Apparatus Competition

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Simple Photoelectric Effect

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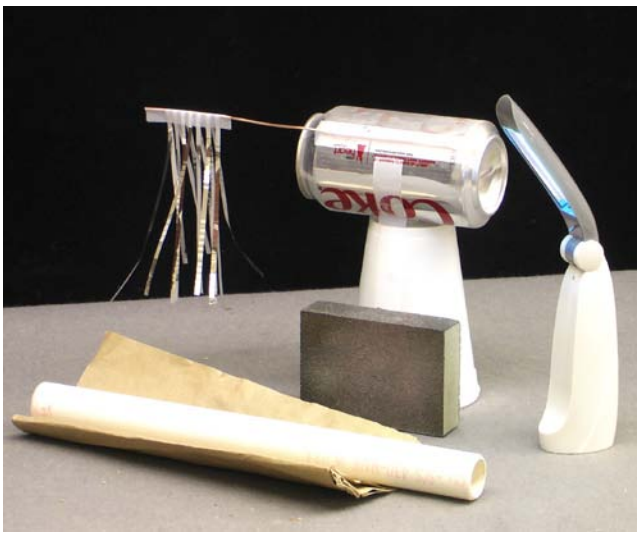
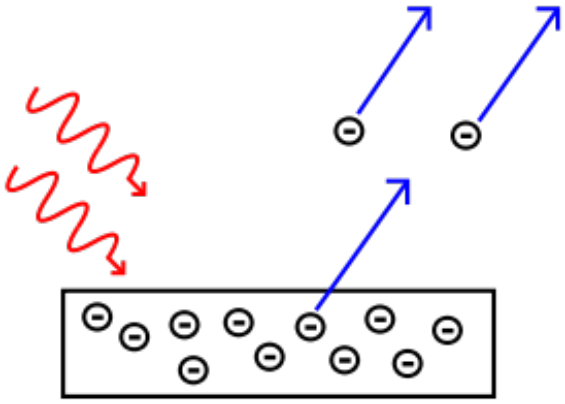
Abstract

Albert Einstein's Nobel Prize winning photoelectric effect has been demonstrated for many years quite effectively, yet now it can be done with simple household items. Past versions used specialized blacklights or carbon-arc lamps to show any effect. This version takes advantage of the currently popular germ sanitizer lights, which are much more affordable and portable. It also uses aluminum pop cans instead of zinc plates and Christmas tree tinsel instead of standard electroscopes.

Construction of Apparatus





- **Materials Needed** ** optional materials*

  - aluminum soda pop can; recycling bin; free
  - sand paper (or something scratchy like an S.O.S. pad); hardware store; <$1.00; http://tinyurl.com/neyyv4
  - Christmas tree tinsel (icicles); Wal-Mart like store; ~$1.00 on clearance
  - tape; neglible
  - two things to rub together for charge:
    PVC pipe and brown paper bag (or towel); hardware store; ~$1.00

OR balloon and hair *OR* Styrofoam plate and carpet *OR* whatever is convenient

- short-wave ultraviolet (UV) germ sanitizer lamp; Amazon.com; ~$10.00-$40.00; http://tinyurl.com/m7bzoo; http://tinyurl.com/n8tb7s; http://tinyurl.com/nwvwlv


UV-A	~380nm - 315nm	Long Wave (black lights, concerts, entertainment)
UV-B	~314nm - 280nm	Medium Wave (forensic applications)
UV-C	~279nm - 200nm	Short Wave (germicidal, sterilization)

* *Styrofoam cup; negligible*

* *short piece of wire (paper clips, coat hanger, etc.); negligible*

* *piece of glass (UV light shield); from picture frame; Amazon.com; ~$3.00; http://tinyurl.com/mzdk7m*

* *blacklight (long-wave); Amazon.com; $12.00; http://tinyurl.com/mb5cf9*

Construction Steps

- Lightly sand one side of your aluminum soda pop can.
  This is to remove any outer coating from the can as well as any oxidation layer that will form. This will most likely need to be done each time you bring out this demonstration in order for the UV light to remove electrons from the aluminum. By the way, the electron work function of zinc (3.6-4.9 eV) and aluminum (4.1-4.3 eV) are similar.
- Attach some Christmas tree tinsel to your can.
  This can be done many different ways, but realize that this is the part where one actually sees something happen. Your are effectively making an electroscope. The tinsel will be given a charge and thus repel from the other tinsel strips. The more effective this display the better. When this charge is removed, the tinsel will relax. It can certainly work to tape some tinsel directly onto the can; however, I suggest taping a conductive wire to the can first, and then taping the tinsel to the other end of this wire. In this way, you can dangle the tinsel more easily and in more varied configurations. It also helps to have the pop can horizontal since many UV germ sanitizer lamps have an automatic safety turn-off function when the lamp is aimed up at the eyes. Making the tinsel strips longer than shorter is generally more effective, too. That way they are not too rigid to move. I prefer not to clump all of the tinsel strips together either, but rather line them up beside each other. This way they do not get as tangled. Please fiddle around with this part until the tinsel effectively shows charge; otherwise, the rest of the experiment is useless. There are of course many other ways to make a homemade electroscope that would work just as well.
- Insulate the can and tinsel (electroscope) from the table.
  Charge should not be allowed to leak off from the electroscope. I chose to simply tape the can to an insulating Styrofoam cup, which then as a "permanent" base and stand.
- Cut (or find) a short piece of PVC pipe and a brown paper bag (or towel).
  I chose these two items because they were handy, cheap, and reliable. Basically you just want two objects that when rubbed together, one becomes net negatively charged and the other net positively charged. Referring to the triboelectric series reveals that when PVC is rubbed with brown paper, the PVC becomes net negatively charged and the paper becomes net positively charged. Rubbing an inflated balloon on your hair results in the balloon becoming net negatively charged and the hair becomes net positively charged.

Use of Apparatus

- After removing any oxidation layer from the aluminum can, charge up the tinsel by rubbing the PVC pipe with the brown paper. Transfer the negative charge from the PVC pipe to the tinsel by running the pipe through the tinsel. The tinsel should now be negative and want to repel from each other. This allows people to see that there is indeed charge on the tinsel. If not, then make sure that the can/tinsel electroscope is insulated from the table and not leaking. Then re-rub the PVC and brown paper and charge up the tinsel again. (If it is too humid, then you may gently heat up the can, tinsel, PVC, and brown paper with a blow dryer and try again.)
- With the tinsel repelling, touch the soda pop can and discharge it. This is to show the audience what happens to the tinsel when the charge leaves the electroscope. The tinsel should relax.
- Charge up the tinsel again with the negatively charged PVC pipe.
- Move the short-wave UV germ sanitizer lamp into position (near, but not touching, the sanded portion of the soda pop can), but do not turn it on yet. This is to show the audience that the proximity of the UV lamp has little effect on the charged tinsel.
- Now turn on the short-wave UV lamp and watch the tinsel slowly relax, meaning it is being discharged due to negative charges leaving the aluminum. This is the photoelectric effect. The energy of the short-wave UV light is enough to eject electrons from the surface of the aluminum.
- Charge up the tinsel again with the negatively charged PVC pipe.
- Before turning on the short-wave UV lamp this time, insert a piece of glass between the lamp and the soda pop can. Now turn on the lamp. Nothing should happen. The tinsel should remain charged. Why? Because the UV light is absorbed (and blocked) by the glass. Now remove the glass and watch the tinsel relax.
- Charge up the tinsel again with the negatively charged PVC pipe.
- Move the long-wave blacklight into position and turn it on. Nothing should happen. The tinsel should remain charged. Why? Because the UV light does not have enough energy (too low a frequency). Now remove the long-wave blacklight and shine the short-wave lamp onto the soda pop can to discharge the tinsel.
- Charge up the tinsel again but this time with the positively charged brown paper.
- Shine the short-wave UV lamp onto the soda pop can. Nothing should happen. Why? Because the photoelectric effect ejects electrons from the aluminum and electrons are negatively charged. The tinsel and soda pop can already have a deficiency of electrons.