1 Abstract

The apparatus description for control of the time parameters of photomultipliers with high time resolution is described. For generation of ultrashort light flashes have been used sonoluminescence effect – emission of the light flashes which is appearing at the stressed interior of collapsing air microbubble by sound wave in water.

2 Introduction.

The modern experiment demands of photoelements with a high time resolution. That problems arises at diagnostic of short electron bunch by synhrotron radiation and the high energy physics experiments, where is used often the time of flight methods of measurements. For this experiments it is necessary to realize metrological attestation of photoelements. Therefore, it is very important to create effective, inexpensive device for generation ultrashort light pulses. This light source have to possess sufficient brightness and wide spectral range. For generation of ultrashort light flashes have been used the sonoluminescence (SL) effect.

The SL phenomenon was discovered in 1934 [1] and until present time is remaining enigmatic one. As it turned out, that SL flashes are possessing of unique parameters:

- at the each flash emit $10^5 - 10^6$ of photons in spectral range from 150 to 800 nm[2];
- the emission spectrum of the flash fit to one of black body at effective temperature about 50000$^\circ$K;
- the flash duration is very small $\tau \leq 10$ psec[3, 2];
- the dispertion of time interval between flashes is about 100 psec[3];
- size of emission region is less than 3 $\mu$m;
- position stable of emission region is better than 3 $\mu$m (at measurement by 1000 flashes) [3].
The good review about SL that we know and that we unknow one can be found in [2]. Today amazing temporal and spectral characteristics of SL phenomena have not of satisfactory explanation. Neither the approach of Shwinger [4] and his followers [6, 5], which is basing of presentations about quantum vacuum in cavity with moving acceleration wall, nor gasdynamics approach are not explaining observation parameters of SL flashes. However, SL is very simply to observe.

3 Apparatus for generating of sonoluminescence

Many time was noted in [2] the apparatus for observation of SL is simple and inexpensive (fig. 1) and its can be done in school physical laboratory. The main part of the apparatus is spherical flask with volume about 100 ml. This flask is filled up clean deaerated water at temperature near 0°C.

The first spherical harmonic frequency of volumetric liquid oscillation is equal:

\[ f = \frac{c}{R} \]

about 25 kHz and little bit one is shifted relatively calculated frequency because of influence of flask wall. The oscillation is excited by four piezoelectric transducers (PZT), which are glued at the flask equator. The fifth PZT is placed to flask bottom and one is used only for control of acoustic resonance. For excitation of four PZT is used highly stabilized generator and powerful audioamplifier (100 W). The amplifier output is loaded by consecutive oscillating circuit, made up by capacity of the PZT and additional inductance. This circuit is tuned to the frequency of basic mode of water-filled flask. A standing spherical wave in water is producing a dynamical trap in the flask center, in which may be captured gas bubble. This bubble is produced by microboiler or quick dive in water thin glass stick. The bubble behaviour depends on the amplitude of sound wave. One can to emphasize four levels of excitation power at which bubble behaviour qualitatively is changed:

1) power level is sufficient for bubble keeping into the trap. The bubble follow in flask center. However, the bubble life time is limited and one quickly dissolve in deaerated water.

2) power level, at which the bubble is stable and one exists unrestrictly long time.

3) ”dancing bubble”, at this power level bubble performs randomize jumps with amplitude about of millimeter.

4) power level, at which ”dance” is ceased and the bubble is stable. In this time bubble brightness is changed. From begining this power level SL is observed.

5) at greate power level bubble is destroyed.

The bubble existence and one stability is controled by fifth PZT drive signal, which one may be observed as Lissague figure on oscilloscope screen.
4 Time measurements

The measurements time resolution of photomultiplier (PMT) was realized with use of correlative method by Brown-Twiss’s scheme (fig. 2). The apparatus includes two photomultipliers, which are placed at equal distances from the flask center and opposite direction. The PMT’s signals have been amplified, formed by discriminators and get to input of time-to-digit converter (TDC). The signal of first PMT get to start for TDC, and the impulse of other PMT after delay line stopped of TDC. In this measurements is used broad band amplifiers (with band 2.5 GHz) and discriminators with watching threshold.

The measurement results for pair of photomultipliers NCT-2 is presented on fig. 3. A value point of TDC is equal 20 psec (all scale 2000 psec). The dispersion of time intervals distribution is determined of time resolution of this correlometer and one equaled 56 psec. The time resolution of each PMT is less in \( \sqrt{2} \) time and equal 40 psec.

5 Conclusion

The simple and inexpensive equipment, which is allowing to get light flashes with a duration about 10 psec, following with a frequency about 25 kHz have been made. In each flashes is emitted \( 10^5 \) — \( 10^6 \) photons in spectral range from 200 to 800 nm. The emission spectrum corresponds to radiation of black body with temperature about 50000 K. The light source appears in practical like point (size of emission region less 3 µm). For the measurement of PMT time resolution have been used correlational method, i.e. it is measured the distribution of time intervals between photocounts from two PMT. The section pathband of registration electronics equal 2.5 GHz and time resolution about 5 psec. For exception of the influence of the PMT impulse amplitude to measurements results we use fast discriminators with watching threshold [9]. The time resolution of PMT with microchannel plate NCT-2 type, which is developing by INP in collaboration with plant ”Ekran” [8], is 40 psec. The dispersion of spread time of the electron avalanche, determining of time resolution, was measured and one amount 40 psec at illumination of all cathode.

Now we are considering the possibility of measurement of flash duration by other method, which based on registration of visibility fluctuation of interference image in Michelson’s interferometer.

References

[1] H.Frenzel and H.Schultes, Z.Phys.Chem.B27 (1934) 421
[2] B.P.Barber et al. Phys.Rep. v.281 N2 1997
[3] M.J.Moran et al. NIM B96 (1995) 651, http://www-phys.llnl.gov/N_Div/sonolum/sonolum_paper.html
[4] J.Schwinger, Proc. Natl. Acad. Sci. USA 90 (1993) 2105
[5] C.Eberlein, Phys. Rev. Lett. v.76 N20 1996
[6] S.Liberati et al. e-print LANL quant-ph/9805031

[7] Lothar Frommhold and Wilfred Meyer Collision-induced Emission and Sonoluminescence, Spectral Line Shapes (1996), v.9, p.471, Firenze, Italy

[8] Anashin V.V., et al., “Photomultipliers with microchannel plates”, Nucl. Instr. and Meth., A357, pp. 103–109 (1995).

[9] Frolov A.R., Oslopova T.V., Pestov Yu.N., “Double threshold discriminator for timing measurements”, Nucl. Instr. and Meth., A356, pp. 447-451 (1995).
Figure 1: Basic apparatus for generating sonoluminescence. LFG – low frequency generator, Amp – amplifier, Osc – oscilloscope, L – inductivity.
Figure 2: The mounting scheme for measurement time parameters. PMT1, PMT2 – photomultipliers, A – amplifiers, D – discriminators, DL – delay line.
Figure 3: Measured distribution of the time intervals between photocounts.
This figure "art_s1.gif" is available in "gif" format from:

http://arxiv.org/ps/physics/9811005v1
This figure "art_s2.gif" is available in "gif" format from:

http://arxiv.org/ps/physics/9811005v1
This figure "x_r_gra2.gif" is available in "gif" format from:

http://arxiv.org/ps/physics/9811005v1