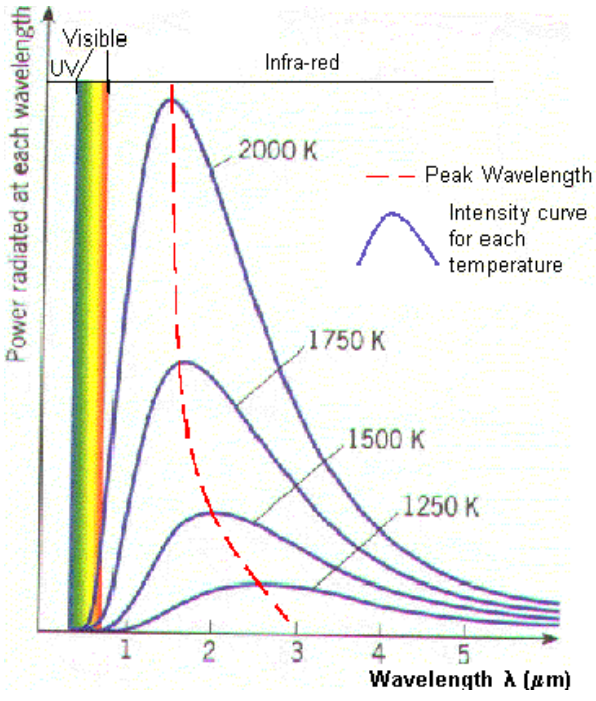
Physics 420 Project Proposal: Infrared Camera

Objective:

Electromagnetic radiation is something we are perhaps most familiar with in the form of visible light. However, this phenomenon is much more common than the average high-school student probably realizes. The objective of this demonstration project is to introduce the basic concepts of the physics of infrared radiation to local high-school students. This will be accomplished by using their previous knowledge of electromagnetic radiation in the form of visible light. Parallels will be drawn between transmission and absorption properties of these two types of radiation. This will provide an introduction to an explanation of the basic functioning of the infrared filters and of the infrared camera.

Theory:

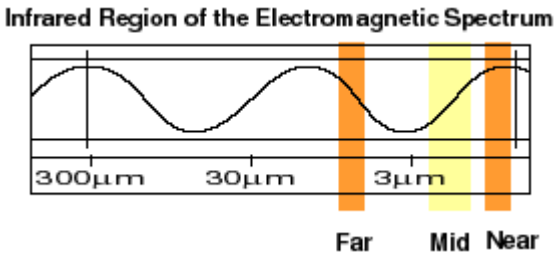


All objects (except when at a temperature of absolute zero) emit energy in the form of electromagnetic radiation. This process is known as blackbody radiation. A blackbody is a theoretical object that perfectly absorbs all electromagnetic radiation directed at it and radiates it back out as a spectrum of all possible wavelengths.

The infrared region of the electromagnetic spectrum is the region for which the wavelengths are longer than for visible light, but shorter than for microwaves. Its wavelengths roughly range from 750 nm (near infrared) and 1mm (far infrared).

While all electromagnetic radiation carries energy, which can be transformed into heat, we often equate infrared radiation with the concept of heat. This confusion arises from the fact that objects heated to room temperature act as black bodies that mostly emit radiation in the infrared range, specifically from 8 to 12 microns. Black bodies begin to emit observable amounts of radiation in the visible range once their temperature exceeds 700K (427 ^{0}C), at which point it starts glowing red ("red hot"). When the object is at a temperature where it emits significant amounts of radiation at all of the visible wavelengths, it glows white ("white hot").

Infrared radiation has several other practical applications, involving mostly different types of imaging but also including short-range communication. The radiation emitted by infrared light-emitting diodes can be concentrated into narrow beams to provide data transmission between computer peripherals or between a remote control and an appliance. Also, free space optical communication using infrared lasers is now being used to provide a cheaper alternative to fiber optics in certain urban settings.



(*http://imagers.gsfc.nasa.gov/ems/infrared.html*)

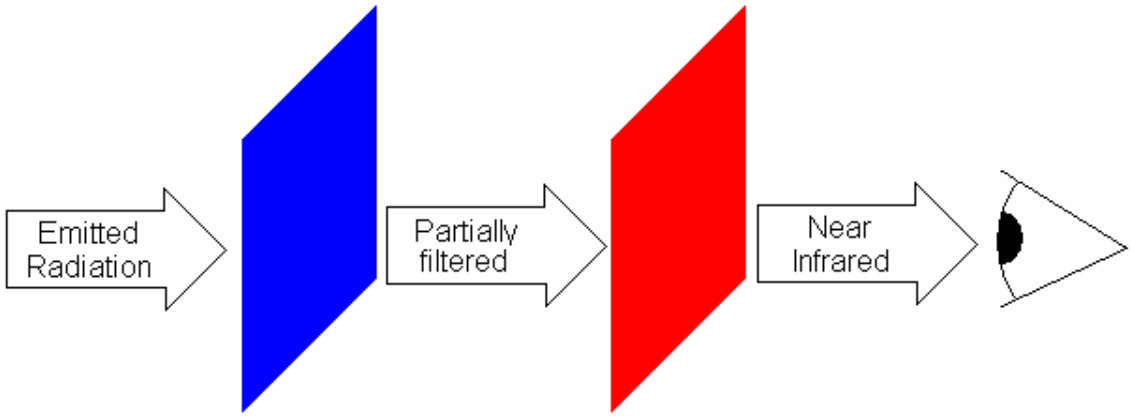
Apparatus:

- 1x Congo blue lighting filter from Lee Filters
- 1x Primary red lighting filter from Lee Filters
- 1x Infrared filter
- 1x Infrared sensitive digital camera
- 1x Pressing iron
- Other heat emitting objects depending on their capacity to emit radiation of the desired wavelengths

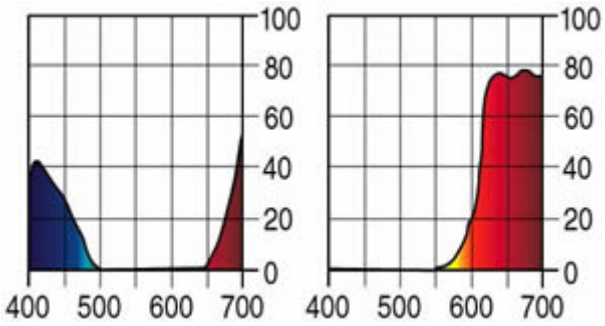
Note: Due to the limitations of our eyes and of the digital camera, the wavelengths that will be examined for this demonstration will be limited to approximately 1 micron for the camera, and the very near infrared (still considered visible light) for the naked eye.

Set-up and Method:

The Congo Blue and Primary Red filters will be used together in a series configuration. Combined, their transmission/absorption characteristics will block all visible light, except for the very near infrared. This will allow us to observe nearly infrared light using only our eyes.



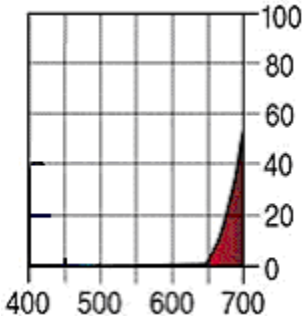
Transmission Properties of the 2 Filters:
(nm vs. % transmittance)



Congo Blue **Primary Red**

(*http://www.leefilters.com/LPFD.asp?PageID=234*)

Resulting Transmission Pattern:
(nm vs. % transmittance)



Heat producing objects, such as the pressing iron, will be observed by the students through the homemade filter and through the manufactured infrared filter. Observed differences will then be recorded and compared.

The transmission properties of the two filters will then be examined using the infrared sensitive camera. This will allow us to see a wider range of frequencies, further into the near infrared. Images captured with the camera will be compared to observations previously made with the naked eye in order to determine differences in the observed intensity and range of emitted radiation.

Conclusions:

Conclusions will be drawn on infrared radiation and its place in the electromagnetic spectrum. This will give students sufficient knowledge to be able to explain and understand the basic functioning of the infrared filters and the infrared camera. Hopefully this demonstration will also show them how different concepts are connected in the world of physics and how they come together in the real world, allowing us to apply them for practical use.

References:

Lee Filters – High Quality Camera and Lighting Filters
http://www.leefilters.com/

Rosco International
http://www.rosco.com/

The Electromagnetic Spectrum
http://imagers.gsfc.nasa.gov/ems/ems.html

Infrared Goggles for Under 10$
http://amasci.com/amateur/irgoggl.html