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Fourier transform spectrometer

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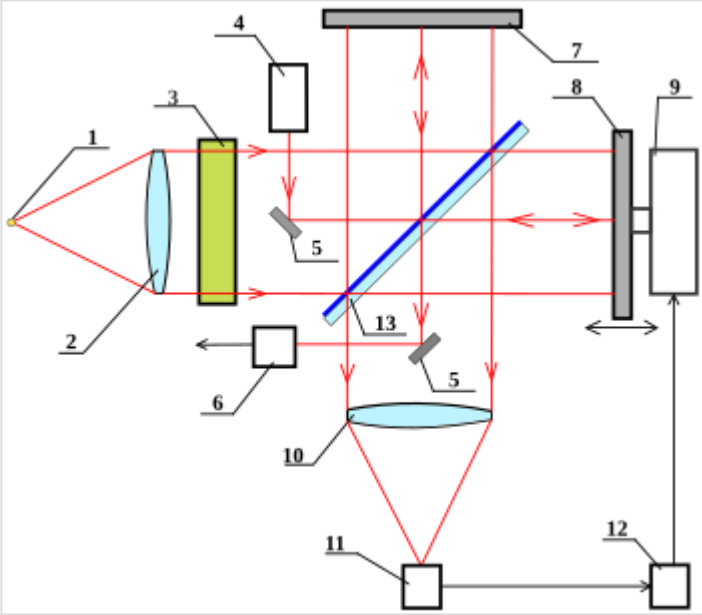
A Fourier spectrometer is an optical instrument used for quantitative and qualitative analysis of the content of substances in a gas sample.

Content



Schematic diagram of an optical Fourier spectrometer. A Fourier spectrometer is a Michelson interferometer in which one of the mirrors is movable, which makes it possible to vary the difference in beam paths. The mirror is shifted by a mechanical drive controlled by a computer.
1 — White light source or source under study;
2 — Collimator lens;
3 — Cuvette with substance under study;
4 — Reference (standard) laser;
5 — Auxiliary mirrors of the reference beam from the laser;
6 — Reference beam photodetector;
7 — Fixed mirror;
8 — Movable mirror;
9 — Mechanical drive of the movable mirror;
10 — Photodetector lens;
11 — Photodetector;
12 — Computer that controls and processes the interferogram;
13 — Beam splitter plate.

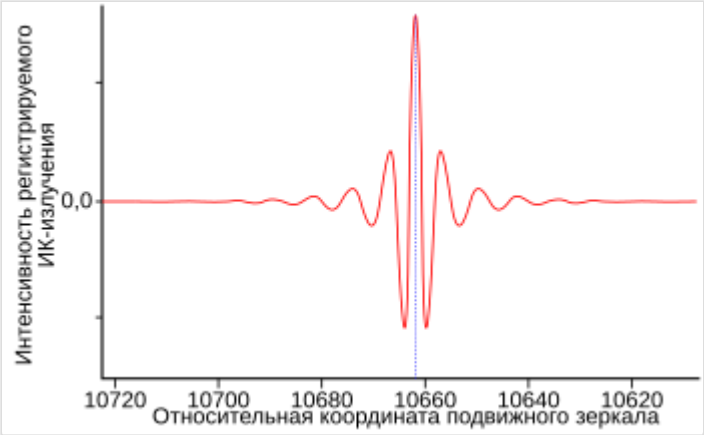
Operating principle

The main element of the Fourier spectrometer is the Michelson interferometer .

Let's assume that we have a coherent radiation source with a certain wavelength. When the path difference of two rays arriving at the receiver is equal to $\lambda/2$ (i.e. the beams arrived in antiphase) the light intensity registered by the receiver is close to zero. When the right mirror of the Michelson interferometer is moved , the beam path difference changes, and the light intensity registered by the receiver also changes. It is obvious that the light intensity is maximum when the beam path difference is a multiple of the wavelength λ.

When the mirror is moved, the receiver output will show a sinusoidal electrical signal depending on the mirror coordinate. The sinusoid period depends on the source wavelength, and the amplitude on the source intensity.

Now imagine that there is a non-monochromatic source at the input. Radiation with each wavelength in the spectrum of the light source will produce its own sinusoid at the output of the receiver, these sinusoids are summed up, so at the output of the receiver we get a complex signal. When performing the inverse Fourier transform on the received signal , taking the coordinate of the moving mirror as a variable, we obtain the spectrum of the input electrical signal, which is also the spectrum of the radiation of the source (that is, the intensity of the radiation of the source at different wavelengths).



Interferogram of polychromatic radiation. When the difference in path lengths to the mirrors is zero, maximum interference is observed.

Application for gas composition analysis of a sample

Each gas has its own absorption spectrum of the radiation passing through it. Moreover, the absorption value depends on the concentration of the given gas.

Usually, a cuvette is installed at the entrance of the Fourier spectrometer, through which the analyzed gas mixture is pumped. On one side of the cuvette there is a light source, on the other side there is a Michelson interferometer . Thus, the spectrum at the entrance of the interferometer will have "gaps" at certain wavelengths. After the inverse Fourier transform , we obtain the absorption spectrum , by which it is quite easy to determine the gases present in the analyzed air and their concentration.

Application

- Ecology and environmental protection : determination of the concentration of harmful substances in the air.
- In control systems of internal combustion engines (for example, lambda probe).
- In explosive and fire hazardous industries to determine the content of flammable gases as a percentage of the LEL .

See also

- Fourier transform spectroscopy
- Spectral analysis

- Gas analyzer

Links

- Fourier Transform Spectrometer (http://scienceworld.wolfram.com/physics/FourierTransformSpectrometer.html) // Wolfram (English)
- Fourier transform spectroscopy (http://thesaurus.rusnano.com/wiki/article1937)
- Homemade Fourier Spectrometer / Habr (https://habr.com/ru/post/253947/)

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