

## THE DYNAMIC FOURIER-SPECTROMETER FOR RAMAN STAND-OFF DETECTION OF CHEMICAL COMPONENTS

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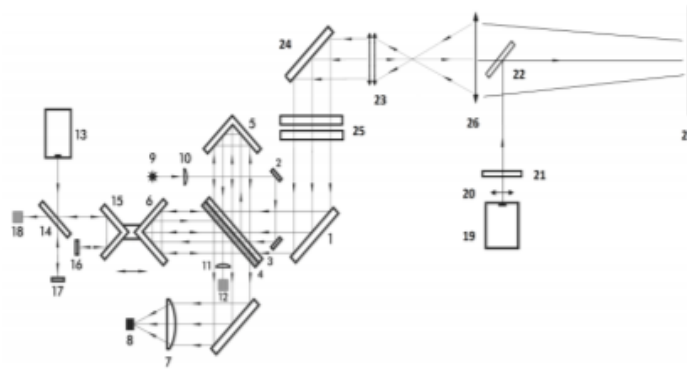
**Introduction.** Raman spectroscopy is widely used to detect and identify chemical compounds. This is because it has a higher selectivity [1-4], which makes it possible to distinguish very similar molecules and chemical compounds. A disadvantage of the method using Raman spectroscopy is a small scattering cross section. Therefore, registration of Raman spectra requires to use high-aperture system. For the analysis of Raman spectra, diffraction spectrometers are mainly used. Instead of diffraction spectrometers, static [6-8] or dynamic Fourier spectrometers [4, 9] can be used. They can provide a large luminosity [4, 5]. It is important for remote analysis or analysis of a small amount of substance.

The layout of a dynamic Fourier spectrometer for distance obtaining Raman spectra in visible and near-IR spectral range is presented in this work.

Layout is shown in Fig.1. The spectrometer consists of four main parts: a measuring channel, a "white light" channel, a reference channel and a Raman attachment for excitation and collection Raman scattering of light, Fig.1.

The emission spectra are observed in the wavelength region 1000-1500 nm, which corresponds to frequencies of 240-3,500  $\text{cm}^{-1}$ .

To excite the Raman spectra, a wavelength-stabilized diode laser with a wavelength  $\lambda = 976$  nm, optical power 27mW is used. A laser spectral line width is  $\delta\lambda = 0.5$  nm (at a level 90 %). To stabilize the laser, a temperature and current controller is used. Laser is stabilized at temperature 25 degree, which provided the position and spectral line width of the laser line.



**FIGURE 1.** Layout of dynamic Fourier spectrometer

A high sensitivity single-element photodetector IG17X3000T9 with cooling systems is used as a photodetector for registration Raman scattering. Cooling system allows to cool photodetector to minus 20 degrees.

The noise equivalent power (NEP) and detectivity ( $D^*$ ) are  $1,10 \cdot 10^{13} \sqrt{\text{Hz}} \cdot \text{cm/W}$  and  $1,3 \cdot 10^{-14} \text{ W}/\sqrt{\text{Hz}}$

In the construction of the interferometer corner reflectors with a second accuracy of the deviation between the incident and reflected rays are used as mirrors. It provides reliability and high stability of the spectrometer in long-term measurements [10, 11].

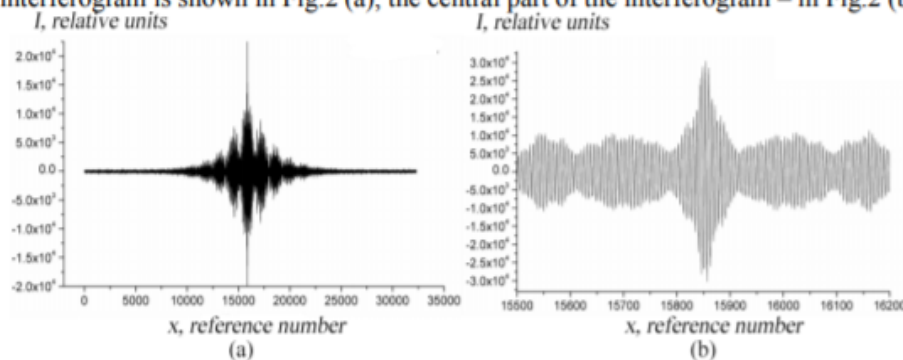
To accumulate of interferograms and correct summation when a weak signal is registered "white light" channel is implemented. It allows to increase the signal / noise ratio in  $\sqrt{M}$ , there  $M$  - the number of summed interferogram.

Also a reference channel with a sampling frequency of  $\lambda/4$  was realized, that further leads to an increase stability and the expansion of the spectral range of work [11].

With the use of the developed spectrometer, experiments of registration interferograms and reconstructing the Raman spectrum spectra from test sample was carried out. As a test substance was used stilbene ( $\text{C}_{14}\text{H}_{12}$ ), acetylsalicylic acid ( $\text{C}_9\text{H}_8\text{N}_2\text{O}_4$ ). These substances was chosen because their spectrum is well known and their Raman cross section is week [10 - 12].

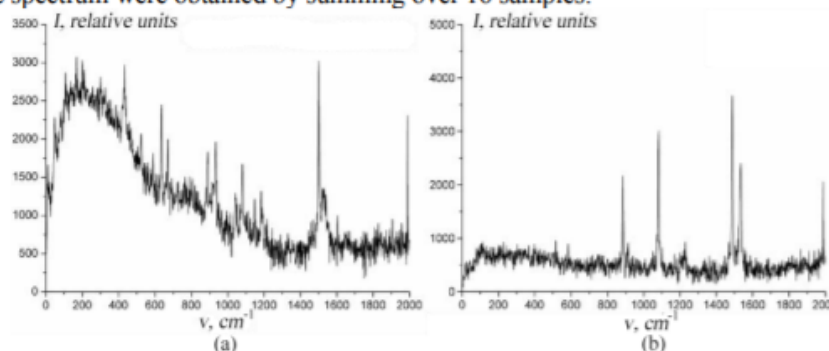
In the developed Fourier spectrometer, a two-sided interference with a total number of points 34000 are recorded. It ensures a spectral resolution of  $2 \text{ cm}^{-1}$ .

An example of a recorded two-sided interferogram of stilbene Raman scattering is shown in Fig. 2. The full interferogram is shown in Fig.2 (a), the central part of the interferogram – in Fig.2 (b).



**FIGURE 2.** Registered interferogram

To reconstruct the Raman spectrum, a full Fourier transform is used [4]. The Raman spectra of the acetylsalicylic acid and stilbene are shown on Fig.3. The samples were located at a distance of 2 meters. The spectrum were obtained by summing over 16 samples.



**FIGURE 3.** Raman spectrum of acetylsalicylic acid (a) and stilbene (b)

On the shown spectrum, separate emission peaks, which correspond to the Raman scattering of test sample, are observed. The main emission peaks in the Raman spectrum of stilbene are located at the following frequencies  $\nu$ :  $1641\text{ cm}^{-1}$ ,  $1597\text{ cm}^{-1}$ ,  $1196\text{ cm}^{-1}$ ,  $1000\text{ cm}^{-1}$ , and the main peaks of acetylsalicylic acid are located on frequencies  $\nu$ :  $3068\text{ cm}^{-1}$ ,  $2936\text{ cm}^{-1}$ ,  $1604\text{ cm}^{-1}$ ,  $1297\text{ cm}^{-1}$ ,  $1042\text{ cm}^{-1}$ ,  $748\text{ cm}^{-1}$ ,  $552\text{ cm}^{-1}$ . Location and number of main peaks in the Raman spectrum, obtained on a dynamic Fourier spectrometer, corresponds to the reference spectrum. Signal noise relation are 39,4 for stilbene and 23,4 for acetylsalicylic acid.

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