NEWSLETTER

ONTARIO ASSOCIATION OF PHYSICS TEACHERS (An Affiliate of the A.A.P.T.. and a charitable organization) November 2009

Reader's Corner

Second Edition

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Readers are invited to share information about exciting science-teaching related books. *This month's review is from the column editor, Marina Milner-Bolotin, Ryerson University*

Rating: * highly recommended;**

**** recommended; *not recommended**

The Trouble With Physics; The Rise of String Theory, the Fall of Science and What Comes Next by Lee Smolin
Penguin Books. ISBN 0713997990

RATING : ***

Lee Smolin's fascinating book *The Trouble with Physics* focuses on the recent developments of physics and examines the lack of progress achieved in our fundamental understanding of nature during the past three decades. Lee Smolin, a leading theoretical physicist and a co-founder of the Perimeter Institute for Theoretical Physics in Waterloo, ON has been working on the foundational physics problems for decades. As a result, his examination of the progress of physics is written with such clarity and passion that it grabs your attention. Smolin makes the reader relive the recent history and struggles of physics by asking the fundamental questions that are often neglected in our science education: What are the major unanswered questions that the physics community has been working on? What progress has been made on answering them in the last thirty years? How do we know that current scientific theories are true? What are the limits of our current understanding of nature? What are the philosophical underpinnings of different theories? How does a scientific community support scientists who decide to work on alternative theories? What should we do as a community to support advances in physics? Lee Smolin's major claim is that in the last few decades physicists have failed to advance our fundamental understanding of nature. He argues that this happened not because we did not have talented people attracted to science, but because of the way the mainstream theoretical physics community has attacked fundamental scientific problems and allowed itself to stick with theories [i.e. a String Theory] that were in principle not testable by the experiment. This approach diverted resources from the scientists who wanted to pursue alternative theories discouraging young theoretical physicists from exploring anything but mainstream theories. According to Smolin, this protectionism of the "accepted theory" has significantly impeded the progress of science.

In a time when the Large Hadron Collider news transcended the realm of scientific journals and often appears in mainstream newspapers, when many high school students and teachers are excited about the search for the Higgs boson, Lee Smolin's book is a true gift. It will help laymen and scientists alike to see a bigger picture of the modern physics, not only by shedding light on what we failed to discover, but more importantly, on what might be there to discover for the new generations.

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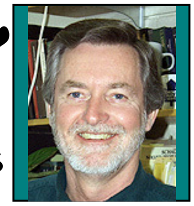
Book recommendations and short reviews will be gladly received by the column editor.

The Demonstration Corner

Making Speakers



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I prefer to do this as an activity as opposed to a demonstration, and have found that it works very well for students in Grades 7 to 12 visiting the University. I start with a discussion about sound and then compare a speaker to the human ear. In the discussion on speakers, I also talk about magnets and how they work, and I explain the difference between permanent magnets and electromagnets. After this discussion, I explain how to make speakers using a plastic cup, a magnet, and a coil of wire. Each student makes his/her own speaker and then tests it.

Figure 1: Materials required

The speaker requires a coil of wire to make the electromagnet. I use 40 feet of 32-gauge wire. This wire tangles very easily so I've had wire winders built (Figs. 1, 2, and 3). A paper strip approximately 3 cm wide is used to create a spool. Slits 1 cm long are cut into both sides of the strip and then the strip is wrapped around the wide part of the spindle and taped. The sides of paper are folded up to form a spool to hold the wire. The diameter of the spindle is used to calculate the number of revolutions needed to obtain 40 feet of wire.

Wire is taped to the spool as shown in Figure 2. Approximately 5 cm at the start and end of the wire must be left exposed. The ends of the wire are scraped with steel wool to remove the protective coating and expose bare wire.

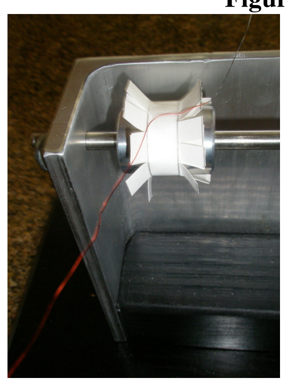

Figure 2: Attaching wire to paper spool.

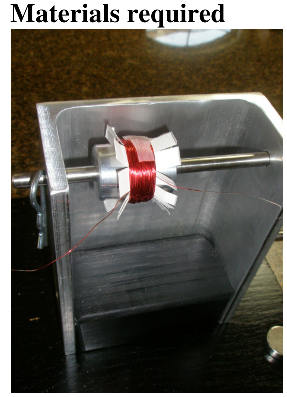

Figure 3: Finished wire spool.

Once the wire spool is complete with 40 feet of wire with bare ends (Fig. 3), the spool is removed from the spindle. A plastic cup is prepared by covering the bottom of the cup with double-sided tape. The paper on one side of the spool is folded back and pressed to the double-sided tape so that the spool is centred on the bottom of the cup. A magnet is pressed onto the tape in the middle of the spool. I've used both neodymium and ceramic magnets. (Although the neodymium magnets give better sound from the speakers, the ceramic magnets are safer to use. Neodymium magnets are so strong that they can snap together and shatter and/or pinch skin hard enough to draw blood.) The other side of the paper spool is folded in and a piece of heavy paper is attached with tape.

A set of wires with alligator clips is plugged into the output of an amplifier. The alligator clips are attached to each end of the speaker wire (Fig. 4). An input device such as an iPod is attached to the amplifier and both are turned on. The amplifier should be set so that sound comes only from the output wires and not from any speakers built into the amplifier.

The speakers are almost fool-proof. Rarely have they not worked, even if the wire spools are not wound properly. If the speaker does not work the first time it is hooked up, make sure that the wire ends are scraped well to ensure a proper connection between the wire and alligator clips.

The time and effort it takes to set up this activity is worth it when you see look of amazement on the students' faces when they hear sound coming from their plastic cups.

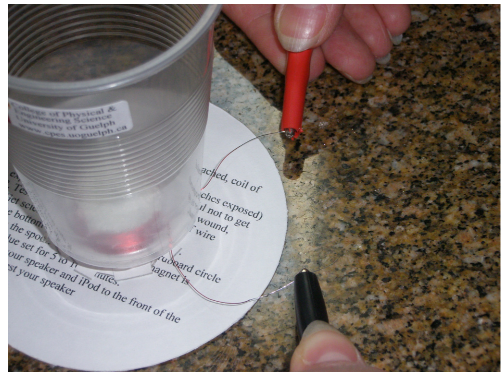

Figure 4: Connecting speaker to amplifier.

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Submissions describing demonstrations will be gladly received by the column editor.

High School Physics

Polarization of Light and 3D Movies

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Polarized light is a key aspect of **Unit E: The Wave Nature of Light** and it is a great vehicle for **Unit A: Scientific Investigation Skills** – especially in interpreting observations with vector analysis.

<u>1) Exploration of Low-Tech Cardboard 3-D Glasses</u>

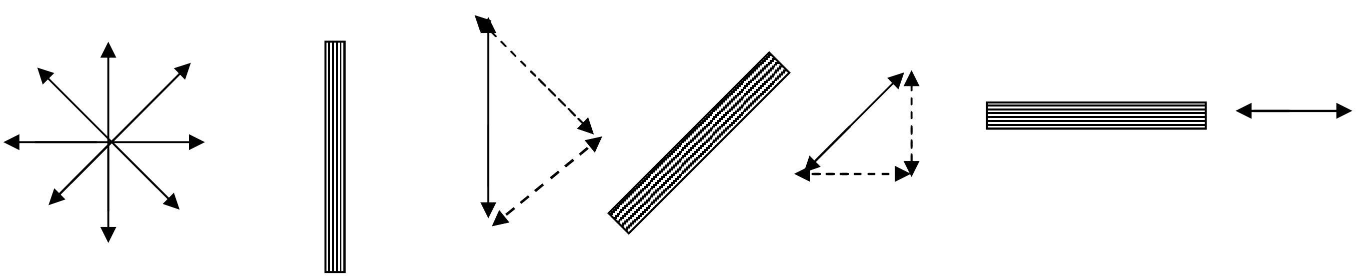
Put on the glasses. Close one eye and look at your partner's eyes through their glasses. What do you notice? One eye looks black and if you tilt your head by 90^o the other looks black.

The glasses have polarizers for lenses, one at +45^o and the other at -45^o. A +45^o polarizer will have no effect on light that has come through a +45^o polarizer but it will block the light coming through a -45^o one. What about other angles? Have small groups use whiteboards to explain why half of vertically polarized light will pass through a polarizer at 45° to it. (The relevant component passes. The intensity is proportional to the amplitude squared. The square of this component is ½ for 45°.) What about 30° or 60°? (1/4, 3/4)

<u>2) Exploration of a Third Filter</u>

Put on the glasses and look at your partner so that you are looking at a completely blacked out eye. Hold a third filter in between your eyes. What do you notice? The addition of a third filter allows <u>more</u> light through!

Have small groups draw arrows and components to explain how this is possible. How much of the original light gets through all three filters? (½ x ½ x ½ = 1/8)

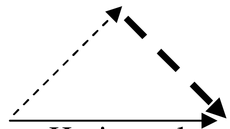


½ passes ½ * ½ passes ½ * ½ * ½ passes

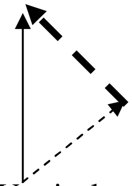
<u>3) Exploration of a Birefringent Material</u>

Put on the glasses and look at your partner so that you are looking at a completely blacked out eye. Hold the material between your eyes. The material can be plastic sandwich bags, several layers of scotch tape or overhead transparencies. What do you notice? The addition of the material allows more light through – even more than a third filter. Colours are sometimes seen, especially if you stretch the sandwich bags.

These are birefringent materials, which have two indices of refraction – one for each polarization axis. Because the two components travel at different speeds, they get out of phase with each other. This allows a vertical polarization to turn into a horizontal polarization by having one component shifted by a half a cycle. Essentially, this means a birefringent material can rotate the polarization of light.



Horizontal



Vertical

4) Projecting Polarized Light

These polarized glasses let in light that is polarized at +45 in one eye and at -45 in the other eye. In the theatre there is one camera rapidly alternating images from one polarization to the other. Project a bright light through a filter onto a white wall or screen. View the spot through the glasses. Both eyes can see the spot. Now, try it with a tin foil screen. Only one eye can see the spot.

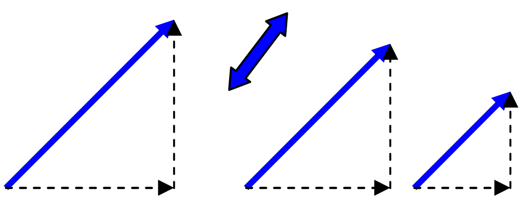
The reflected light from a metal screen remains polarized and is brighter. Originally all movie screens were metal because the dim projectors needed the brighter reflection. This is why it is referred to as the 'silver' screen. However, the angle of view is smaller and when projectors got brighter the screens were changed to non-metal. At a movie theatre that is showing a 3-D movie, go up and touch the screen – it is metal.

5) Exploration of the New High-Tech 3-D Glasses

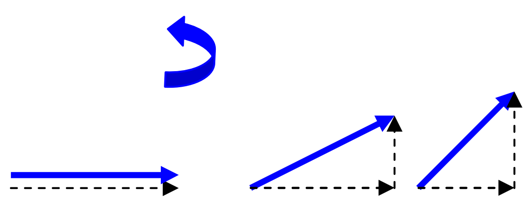
Put on a pair of the better plastic glasses from a theatre. Close one eye and look at your partner's eyes through their glasses. Tilt your head. What do you notice? It doesn't change much as you tilt your head

These glasses have two layers. The inside layer is a standard polarizing filter. The outside layer is a birefingent material thick enough to slow one component until it is 45° out of phase with the other. This is called a ¼-wave plate and this turns the linearly polarized light into circularly polarized light. Suppose the filter produces light polarized at +45°. Have students model this by moving one hand up to the left and then down to the right a la John Travolta. Have the students model this same wave as the horizontal and vertical components using both hands. The ¼-wave plate will slow the vertical component by 45° relative to the horizontal. Now instead of the components moving in and out at the same time, one hand goes in while the other goes out. What does the sum of the two look like? Have students try drawing a series of diagrams to show what it forms.

Linear Polarization Components



Circular Polarization Components



The light has become **circularly polarized**. It then enters the circular polarizer of your glasses. The quarter-wave plate slows it down again so that the +45° polarization has become -45°. This is exactly what is needed to pass through your glasses because when you look through a +45° polarizer from the other side it looks like it is at -45°. Why does tilting your head have so little effect? If you tilt your head, a vertically polarizing lens becomes horizontal, but a clockwise polarizer is still clockwise. This means that the viewer doesn't have to keep their head vertical while watching the movie. (Note: The cheap glasses are also somewhat vertically polarized – just not as much as the plastic glasses.)

Supplies

1) Polarizers - 17" wide, $15.00/foot - http://www.polarization.com
2) Cardboard (linearly polarizing) Glasses - $0.50 each - http:// www.rainbowsymphonystore.com
3) Plastic (circularly polarizing) Glasses - Go to a 3-D movie and ask the manager for some or you can order them from http://www.the3Dmarket.com for about $2 each.

Further Information: Feel free to contact the author at addresses listed above AND…

There is a lot more to be explored in polarization. **Physics 2000** is a great site which combines the PhET simulations of the University of Colorado with well-organized explanations. It has a very good interactive lesson about polarization. First it goes through linear polarization and then it looks at LCD screens in great detail. http://www.colorado.edu/physics/2000/index.pl