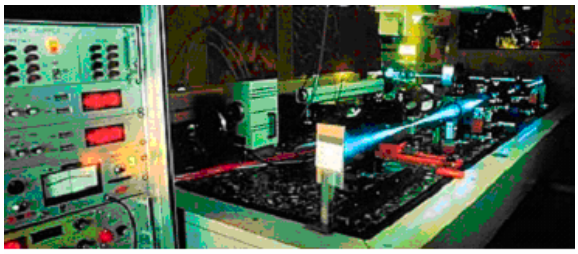
Information from the metrological laboratories

Radiometry at METAS

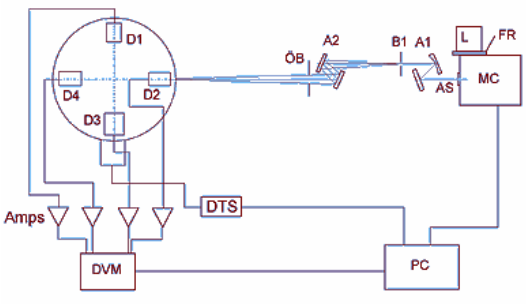
Radiometry is concerned with the determination of the power of electromagnetic radiation in the field of optical radiation. The most accurate realisation of radiometric quantities today is achieved in a cryogenic absolute radiometer. Thanks to the new cryogenic radiometer METAS is a possession of its own primary realisation in the field optical radiation metrology.



Radiometry is concerned with the determination of the power of electromagnetic radiation in the field of optical radiation (wavelength range from c. 100 nm up to c. 100 µm). The multitude of radiation sources, the geometrical dispersion of the radiation, and the broad wavelength range, demand a number of testing facilities with very differing equipment. METAS's Radiometry Laboratory concentrates its activities on the most frequently requested wavelength range from the ultraviolet to the near infra-red (currently 250 nm to 1100 nm).The most accurate realisation of radiometric quantities today is achieved in a cryogenic absolute radiometer. This is a thermal substitution radiometer. The radiation is absorbed by a detector and converted to heat. The resulting temperature rise is compared to heating produced by a known direct current. This allows the radiation quantities to be traced to the electrical quantities of voltage and current. The high level of accuracy is achieved through operation at temperatures below 10 K.

Spectral Calibration of Detectors

For the dissemination of the scale of spectral responsivity - in particular to implement the new detector-based realisation of the photometric base unit - an automatic testing station is required. The figure below shows the principle behind the measurement arrangement. A grid monochromator is used as the monochromatic tunable radiation source, the entrance slit of which is illuminated by a current-stabilised halogen lamp. The exit slit of the monochromator is projected onto a circular aperture, which for its part is projected with small opening ratio onto the detector. This results in a close to collimated beam of light projecting a sharp image of the circular aperture on the detector surface. The detectors - three reference detectors and the testpiece - are mounted on a turntable, by means of which they can be moved into the beam path as required.



D1: test detector
D2, D3, D4: reference detectors
Amps: photocurrent amplifier
DVM: digital voltmeter
DTS: turntable control
MC: monochromator
L: lamp
FR: filter disk
AS: exit slit
A1: projection 1, 1:2
B1: intermediate beam aperture
A2: projection 2, 1:1
ÖB: opening

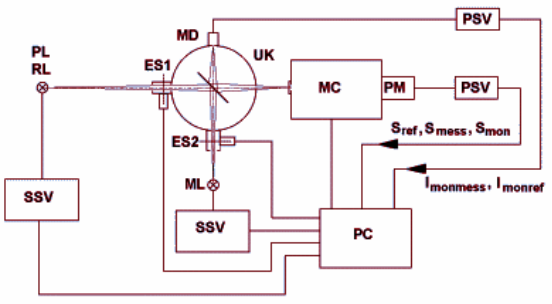
Test set-up for the spectral calibration of detectors

The test procedure has been selected in such a way that the monochromator moves to the first required wavelength, all the detectors are swung into the beam path in sequence and their output signals recorded, before the procedure advances to the next wavelength. This test procedure effectively eliminates the effect of unavoidable long-time drift in the lamp power and the transmittance of the monochromator. The calibration of the test piece is therefore carried out by comparison to the reference detectors in an effectively identical beam of radiation. The detector's photoelectric current is measured by a calibrated current amplifier and a calibrated voltmeter with input selector switch for the four amplifiers. For test pieces with integrated measuring electronics, the output signals can be analogue recorded via the voltmeter or digitally via a computer interface.

The control software permits a selection between repeated single measurements of the detector signals or a number of measurements of the entire spectral scan. In this way, the short and long-time stability of the measuring system and the repeatability and reproducibility of the results can be verified experimentally.The test arrangement is suitable for the calibration of silicon photocells with and without spectral filter, as well as for the calibration of spectral transmittance of optical filters. In particular, this arrangement is used to realise the basis for photometric units in the form of radiometrically calibrated illuminance meters.

Spectroradiometry of Lamps

The design and layout of the METAS spectroradiometer is shown in the figure below. The measuring system consists of four main components: input optics, wavelength selection, detection, and finally evaluation and control electronics. The beam from the reference or test lamp passes through a defined entrance aperture, at a pre-determined reference distance from the lamp, into an Ulbricht sphere with an internal diffuser screen. A beam from a monitor lamp with highly stable power can be symmetrically aligned at 90° to the test beam path. Two electronic shutters allow the selection of the beam to be measured. The reason for this arrangement arises from the mechanical properties of the monochromator grid drive. As a result of unavoidable small variations in the grid positioning, the transmittance of the double monochromator can vary slightly and randomly from one measurement series to another, which leads to fluctuations in the measurement results. By taking the measurements with both the test lamp and monitor lamp at every wavelength setting, this error can be effectively eliminated from the measurement, provided the monitor lamp is sufficiently stable. In addition, the effect of time-dependent fluctuations in the photoelectric multiplier amplification is reduced, since the single wavelength measurements with the test and monitor lamps are made in rapid time sequence.



PL: test lamp
RL: reference lamp
ML: monitor lamp
UK: Ulbricht sphere with diffusor disk
SSV: stabilised power supply
MC: double monochromator
PM: photoelectron multiplier
M.D: monitor detector
PSV: photocurrent amplifier
PC: computer for control and data acquisition
ES1, ES2: electronic shutters with defined entrance apertures

Test arrangement of an METAS spectroradiometer

The entrance slit of the monochromator is fully and evenly illuminated from the rear of the diffuser in the Ulbricht sphere. The beam passing out of the exit slit is detected by a photo-electron multiplier. The detector current is converted to a voltage, measured digitally and stored in the computer. A monitor detector on the wall of the Ulbricht sphere permits the monitoring of the lamp stabilities during the course of the spectral measurement. All readings of the amplifier, the monochromator wavelength drive, and the shutters are controlled by the computer.

The Federal Office of Metrology (METAS) maintains the national calibration standards of Switzerland, ensures their international recognition and disseminates them with sufficient accuracy to Switzerland's research, economy and society. METAS takes the necessary steps to ensure that the measurements required for the protection and safety of the population and the environment are made correctly and in compliance with the applicable laws and regulations.

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