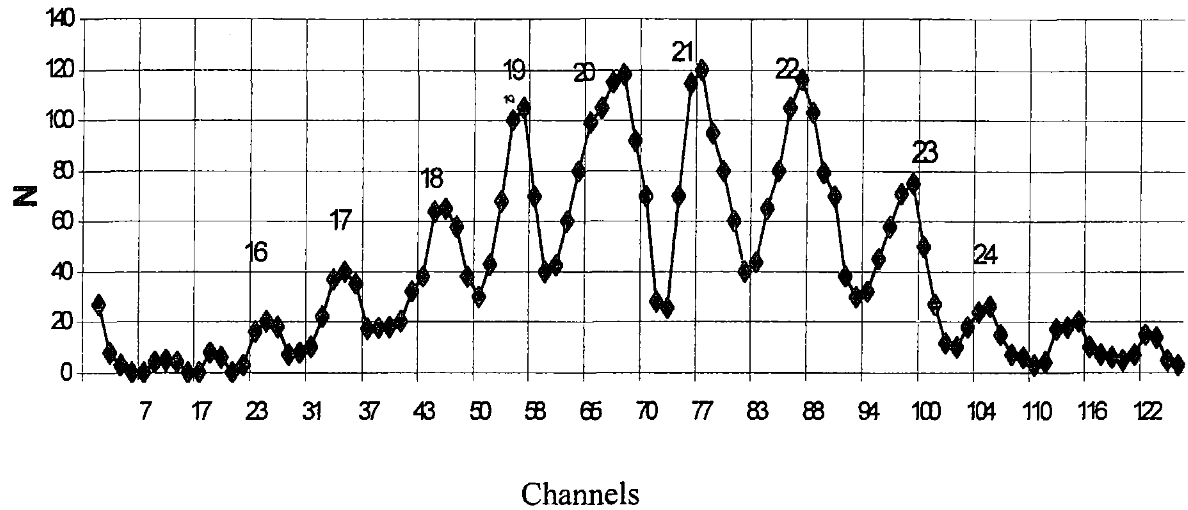

Fig. 4. An energy spectrum of fission products of nucleus ^{235}U, registered by the detector after an electrostatic analyzer. Numbers for peaks - value of ionic charges expressed in an elementary charge e_0.

Such spectrum is convenient for measuring, as the time of its measurement decreases 20 times, and the same quantity of FP can be recorded faster.

In our case:

Errors	%
Statistical: a) without the filter b) with the filter	±0,78 ±2,49
Accuracy of geometrical parameters	< 0,1
Instability of electrical and magnetic fields	±0,015

To reduce a statistical error the time of measurement have increased 12 times, thus the statistical error (in case - with filter) has decreased up to 0,72 %.

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HIGH-SENSITIVITY BROADBAND INFRARED MONITOR OF SPATIAL STRUCTURE OF RELATIVISTIC BUNCHES AND THERMAL FIELDS

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In some physical experiments performed for the investigation of fast processes in the presence of strong electromagnetic and radiation noise, it is necessary to perform accurate measurements of intensity of infrared radiation and its profile. For a number of proton and electron accelerators the conforming calculations are made, the outcomes which allow one to elaborate methods and highly sensitive detectors of an infrared radiation for remoting contactless non-destructive diagnostics and research of bunches and high-speed processes in ring-type (CERN/SPS-LHC) and linear (GSI) accelerators, as well as thermal fields in electro-nuclear-power equipment [1].

MEASUREMENT PROCEDURE

To solve this problem we developed a special method and to implement the method we created and checked in the physical experiment a noise-proof information-measuring system [1, 2]. The method of measuring and investigating the intensity is based on comparing the integral radiation fluxes, registered in different regions of the spectral distribution of the radiation from the experimental source. The method consists of using two integral photodetectors, which are of different type and manifest the photo effect differently, and their spectral sensitivity characteristics are different and they record radiation in the spectral range of wavelengths $\Delta\lambda/\lambda >> 1$. This method for measuring the geometry of the radiation beam and the radiator has the drawback that it is impossible to obtain an instantaneous picture of the distribution in each accelerator cycle (duration 1 ms).

MEASUREMENTS APPARATUS

Its advantage is that it is simple and hence reliable and cheap. On the basis of the conditions and requirements of the physical experiment and method of measurement, accurate photodetectors - photodiode and photoresistor - that operate at room temperature were chosen to convert the radiation power into an analog electron signal. This combination makes it possible to register the radiation flux in the spectral range $\Delta\lambda \approx 0.4 - 4.8$ μm, which greatly exceeds the visible range. The channels are independent, and the radiation can be registered simultaneously in both channels (in the case of correlated measurements) or in each channel separately.

The photodiode is fabricated in a single case with a preamplifier by the integrated technology. The entire photodetection unit does not exceed 1 cm^3 in size. Due to the small dimensions and the minimization of the electrical contours in the photodetector apparatus, the sensitivity of the apparatus to radiation fields and induction interferences allows one to work close to the radiation source under conditions of high electromagnetic and radiation noise. Such photodetectors in the case when the synchrotron radiation is registered have an advantage over the previously used photomultipliers. While the photomultipliers are more sensitive, which is not important for the level of accelerator synchrotron radiation, the photodetector has a wider dynamical range and wide bandwidth of the spectral characteristic ($\Delta\lambda \approx 0.4 - 1.1$ μm).

The measurement channel with an uncooled photoresistor as a detector makes it possible to measure the instantaneous (within 1 μs) infrared signal using its pulse conversion from the photodetector and introducing a special device for active suppression of interference in the measuring channel before registering in the ADC. The detector consists of two photoresistances ($\Delta\lambda \approx 0.8 - 4.8$ μm) with a 0.2 mm sensitive element, one of which is compensating and is covered from infrared radiation. Carefully selected photoresistances with parameters and characteristics that are as close as possible are secured on different sides of the same substrate, which is opaque to infrared radiation but does not screen electromagnetic and radiation fields. This structure of the detector and the use of a differential amplifier made it possible to employ a balanced extraction of the signal from the detector and to decrease substantially the level of in-phase interference on the output signal and drift at the output to the measuring channel. In addition, all input circuits were placed inside electrical screens, the conductors of the photoresistances on the differential inputs of the amplifier were made in the form of twisted pairs, and the amplifier itself was removed from the detector, located directly near the infrared source, at a distance of 2 m.

The following method was used for active suppression of interference. The measured signal from the detectors is transmitted with the aid of a modulating pulse 4 μs from the control unit, triggered by an external triggering pulse. The duration of the modulation pulse was chosen to be equal to 4 μs taking into account the possibilities of the electronic circuits and in order to improve the temporal resolution. This operation can be performed either by pulsed powering of the photoresistors or by a special electronic circuit for commutating the signals from the detectors. From the output of the amplifier the short measured pulse, whose amplitude is proportional to the instantaneous intensity of the infrared synchrotron radiation at the moment of measurement, is fed along a 50 m long cable into the output amplifier, covered by a wideband negative feedback delayed by 4 μs. This device effectively suppresses the drift of the entire amplifier as well as the interference signals in the range up to 10 kHz but it transmits without any distortions the measured signal with a duration of 4 μs. The moment at which the instantaneous synchrotron radiation is registered is fixed by a 1 mks gating pulse at the end of the modulation pulse (when its transient process is over) from the control unit, which in turn is triggered by an external pulse. The unit makes it possible to control the delay time in triggering the entire measuring channel relative to the external triggering pulse, it forms the pulse modulating the signal from the detector, and feeds to the ADC a gating pulse at the end of the modulation pulse.

MEASUREMENT RESULTS

The measurements were performed in the range of radiation intensities of $3\cdot10^{-6}$ - $8\cdot10^{-1}$ W/cm^2. To ensure that the measuring system operates on the linear section of its sensitivity, a collection of calibrated neutral radiation attenuators and infrared objectives made of optical ceramics for focusing the radiation were used. The temperature range registered in different measurements is 30 - 2700 °C. The relative instrumental accuracy in the measurement of the intensity of the thermal radiation is equal to 0.2 %. The absolute error depends on the calibration of the detectors and may not exceed 5 %.

CONCLUSIONS

The measuring system examined above exhibited high noise-resistance, stability, and reliability during long (several weeks) working sessions. The measurement results were read either according to a digital indicator from the ADC or with the results fed into a computer and printed out together with other registered parameters. Accurate photoresistors determined the possibility of registering with a high relative degree of accuracy of up to 0.2 % at room temperature the visible and infrared radiation under conditions with a high level of electromagnetic and radiation noise. The described method with modulation of the measured signal can be used both for one-channel integral measurement of radiation and for multichannel system for registering geometric parameters of the object being observed. The measuring system was calibrated using a thermal standard source, and it was used to measure the absolute values of the current of the electron bunches, and the dimensions of the synchrotron infrared radiation beam were also determined.

On account of their unique properties with respect to sensitivity, reliability, operating simplicity, noise-resistance, accuracy, and stability of the parameters, the meter could find application in physical experiments for investigating beams of relativistic charged particles (electrons and protons) in ring accelerators and accumulators - generators of synchrotron (edge) radiation, in linear accelerators for determining the intensity and transverse and longitudinal dimensions of the accelerated beam according to the temperature of the target, through which the beam passes, and in nuclear power plants for monitoring the temperature of units and systems, for metrological purposes, in pulsed photometry, and other fields in optoelectronics.

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