P-42: Device for the HIFU Cavitation Activity Monitoring

Nikolai V. Dezhkunov*, Mikhail P. Fedorinchick, Alexzander V. Kotukhov

BSUIR, P. Brovka St.6, 220013, Minsk, Belarus, dnv@bsuir.by

A device for the HIFU cavitation activity investigation and measurements, Cavitometer ICA-3HF, is described in the presentation. The Cavitometer consists of an electronic block and a wide-band hydrophone protected against cavitation erosion. Main application of the device is detection of cavitation in liquids and biological tissues and measurement the cavitation activity. Its operation principle is based on analysis and elaboration of cavitation noise spectra. This principle was backgrounded by the investigation the cavitation noise spectra generated at different conditions.

Voltage U applied to the transducer was increased linearly in experiments. Sonoluminescence intensity L and hydrophone output H were recorded simultaneously with the noise spectra registration. Figure 1 shows spectra of the hydrophone output registered at different stages of the HIFU cavitation zone development for pulsed irradiation in 720 kHz focused ultrasound field, pulse periods T=30ms and pulse durations τ=3ms.

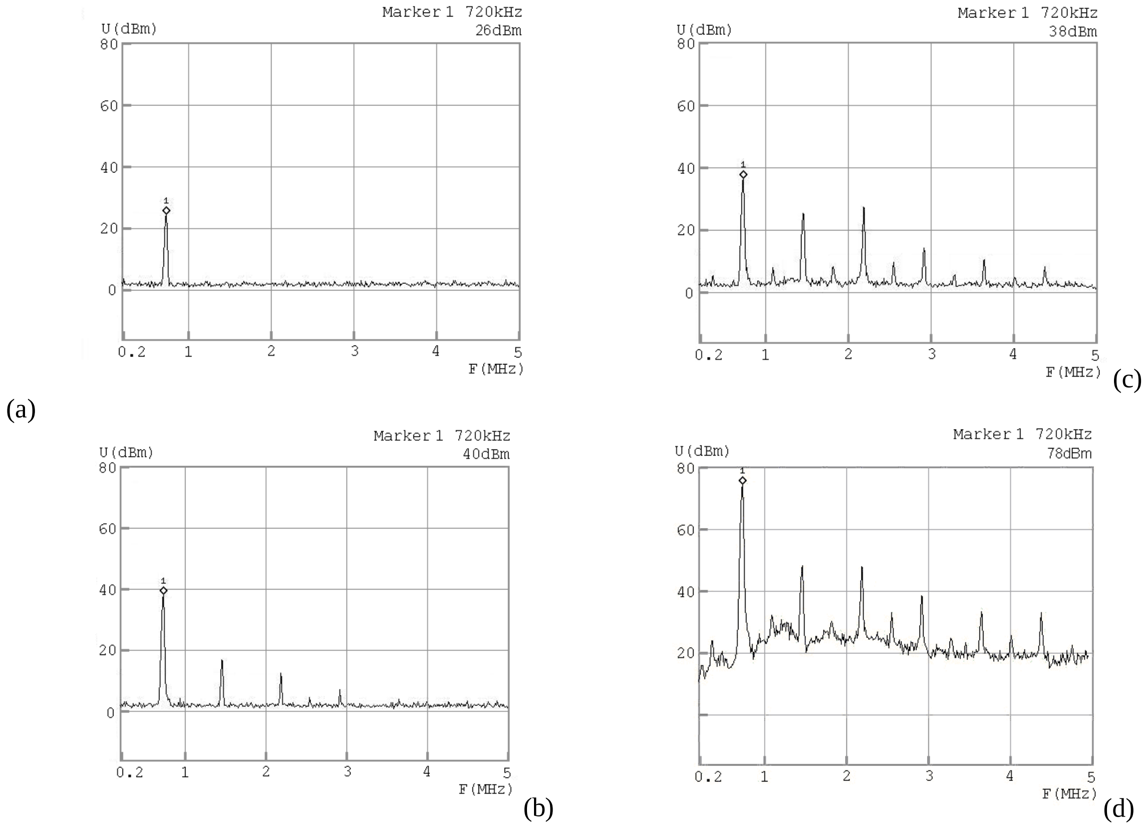
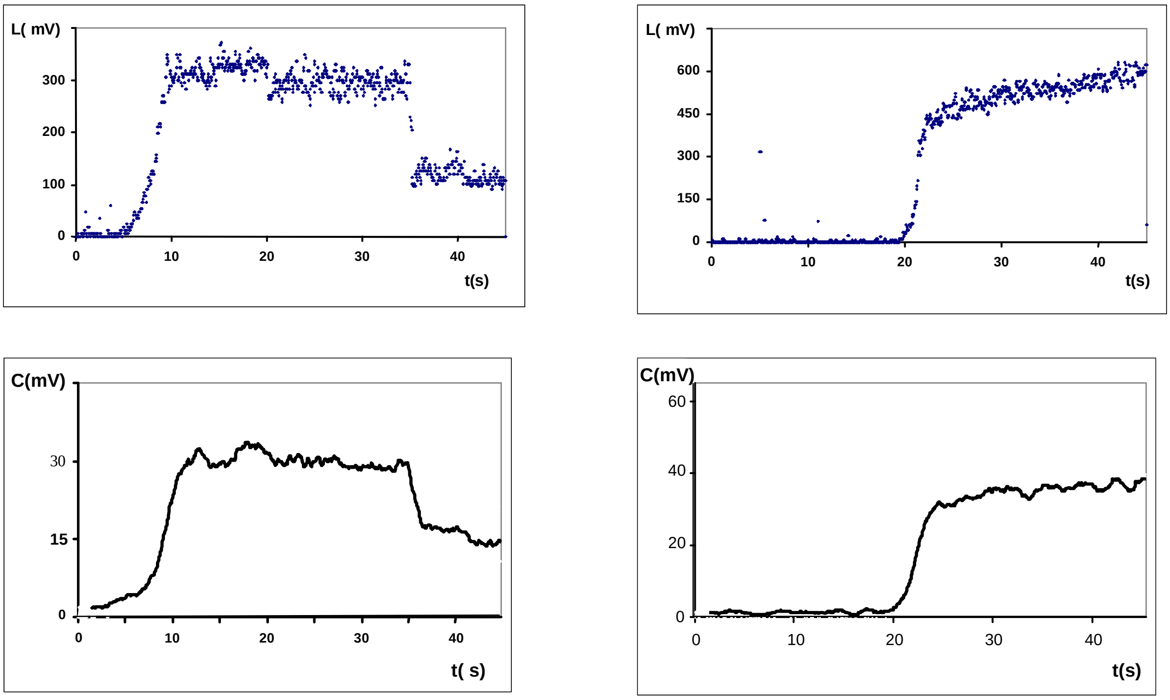


Figure 1: Spectra of the hydrophone output at different stages: stage1(a) below cavitation threshold , stage 2(b) non-linear bubbles pulsation and SL emission appearance threshold, (c)- stage3(c) low intensity SL emission, (d)- stage 4: high intensity SL emission.

At the beginning the hydrophone output increases linearly with increasing the applied voltage. This means that the absorption of ultrasound energy is not increased under ultrasound in this condition (stage 1) and that the volume concentration of bubbles in the focal zone of the transducer is negligible. Then the slope of H(U) curve tends to decrease, evidently as a result of the appearance of cavitation bubbles in the focal zone (stage 2). The onset of the SL emission is accompanied normally by the onset of the higher harmonics and wide-band pattern in the cavitation noise spectra (fig. 1c). SL intensity grows smoothly after its appearance with voltage U applied to the transducer (stage 3). Absorption of ultrasound energy in cavitation zone increases as well. The hydrophone output begins to give pulses having spread intensities. The deviation of the H(t) curve from the straight line and the spreading of intensities of H pulses are caused evidently by bubbles in the focal zone. Big stable bubbles and bubbles in the growth phase decrease acoustic transparency of the focal region; this could be the reason of decreased peak values of the hydrophone output. Collapsing bubbles produce shock waves, which may be the reason of higher H pulses. At some critical value of voltage U the SL intensity increases in a jump-like manner and the slope of L(U) changes considerably. This situation we call here the second threshold, as it was proposed by Dezhkunov et.al (2008). Both maximal and average values of H in this condition are decreased abruptly. At ultrasound intensities higher than the second cavitation threshold (stage 4) both wide-band pattern of spectra and harmonics increase when SL intensity increases.

Figure 2 shows examples of simultaneous recordings of sonoluminescence intensity L (upper recordings) and the cavitometer C output recordings at different conditions of cavitation zone development (left and right columns).



(a) (b)

Figure 2: Results of simultaneous recordings the photomultiplier output (SL intensity – upper curves) and the Cavitometer output (C – lower curves). Ultrasound pulse parameters: pulse period T=30ms(a) pulse duration τ=3ms

The driving voltage U_{p-p}=240V was applied to the transducer at t=0, and then it was decreased in a step-like manner to U=160 approximately at t=35s (a). In the case (b) voltage was constant U_{p-p}=240V as well as pulse duration τ=3ms, pulse period T was decreased with velocity 10ms/s starting from T=300 ms.

It is seen from the above data that the cavitation activity data produced by the Cavitometer are correlated rather well with the sonoluminescence intensity.

Acknowledgements

The research has been supported by the Belarusian Foundation for Fundamental Research and by the University of Trieste.

References

Dezhkunov N.V., Francescutto A., Calligaris F., Ciuti P. and Sturman F., 2008, In the book: Non-linear acoustics – fundamentals and applications. Melville, New-York (Proceedings of 18-th International Symposium on Non-linear Acoustics), 193-196.