# OBSERVATION AND INVESTIGATION OF $He^4$ FUSION AND SELF-INDUCED ELECTRIC DISCHARGES IN TURBULENT DISTILLED LIGHT WATER

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# INTRODUCTION

The aim of the report is to present some preliminary results of both experimental and theoretical investigation of the processes and phenomena that are connected with the optimal fusion reactions in liquid targets.

It is well known that the most perspective and ecologically safe type of fusion reactions is connected with the $p + B^{11} \rightarrow 3\ He^{4}$ reaction with $\Delta E = 8.7$ MeV energy release and without the creation of neutrons and formation of any radioactive waste.

For this reaction the optimal energy of interacting moving protons is about $E_{pB,opt} = 675$ KeV. In usual uniform systems like cold or warm stationary plasma the probability of such reaction is very low. It is the direct result of high Coulomb potential barrier presence.

In our opinion one of the most perspective methods for optimization of such reaction is connected with using of turbulence and cavitation phenomena in the volume of a liquid (in this case - in volume of light water).

We suppose that the same optimization should take place practically for **any type of nonthreshold fusion reactions** with positive release of energy in the volume of cavitation bubbles in any liquid with the presence of necessary isotope components.

There are several theoretical models for such optimization.

One of them ("coherent non-stationary interference model") is connected with the method of barrier-free fusion in a volume of nonstationary (e.g. self-compressing) micro cavity: (e.g.,

*V.I.Vysotskii, On possibility of non-barrier dd-fusion in volume of bolling $D_2O$ // Proceedings: ICCF4, 1994, v.4, p.6-1- 6-3;*

*V.I. Vysotskii, Conditions and mechanism of non-barrier double-particle fusion in potential pits // Proceedings: ICCF4, 1994, v.4, p.20-2 - 20.5;*

*V.I. Vysotskii, R.N. Kuzmin, Nonequilibrium fermi - condensate of deuterium atoms in microcavity of crystals and the problem of nonbarrier cold nuclear fusion realization // Soviet Phys. - J.T.P., v. 64, # 7, (1994) 56-63;*

*V.I. Vysotskii, A.A.Kornilova. Nuclear fusion and transmutation of isotopes in biological systems, Moscow, "MIR" Publishing House, 2003*).

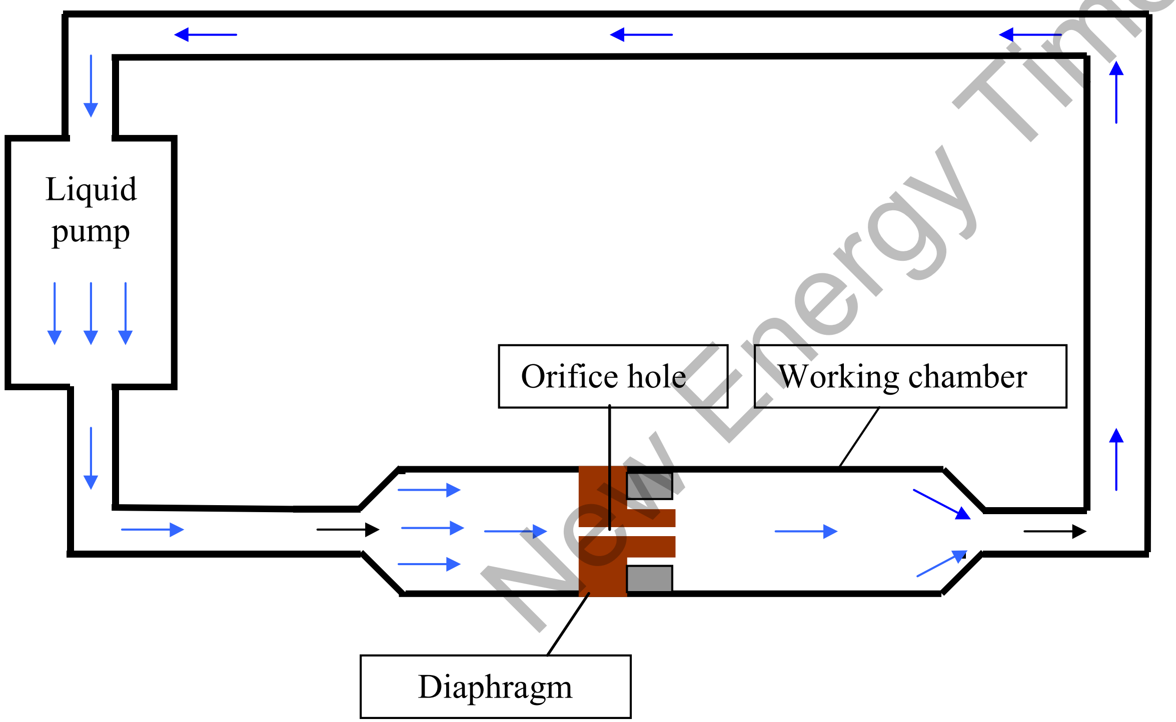
For such model the process of nonstationary barrier-free fusion in a volume of nonstationary microcavity is possible for any non-threshold reaction with positive energy release.

Other ("direct") models are connected with both high impulse pressure and high temperature at collisions of atoms of cavity walls at the end of cavitation process. In fact such models are connected with microaccelerating (microhot) method of fusion with surface forces.

We suppose, that these "direct" models are not capable to ensure necessary requirements for effective fusion because of relatively low temperature (no more than 5 000 - 10 000 K in multibubble systems) and relatively low pressure in a cavitation area [e.g., *D.J.Plannigan, K.S.Suslick, Nature, v.434 (2005) p.52*]. It is also evident that tunneling quantum processes can’t provide a great probability of nuclear transmutation. Theoretical aspects of such processes will be discussed in another report.

## Experimental setup

The scheme and general form of the installation for formation of controlled turbulence and formation of cavitation bubbles in the volume of working chamber are presented.




The total volume of circulating liquid is 20 liters.

The working chamber is made from plexiglass tube with diameter about 8 cm and length about 15 cm.

Thickness of chamber wall is about 3 cm.

Inside the working chamber the special diaphragm with orifice hole is situated. The diameter of the orifice hole is about 1 mm.

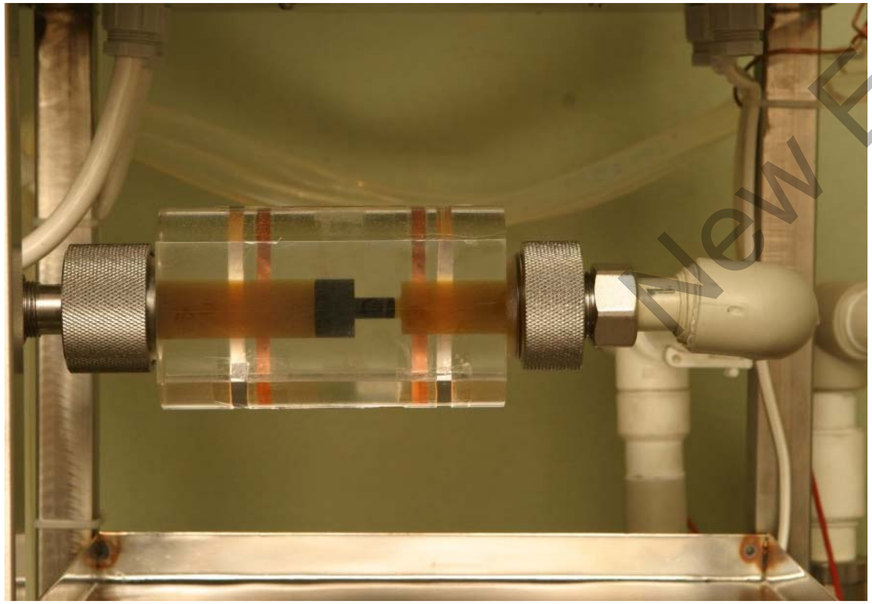
In the experiments the different kinds of orifice hole with special variable profile and variable cross-section has been used. Two different liquids were investigated in the system: machine oil and distillated light.

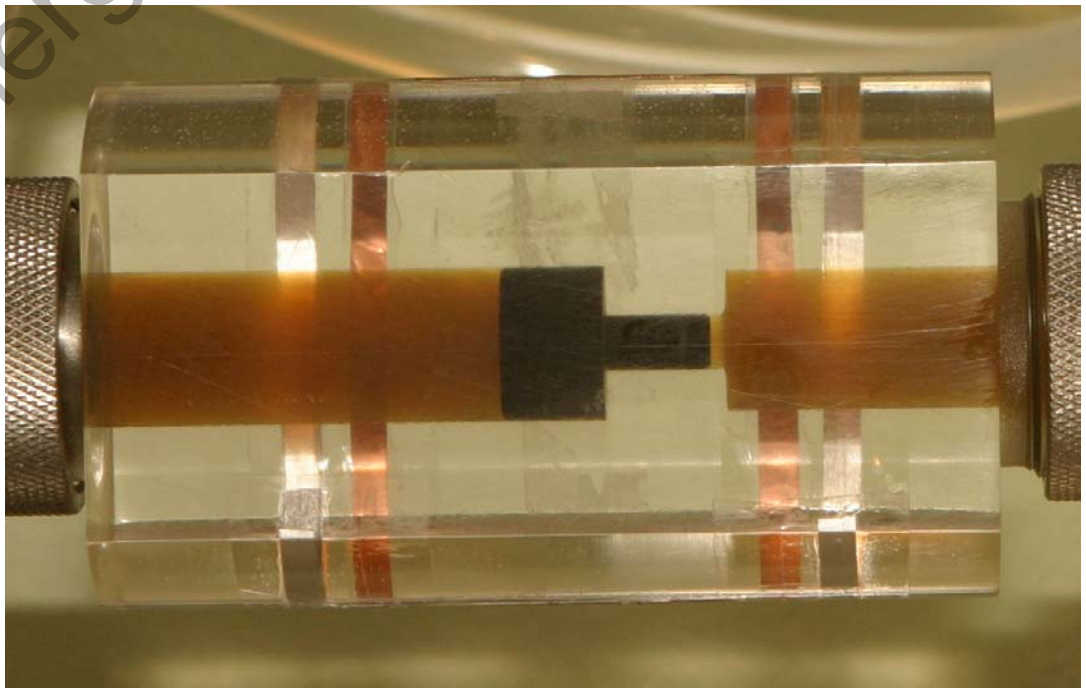
The general form of the installation.

## Experiments and results of investigation of cavitation of pure machine oil

In the first case we have studied the optical and nuclear processes that take place at cavitation of pure machine oil. In this case several different successive phenomena were observed at the pressure increasing. There are several stages of a cavitation process.

**1 STAGE**. At low pressure (less than 20-30 atmospheres) and low velocity of machine oil the color of moving liquid in the working chamber is tawny.

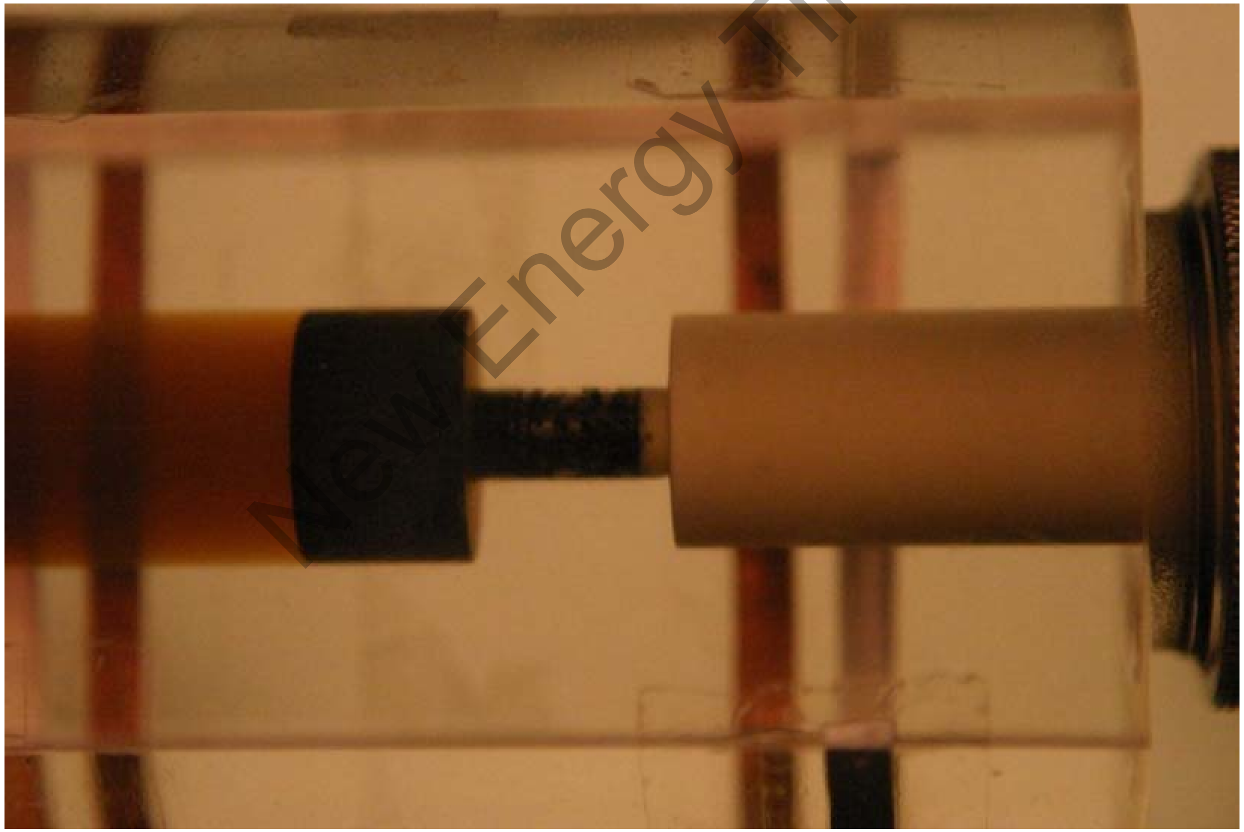




**2 STAGE** At pressure about 30 atmospheres the process of formation of cavitation bubbles in the volume behind the orifice hole starts. In this area at such pressure the process of initial turbulence and generation of large size fluctuations of machine oil density behind the orifice hole takes place. These fluctuations are visible.

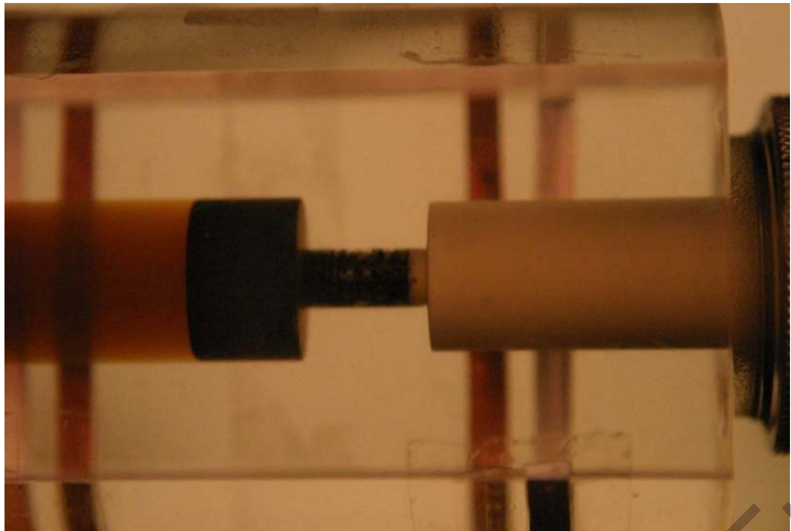
**3 STAGE**. At pressure about 40 atmospheres the averaged size of any fluctuation becomes small. The space behind the orifice hole is similar to a fog without any transparency and has the color like milk instead of initial tawny.



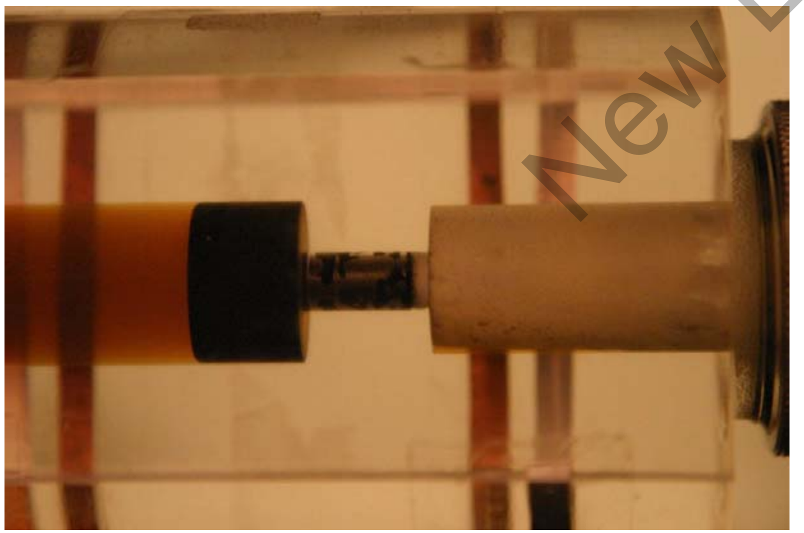


**4 STAGE** At pressure about 60 atmospheres the process of sharp increasing of transparency of turbulence machine oil takes place. In a result the volume with machine oil cavitations behind the orifice hole becomes completely transparent. The steps of this process at increasing of the pressure P are presented in next photos ($P_1 < P_2 < P_3 < P_4$ ).

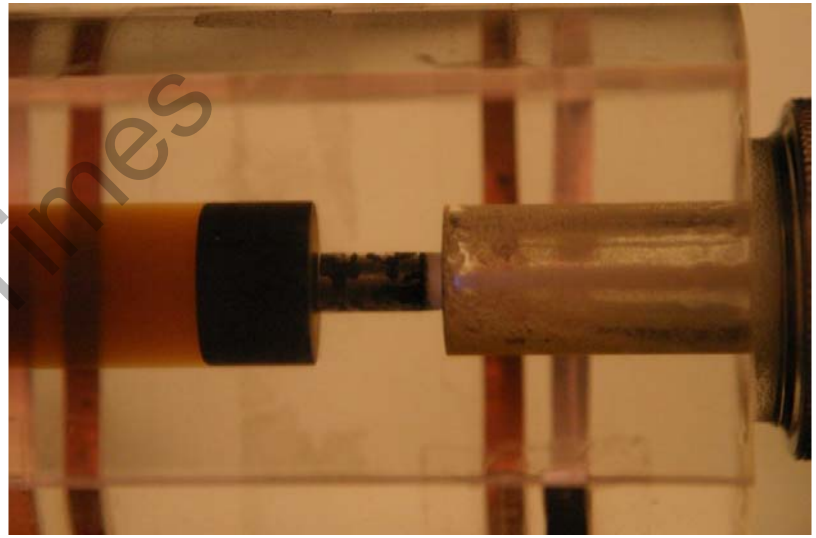
$P_1$



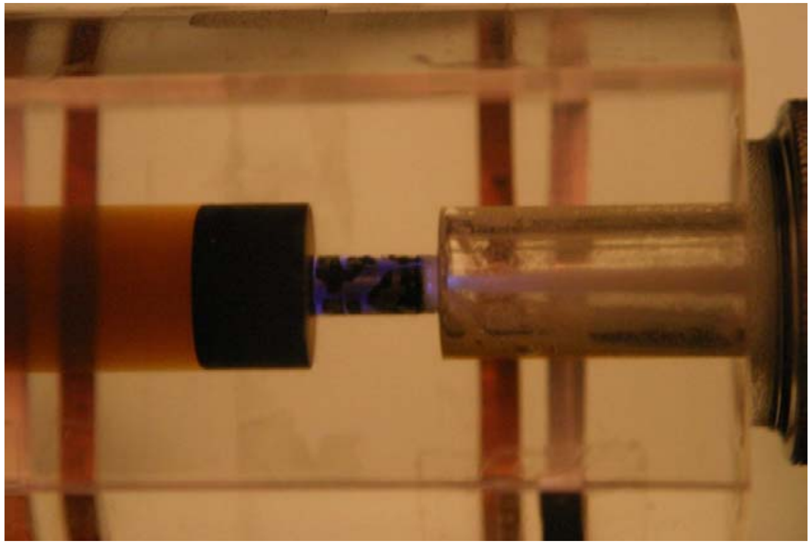
$P_2$

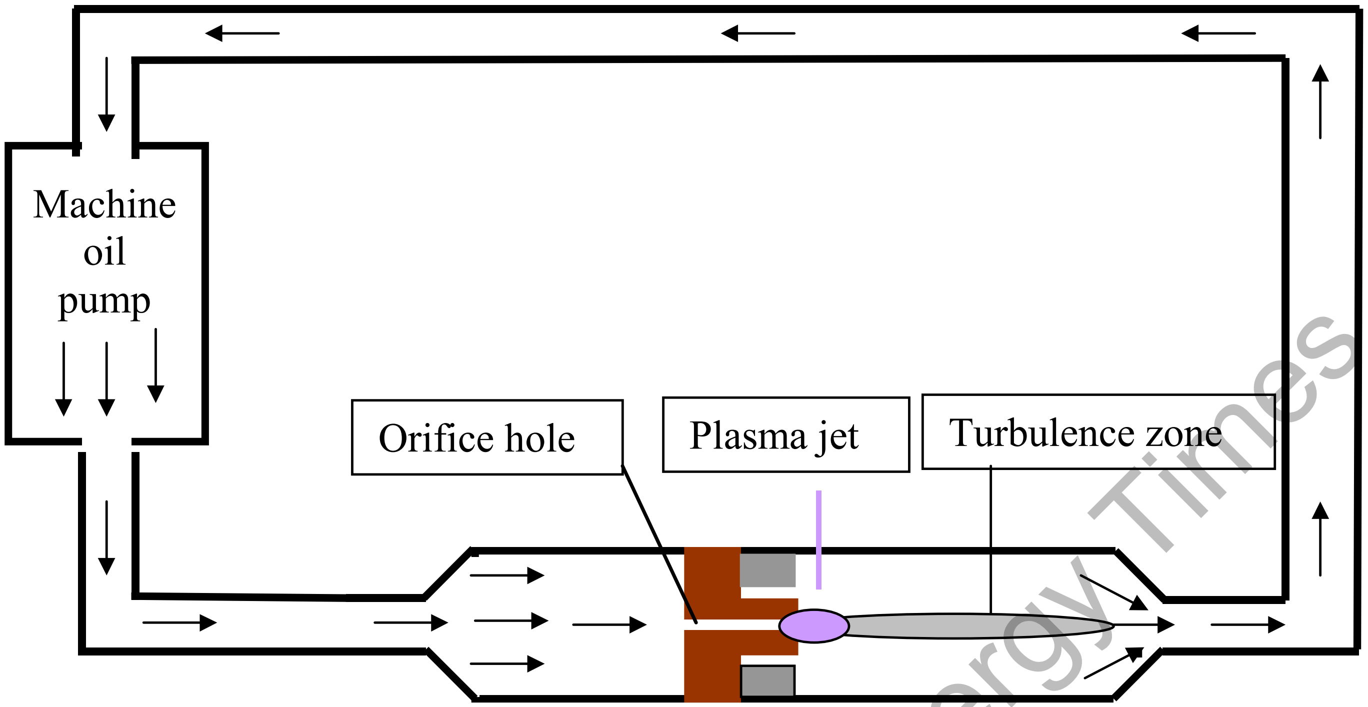


$P_3$



$P_4$



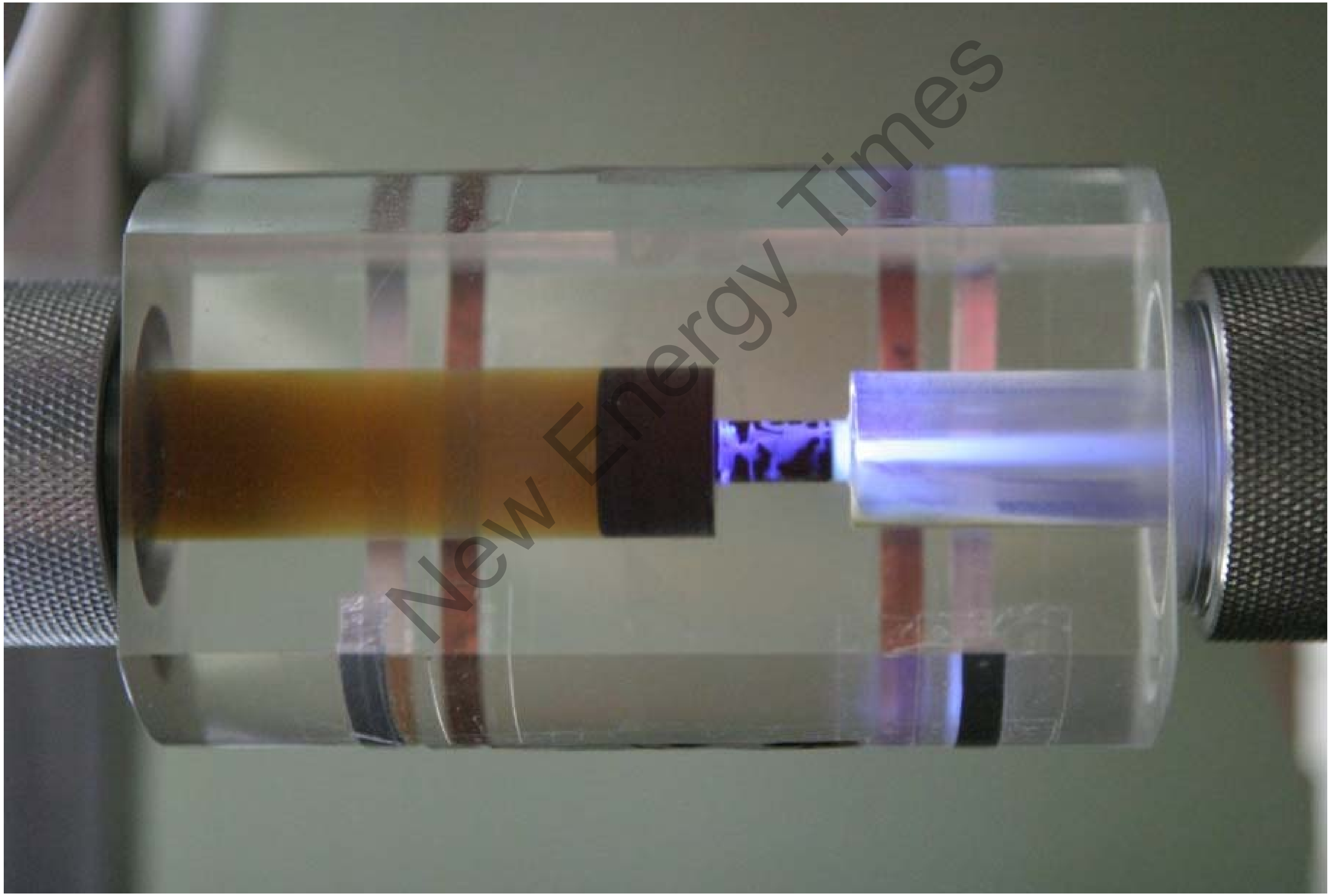



At such conditions in the volume of cavitation zone the small blue plasma jet is shaped. It forms in the region of turbulence and cavitations of circulating stream of the liquid immediately behind the orifice hole of a diaphragm.

Such stationary plasma jet has the longitudinal size and diameter about 2 mm.

**5 STAGE**. At additional increasing of liquid pressure up to 70-80 atmospheres in the central part of working chamber the directed light beam is shaped. The color of the beam is white-blue and is very bright.

The initial diameter of the beam is 6 mm.

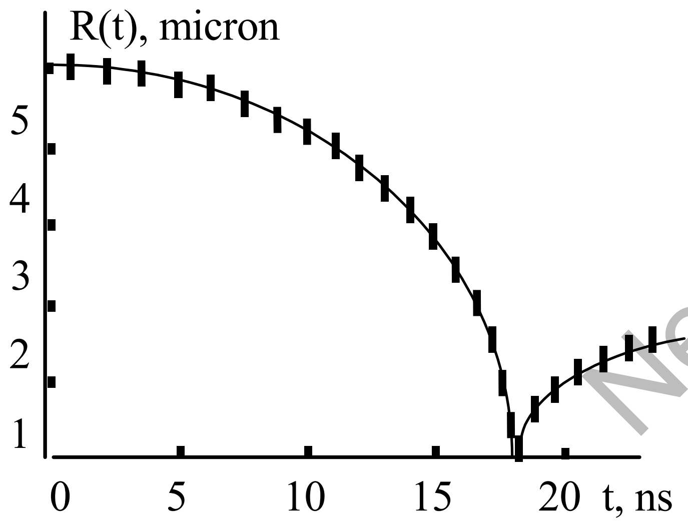


## What is the nature of the directed luminous beam?

It was not the directed luminous light beam from the internal part of the hole because the initial diameter of the directed beam (about 6...7 mm) was 4 times more than the diameter of the output window in the diaphragm (about 1...1.3 mm).

It also was not the equilibrium thermal radiation (**stationary sonoluminescence**) of heated part of the machine oil in the volume of cavitation area! There are several important arguments for such conclusion:

1 argument. The longitudinal size (about 5-10 cm) and very narrow cylinder like form of directed luminous beam are sharply different from the parameters of usual cavitation areas (jet like cone, sphere or short cylinder). It follows from the simple calculations:




The processes of formation and collapse of bubbles takes place immediately after transition zone on the exit of orifice hole. The size of this transition zone approximately equals the diameter of orifice hole (D = 1...1.3 mm).

From one hand it is well known (e.g., [*B.P. Barber et al, Phys Report, v.281 (1997) 65*]) that the duration of typical collapse process of cavitation bubbles with typical initial radius $R_0 \approx 5$ microns doesn't exceed $\tau_{max} \approx 20$ ns (see Fig.). The approximately same time need for formation of bubbles in the volume of moving liquid behind the orifice hole.

From the other hand from the hydrodynamics follows that the longitudinal velocity of moving liquid (moving babbles) at $P \leq 100$ atmospheres doesn't exceed $v_{max} \approx 10^4$-$10^5$ cm/s.

In the result the size of cavitation area doesn't exceed $L_{max} \approx D + v_{max}\, 2\tau_{max} \approx 1 \ldots 1.3$ mm.

It's very low in relation to the longitudinal size of directed luminous beam (5-10 cm)!

The angular properties of this directed light beam are similar to the laser beam!

2 argument. It's well known that the process of sonoluminescence takes place mainly in pure water (in other liquids the intensity of sonoluminescence is very low) [W.B.NcNamara et al, Nature, 401 (1999) 772].

We have observed the process of generation of brightly directed light irradiation in machine oil.

3 argument. The rather bright luminescence and rather high temperature (about 100 000 K) is observed only in a case of sonoluminescence of single babble. It is the direct result of spherical symmetry of babble at collapse.

In the case of multibabbles sonoluminescence the temperature inside each babble is relative low (about 2000-5000 K) and the intensity of sonoluminescence is also low. It is so name "**cold sonoluminescence** " [*W.B.NcNamara et al, Nature, 401 (1999) 772; K.Yasui. Phys Rev Lett, v.83 (1999) 4297; O.Baghdassarian et al, Phys Rev Lett, v.86 (2001) 4934*].

In our system with multibabbles cavitation the rather bright luminescence and rather high temperature are observed.

4 argument. The intensity of sonoluminescence decreases strongly at the increasing of temperature of a cavitation liquid (e.g., at increasing temperature from $1^0$ C up to $40^0$ C the intensity decreases by 100 times [*W.B.NcNamara et al, Nature, 401 (1999) 772*]).

In our system the intensity of radiation does not depend on the temperature in an explored interval [$20^0$C - $60^0$C].

So, the observed phenomena is not usual sonoluminescence!

What is the frequency of such directed radiation?

The frequency of directed light radiation is unknown because of very strong absorbtion of UV-, VUV and soft X-radiation in machine oil and thick layer of plexiglass (total thickness of machine oil and plexiglass in transversal direction is about 5 cm). It's possible that the frequency of directed laser-like radiation is hard or very hard and differs from the observed visible frequency. In this case the observed visible white-blue radiation may be the result of secondary fluorescence of more hard radiation in machine oil.

There are the reasons to consider that the bright directed beam corresponds to three different possible mechanisms:

**1) it is the process of Cherenkov emission by fast electrons;**

**2) it is the process of single-pass laser generation with UV-, VUV- or soft X-Ray frequencies of radiation;**

**3) it is the area of stimulated nuclear reactions in the volume of directional turbulent machine oil jet for formation of spontaneous optical radiation.**

1). Possible mechanism of generation of such beam may be connected with Cherenkov emission by fast electrons with velocity $v > c/n(\omega)$ that are accelerated in the field of large separated charges along axis of the chamber.

We have studied such (Cherenkov) mechanism in details by three different methods.

a). We have used the special ground connection for neutralization of separated volume charges in the chamber.

Such operations did not influence the directed properties and intensity of the laser-like beam!

b). We studied the angular distribution of the directed beam.

Direction of light emission from this beam differs from the reference direction $\sin\theta = c/n(\omega)v$ of Cherenkov radiation!

c). We have investigated the action of external transverse magnetic field to the direction and angular properties of the directed beam.

The result was negative - transverse magnetic field with magnitude about 300...500 Oersted don't influence on the directed beam!

So, this directed beam not connected with Cherenkov radiation.

2). The possible mechanism of single-pass induced laser generation is connected with the sequence of processes of ionization and recombination of machine oil in cavitation area. This mechanism is similar to processes in gas-dynamic laser.

First step of such mechanism is connected with deep ionization of moving atoms and molecules. Formation of moving hot plasma takes place in the area of cavitation immediately after the orifice hole.

During the second step the process of recombination of moving atoms and molecules and formation of inverted state of active medium is connected with self-cooling of this moving plasma in a distant area.

Such two-stage process is stationary and can lead to single-pass generation of stationary laser beam.

**What is the pumping source of such laser-like regime?**

It's well known from the foundation of laser and plasma physics that for pumping of plasma laser (which is based on the processes of ionization and recombination) we need the temperature of active medium $k_B T \geq 5\varphi_i$ .

Here $\varphi_i$ is the potential of ionization of working atoms. In any case $\varphi_i \geq \hbar\omega_{generation}$.

In the result for laser generation in the region of white-blue or more hard radiation the pumping source with temperature more $k_B T \geq 5\hbar\omega_{generation}/k_B \geq 200\,000$ K is needed.

From the other hand the temperature in the center of cavitation multibubbles system in any case is no more than 5 000-10000K [e.g., *D.J.Plannigan, K.S.Suslick, Nature, v.434 (2005) p.52*].

**So, the other much more intensive (in relation to cavitation process) pumping source is required.**

We suppose that one of the possible sources of intensive plasma heating for hypothetical laser generation may be connected with different fusion reactions in nonstationary bubbles in cavitation area or turbulent jet zone (for laser generation).

3). The same nuclear process need for generation of spontaneous optical radiation in the area of nuclear reactions in the volume of directional turbulent machine oil jet.

**In both cases the source of nuclear energy is necessary!**

There are a lot of proper reactions in cavitating machine oil. Part of them is connected with the carbon-nitrogen cycle:

$$N^{14} + p \to O^{15} \to N^{15} + e^{+} + \nu + 10.05\ \text{MeV}$$

$$C^{12} + p \to N^{13} \to C^{13} + e^{+} + \nu + 4.16\ \text{MeV}$$

$$C^{12} + C^{12} = Mg^{24*} \begin{array}{l} \nearrow Ne^{20} + He^{4} + 4.02\ \text{MeV} \\ \searrow Na^{23} + p^{1} + 2.22\ \text{MeV} \end{array}$$

$$O^{16} + O^{16} = S^{32*} \begin{array}{l} \nearrow Si^{28} + He^{4} + 9.6\ \text{MeV} \\ \rightarrow P^{31} + p^{1} + 7.7\ \text{MeV} \\ \searrow S^{31} + n^{1} + 1.4\ \text{MeV} \end{array}$$



Obviously, no modification of micro-accelerating mechanisms of middle mass isotopes fusion connected with fast motion of cavity walls and similar processes can take place in a liquid medium. The energy of such motion and the probability of such mechanism of reactions optimization is very low.

These reactions are researched now in cavitating machine oil and some positive results will be reported in the nearest future.

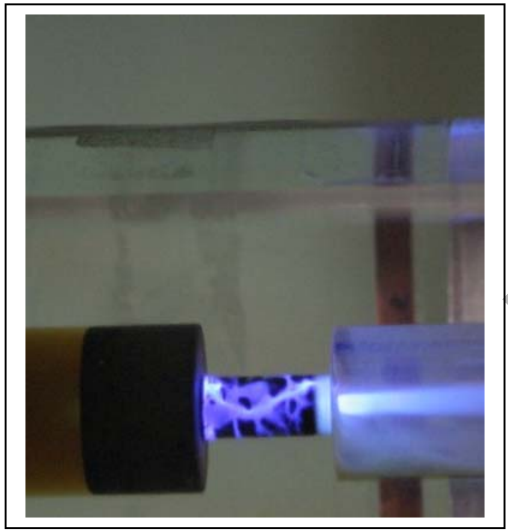
During stationary stages of activity of investigated chamber we also have observed another phenomenon - formation of pulse sequence of self-induced electric discharges (lightnings) near the plasma jet (along exterior surface of the diaphragm) during operating time of the water pump.

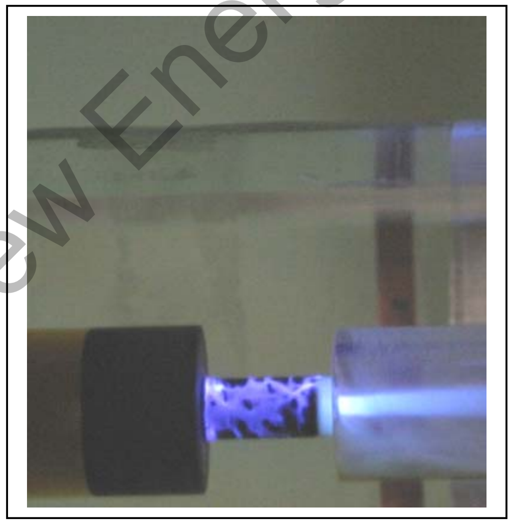
The lengths of such lightning was about several cm. Such discharges are connected with the process of atoms and molecules ionization in the region near the orifice hole and with accumulation of these free charges on the exterior surface of the diaphragm.

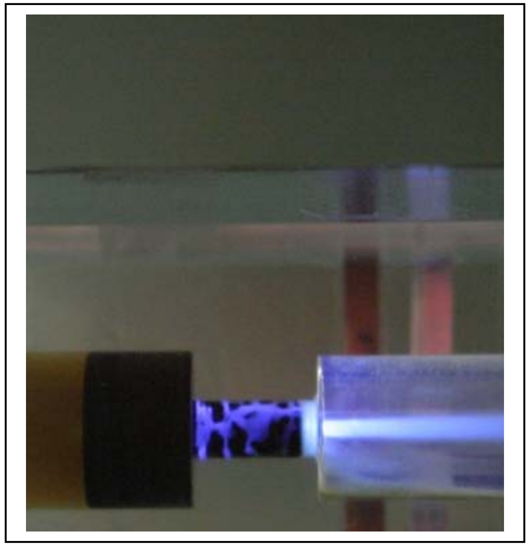
The typical frequency of such lightnings formation is about several Hertz.

The examples of lightnings photos are presented on the pictures.





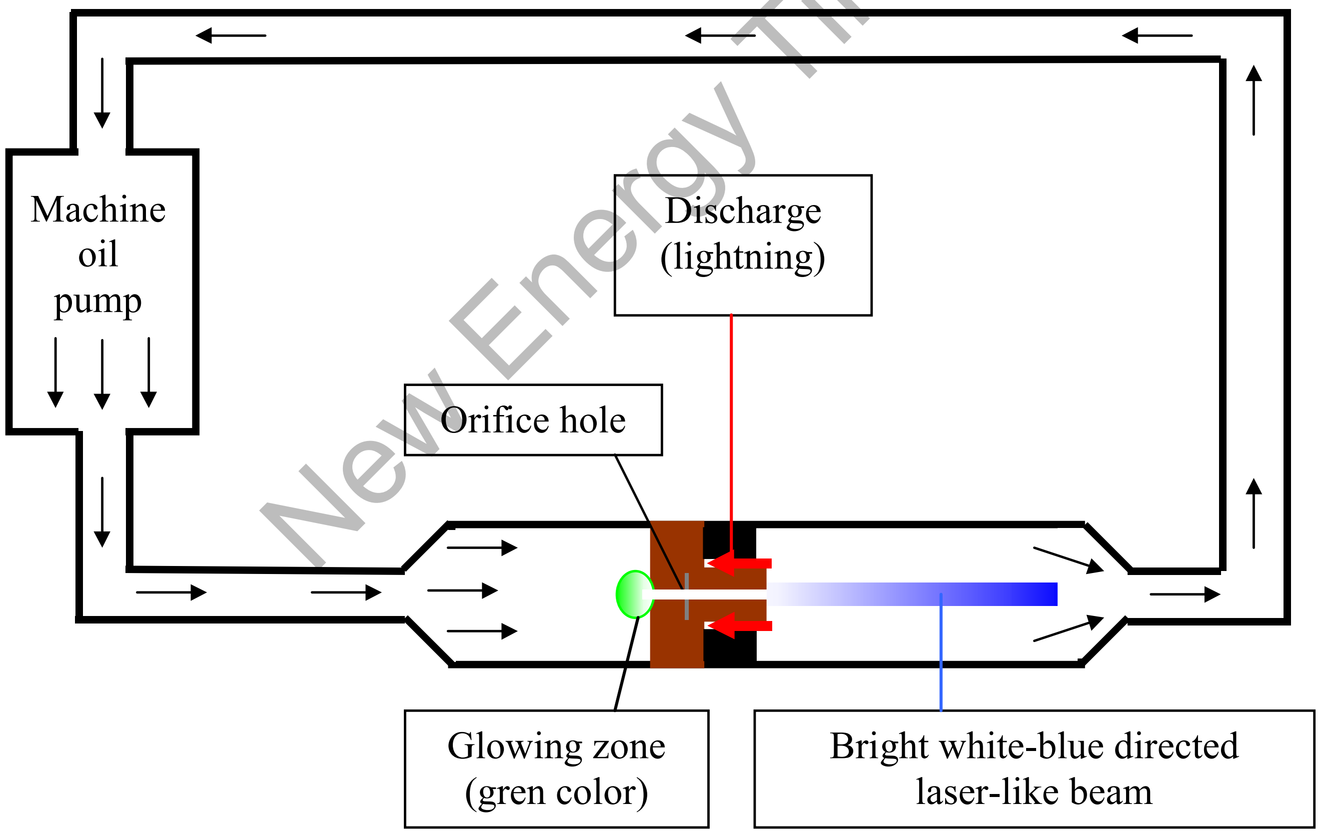




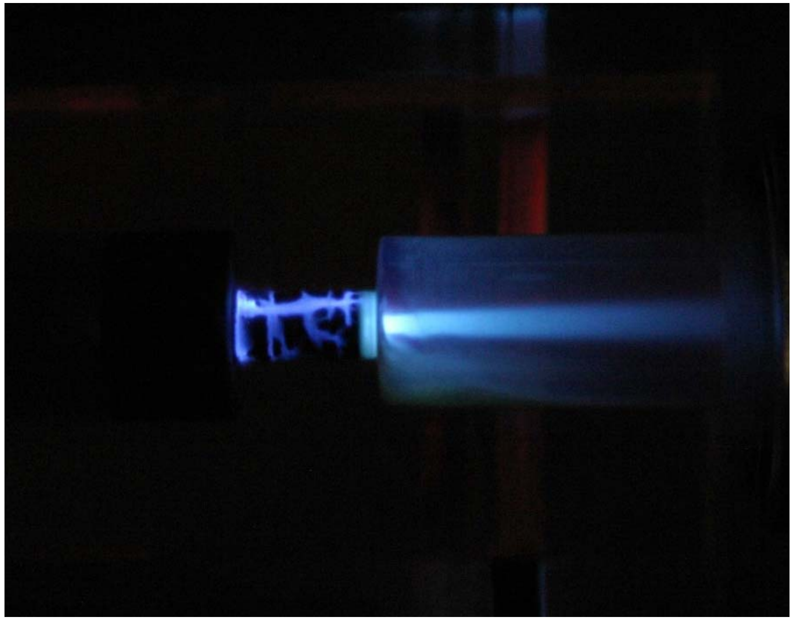
**6 STAGE**. At increasing of pressure up to 90-95 atmospheres the process of sharp increasing of intensity of this white-blue directed beam takes place. The frequency of lightnings formation is also increasing.

At this time in the space before the input hole (in front of opposite end of orifice hole) the process of formation of additional brightly green short jet takes place. For stimulation of such green jet we have used the special ground connection for neutralization of separated volume charges in the chamber.

It is not the region of turbulence and cavitation! The color of machine oil in this area remains tawny and the motion of liquid is laminar!

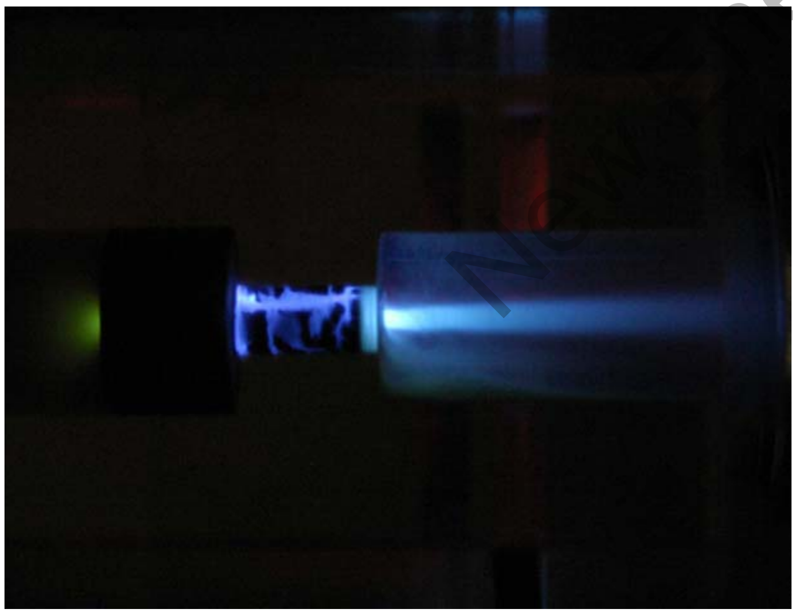


$P_1$

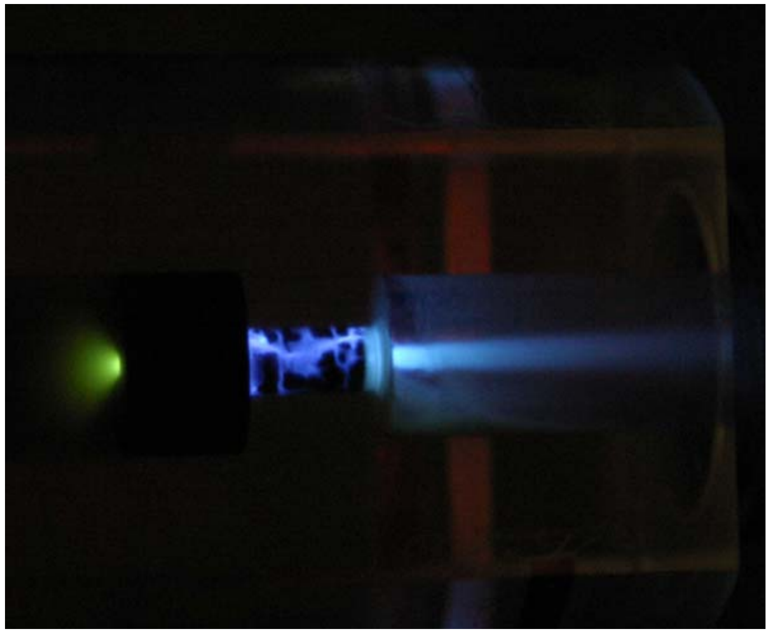


Three steps of pressure-dependent process of formation of back green jet at increasing of the pressure of liquid ($P_1 < P_2 < P_3$).

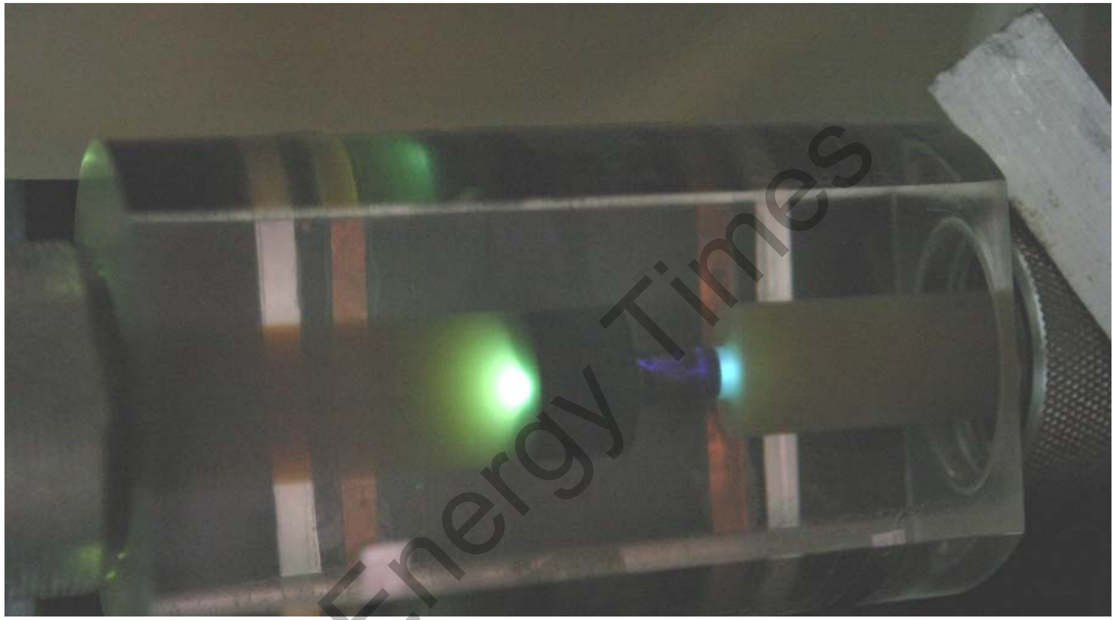
$P_2$



$P_3$



Additional photo of the back green jet was made from the back part (back direction) of the working chamber. That is why the directed white-blue beam in right side is invisible.



There are two possible mechanisms  for formation of such green short jet.

One mechanism is connected with possible action of white-blue back directed light beam to non-excited atoms of machine oil and corresponds to a usual luminescence.

The other one is connected with microdischarges from the acute edge of a charged dielectric diaphragm in the volume of a neutral liquid. The process of formation of a high charge on a diaphragm is the result of  friction of water transiting through a diaphragm.  This mechanism is more real because it takes place only in the case of additional ground connection of the liquid in the volume of working chamber..

## Other experiments were conducted in the same system where another circulating liquid - distilled water - has been used.

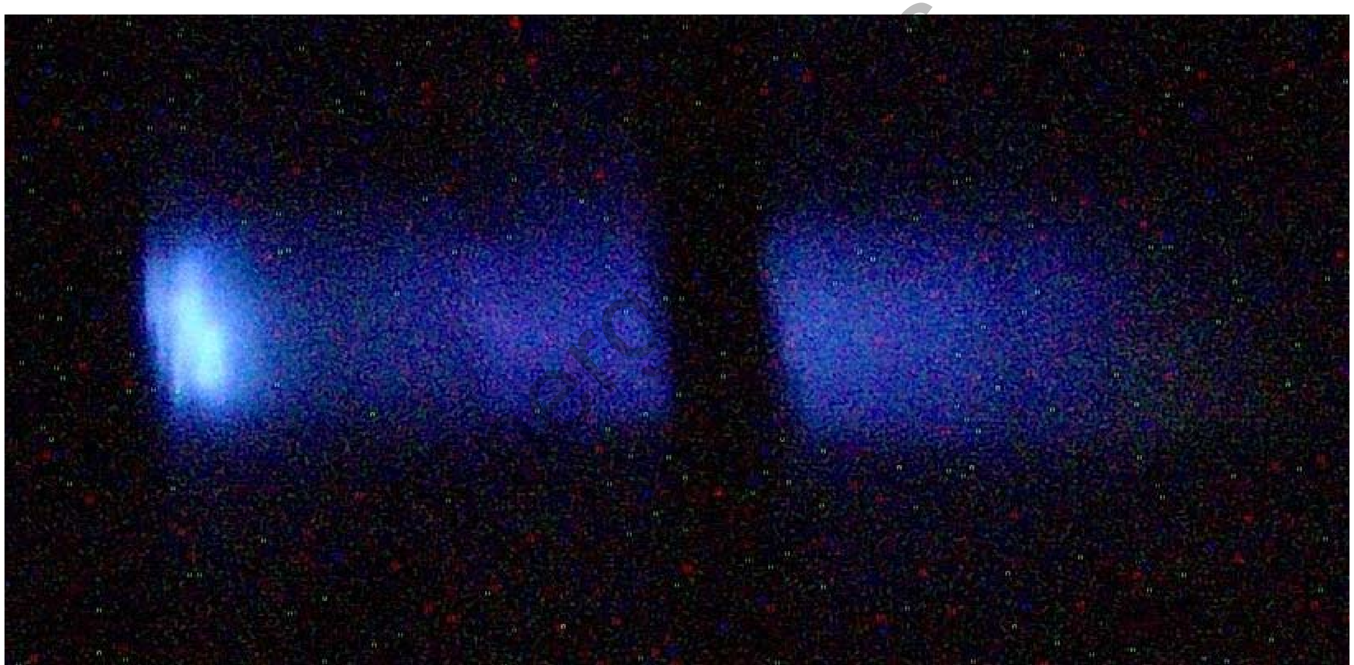
In this case the observed properties of cavitation area fundamentally differ from the discussed above case of machine oil. Several different diaphragms with different orifice holes were used during experiments. There are also several stages of a cavitation process.

In this case the intensive laser-like directed beam was absent at any regime and any pressure. The brightness of sonoluminescence in pure water at any pressure was low in relation to directed laser-like beam.

The processes of cavitation bubbles formation and distraction at pressure about 30-40 atmospheres are presented on the photo.

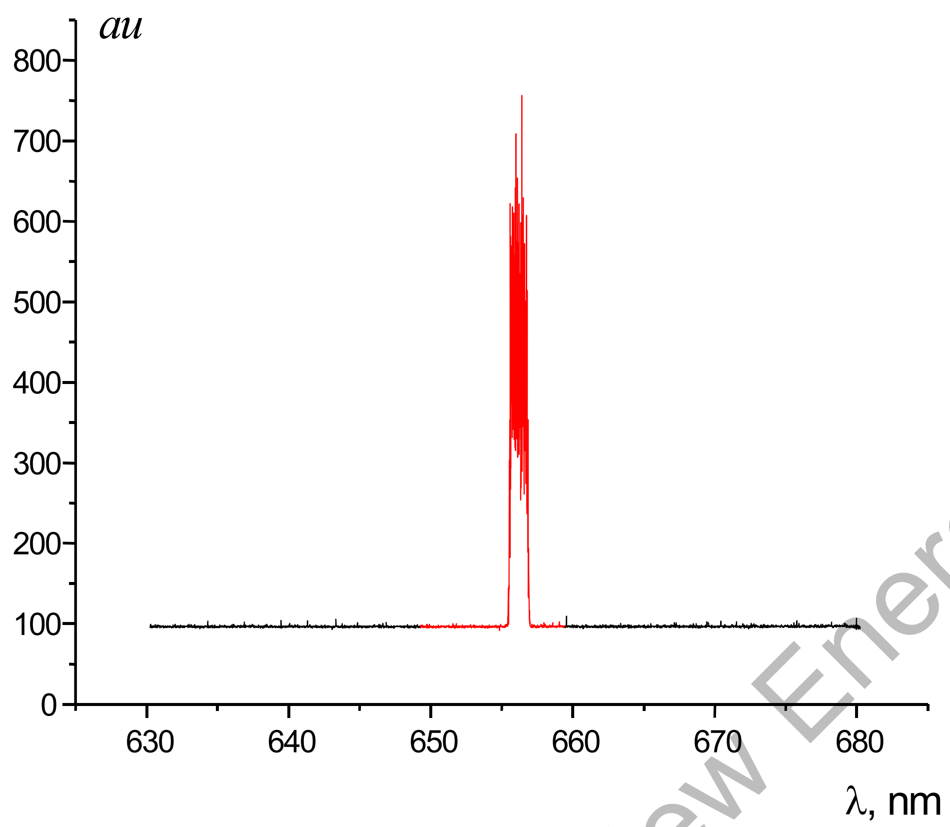


At pressure more than 50-60 atmospheres the process of weak sonoluminescence of caviting babbles takes place.
The color of low intensive sonoluminescence is blue. Sonoluminescence zone is in the left side of the photo.
The luminescence in central and right parts of the photo is connected with the process of scattering of light in pure turbulent water.



The intensity of radiation weakly depends on the pressure in the interval 60 ... 90 atmospheres and decrease at the increase of distilled water temperature. According to all tests that were discussed above it is usual multibabbles sonoluminescence.

The spectrum of hydrogen from this sonoluminescence was investigated. The spectrum of the most intensive line is submitted.




At the analysis of a relation of intensities of two measured lines in a spectrum of hydrogen (magnitudes of lines with wavelengths 566.28 nm and 486.13 nm were 620 *au* and 13 *au*) the temperature of luminescence area was calculated and equals about T≈ 3000 K.

It is the typical temperature of multibubbles sonoluminescence.



In several cases the process of generation of directed intensive hard X-Ray (or gamma-Ray) beams outside the working chamber was observed. This hard irradiation was detected by help of several X-ray photographic plates that were isolated in black paper and fixed on the external surface of working chamber made of plexiglas.

The possibility of realization of one of the most optimal fusion reaction $p + B^{11} \rightarrow 3\ He^{4}$ for different liquids also was investigated. The process of $He^{4}$ creation was investigated by the analysis of the optical spectrum of luminescence of stationary plasma jet and registration of He spectral lines in real time.

One of the main problems at realization of such reaction is connected with the search of optimal method of controlled $B^{11}$ isotope implantation in cavitation zone in distilled water. Uncontrollable implantation of ions of $B^{11}$ isotope as admixture leads to suppression of the processes of cavitation and sonoluminescence.

The possibility of realization of reactions of carbon-nitrogen cycle in moving turbulence machine oil was also studied.

All these processes were studied by different methods of nuclear- and spectral- investigations (including correlation methods of analysis of radiations from the luminescence area).

Initial calorimetric tests have shown that the final (output) thermal energy of hot circulating machine oil exceeds input electric energy that had been used for water pumping.

These results (including some positive aspects of nuclear transmutation and energy release) will be reported in the nearest future after extra checkout.