a lot there is to learn about the properties of light! Thanks to John Lesoine for sharing some of the NIST work using light as a tool, and teaching us some fun activities to do with our students.

Notes from John Lesoine in preparation for this Science Afternoon at NIST:

I found this website on causes of color, the site itself looks beautiful to me.
http://www.webexhibits.org/causesofcolor/17.html

Reflection

1. Wave nature of light, standing waves in slinky or rope. Try to make standing wave patterns in rope. Wavelength
2. Reflecting activity: Multiple reflections using two planar mirrors and the letter R.
3. Build periscope, to see around corners, spy games
4. Build Kaleidoscope, multiple reflections ***scitoys****.com/*
5. Design a solar hot dog cooker to concentrate the suns rays ***scitoys****.com/*

Polarization (Using kit and glycerol etc, I think you have materials if not let me know)

1. Directionality of light
2. Polarized sun glasses reduce glare
3. Stress birefringence polariscope

Scattering http://www.webexhibits.org/causesofcolor/14F.html

1. Sunset in a glass: Skim milk in water and white paper flashlight
2. Diffuse reflection, scattering depends on wavelength
3. Test polarization dependence before and after scattering

Invisible Light ***scitoys****.com/*

1. Take a photo of remote control light, infrared can be detected by camera sensor
2. UV light detection using UV changing beads
3. Test sunlight, UV light even in shadows (scattering) may get sunburn in the shade or on a cloudy day
4. Invisible ink
5. Design UV meter and calibrate ***scitoys****.com/*
6. Test sunscreen different spf 15/30 on clear plastic sheet ***scitoys****.com/*
    a. *Could design experiments to see how long sunscreen lasts, how water affects the UV blocking(waterproof sunscreen), why do we need to reapply sunscreen etc (potential science fair projects)*
7. Cream cheese on plastic sheet ***scitoys****.com/*

Spectrometer

1. Building a spectrometer using CD or diffraction grating ***scitoys****.com/*
2. CD method uses boxes and razor blades
3. Diffraction grating method uses ABS plastic tube ***scitoys****.com/*
4. Can use with software online to calibrate light source and then see spectral profile of different materials ***scitoys****.com/*

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