A Guide to the Prisms Used in Spectroscopy

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Prisms are commonly used in spectroscopy for dispersing or controlling the direction or polarisation of light. This can be helpful for splitting the incoming light into its wavelength components to maximize the information recorded with a multi-channel detector, such as a CCD camera, or performing polarization-controlled experiments. Using different polarisations of light can help assign certain spectral features, such as the nature of vibrational modes in a Raman experiment.

There are a wealth of prisms available with different properties and specifications for all of these applications, including the ability to either change or retain the direction of the incoming light. Some, such as Dove prisms, will not deflect the beam or introduce any refraction but will invert the image top to bottom. This makes them useful for changing the direction of linearly polarised light without affecting the beam steering.

Prisms for Beam Steering

Beam steering is one of the most common uses of prisms in spectroscopy. While mirrors tend to be cheaper and result in fewer transmission losses, as with a prism the beam must pass through the prism's material, for very compact experiment with very accurate alignment, prisms can be preferable. The error on mirror alignment is always doubled due to the Law of Reflection and, while mirrors allow for more alignment flexibility, it can be difficult to set them up and adjust them to get precise reflection angles.

Commonly used prisms for beam steering include right angle prisms, that can be used to reflect a beam either 90° or 180°, depending on the prism's orientation. Wedge prisms are highly versatile and can deflect the beam any number of degrees while also helping to correct for small ellipticities in the output beam shapes from diodes. Other prisms used for steering include pentaprisms or Pellin-Broca prisms. Pellin-Broca also has the advantage that the angle of rotation of the prisms will deviate only a specific wavelength of the incident light by 90° and can, therefore, be used for separating wavelengths following a process like frequency doubling, where some of the residual fundamental may remain colinear with the output beam.

Dispersing Light

There are a number of different prisms designs that are suitable for maximum dispersion of the incident light. Probably the most iconic of these is the triangular prism, which resembles an equilateral triangle. Dispersion in the material occurs as the different wavelength travel at different speeds changing the path accordingly. Changing the prism design can also influence the amount of dispersion, for example, triangular prisms tend to be more expensive to manufacture, so Littrow prisms were often used in their place and can be useful where a narrower range of dispersion is required.

For dispersion of light in spectrometers for detection, the increased affordability of diffraction gratings means that prisms tend to be used only for applications where the poor transmission of gratings causes issues. However, control of the dispersion of light with prisms is of utmost importance in ultrafast spectroscopy as it is essential for keeping laser pulses temporally compressed and maintaining good time resolution. Here, triangular prisms are often used in opposing pairs to compensate for the dispersion each individual prism applies to the light.

Prism Materials

As spectroscopy makes use of most of the regions of the electromagnetic spectrum, the materials of a prism need to have relatively high transmission in the wavelength region being used. Fused silica is a popular choice for the UV and visible range and the addition of anti-reflective coatings can help enhance transmission for specific wavelength regions as well. BK7 is a cheaper alternative in the visible to infrared range, though, for longer IR wavelengths zinc selenide, germanium and silicon are necessary.

Versatile Optics

Prisms can be used for a number of purposes in spectroscopy, including beam steering, dispersion and polarisation control. The number of different prism geometries and coatings, as well as their compact footprint, means they are also easy to integrate into a range of devices and experiments.