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Tunable diode-laser spectroscopy of the para- and ortho-water vapour as a tool for investigation of metastable states of liquid water

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A possible mechanism of the electromagnetic (EM) field effects on biological systems relates to altered states of liquid water. The alterations are induced by the EM field and transduced then on biological level due to participation of water in various metabolic reactions. Therefore, the question is raised of what in water could be the target for EM fields.

Metastable changes in physical properties of liquid water have been discussed earlier in both experimental and theoretical works. Low frequency spectra of the electric conductivity of liquid water under EM field exposure were studied in [Fesenko et al., FEBS L. 367:53] and ascribed to formation of clusters of water molecules. Metastable changes of water structure were observed [Lobyshev et al., J. Mol. Liquids 82:73] as changed UV luminescence spectra and assumed to stem from defects of water structure at the microscopic level. In [Binhi, Biophysics 40(3):671], nuclear spins of protons of water were considered as primary target for the external magnetic field. It was suggested that proton spins take part in spin-orbit interactions thus modifying proton motion and influencing the rate of water clusters formation and breakup. Later, it has been experimentally detected that magnetic field tuned for proton magnetic resonance actually changed the adsorption rate of the ortho-fraction of water that had been measured by means of sub-millimeter spectroscopy of water molecules in vapor [Konyukhov et al., Short Comm. Phys. FIAN (1–2):12]. However, this technique is rather difficult for regular measurements of different water samples and solutions.

The middle IR spectral region is more suitable for such a study. We consider an indirect method to study liquid water states. The method is the IR spectroscopic measurement of the ratio para-H_2O/ortho-H_2O above the water sample surface. It is based on the fact that the vibrational IR spectra of many molecules depend on their nuclear spin state. First, it should be selected a narrow spectral range including two close lines belonging to the different water molecule modifications [Stepanov et al, UFN, 170(4)]. If they are of the same quantum transition, the relative heights of lines equals 1:3, natural para to ortho composition of water. Figure below depicts two different spectra of water molecules in para and ortho states that include such lines. These lines are close enough to be covered by one single mode of proper tunable diode laser and thus variations in partial content of the different water modifications could be measured precisely with an accuracy of better than 1‰.

The method may be used for investigation of metabolic processes and biochemical reactions with proton exchange. Supposedly, mixtures of water and gases like $^{13}CO/^{12}CO$, H_2O_2, NH_3 will bring different para/ortho ratios at the liquid's surface after exposure to magnetic fields. As far as water molecule in triplet state possesses a magnetic momentum, the method is also suitable to explore magnetic field effects on the above biochemical reactions and separated water samples.

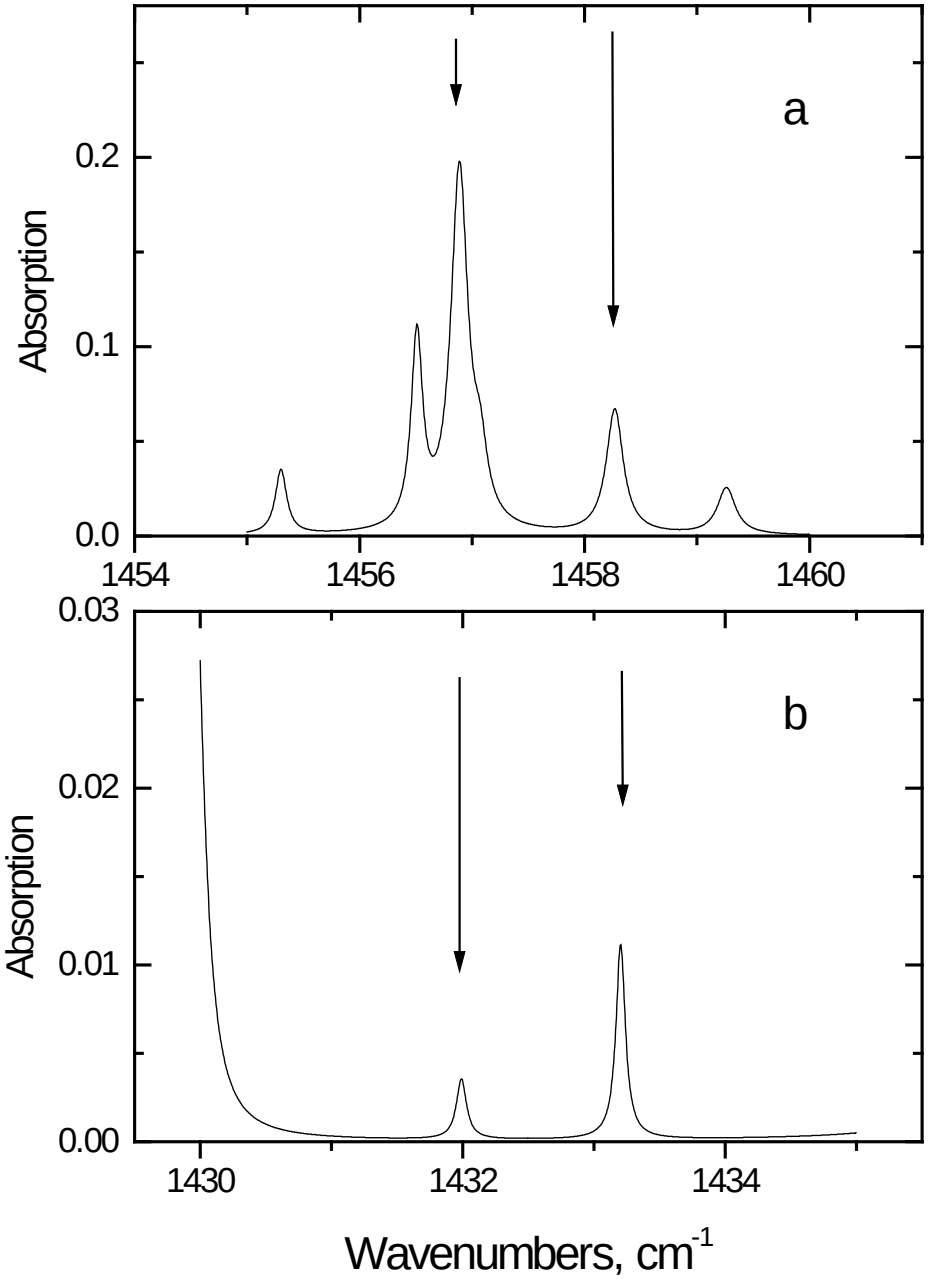

Figure. Water vapour absorption lines from ν_2 fundamental band suitable for the para/ortho ratio detection , a — 221–330 and 220–331 vibration-rotational transitions, b — 919–928 and 909–918 vibration-rotational transitions.