Scattering, Light, Particles, Waves, and Structure
What do they have in common?
Prof. Julia Thompson, University of Pittsburgh and SIUE

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1 Scattering

Baseballs scatter from bats. Billiard balls scatter. Sonar scatters from boats. Radar scatters from planes. In ultrasound, sound scatters from organs in your body. Light scatters from clouds to make sunsets and water droplets to make rainbows. And scattering has been responsible for understanding the structure of atoms, molecules, nuclei, and nucleons, even finding the "quark" substructure of neutrons and protons.

Scattering is a theme which runs through much of physics. And not just straight-line "particle" scattering. When the thing being scattered is close in "wavelength" to the thing being scattered from, we have to think of the thing being scattered as a wave. Even you can be considered a wave... but your "wavelength" is so small that for practical purposes you are always considered a "particle" or "projectile" (as you have already noticed).

2 Light, waves, and scattering

But in some cases wave motion is important. Today we are going to observe light scattering from "apertures"... slits, diffraction gratings, a hair of a colleague. Light can be treated as either a straight line "particle" or as a wave. In cases where it is considered as a "wave", when it scatters, it does not scatter uniformly, but "bunches" up in some places. If you have already studied waves, you will understand this as "constructive and destructive interference" of the waves from different parts of the "aperture". If you have not studied waves, it will seem very odd to you, but we will see that it really happens, and then when (or if?) you study waves later you will (I hope!) remember that you really saw it happen.

The formula which describes light scattering is:

$$sin(\theta) \approx n * \lambda/d$$

where: theta is the angle of bending from straight ahead at which the light is "bunched up" (or put another way, at which we see "maxima of intensity"); n is some integer (it happens at more than one place.. n can be 0,1,2,..); λ is the "wavelength" of the light; and d is the size of the object (or "aperture") being scattered from.

3 $sin(\theta) \approx n * \lambda/d$ How to measure?

We will use some lasers, with wavelength about 620 nm, some apertures, and a meter stick to observe the wave scattering of light. We will put the aperture close to the laser, and measure the "maxima" or places where the light is bunched up, about a meter away from the laser, in order to give the bunched pattern space to spread out, so that we can measure it. If there is time you can substitute a hair from one of your colleagues and find out how thick it is, by using the same idea. Are the hairs of your different colleagues the same?

4 How does this relate to elementary particles and my research?

This same idea of wave scattering can be used for elementary particles, and one of the ideas in my field of research is to find what the smallest pieces of matter are and what their structure is. You may have heard of "quarks"... which come in different "flavors"... up, down, strange, charmed, top (or truth) and bottom (or beauty). These were all found in some variation of scattering.

5 What is that funny looking equipment?

Light is also frequently used to "calibrate" or "test" equipment. In my case, our group at the Univ. of Pittsburgh built big "Cerenkov counters" (Cerenkov radiation is like a sonic boom, but for light instead of sound; it is used to identify different particles, since they give off different radiation, depending on their speed) for an experiment at Brookhaven National Laboratory in Long Island, NY. The equipment I brought is some very specially designed mirrors used to collect this Cerenkov light. Some of the same ideas of light collection are used in solar light collection, and some of my colleagues have used their experience in Cerenkov counters to design solar light collectors.