MEASUREMENTS OF LIGHT BACKGROUND AT LARGE DEPTH IN THE OCEAN

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ABSTRACT

The mean intensity of Čerenkov emission from the products of K^{40} decay and bioluminescence was measured at depth to 5 km. The intensity of Ocean light background is founded to depend upon depth and at the 5 km level is equal on averaged to 300 ± 60 quanta/cm^{2}s into spatial angle of 2π sterradian in transparency window. The amplitudes, duration and number of BL flashs were measured at various depth. The intensive flashs due to BL are shown to be observed rather seldom at depth over 4 km.

1. Introduction. Deep underwater Čerenkov detector of muons and neutrinos with the volume of 10^7-10^8m^3 [1] can serve as a tool of investigation of the fundamental properties of microworld (neutrino microscope) as well as the structure and development of the Universe (neutrino telescope). Besides the problems of microworld and macrocosmos are closely connected with problems of Ocean Physics, sea-biology and deep underwater engineering. One of the main problem, required a preliminary solution, is an investigation of Ocean light background (LB) at large depths. The data on LB are essential for the choise of optimal parameters of registration system of short (10^{-8}s) light pulses due to Čerenkov emission of relativistic muons or electron-photon and hadron cascades from muons and neutrinos passed by a photodetector at a considerable distance. The main varieties of LB are: a)a background from radioactivity; b)a background from bioluminescence (BL).
LB from radioactivity in salt water arises from mainly at the expense of K^{40} decays. At the 25 m transparensy the flux of Čerenkov emission from β-electrons and Compton electrons into the spatial angle of 2π sterradians is 150 photon/cm^{2}s in the wave range 400-600 nm [2]. At better transparency background from K^{40} will be greater. Background from BL can be divided into two types [3]: i)quasi-isotropic background from spontaneous BL of organisms averaged over large volume of water; ii)pulse flashs of BL close by the device, exited by its movement. At present time the dependence of structure of background from BL versus depth has not been clear yet completely. To obtain the complete information about LB of Ocean it is necessary to carry out the detail investigation of its structure: mean intensity of background at a given

depth, as well as duration and amplitudes of light flashs at various depths.

2. Block diagram of measuring apparatus of weak light fluxes. For the purpose of detail investigation of the structure of LB of Ocean a complex of measuring apparatus was developed and tested during the 40th cruise of the scientific-research Ship "Academic Kurchatov". The block diagram of a submerged device is shown in Fig.1. The emission measuring apparatus is composed of the following blocks: 1 - a block of photodetectors (four PMT-130); 2-a block of amplifiers; 3 - a block of discriminators; 4 -a block of counters; 5-a summator 6-an electronic commutator and a code convertor; 7-a time interval measurement system; 8-a time pulse generator; 9-a block of pressure detector; 10-a block of data storage. The maximum intensity of light flashs registed by the measuring apparatus is equal to 10^6 pulse/s. The minimum duration of flash that can be measured is equal to 10^{-3}s. The maximum depth of submersion equals 6 km. The device works in an autonomous regime with recording the information on a compact-casset. Four PMT-130 are used as detectors of optical emission. The angle of aspect of each PMT is 120°. The construction of the advice allows to investigate Ocean optical emissions: a)in the regime of integral count of one electron pulses simultaneously with determined of duration and intensity of pulse flashs; b)in the regime of count of coinciding events from various PMT-s.

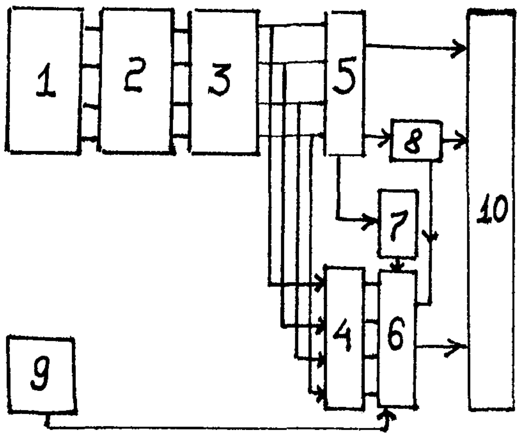

Fig.1. Block-diagram of submerged device.

3. Experimental results and discussion. The set of measurements of luminosity at various depths was taken in the central part of the Atlantic Ocean. Consider the results of the measurements made in the region 22°09'sl and 37°15'w.l. on the 7th of October, 1984. Detection of the light flux was made in the regime of one-electron pulses. The one-electron tresholdes were set up for two PMT, but for another two PMT the value of the thresholdes conforms to the amplitudes of two-electron pulses. Such experimental scheme allows to consider possible counting losses at the intensities more 10^6 pulse/s. The change of the mean intensity for a stay time at given depth of Ocean luminosity versus a device submersion depth is shown in Fig. 2a. The fluctuations of the mean intensity is seen to decrease considerably with depth. On submersion from 4 to 5km the mean intensity decreases 1,5-2 times. The dependence of the mean intensity versus time at the 5000 and 4000 m levels are shown in Fig. 2b and 2c respectively. Here averaging is made over storage time of 32512 pulses. The counding rate of one-electron pulses due to background from K^{40} calculated for

a given device at the 20 m transparency of water is shown by a dotted line. At the 5000 m level the mean intensity of Ocean luminosity changes slightly with time and twice exceeds the calculated background from K^{40}. At the 4000 m level the fluctuations of background intensity are far in excess the fluctuations of the background at the 5000 m depth. The mean intensity is approximately three times greater than the calculated one for K^{40}.

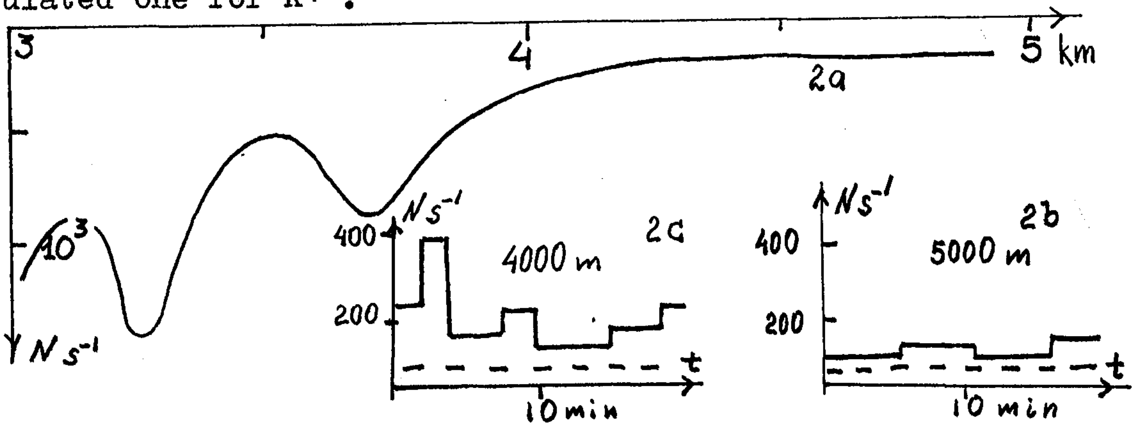

Fig. 2. 2a - a dependence of counting rate of one-electron pulses versus depth of submersion, averaged for stay time at given depth;
2b and 2c - a dependence of counting rate of one-electron pulses versus time at the 5000 m and 4000 m depths averaged for storage time of 32512 pulses.

The excerptions made at regular time intervals at the 5000 m and 4000 m levels with the time resolution of 10^{-3}s are shown in Fig.3. There are practically no intensive pulse flashs of small duration (10^{-2}-10^{-3}s) at the 5000 m depth. There is another situation for the 4000 m depth. Fig. 3b demonstrates the presence of the narrow (0,02-0,03 s) intensive pulse flashs repeated at unregular time intervals. One can suggest that the quasi-isotropic background at depths more 4000 m is caused mainly by Čerenkov emission from K^{40}(the calculated background for our device must be approximately 60 pulse/s at the 20 m transparensy) and from spontaneous BL of micro-

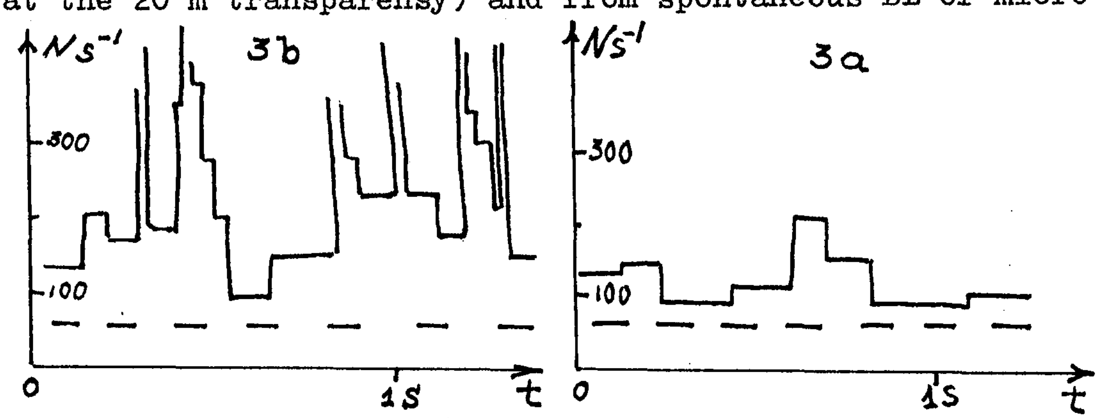

Fig. 3. A dependence of counting rate versus time.
Time resolution is 10^{-3} s. 3a -5000 m, 3b-4000 m.

organisms averaged over a large volume of water (at the 4-5 km depth the background from spontaneous BL minus the background from K^{40} was 80-90 pulse/s). Small number of intensive pulse flashs at the 5000 m depth demonstrates small concentration of glowing micro-organisms at large depth.

4. Conclusion. Hense, the measurements of LB showed:

i) the intensity of LB at the depth of 5 km order is equal on average to 300±60 photon/cm^{2}s into the spatial angle of 2π sterradian and is characterized by comparatively high homogeneity (rather small number of short pulse flashs). At the 20 m transparency of salt water the background from K^{40} must be twice less and hense there is also spontaneous BL of microorganisms at large depths;

ii) at the 2-3 km depth mean intensity is greater than at the 4-5 km depth and is undergone by sharp fluctuations. These flashs can be connected with BL of microorganisms nearby an device exited by its movement;

iii) a comparatively low LB at the 5 km level makes these depths promising for employment of large optical detectors of DUMAND.

References

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