PHYSICS

Timing of Sonoluminescence Flash

It has been pointed out[1] that theories attempting to explain the origin of the sonoluminescent flash, which is sometimes observed in acoustic cavitation, can be divided according to whether they predict the flash to occur at the moment of birth or collapse of the bubble.

Negishi[2] has shown that light is emitted when the bubble volume is at a minimum, and this is taken to favour the second class of theories. It also appears, however, that individual cavitation bubbles may rebound or re-form for many cycles of the acoustic field[3]. In this case, it is not possible to distinguish with certainty between the collapse and birth, or rebirth, time. Furthermore, it was shown that then only one flash is usually emitted which is followed by a series of rebounds lasting for some milliseconds. The only obviously unique occasion when the bubble volume is at a minimum is at the initial birth, which in Hahn's case[3] was nucleated by fast neutrons from an isotope source.

We have carried out similar experiments in which cavitation bubbles are nucleated by fast neutrons from a pulsed source. The time delay between the neutron burst and the emission of the flash was observed, using a 100 channel time sorter on 1 μsec channels. The flash was not emitted during the burst, that is, at the time of nucleation and the initial growth of the bubble, but on average more than half a period of the sound wave later.

Two 1 in. photomultipliers were arranged to view the central pressure maximum of a cylindrical glass container of liquid, excited in the 101 mode by a barium titanate ring cemented to the outside of the container. The liquid used was degassed tetrachloroethylene and the exciting frequency about 20 kc/s, the sound pressure amplitude being 10–15 atm. peak. A block diagram of the electronics is shown in Fig. 1. The outputs from the photomultipliers were arranged in coincidence, and provided a stop pulse for the 100 channel analyser. An 8 pulses/sec pulser (not phase locked to the 20 kc/s sound wave) triggered the neutron generator, a modified Elliot K-tube generator, which accelerates deuterons from a plasma onto a tritiated target to produce a 2 μsec wide burst of 14·3 MeV neutrons. A magnetic field is used to assist in the production of the deuterium plasma and there is a delay of about 60 μsec after the trigger pulse while this field is established and before the neutron burst. A delay unit was arranged to start the sweep of the time sorter approximately 12 μsec before the neutron burst. The neutron intensity was adjusted to give approximately two bubbles/sec, that is, only about one neutron burst in four resulted in bubble nucleation.

The time spectrum obtained in this way is shown in Fig. 2. It is clear that there is a long delay between the burst and the emission of the sonoluminescent flash. There are 1,376 counts in the spectrum. When the liquid container was replaced with a cylinder of plastic scintillator, a single sharp peak about 2 μsec wide was observed in the spectrum at the point marked "neutron burst time".

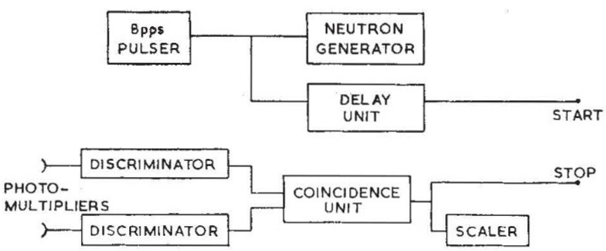

Fig. 1. Block diagram of the electronics of the experiments.

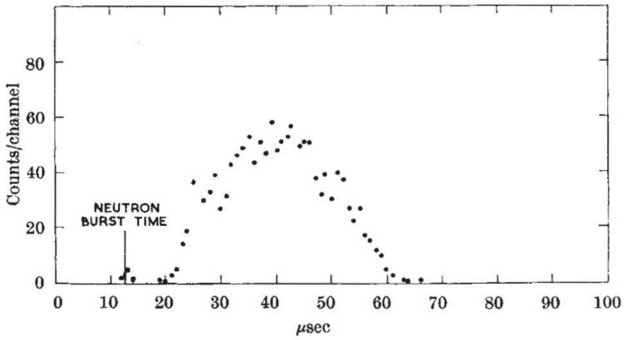

Fig. 2. The time spectrum of sonoluminescence flashes. The spectrum is made up of a total of 1,376 counts.

The rise time of flash, as observed by the photomultipliers, was not greater than 12 nsec.

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Received June 19, 1967.

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Upper Limit on the Abundance of Anti-protons in the Low Energy Galactic Cosmic Radiation

The existence of anti-matter in the universe has intrigued astrophysicists for quite some time. Several authors have suggested the existence and creation of anti-matter at various places in the universe[1,2]. One way of attempting to verify such possibilities is to see if cosmic rays, which include nuclei accelerated from various regions of our galaxy (if not the whole universe), contain anti-nuclei. Alfven[1], however, argues that cosmic rays at the Earth may not contain anti-nuclei for various reasons. Even if this were so, cosmic rays should contain secondary anti-protons produced in collisions of cosmic ray protons with interstellar hydrogen. Estimates of the abundance of secondary anti-protons have been made by several authors: Fradkin[3] gives a value $(\bar{p}/p) \sim 5 \times 10^{-4}$ for anti-protons of energy $E_p > 1{\cdot}7$ GeV; Milford and Rosen[1] estimate that for $E_p \sim 0{\cdot}5$ GeV, $(\bar{p}/p) \lesssim 3 \times 10^{-3}$ and more recently by calculating the energy spectrum of such anti-protons they state[5] (the numbers are not published to my knowledge) that the ratio $(\bar{p}/p)$ at low energies may be greater by several orders of magnitudes than that calculated at high energies.

There have been several attempts made in the past to detect anti-nuclei with charge $Z \geqslant 6$ in cosmic radiation[6–8]. These experiments consisted of examining the ends of tracks of cosmic ray nuclei, brought to rest in nuclear emulsions, for characteristic annihilation interaction. No such nucleus has been detected so far; therefore upper limits have been set to the ratio of these anti-nuclei to normal nuclei[6–8], the lowest being 10^{-3}. If anti-nuclei exist in the cosmic rays at balloon altitudes, however, it is likely that they exist as anti-protons, because the mean free path of anti-nuclei ($Z \simeq 6$) for annihilation (~ 3 g/cm^2 of hydrogen) is much smaller than that of anti-protons (~ 18 g/cm^2) and the nuclei are observed after crossing several g/cm^2 of interstellar hydrogen. Aizu *et al.*[7] have examined the stopping ends of singly charged nuclei obtained in their experiment, and give an upper limit for the ratio $(\bar{p}/p)$ as 10^{-3}, assuming that all the singly charged nuclei which they observed were of cosmic origin.