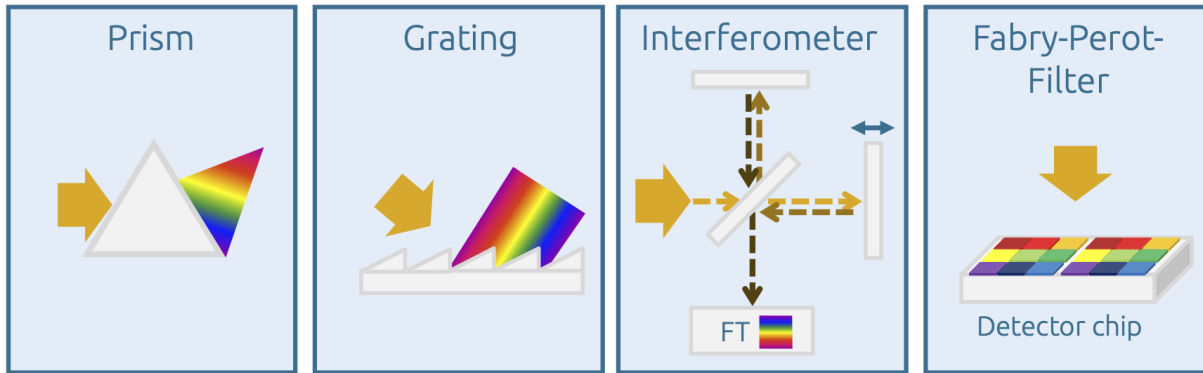


Optical dispersion

The essential component to obtain the spectrum at all is the 'dispersive element' or the 'dispersive unit'.⁷ If the dispersive element is additionally coupled with a slit to select a single wavelength, it is also referred to as a monochromator.



Fundamental arrangement of some dispersive elements

The simplest and most illustrative dispersive element is a prism, but it is now practically irrelevant for spectroscopy. Gratings are most frequently used for dispersion. These can be designed as transmission or reflection gratings. They can be found in practically all UV-VIS and fluorescence devices and also in spectrometers for hyperspectral imaging. The gratings are specific to the desired spectral range and the desired spectral resolution.

Interferometers are used in Fourier transform (FT) spectrometers, the most common type being the Michelson interferometer. The interferometer superimposes the light in a time-dependent manner through a moving mirror, after which the spectrum is calculated by Fourier transformation from the resulting time course of the recorded interferogram. This technique has established itself in IR and RAMAN spectroscopy in particular, as it offers a significant speed advantage.

Fabry-Perot filters, which are applied directly to the detector chip, have become established for multispectral imaging. For each pixel on the detector chip, a 'subpixel' pattern is imprinted from the filters, which are selective for individual wavelengths. However, no continuous spectrum is obtained, as is the case for the other dispersive elements. In most cases, the sub-pixels are arranged symmetrically, from 3x3 to 5x5 wavelengths, so that 9-25 points are obtained from the spectrum as a result.⁸

The detectors used in optical spectroscopy are often silicon-based in the visible and UV range (high availability, low cost), while radiation detection in the infrared spectral range is performed by semiconductor detectors such as indium gallium arsenide (InGaAs), mercury cadmium telluride (MCT) or pyroelectric detectors such as L-alanine doped triglycine sulphate (DLATGS). The materials InGaAs and MCT, which are also used for the array detectors of imaging IR spectroscopy, are particularly expensive, limited in size/pixel count and, in the case of MCT detectors, not error-free (the defective pixels are then spectrally interpolated using stored corrections).

The optical beam path, the optics and possible apertures determine the size of the measuring point or the field of view during the measurement. The setup (transmission, reflection, etc.) in which the measurement is carried out can often be freely selected using interchangeable modules. In hyperspectral imaging spectroscopy, the reflection methods are of greater importance, and for measurements in the open field also with the aid of normal daylight or the sun. The optics and the working distance to the sample determine the spatial resolution in particular.

References:

⁷ from dispersion: lat. 'dispersio' for dispersing, from lat. 'dispergere' for distributing, spreading, scattering: in optics, the speed of propagation of light depending on the frequency

⁸ A spectrum is called 'multispectral' if there are fewer than 100 points in the spectrum, otherwise it is considered hyperspectral. The points should be as equidistant as possible on the wavelength or wavenumber scale. In reality, however, both terms are often used arbitrarily.

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