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LASER INDUCED ACOUSTIC PULSES IN SOME LIQUIDS

ВОЗБУЖДЕНИЕ АКУСТИЧЕСКИХ ИМПУЛЬСОВ В НЕКОТОРЫХ ЖИДКОСТЯХ ПРИ ПОМОЩИ ЛАЗЕРА

PETR LOKAJ*, PETR SLADKÝ*, Praha

Thermoelastic waves generated by the absorption of light energy have been well known since the end of the last century from the works of Bell [1], Tyndall [2] and Roentgen [3]. Recently there has been a revival of this effect, which is now generally known under the name photoacoustic effect (in contradistinction to the acousto-optic effect caused through elasto-optic coupling) [4].

It is the purpose of our brief contribution to describe a simple photoacoustic cell for the photoacoustic spectroscopy of liquids in the medium power range of the laser light and to present some preliminary results on laser induced acoustic pulses detected with the aid of this cell.

The cell is constructed in the form of a cylindrical cuvette, consisting of a ring made from radially polarized piezoelectric ceramics and circular glass windows. The windows were fastened to the piezoceramic ring through two "O" ring seals by means of a metal frame with screws (see Fig. 1). The charging of the cell with the liquid under study was accomplished simply through the "O" ring seal with the aid of an injection syringe needle.

The experimental arrangement is shown in Fig. 2. The preliminary experiments were performed with the Q-switched Nd : Glass laser ($\lambda = 1.06$ μm) of 20 MW power and 30 nsec pulse width. A set of neutral filters was used to vary the light intensity from 2 to 100 %. The output light was monitored by means of the fast planar photodiode (FPPD). The signals from FPPD as well as from the photoacoustic cell were directly displayed on a double beam storage oscilloscope.

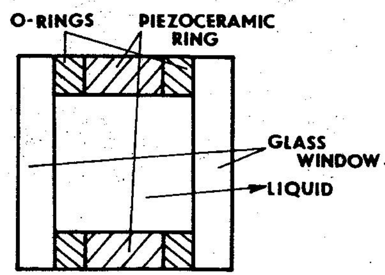

Fig. 1. Photoacoustic cell.

* Katedra chemickej fyziky, Matematicko-fyzikálna fakulta Karlovej univerzity, Ke Karlovu 3, CS-121 16 Praha 2.

The first measured liquid was 96 % ethanol. The voltage pulses from the laser induced sound pulses were of the shape shown in Fig. 3. When the light beam enters the central area of the piezoceramic ring within one half of its diameter, the form of the signal and the peak to peak maximum voltage pulse are very well reproducible. The roughly estimated acoustic power yielded ~0.1 W at e^{-1} pulse width of 200 μsec. The acoustic parameters of the cell filled with ethanol (i. e. the resonance frequency and the mechanical Q) established from the optically induced acoustic signal were 50 kHz and 60, respectively, and were within a 5 % agreement with the electrically measured acoustic parameters of the cell alone. Similar results were obtained for other pure liquids (distilled water, aceton, xylen) and coloured liquids for light pulse energies less than their electric and mechanical strength.

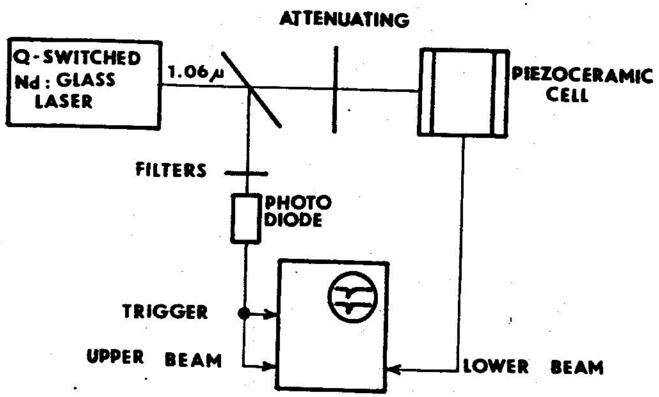

Fig. 2. Experimental arrangement.

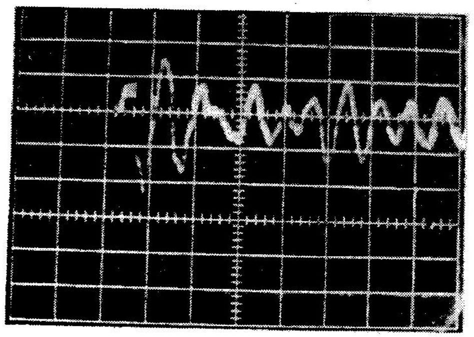

Fig. 3. Voltage pulses laser induced sound pulses in 96 % ethanol. Time scale 25 μsec per div.

Fig. 4 shows the typical dependence of the photoacoustic signal (open circuit transducer voltage) vs. the laser pulse energy. The dependence is through the described results (10^2) linear within the experimental error. Similar results (i. e. the linear dependence) were obtained for the other liquids except the different slope.

An interesting result was obtained: namely, a surprisingly small mean square deviation for each series of ten shots (with a ~30 sec repetition rate). At the begining of the experiment it yielded 2 %, after approximately 30 minutes it was 0.5—0.75 %.

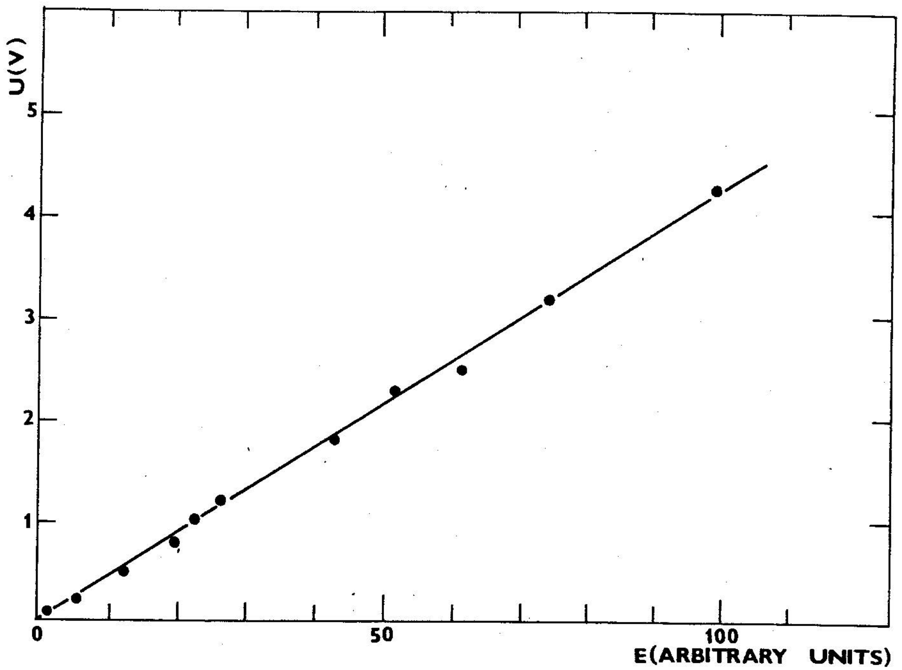

Fig. 4. Photoacoustic signal vs. laser pulse energy.

Despite a lack of detailed theoretical considerations (i. e. a detailed interaction mechanism), supposing only the laser pulse energy to be under the threshold level of mechanical and/or dielectric strength of liquids, we can draw some preliminary conclusions. 1. The photoacoustic signal is linearly dependent on the input energy of the laser pulse at least over two orders of magnitude between approximately 0.2 and 20 MW cm^{-2}. This is in agreement with the results of previous measurements by authors [5, 6] and the theory of the effect [7, 8]. 2. The low fluctuations of the photoacoustic signal indicate a low fluctuation of the power of the used laser. Even with such a simple arrangement the cell is very suitable as a laser radiometer in the above mentioned power range. This is also one possible application of the cell. The second application is the use of the cell in measurements of acoustic properties of liquids. The last possible application of the cell is its use for the photoacoustic spectroscopy of liquids especially in conjunction with the dye laser source. This application needs of course a detailed knowledge of both acoustic and optical spectral properties of the cell itself.

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