NUCLEAR SPECTROSCOPY

CASPAR LANT

Intermediate Experimental Physics II

Section:	002
Date Performed:	April $\sqrt{2}$, 2016
Date Due:	April ∞, 2016
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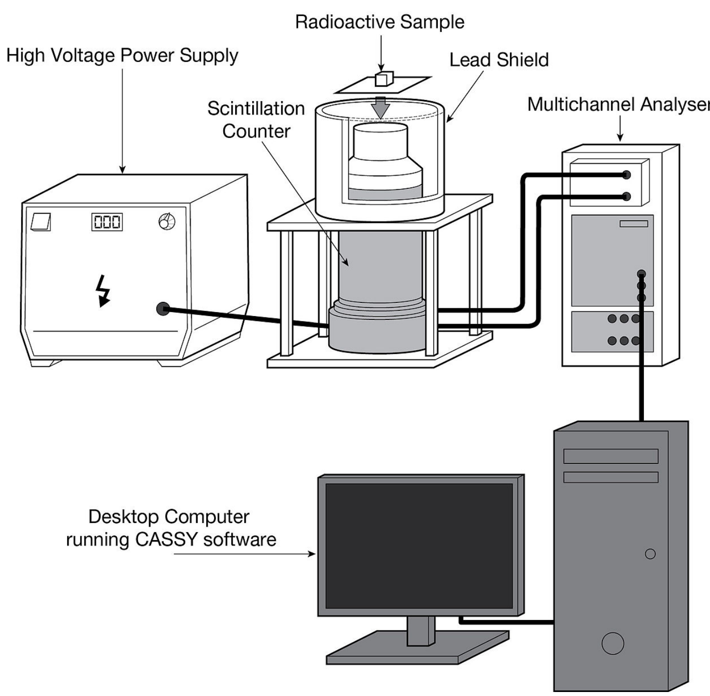

Date: April 27, 2016.

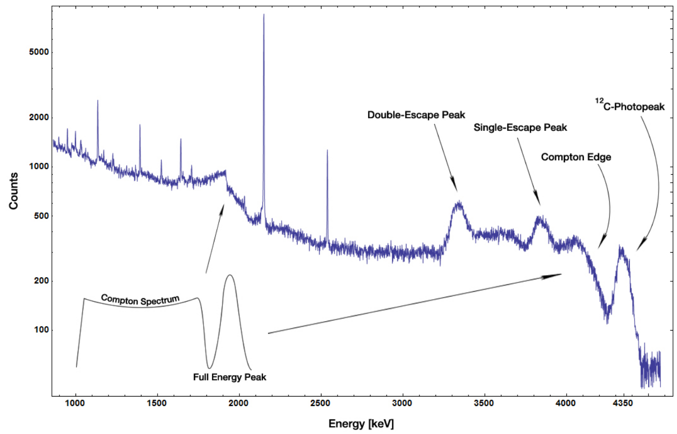

FIGURE 1

The Objective of this week's experiment was to nullify the claim that light requires a medium of propagation (the so-called "ether") and to measure the wavelengths of light using our extant knowledge of wave propagation.

1. Theoretical Background/ Abstract

Beta decay is a process in which the proton of an atom is transformed into a neutron, or vice-versa. This happens inside the atom's nucleus, which the resultant particles and energy soon escape. There are two types of beta decay, β^- and β^+. As you may have guessed, β^- decay produces a negatively charged particle (among other things), where β^+ produces a positively-charged particle, known as a positron.

$$p \to n + \beta^+ + \nu_e \tag{1}$$

Where β^+ is a so-called beta particle: a high-energy, high-speed positron emitted in radioactive decay.

$$n \to p + \beta^- + \bar{\nu}_e \tag{2}$$

β^- is again a beta particle, but this time it's an electron instead of a positron. $\bar{\nu}_e$ is an **electron anti-neutrino**, the antiparticle of the electron neutrino shown in Equation 1. It's largely there to make sure that energy is conserved in the decay process.

$$\frac{\mathrm{d}E}{\mathrm{d}x} \propto \frac{z^2 e^2 N Z}{m V^2} \tag{3}$$

$$\sigma_{pe} \approx \text{constant} \frac{Z^4}{(h\nu)^3} \tag{4}$$

$$E_{\gamma'} = \frac{1}{1 + (E_\gamma/mc^2)(1 - \cos\phi)} \tag{5}$$

$$I = I_0 e^{-\mu x} \tag{6}$$

2. Experimental Procedure

(1) Verify that the laser is off before you begin to set up the experiment.

(2) Arrange the optical components on the table in the manner depicted above.

(3) Remove the air cylinder from the laser's path.

(4) Dim the lights and turn on the laser, taking extra precaution not to look at it directly.

(5) Tune the laser to a desired frequency, ideally one who's intensity is large.

(6) Arrange the lenses and mirrors such that the light is most concentrated. ie, minimize the size of the projection on the wall.

(7) Play with the fine adjustment of one of the meters to produce interference patterns like the ones shown.

(8) Measure the wavelengths of several colors of visible light by counting the number of fringes that pass with each movement of the moveable mirror.

(9) Turn off the laser without looking at it!

3. Graphs and Tables

The uncertainty of our measurement for the index of refraction of air is produced by our error in the distance between the reflector and the laser source. It is equal to 0.016 and is unitless. Our expected value for the index of refraction of air (which of course depends on the density of the air, which depends on the ambient temperature and pressure) is 1.00, which falls within our estimated uncertainty.

Table 1. My caption

Material	Thickness (mm)	N
None	0	10,338
Aluminum	3.1	10,345
Aluminum	3.1	10,176
Copper	3.0	9,495
Lead	1.1	9,246
Lead	2.4	7,862
Lead	3.4	6,849
Lead	8.4	4980

4. Questions

(1) *Were you able to discern any dispersion for air?*

Yep, we were able to calculate a value for the index of refraction too! 1.0003!

(2) *To observe white light fringes, you must use a compensating plate. Why?*

As we know, true white light is comprised of the full spectra of visible wavelengths. Waves of different wavelength reflect off surfaces at slightly different angles. It is for this reason that rainbows are formed and a compensating plate must be used to observe interference patterns in not coherent (incoherent?) light.

(3) *Could you devise a way to measure the index of refraction of a transparent solid?*

Of course. We know that the index of refraction of a transparent solid is defined as the ratio between the speed of light in free space and the speed of light in the medium. This, by definition, makes the index of refraction of free space 1, and the indexes of refraction of all other media greater than one. To measure the index of refraction of a transparent material using a Michelson interferometer, I would first obtain a value for the speed of light in the interferometer with no translucent medium. I would then place a medium in the path of the beam, measure the portion of the total light path that went through the new material, and record the new speed of light through the interferometer. The old speed over the new speed times the aforementioned ratio would give me the index of refraction of the transparent medium.

5. Analysis

The uncertainty of our measurement for the index of refraction of air is produced by our error in the distance between the reflector and the laser source. It is equal to 0.016 and is unitless. Our expected value for the index of refraction of air (which of course depends on the density of the air, which depends on the ambient temperature and pressure) is 1.00, which falls within our estimated uncertainty.

It was more difficult to determine the uncertainties in our measurements of the wavelengths of light. As we know, light exists on a continuum, and it is for this reason that it is hard to say where the boundary between two colors of light lays. From tables found online of the visible light spectrum, the wavelength of red light falls within 620 and 700 nanometers. Our measurement comes to 640, which fits snugly within of this range. According to the same table, the range for orange light is 597 to 620 nm, when our measurement was 627. The wavelength of green light falls within 492 and 577 nanometers. Our measurement comes to 480, which falls slightly outside of this range. If we consider the possibility that the experimenters (me) miscounted the number of fringes that passed by, we are able to formulate an estimated uncertainty. Allowing for an uncertainty in count of 2 fringes, our uncertainty for the wavelength of light is $\pm$24nm, which puts the error bars of all of our measurements within our bounds of expected values for wavelength.