Wave and Particle Motion:
Variable and Measurable Interactions Sub atomically Oriented

Wesley Hunt
DeKalb School of Arts

Abstract

During the younger years when we explore the forces of motion from a layman’s perspective, our automatic conclusion is that objects tend to move outward when moving in a circular path. Upon closer examination it becomes evident that we are partly right and partly wrong in this assumption. After some years of education and training we come to understand that there is no external force pulling outward and that the forward and reverse forces are canceled. By conducting simple experiments we discover the inertial and gravitational components that govern matter and pure energy thus giving rise to our understanding of atoms. This further establishes our knowledge of the slight pull inward in a perpendicular manner on the subatomic components. In this lesson and experiment the students will examine the characteristics of selected elements as waves, particles and electromagnetic spectra.

Investigation

By first examination it can be easily observed that light is composed of both waves and particles in its substance. When passed through a diffraction grating the light will separate into individual wave energies visible in a small portion of the total band of EM energy between the range of 400-700nm (nasa.gov, 26 October 2006). Using Einstein’s theory of relativity we discover that EM energy has mass thus it must be particle in nature. The work of early pioneers such as Planck, Bohr, and the afore mentioned Einstein has led to the development of the modern model of the atom which can not be bound by the constraints of “orbital” ideology but rather by comparing energy of the electron vs. position. In short, by examining the atom from the subatomic perspective, modern physicists have discovered that the electron is not bound in fixed orbital but rather its energy and therefore that of the atom itself is governed by the position of the electron (see attachment: Schrodinger Equation). From this perspective only Hydrogen works as fixed energy model and the rest of the known elements nullify this perspective. Once the atomic spectra of individual atoms were observed, scientists then correctly identified light as both waves and particles and discovered it had mass as well which further dispelled the classical model of the atom.

State Education Standards

SP2- Students will evaluate the significance of energy in understanding the structure of matter and the universe.
SP3- Students will evaluate the forms and transformations of energy.

SP4- Students will analyze waves and particles as forms of energy.

Objectives/Learner Outcomes

- Students will complete a study of the line spectra of specific elements and interpret the components of the electromagnetic spectrum.
- Students will show proficiency in using an Analytical Spectrometer.
- Students will prepare a two dimensional diagram of the EM spectrum showing the data collected.
- Students will demonstrate knowledge and understanding of spectral lines and correlate results mathematically using reference sources to substantiate their data.
- Students will design an experiment for testing additional elements to show they are made of particles and have wave properties.

Rubric

Students will be rated on their accuracy of reporting, data collection, use of equipment, lab protocol and efficiency, use of time, and concept mastery on the following scale:

10-9………Complete concept mastery and exceptional readiness for post secondary study; learner independent.

8-7……….Shows overall concept mastery and readiness for post secondary work needing some assistance.

6-5………..Further instruction in the math and sciences is recommended for student to grasp concept and core objectives.

4-3……….Science and math lab skills not developed; needs in depth instruction; deficient in content mastery.

2-1……….Student is not grade level and/or academically proficient for the lab course; requires in depth instruction of basic math and sciences.

Materials

Hydrogen, Argon, and Neon spectrum tubes
Spectrum Tube Power Supply
Analytical Diffraction Grating Spectrometer
Trifold Display Board
Black Butcher’s Paper or Black Felt Material
Scissors, exacto knife, glue or tacks, and Black tape
Blank paper and colored pencils
Blank EM scales (x3)
Reference Book(s)

Procedural Components

The students should understand the basic operation of the Analytical Diffraction Grating Spectrometer in their investigation of the internal properties of matter. The type of spectrometer to be used can be purchased from most scientific supply warehouses and manufactures. It is a simple yet complex stationary device with stand and achromatic assembly with two built in scale magnifiers which give 10x capability. The EM source is captured as it passes through the diffraction grating allowing for ease of use. By aiming the objective end at the emission source, light spectra will pass through the diffraction grating separating into the various wavelengths along the internal scale. The scale itself has a range of 400-700nm (www.fisher.com (Vernier)) and it is easy to read and transfer the data.

I. Screen Assembly
1. Lay the Trifold board on a clean dry flat surface.
2. Trim the butcher’s paper or felt to the dimensions of the Trifold surface.
3. Remove the paper/felt and place glue over the surface of the Trifold surface.
4. Gently apply the paper/felt to the surface making sure the press the substrate on evenly and firmly. Allow 5-10 minutes for drying.
5. After drying, use the exacto knife to carve a slit 3mmx10cm into the Trifold board.

II. Emission Source- Note that the room must be darkened and no external light source present.
1. Plug in the power supply to an 110V source.
2. Carefully place the Hydrogen Spectrum tube in to the power supply making sure to secure the ends into the electrical conduction posts.
3. Turn on the power supply and align the source behind the Trifold board. The source must be securely affixed to the back of the board using black tape (or duct tape) to reduce stray wavelengths of light.

III. Using the Spectrometer
1. Place the device 10 to 12 inches from the emission source.
2. While looking through the tube change the lateral view of the tube with respect to the source until the spectral lines come into view. Record the position of each line observed until the scale begins to repeat. Measured values over 700nm are indicative range error.
3. Record your results on a blank EM scale as points.
4. Using colored pencils draw lines to indicate the points you observed.
5. Reference your results with the accepted values from scientific standards.
6. Repeat the process using the other two elements.
Analysis and Conclusion

1. What were the observed wave energies generated by the spectrum tube samples?
2. How can the data you collected be used to show that light is also particle by nature?
3. Use Planck’s constant to calculate the frequency of the heist and lowest wavelengths of observed light for each sample.
4. How do your results compare to the accepted and known values for each of the elements?
6. How do these results confirm the fact that the Bohr model of the atom is only accurate for the Hydrogen atom?

Bibliography

Holt Modern Physics Program for High Schools, by F. Trinklein, HBJ, 1990
www.fishersci.com