Multicolor Pump-probe System with the Broadly Tunable Range Frequency Difference for THz Vibrations Studies

P.D. Rudych
Institute of Automation and Electrometry,
SB RAS,
Novosibirsk, Russia

Abstract—Solvations of molecules in water are at the heart of understanding of chemical reactions and biological processes. Study of THz vibrations in water is a clue to the process understanding. We report the method of pumping THz vibrations in water and the measurements of its interactions with probe light

Keywords—CARS; terahertz; water vibrations

I. INTRODUCTION

A lot of THz wave applications require the THz wave excitation in the sample. By complementing well-established approaches, it has been shown, that laser spectroscopy in THz offers new insights into hydration from small solutions to proteins and lipids. Competing the direct THz waves irradiation and absorption, using of two-color pumping systems with the THz wave shift has some advantages of enhancing the THz vibrations localized in small area in media and opens the possibility of study by microscopy technique. The common visible-range lasers can be used for exciting the THz vibration in the sample and the interactions of the THz sample phonons with the visible light lead to the anti-stokes shift of the visible light, that can be directly measured with the detector suitable for the visible light.

II. EXPERIMENTAL SETUP

One of the methods of producing of radiation with the steady permanent frequency outtune between the colors is based on usage of the Fabri-Perot resonator filled by active emissive media. In this scheme the color outtune is direct natural property of resonator modes, which is strictly connected with resonator length. To get the THz outtune the length of resonator have to be in sub millimeter range. If the media irradiation spectrum is high enough to produce multiple light modes, each two near modes have exactly the same frequency difference as the other pairs and excite the THz wave of the same frequency. The THz wave thickness is formed by free spectral range of the interferometer. The high stabilization of resonator base length provide the high stabilization of THz wavelength.

The amount of ultrathin resonators was constructed with the length from 40 mkm up to 1 mm. The frequency separation $df$ if defined by resonator length $a$:

$$df = \frac{c}{2dn}$$

Here, $c$ is the light velocity and $n$ is a refractive index of the dye, used as a active media. The dye was pumped with the Nd:YAG pulse laser with the subnanosecond pulse duration. The high conversion efficiency of pumping energy to the multicolor was obtained. High frequency and intermode stability was achieved. Obtained high finesse of generated modes leads to the high spectral quality of THz. The possibility of tuning the THZ shift difference was demonstrated in the wide range.

III. RESULTS

As the first experiments to demonstrate setup operation we used the pure liquid water as a sample media. The yellow lines from dye laser were focused in the sample and generate the THz vibrations and the green probe 532 nm light scatters after interactions with the coherent set of THz one. The interaction shifts the wavelength of probe light to anti-stokes direction (the spectrum shown on figure 1). The THz outshifted comb is dominate on the spontaneous anti-stokes radiation background.