Ideas to Implementations

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Introduction

In this workshop, we explore the module "From Ideas to Implementations". We will look at practical demonstrations to use in the classroom, conceptual difficulties, misconceptions in textbooks and share ideas on teaching this module.

CRTs in Everyday Life

Cathode ray tubes are used today in three common items: TVs, computer monitors and cathode ray oscilloscopes.

In our cathode ray tube, you can identify a number of the features of these three devices: anodes, the steering plates, and the screen.

You can alter the direction of the electron beam in a TV without damage by using a magnet – as long as the TV is a black and white model. Colour TVs will be damaged by the magnetic field.

NOTES

The Photoelectric Effect

Observing the photoelectric effect allows you to see a quantum effect first hand. A simple demonstration can involve the following steps:

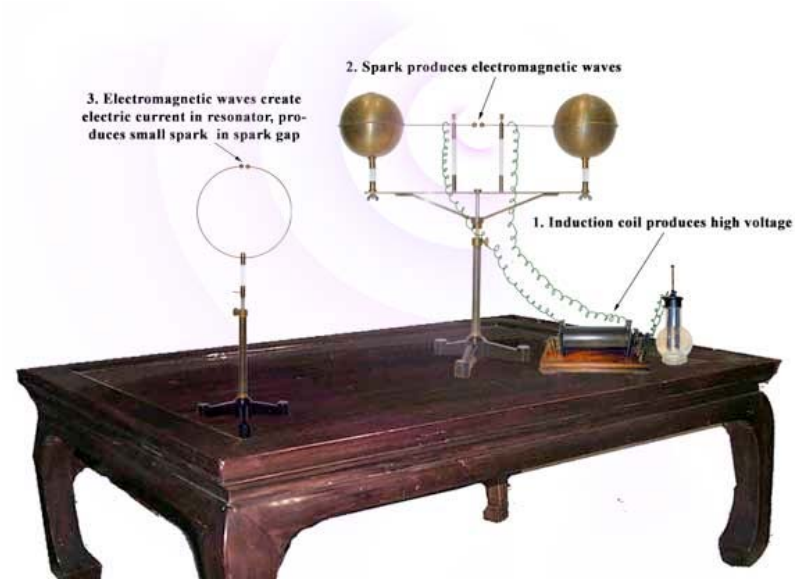
Place a piece of metal on an electroscope, and give it a negative charge. Shine light onto the metal and electroscope should show the charge decreasing as electrons are emitted from the metal.

There are a number of points to note about performing the experiment. A possible checklist looks like this:

- Is the charge negative?
- Does the metal have a low work function, e.g. zinc?
- If using zinc, is it free of oxidation?
- Does the lamp have a high enough frequency for the metal you are using? (We use a mercury lamp.)
- Is the lamp intense enough? (This will only affect the speed of the demonstration.)

NOTES

How Hertz Discovered v, f and λ for Radio Waves



Mock up of apparatus used in Hertz's experiments on radio waves.
Image from http://www.sparkmuseum.com/HERTZ.HTM

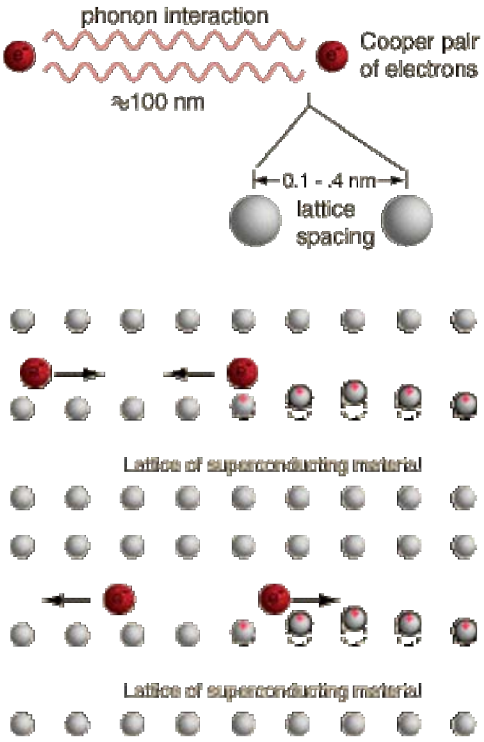
Heinrich Hertz performed experiments that confirmed many of Maxwell's predictions about electromagnetic spectrum. Hertz was able to make sparks jump rapidly back and forth across a gap in a receiver loop, when an oscillating spark was set up in a nearby apparatus.

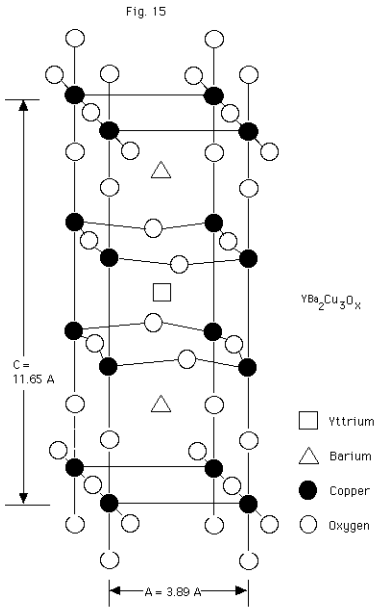
Hertz's experiments showed that he had found invisible waves with the same speed predicted by Maxwell, and the same properties as visible light, the most commonly known electromagnetic wave. The frequency of the emitted waves was determined by the number of windings in the induction coil, and the voltage and current in the circuit. Hertz devised an ingenious way of determining the wavelength – he reflected the emitted waves back towards their source, to set up standing waves. Hertz achieved this by lining the walls of a room with copper, which he had observed to be reflective. The receiver loop would spark strongly in certain positions around the room, where the antinodes of these standing waves were.

The velocity was found by multiplying the frequency and the wavelength. Hertz's number matched up well with Maxwell's theoretically derived value.

NOTES

Cooper Pairs in Superconductors





Above is a diagram of a one particular superconductor $YBa_2Cu_3O_7$. Image from http://www.ornl.gov/info/reports/m/ornlm3063r1/fig15.gif

Above are two images from http://hyperphysics.phy-astr.gsu.edu/hbase/solids/coop.html

Note that the total momentum of the electrons is zero. This is because the perturbation of the lattice of an electron moving one way draws a second electron towards it.

You can also notice that the top diagram shows that the electrons interact over a large separation. This is not displayed in the bottom diagram, or most textbooks.

NOTES

Demonstrating Semiconductor Resistance

A simple circuit can demonstrate the differences between the resistances of insulators, semiconductors and conductors.

One of the things which increases electrical resistance is the increased motion of the atoms and free electrons of a conductor caused by heating. This is due to their random collisions with the electrons making up the current. This interferes with the forward progress of the free electrons due to the applied voltage.

In a semiconductor, there are practically no free electrons at room temperature. Heating provides the energy for electrons to "jump" free of the atoms they are bound to. They then reside in the conduction band.

Comparing the current in two circuits, one with a tungsten resistor and one with a germanium resistor, as heat is applied to the resistors, shows these two different phenomena.

NOTES

Resources

- The UniServe site for links to many HSC resources, in particular the School Teaching Resources: http://science.uniserve.edu.au/
- Hyperphysics, at Georgia State University, for a succinct explanations of physics topics, all cross-referenced: http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html
- KickStart Physics is a set of workshops for senior high school students where they can perform experiments from the HSC syllabus that are difficult to do in the classroom. The workshops are Ideas to Implementations, Motors & Generators, and Relativity: http://www.physics.usyd.edu.au/kickstart.html
- An applet showing electromagnetic wave propagation from National Taiwan Normal University: http://www.phy.ntnu.edu.tw/java/emWave/emWave.html
- Further details on Hertz's experiments with radio waves - http://chem.ch.huji.ac.il/~eugeniik/history/hertz.htm

KickStart workshops

The School of Physics offers a service to senior high school students where they can perform experiments from the new HSC syllabus that are difficult to do in the classroom: KickStart Physics

There are three modules available in physics: Ideas to Implementations, Motors and Generators and Relativity.

Dates and Times: We can arrange a booking most weekday mornings anytime from 9:00am to 1:30 pm. Feel free to contact us to ask about other times.
Duration: The workshops run for about 2.5 hours
Class size: Up to 30 students.
Program fees: $20.00 per student for groups of 10 or more
$25.00 per student for groups of less than 10

More info at www.physics.usyd.edu.au/kickstart.html