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Abstract

Full Text

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(Presented by Academician B. P. Konstantinov on 8 May 1969)

The principal drawback of existing bubble chambers is the presence of mechanically complex expansion systems ([1]), which limit the increase in the response speed of the chambers and completely preclude implementation of a controlled mode, which is of considerable interest for the recording of rare events. In this connection, broad investigations have been carried out in recent years aimed at creating a superheated state of a liquid without the use of mechanical expansion systems. In a number of works ([2–4]) attempts were made to detect the sensitivity of various liquids to ionizing radiation under the action of ultrasound; however, in this case sufficiently clear—

Fig. 1. Liquid-hydrogen bubble chamber with an ultrasonic emitter.
1 —chamber body; **2** —ultrasonic emitter; **3** —pressure receiver; **4** —emitter lamella; **5** —bandage; **6** —stereophotographic camera; **7** —illuminator; **8** —current leads; **9** —window for beam entry; **10** —thermostating jacket; **11** —expansion device

ly [[unclear: continuation of hyphenated word]] experimental results were not

Fig. 2. Block diagram of the experimental apparatus.

Figure 2: Fig. 2. Block diagram of the experimental apparatus.

obtained.

it was not possible to observe particle tracks. Finally, in work ([5]) experiments were described in which tracks of pions and protons were observed in a helium bubble chamber when superheating was produced by a plane standing ultrasonic wave with a frequency of 110 kHz.

Independent studies of the influence of ultrasound on the formation of tracks of high-energy particles in a bubble chamber, beginning in 1967, were carried out jointly by staff members of the Laboratory of Nuclear Problems of the Joint Institute for Nuclear Research and of the Acoustics Institute. The aim was to study the influence of ultrasound on the sensitivity of liquid hydrogen, which is of greatest interest in investigations of interactions of elementary particles.

The investigations were carried out in the 25-cm liquid-hydrogen bubble chamber of the JINR LNP ([6]), in whose working volume an ultrasonic transducer and receiver were placed. As the transducer, a cylindrical focusing system made of sectioned barium-titanate ceramic was used, emitting ultrasonic energy at a resonance frequency corresponding to the zero mode of oscillations, equal to 14.0 kHz. The transducer was positioned axisymmetrically in the central part of the chamber, as shown in Fig. 1. The inner diameter of the transducer was 70 mm, the outer diameter 115 mm, and the depth 60 mm.

Fig. 2. Block diagram of the experimental apparatus.
1 –synchronization unit of the bubble chamber; **2** –pulse generator; **3** –powerful ultrasonic generator; **4** –pulse voltmeter; **5** –ultrasonic transducer; **6** –pressure receiver; **7** –liquid-hydrogen bubble chamber; **8** –expansion system; **9** –beam-entry window; **10** –preamplifier; **11** –oscilloscope; **12** –tube voltmeter; **13** –stereocamera; **14** –transmitting television camera; **15** –receiving television camera.

The block diagram of the experimental apparatus used is shown in Fig. 2. The chamber was in a beam of π^--mesons with an energy of 340 ± 10 MeV, obtained from the JINR LNP synchrocyclotron. The moment at which particles passed through the working volume of the chamber was strictly synchronized with the emission of the ultrasonic pulse by switching on the expansion system and photographing the working volume of the chamber with a stereocamera.

Figure 3 presents photographs of particle tracks from the synchrocyclotron in the liquid-hydrogen bubble chamber with a magnetic field of about 2.5 kOe, at an operating temperature of 27°K and with an expansion reduced by a factor of two compared with the usual expansion regime and corresponding to the minimum sensitivity of the chamber (piston stroke 10 mm). An ultrasonic pulse of duration 15 msec, at a voltage of 1.2 kV, was applied to the transducer simultaneously with the pulse of the expansion system. The amplitude of the pressure of the ultrasonic pulse, creating additional superheating in the liquid, was approximately 1.0 atm. In Fig. 3b, in the field of the ultrasonic wave, tracks of negative pions from the synchrocyclotron are clearly visible.

It is not difficult to see that the introduction of ultrasound has a noticeable effect on the growth of bubbles forming tracks. Excitation of the transducer at the frequency of the zero mode of oscillations made it possible to obtain such an acoustic field in the working volume of the chamber that tracks continuous in space were observed, while the use of a focusing system made it possible to create

Fig. 3. Photographs of tracks of negative pions with an energy of 340 MeV in a liquid-hydrogen bubble chamber in an ultrasonic field at an expansion ratio corresponding to the minimum sensitivity of the chamber. (The arrow indicates the direction of the particles from the synchrocyclotron.) *a*—without ultrasound; *b*—with ultrasound; pulse duration 15 ms, oscillation frequency 14.0 kHz, voltage on the emitter 1.2 kV.

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in the liquid, acoustic-pressure amplitudes that substantially exceed the pressure at the surface of the radiator, which is of considerable importance for reducing parasitic boiling.

The results obtained indicate the fundamental possibility of completely replacing the expansion device of a liquid-hydrogen bubble chamber with an ultrasonic oscillatory system.

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Note: Figure translations are in progress. See original paper for figures.