NATIONAL STANDARD OF BELARUS OF THE UNITS OF RADIANT INTENSITY, SPECTRAL RADIANCE AND IRRADIANCE IN THE SPECTRAL RANGE FROM 0.2 μm TO 3.0 μm

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In 2019, a National standard of Belarus of the units of radiant intensity, spectral radiance and irradiance in the wavelengths range from 0.2 μm to 3.0 μm was created. This report describes the details of a based spectral irradiance and radiance facilities.

INTRODUCTION

Spectral irradiance and radiance is one of the most important fundamental radiometric units. It is a key quantity with wide spread applications in industry, medical research, remote sensing and in our day to day life. In 2019, the National standard of Belarus of the units of radiant intensity, spectral radiance and irradiance in wavelengths range from 0.2 μm to 3.0 μm (NSSRI) was developed and constructed in the Institute of Physics of the NAS of Belarus together with the National Metrology Institute of Belarus (BelGIM). The purpose of establishing national standard is to provide metrological services to various R&D laboratories and industries.

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The main components of NSSRI are: high-temperature blackbody radiator BB3500M, Linearpyrometer LP5, set-up of the multifunctional spectral facility (MSF), integrating sphere source (ISS), monochrome radiation source (MRS), standard lamps.

The high-temperature blackbody radiator BB3500M is used as the national primary standard for spectral radiance and irradiance in the spectral range from 0.2 μm to 3.0 μm. It was constructed by the All-Russian Institute for Optical and Physical Measurements (VNIIOFI), Moscow. The radiometric temperature of the blackbody is determined with Linearpyrometer LP5 at the distance of 0.7 m. A precision aperture, which circulating cooling water, is placed in front of the blackbody to define the area of uniform radiance.

Spectral radiance of the blackbody is calculated by the Planck's law. Spectral irradiance on a measurement plane is calculated by using the spectral radiance of the blackbody, precision aperture area and distance between the aperture and input aperture of integrating sphere. A water cooling system has been developed for the BB3500M black body that maintains the temperature of the water in the system with an accuracy of 0.2 ºC.

The set-up of the multifunctional spectroradometrical facility consists two spectral systems, translation table (2.8 m) and portable radiometric benches. Spectral systems consist of UV-VIS and VIS-NIR double monochromators on base monochromators MS266 (SolarLS, Belarus) for ranges 0.20-1.20 μm and 0.35-3.00 μm respectively. The double monochromators there is one entrance and three output ports. To input radiation into the monochromators, an entrance optics block based on a torroidal mirror is installed on the input port. At the output ports, detectors are installed.

The spectral irradiance of the lamp is obtained by using the measured ratio of the multifunctional spectroradometrical facility output signal for the lamp to that of the spectral irradiance of blackbody at the entrance aperture of the entrance optics.

The working standards used for the spectral irradiance in the spectral range from 250 nm up to 2500 nm are 1000 W FEL-type quartz-halogen lamps (Gigahertz-Optik, Germany) and in the spectral range from 200 nm up to 400 nm are deuterium lamps. The working standards used for the spectral radiance in the spectral range from 350 nm up to 2500 nm are temperature lamps 1000 W TRU 1100-2350 and 200 W SIRSh 8.5-200-1 (Lisma LLC, Russia). The whole NSSRI is optimized for such lamp standards.

The working standards used for the radiant intensity in the spectral range from 250 nm up to

1100 nm are filter radiometers based on 3-element trap detectors (Hohenheide OÜ, Estonia).

SPECTRAL IRRADIANCE CALIBRATION FACILITY

Fig. 1 shows the schematic diagram of spectral irradiance calibration facility.

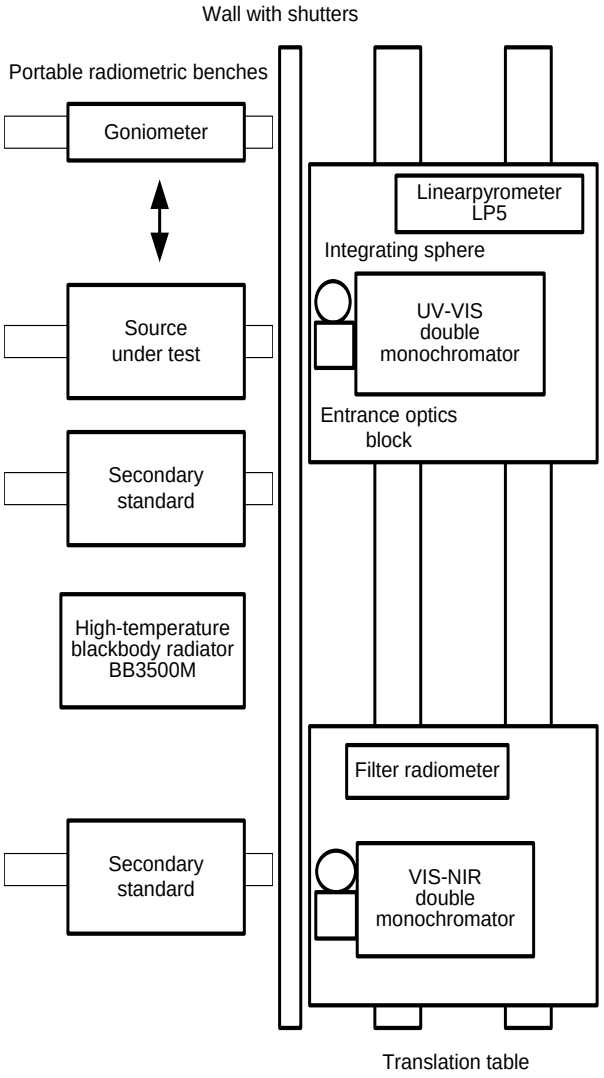

Figure 1. Schematic diagram of the spectral irradiance calibration facility

For measurement of the spectral irradiance an integrating sphere is installed on the input optics block. The inner surface of the integrating sphere used as a diffuser is made of PTFE with inside diameter of 50.8 mm. Its entrance aperture is aligned to radiation sources.

The four gratings with different blazed wavelengths are used by changing one by one corresponding to wavelengths. A PMT, Si-photodiode and InAs infrared detector are used to measure the output signal from the spectral systems from 200 nm to 800 nm, from 650 nm to 1200 nm and from 1200 nm to 3000 nm respectively. Among detectors, the IR enhanced InAs detector is operated in combination with chopper and lock-in amplifier to measure the small signal at long wavelengths.

The sources can be placed at distances from 4 mm up to 2 m to the opening of the entrance optics.

The design of the spectral irradiance calibration facility allows to measure the spectral irradiance of any radiation sources at distances from 4 mm to 2 m.

In addition, to measure the optical characteristics of LEDs, as well as small-sized sources, the spectral irradiance calibration facility includes an automated goniometer and a number of power supplies and TEC.

SPECTRAL RADIANCE CALBRATION FACILITY

To measure the spectral radiance two mirrors are placed in front of the input optics block. Its entrance aperture is aligned to radiation sources. As well as when measuring spectral irradiance the four gratings with different blazed wavelengths are used.

A PMT, Si-photodiode, CCD matrix, InAs infrared detector and InGaAs linear imaging sensor are used to measure the output signal from the spectral systems from 350 nm to 800 nm, from 650 nm to 1200 nm, from 350 nm to 1200 nm, from 1200 nm to 3000 nm respectively.

For calibration of spectroradiometers by spectral radiance sources MRS and ISS are used. The MRS is used for measurements of relative spectral responsivity of the devices, and the ISS is used for determining of absolute responsivity. The MRS is based on the monochromator M266-IV (SolarLS) and a temperature lamp SIRSh 8.5-200-1.

The diameter of the ISS is 0.6 m. It has an aperture with diameter of 0.24 m. The ISS is equipped with a set of 6 tungsten halogen lamps of 150 W and 6 tungsten halogen lamps of 250 W each located inside the sphere along the aperture perimeter. The ISS realizes 28 levels of spectral radiance. Radiance homogeneity of the ISS at 650 nm is within about 2 % over the aperture area, whereas the central-point radiance differs from the weighted average radiance by about 0.5 %. Calibration of ISS is carried out by comparison with a blackbody.