ORTHO H_2O ENRICHMENT of WATER: THz FOUR-PHOTON and NMR SPECTROSCOPY

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It is known that the ortho-para nuclear spin isomers of H_2O, H_2 and others molecules are different due to orientation of the hydrogen spin. The ortho-isomer has parallel spin (the total nuclear spin is unity, *J=1*) and para-isomer – the total nuclear spin is zero, *J=0*. According to the quantum statistics these isomers have the equilibrium ortho/para ratio (OPR) 3:1 in air at the room temperature. Moreover, the ortho/para conversion is strongly forbidden in the dipole approximation. For instance, the liquid para-hydrogen can be stored for the several months without conversion into the ortho-isomer. The presence of paramagnetic impurities reduces the relaxation time to the equilibrium ortho/para ratio. Nevertheless, the divergence from the OPR equilibrium state for a long time was observed not only in the liquid hydrogen, but also in water gas phase. The ortho-H_2O enrichment of water vapor up to OPR value 10:1 [1] and 5:1 was achieved by the water vapor transfer through the porous surface.

Recently, the rotational resonances of H_2O molecules in water were observed by four-photon spectroscopy in the low frequency 0-100 cm^{-1} (0 - 3 THz) range. It was established that the rotational transition frequencies coincide with the H_2O resonance lines in a gas phase. The rotational lines of ortho and para-spin isomer of H_2O was identified also [2]. The spin-selective interaction of para-H_2O with proteins and DNA was observed in its aqueous solution [3].

We present here the experimental data, which indicate ortho-H_2O enrichment of liquid water, which passed through cavitation treatment procedure such as ultrasonic fountain evaporation or treatment in specially designed cavitation chamber (US patent 6,521,248). To verify the obtained results both four-photon and NMR spectroscopy measurements were also done. NMR signal was measured in proton density units. Twofold raise of ortho-H_2O line amplitude of four-photon spectra and 17% increase of proton density in NMR signal were shown.

The following mechanism seems plausible: The enrichment of distilled water by ortho-isomer H_2O molecules occurs after cavitation treatment of water because its passes through the supercritical state – high temperature (up tp 10 000 K) and pressure. As a hole the behavior of two water molecule fractions (protons and hydroxyls) due to this state, and particularly the resulting proton spin orientation, is rather complicated and not well understood. Nevertheless the ortho/para ratio should be not greater than the equilibrium value of 3:1 according to the quantum statistics at the high temperature when the recombination of H_2O molecules were occurred. So the observed enrichment of water by ortho-H_2O due to cavitation procedure shows us that the ordinary state of water at the room temperature is non-equilibrium in sense of the spin temperature.

ОБОГАЩЕНИЕ ВОДЫ ОРТО-ИЗОМЕРАМИ H_2O: ТГц ЧЕТЫРЕХФОТОННАЯ и ЯМР СПЕКТРОСКОПИЯ

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Эволюция орто/пара отношения спин-изомеров H_2O в дистиллированной и кавитационной воде изучалась методом терагерцовой четырехфотонной спектроскопии и ЯМР спектроскопии. Было установлено 2-кратное увеличение амплитуды линий орто-H_2O и 17% увеличение ЯМР сигнала в единицах протонной плотности.

References

1. Tikhonov V.I. and Volkov A.A., *Separation of Water into ItsOrtho and Para Isomers* // Science 2002, **296**, 2363.
2. Bunkin A.F., Nurmatov A.A., Pershin S.M., *Four-photon spectroscopy of ortho/para spin-isomer H2O molecule in liquid water in sub-millimeter range //* Laser Phys. Lett. 2006, **16**, 468.
3. Bunkin A.F., Pershin S.M. *Four-wave mixing spectroscopy of hydration layers in biopolymers and carbon nanotubes aqueous solutions* // J. of Raman Spectrosc. 2009, **40**, in press.