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Interaction of phase-diffusion field with a molecular gas

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Abstract. You should leave 8 mm of space above the abstract and 10 mm after the abstract. The heading Abstract should be typed in bold 9-point Arial. The body of the abstract should be typed in normal 9-point Times in a single paragraph, immediately following the heading. The text should be set to 1 line spacing. The abstract should be centred across the page, indented 17 mm from the left and right page margins and justified. It should not normally exceed 200 words.

The coherent signal induces macroscopic polarization in the molecular gas at the resonant frequency [1]. Based on this molecular response concentration of studied component of the gas mixture is determined with high accuracy [2]. To obtain high resolution a source with extremely narrow generation lines is usually used. This is achieved by applying a phase-lock loop (PLL) system combined with an adjustment system, which considerably complicates the device structure.

An alternative way is to use a radiation source with a noise signal. Previously it was predicted [3] that phase-diffusion field (PDF) of the terahertz range induces in the system macroscopic polarization comparable in magnitude to the polarization in case of a coherent signal. The PDF source does not require a PLL system that simplifies the spectrometer. In this case the resolution is determined by the spectral characteristics of the receiver.

At present the only spectrometer using a noise radiation source in THz ranges is a Fourier transform spectrometer based, for example, on a heated ceramic plate. This radiation source generates almost "white" noise and requires a Michelson interferometer to obtain the molecular spectra. Spectral resolution in this case is determined by the finite path of a moving mirror which is insufficient for gas spectroscopy.

The present study is aimed to demonstrate a new method of GHz absorption spectroscopy based on the noise source of radiation.

The experiment was as follows: the source emitting phase-diffusion signal was an oscillator based on the stacks of $Bi_2Sr_2CaCu_2O_8$ (BSCCO) intrinsic Josephson junctions [4-5]. The backward-wave oscillator was used as a source of coherent signal [6]. As a molecular gas the ammonia mixed with water (10% solution) was probed. The signal was measured by the superconducting integrated receiver with local oscillator phase locked at

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566 GHz and intermediate frequency region 4 - 8 GHz [7-8]. As the results of measurements the absorption line at 572.5 GHz was observed.

The working area of BSCCO was in the frequency range of 400-600 GHz, the linewidth approximated by the Lorentz profile was reached 200 MHz [9[. In the case of BSCCO linewidth a hundred times larger than the linewidth of the molecular spectra, on the spectral characteristics the power drawdown was observed. This value of power was equal to the power absorbed by molecular gas. Thus the absorption coefficient of ammonia was calculated as the ratio of the absorbed power to the incident one.

In the experiment with source of coherent signal the backward-wave oscillator operating in the output range of 450 - 750 GHz was equipped with a phase-lock loop system to obtain a narrow linewidth of 20 kHz. For spectral line narrower than the linewidth of the molecular spectra it was necessary to change the frequency and register the maximum transmitted power depending on the frequency.

Thus the absorption coefficient was derived for both cases and the comparison the values obtained with two different sources were performed. Taking into account the measurement errors the obtained absorption coefficients for the case of coherent signal and phase-diffusion field was close enough. Possible reasons for the observed small deviations may be the following factors:

- In the case of phase-diffusion field there was insufficient power reached the receiver after the absorption of the gas. As a result, the signal-to-noise ratio and the absorption coefficient decreased.

- According to the theory, a noise signal in contrast to the coherent one provides general heating of the system. This decreases the difference of level populations, and, consequently, decreases the absorption coefficient.

Thus the work has investigated the possibility of using the phase-diffusion field for detection of the molecular spectra in the THz range. It is shown that the interaction of PDF with gas leads to macroscopic polarization comparable to the polarization in case of a coherent signal. Investigations demonstrate the possibility of practical application of the phase-diffusion field in the THz range high-resolution spectroscopy. In particular the BSCCO generator can be used to develop compact THz spectrometer with high resolution

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