SH 7.1-14

HIGH PRECISE MEASUREMENTS OF COSMOGENIC RADIOCARBON ABUNDANCE BY COMPLEX OF SCINTILLATION EQUIPMENTS

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The main characteristics of scintillation equipments which enable the measurements of radiocarbon content with high accuracy of 0.2-0.3% have been considered. The complex of scintillation devices has been operating very well for the last 15 years and has allowed to investigate the temporal variation of solar activity and intensity of cosmic rays for the last 300 years.

Studies of various astrophysical, geophysical and ecological phenomena by way of investigation of radiocarbon activity in dendrocronologically dated samples have been under way since 1965 [1].

Two types of detectors are used at present for the measurement of the ^{14}C concentration in dendrochronologically dated tree-rings: proportional and liquid scintillation counters. We prefer the liquid scintillation counter because it allows to use tens of gram of carbon in relatively small volume, which is important for high precise measurements of astrophysical samples. Firstly single-channel equipment with a stabilization of the photomultiplier and amplifiers was developed and used [2-3] . For stabilization the special light impulse generator with stable amplitude was developed. Counting rate of onefold standard was 48.33 imp.per min. at a background 6.5 imp.per min. Precision of radiocarbon measurements was of 0.3-0.4%.But use of an electron lamp 6G-14 B as a light impulse generator had several defects: a necessity of stabilization of light impulse amplitude, short life time of the electron lamp, increased background of the scintillation equipments and so on. That is why light impulse generator using light diode KL 102B has been developed, which is smaller, more simple and has longer life in comparison with device with electron lamp.

Block-diagram of developed two-channel scintillation equipments is shown in Fig.1.

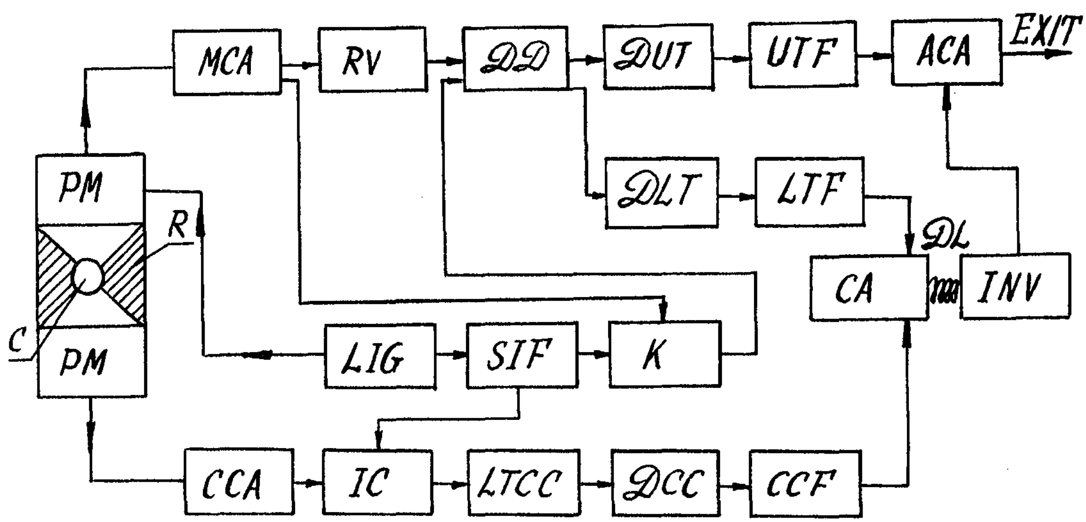

Fig.1. Block-diagram of two-channel scintillation equipment. C-cuvette with investigated sample, R-reflector, PM-photomultiplier, MCA-main channel amplifier, CCA-coincidence channel amplifier, LTG-light impulse generator, SIF-synchronous impulse former, RV-reference voltage, K-key, IC-intermediate cascade, DD-differential discriminator, LTCC-lower threshold of coincidence channel, DCC-discriminator of coincidence channel, DUT-discriminator of upper threshold, DLT-discriminator of lower threshold, UTF-upper threshold former, LTF-lower threshold former, CCF-coincidence channel former, CA-coincidence assembly, DL-delay line, INV-invertor, ACA-anticoincidence assembly.

Stabilization is made by light impulses of the diode KL 102B which is triggered by signals of electric impulses generator with a stable amplitide and definite frequency 1700 Hz. Generator operates the key which forbids a passing of the stabilization impulses.

Light impulses passing through photomultiplier and main amplifier form a voltage in the scheme of reference voltage which is proportional to the value of stabilization impulse and operate the thresholds of differential discriminators. With the variation of amplification coefficient of PM and amplifier the thresholds of discriminators are automatically changed into necessary direction and prevent the system from destabilization.

To study temporal variation of radiocarbon abundance in the samples with high precision it is necessary to make longcontinued measurements. To increase the number of measured samples five two-channel scintillation equipments were made (Table).

Table.

Volume ml	Counting rate of the background N_b imp./min	Counting rate of the standard N_{st} imp/min	$\frac{N_{st}}{\sqrt{N_b}}$	Detection efficiency ε,%
6	4.77	39.42	18	58
10	5.48	55.98	24	53
13	7.75	82.42	30	58
15	9.59	92.48	30	58
21	9.25	146.90	48	64

Different values of cuvettes allow to use the samples with different masses of carbon without dilution.

To investigate time variation of ^{14}C abundance in the Earth's atmosphere dendrochronologically dated annual rings of the trees of different species and from different regions of the Earth were used. Dated samples were transformed to a benzene in a chemical way.

Activity of investigated sample relative to the standard is calculated by the following formulae:

$$\delta^{14}C\,(‰) = \frac{N_s - N_{st}}{N_{st}} \cdot 1000.$$

where N_s and N_{st} - are counting rates of the sample and standard accordingly.

For fractionation correction we measured $^{13}C/^{12}C$ in the samples.

$$\delta^{13}C = \left[\frac{R_s - R_{st}}{R_{st}}\right] \cdot 1000\%$$

R_s and R_{st} are the ratios of $^{13}C/^{12}C$ in the sample and standard accordingly.

Radiocarbon activity with taking into account fractionation correction is calculated by the formulae:

$$\Delta^{14}C = \delta^{14}C - (2\delta^{13}C + 50)\left(1 + \frac{\delta^{14}C}{1000}\right)‰ .$$

Obtained results on time variation of cosmic rays are discussed in paper SH 7.1-15 presented at this conference.

References.

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