Fraunhofer IPM

Q-FTIR
Quantum Fourier transform infrared spectrometer

Mid-infrared interaction observed with a silicon detector

Making the »invisible« visible: Using entangled photons and quantum mechanical interference effects, midinfrared spectra of molecules can be detected with silicon detectors. The Q-FTIR is no longer a laboratory setup for specialists but a portable device for on-site tests.

The mid-infrared wavelength range carries a wealth of spectral and structural information that can only be harvested by suitable light sources, sensors, and measurement schemes. Q-FTIR by Fraunhofer IPM is a novel technology platform merging the concept of entangled pairs of near- and mid-infrared photons with classical Fourier transform infrared spectroscopy for a new path towards performant and efficient mid-infrared spectroscopy.

Finding the right tool for your infrared spectroscopy task

Spectral information on molecules, chemical compounds and organic substances is useful in contexts such as chemical production, environmental control and health monitoring. It is often available in the mid-infrared wavelength range. But there is a challenge: Light sources, optical components, detectors and cameras are technologically well-advanced for »everything visible« while generation and detection of mid-infrared radiation is much more challenging and expensive, often requiring cryogenic cooling. Our approach is to »spectrally separate« the interaction of the mid-infrared radiation with the sample from the recording of the spectral information. The latter can then be performed with a wavelength suitable for ordinary cameras or sensors.

Tailor-made photon pairs bridge the wavelength gap

Pairs of correlated photons can be used for this purpose. They are created by a pump beam illuminating a suitable nonlinear-optical crystal. Here, the pump photons are »split« into photon pairs in the following way: The »signal« photon carries a wavelength visible for the camera, while the wavelength of the idler« photon is tailored for the interaction with the sample. To pass information from the idler to the signal photons, an interferometer is constructed, comprising two such sources

Fraunhofer Lighthouse Project

Quantum Methods for Advanced Imaging Solutions

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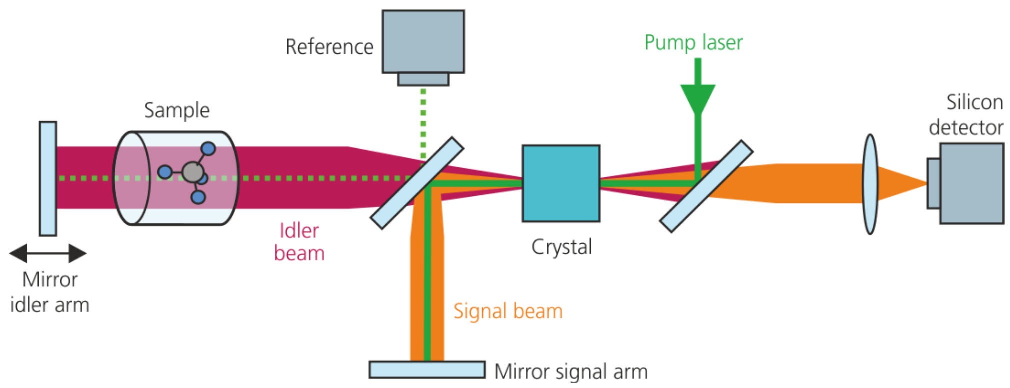
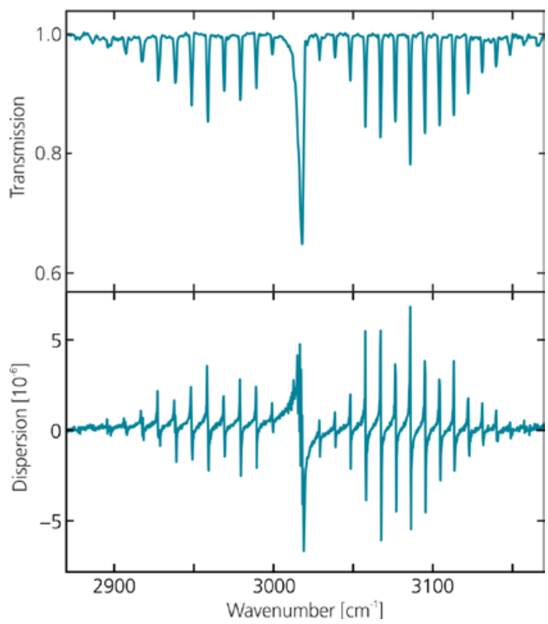
QUANTUM PHOTONICS by FRAUNHOFER



The »entangled version« of the Fourier transform spectrometer: The idler beam interacts with the sample, but the detector records the interferogram generated by the signal photons.

of correlated photons. Pump, signal and idler beam from the first process overlap in the nonlinear crystal. They influence the generation of the second signal and idler pair and hence the interference pattern created by the first and second signal photons. This way, any modification of the mid-infrared idler beam in amplitude or phase is transferred onto the signal interference and becomes visible for a silicon-based detector. Thanks to the high sensitivity of these detectors, mid-infrared spectroscopy can be performed with extremely low optical power.

Exploiting that interferometer approach even further, the setup developed by Fraunhofer IPM operates like a Michelson interferometer as found in classical Fourier transform spectrometers. The interferogram is recorded using a single-pixel detector while moving the mirror of the idler arm. A subsequent Fourier transformation reveals the full spectral information. The advantage: Wavelength range and spectral resolution can be tailored to the sample to be analyzed (gas, liquid or solid) without changing the detector unit. With the sample placed in the idler arm, both absorption and dispersion of the sample are recorded simultaneously.



Transmission and dispersion of gas samples can be measured with high resolution and sensitivity (here: methane).

A new technology platform

In its current version, the Q-FTIR platform operates in the wavelength range between 3 and 4 µm and offers a spectral resolution better than 1 cm^{-1}, giving access to absorption bands of hydrocarbons and polymers.

It is intended to serve as an exploration tool for identifying applications which benefit from the tailored emission range. Designed as a self-contained unit including pump laser, optics, electronics and data processing, it is available for on-site tests to open up novel research fields.

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