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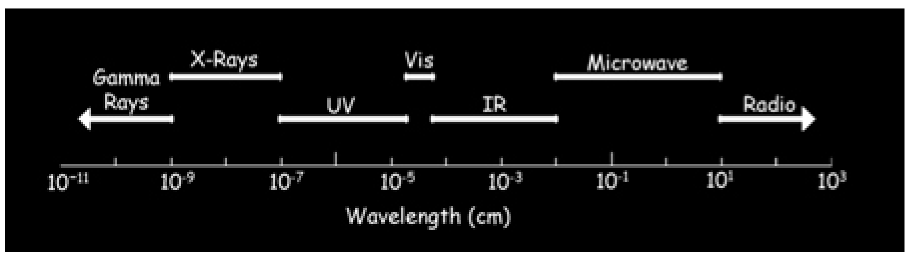
Science - Spectroscopy - The Plan

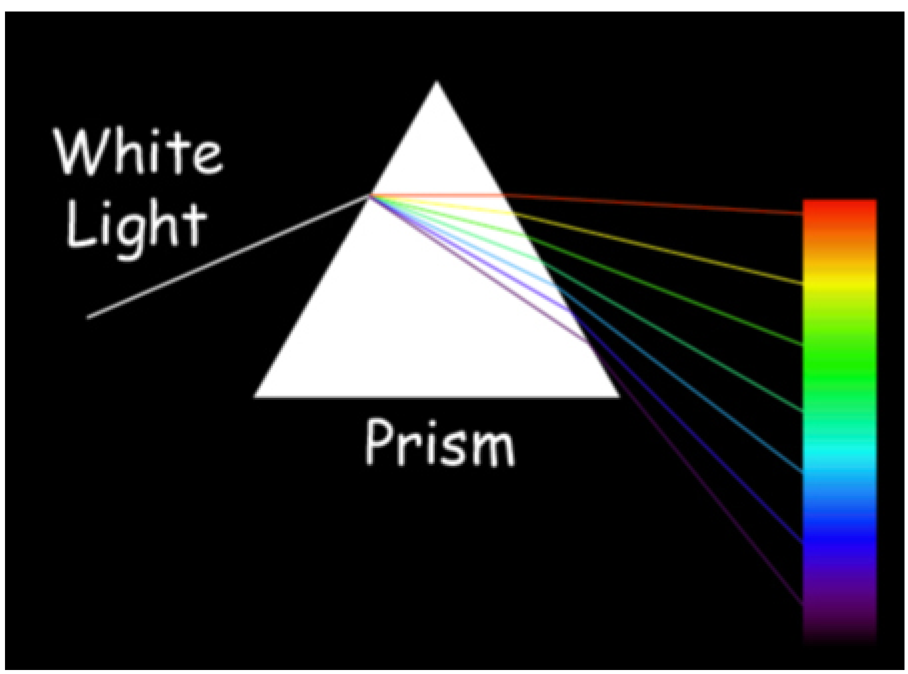
What is spectroscopy?

Spectroscopy is a scientific measurement technique. It measures light that is emitted, absorbed, or scattered by materials and can be used to study, identify and quantify those materials.

One thing that you need to remember is that "light" is a lot more than just the colored visible light that we can see. In addition to the traditional "**ROY G. BIV**" (**R**ed, **O**range, **Y**ellow, **G**reen, **B**lue, **I**ndigo, **V**iolet) color spectrum, there are gamma rays, x-rays, ultraviolet (UV) radiation, infrared (IR) radiation, microwaves and radio waves!



It is possible to take the light that a material reflects, absorbs, or emits, and separate it into its parts - just like a prism can break white light up into the visible light spectrum. If you break up a sample of light of all wavelengths, you get what's called a continuous spectrum. Below is an example of a continuous spectrum for visible light.



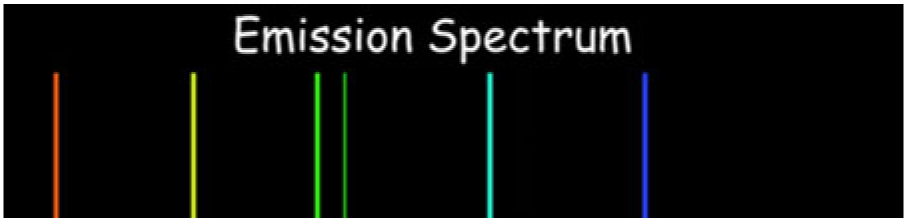
Something similar can be done across the full electromagnetic spectrum using prisms made of different materials, or what are called diffraction gratings. Devices that use these elements are called spectrometers.

When light is absorbed or reflected by materials, not all of the light behaves the same. Only certain wavelengths of light get absorbed, others get reflected. You may recall this from past science classes - it's why a red object looks red!

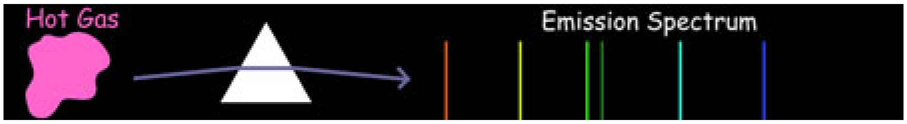
Some materials emit light without being hit by light first - another energy source (for example, heat or electricity) is used instead to first excite the material, and then that energy is turned into light. For example, a common light bulb emits light when electricity is passed through it.

When you separate the light that is passing through a sample, or reflecting off a sample, you end up with an emission spectrum or absorption spectrum, as opposed to the continuous spectrum you would get if you break up a source of all wavelengths of light.

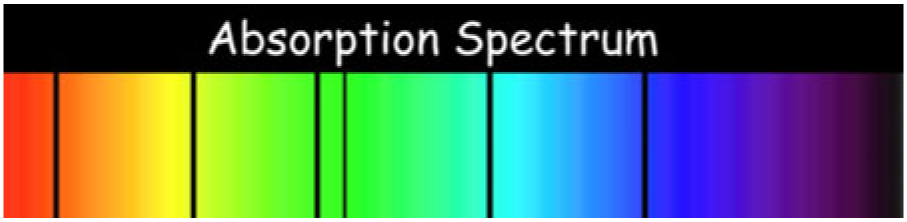
An emission spectrum in the visible light range may look like the picture below. Such a spectrum would be created when material is given extra energy somehow (it's heated, electrified, radiated with light, etc.) and that extra energy is later emitted as light energy.



If that light is separated into its component parts, you can see the spectrum of the emission. In this case, only the wavelengths of light which are emitted come out in the spectrum.



An absorption spectrum in the visible light range may look like the picture below. Such a spectrum would be created when light is passed through a gas or a liquid, or strikes a solid. Certain wavelengths of light will be absorbed by the material, and later emitted in random directions. Most of the wavelengths, however, will pass through the gas or liquid (or be reflected off the solid) without being absorbed.

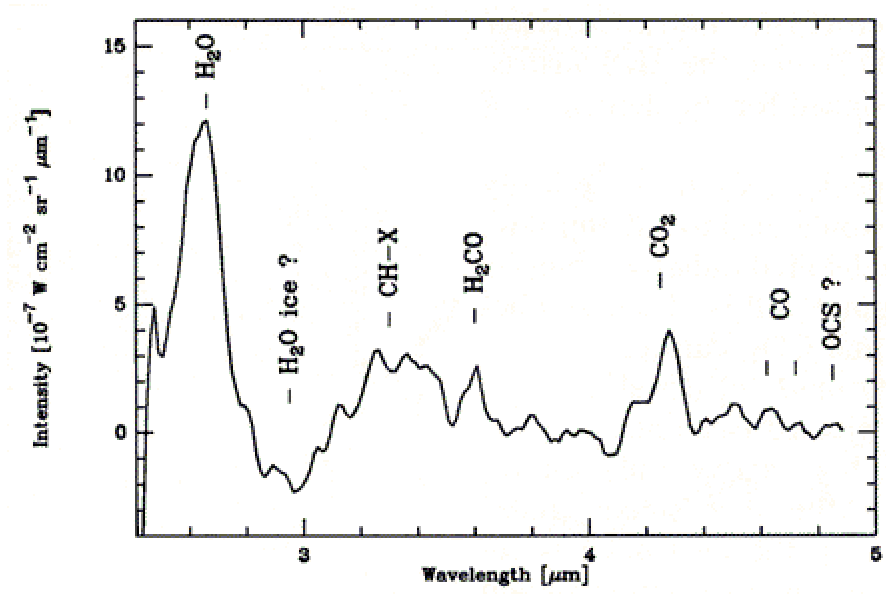


If the light that passes through (or reflects off) is then separated into its component parts, you can see the spectrum of the absorption. In this case, the wavelengths of light absorbed by the material are absent in the spectrum, leaving blank spaces behind.

How will spectroscopy be used in the Deep Impact Mission?

The emission or absorption spectrum of a substance is as unique to that substance as a fingerprint is to a human being. The Deep Impact flyby spacecraft will include the High Resolution Instrument, which contains an infrared (IR) spectrometer. This means that while some of the pictures that the flyby spacecraft takes will be essentially camera shots, there will also be information about which portions of infrared energy are being emitted by the energized gases being released during the impact. This imager will be aimed at the ejected matter as the crater forms, and an infrared "fingerprint" of the material from inside of the comet's nucleus will be taken.

Once these data are collected, they can be analyzed and compared against the known spectra of materials likely to be found in comets. If matches are found, then identification of the material inside the comet is accomplished.



Above is an IR emission spectrum of Comet Halley (taken from M. Combes, et al , Icarus, 76 404 1988). The peaks indicate that a greater amount of light with that wavelength was being emitted from the sample than other wavelengths. Notice that several substances have distinct sections to them - these are known areas of emission for these substances, their IR "fingerprint," if you will. Deep Impact will be imaging from 1.0 to 4.8 micrometers, so the data obtained will cover a slightly larger area than this spectrum, but it gives you an idea of what the data may look like after analysis.

Here's an example of a specific use for spectroscopy. One of the questions Deep Impact will hopefully answer is how deep the pristine matter (that is, matter which has remained unchanged since the formation of the solar system) inside a comet is. Theories vary from a few centimeters to a few kilometers - that's a lot of room for error! When the ejecta is thrown from the crater, the earliest ejecta will be from the top layer of the comet, and will land the farthest from the crater when making the ejecta blanket. The later the ejecta comes out, the deeper in the nucleus it was, and the closer it will be to the crater when it lands. The flyby spacecraft will take images of the ejecta as it comes out, and also of the ejecta blanket once it forms. By comparing the spectra of the earlier ejecta to the later ejecta, it should be possible to determine how thick the outer layer of the nucleus material is.

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