Polarization effects in diffuse reflection measurements at the transition between the UVA and VIS spectral range

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Polarization effects play an important role in diffuse reflection measurements. Even for matte, quasi-Lambertian reflection samples, a large degree of polarization can be induced by reflection in certain bidirectional geometries. To study this effect, the Stokes parameters of the reflected light have been determined for several samples at the transition between the visible (VIS) and ultraviolet (UVA) spectral range. As radiation source, a newly designed LED-based sphere radiator has been characterized and applied.

EXPERIMENTAL SETUP

In diffuse reflectance measurements, the main quantity of interest is the spectral radiance factor $\beta(\lambda)$. The gonioreflectometer at the Physikalisch Technische Bundesanstalt is a measurement facility dedicated to the determination of β in bidirectional geometries. The sample under test is mounted on a five-axis robot arm. It is illuminated by a broadband light source which can be swivelled around the sample on a large rotation stage. A fixed detection path collects the reflected light. This combination facilitates the determination of β in almost any arbitrary bidirectional geometry [1].

To determine the Stokes parameters of the reflected light and thus its polarization state, a special polarization-analyzer unit is placed in the detection path. It consists of a quarter-wave plate which can be rotated, and a linear polarizer with a fixed transmission axis. Taking measurements at different orientations of the wave plate allows one to calculate the Stokes parameters [2].

As a light source in the VIS and near-infrared spectral range, a sphere radiator with a quartz-tungsten halogen lamp is used. This is an easy-to-operate and reliable light source which produces a spatially homogeneous, unpolarized irradiation. However, it has the limitation that the irradiance and stability quickly decrease towards UVA, where also various materials exhibit higher absorption.

Thus, we developed a new sphere radiator, which uses light-emitting diodes (LEDs) as radiation source, covering wavelengths from about 365 nm to 440 nm. It generates a much higher irradiance compared with the halogen source and considerably improves the signal quality and stability at short wavelengths [3].

POLARIZATION EFFECTS

In reflectometry the control of polarization is essential since almost every reflectometer contains polarization-sensitive components like diffraction gratings. Previous studies have shown that the degree of polarization caused by reflection can be very large even for frequently used matte, quasi-Lambertian samples, depending on the wavelength and geometry [2,4]. All these studies have been performed at wavelengths above 450 nm because the signal-to-noise ratio was too low at shorter wavelengths if the halogen source was used. This obstacle can be overcome if the LED-based sphere radiator is utilized. Measurements of the LED-based sphere radiator which show its unpolarized emission will be presented. Different types of reflection samples were studied and their polarization properties were determined. Exemplary results will be discussed, highlighting the influence of bidirectional geometry and wavelength.

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