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Improved diffusers for solar UV spectroradiometers

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High quality entrance optics are needed in solar UV measurements to match the spectroradiometers to have a cosine response. The responsivity of a cosine-corrected device is proportional to the cosine of the zenith angle. Cosine responsivity may be obtained using an integrating sphere or a thin transmitting diffuser. With diffusers manufactured from polytetrafluoroethylene (PTFE, Teflon) the deviation from cosine may be as low as 2.4 % [1].

Diffusers are typically shaped as plain flat disks or domes. It is demanding to design a good diffuser. The thicker the diffuser, the better the cosine-response but at the same time, the signal level is reduced. This limits the thickness of a PTFE diffuser to a couple of millimeters in solar UV applications. Diffusers are used outside so in addition to good optical properties, the entrance optics need to be weatherproof. Most entrance optics designs for outdoor use include a quartz dome to protect the diffuser.

We are developing new diffusers and design methods for diffusers in order to further improve cosine responses of solar UV spectroradiometers to better than 1 % over zenith angles 0 – 80 deg. The design starts with careful selection of material. In addition to various PTFE materials, we study feasibility of new quartz based materials where tiny gas bubbles have been formed inside fused silica to act as scattering centers [2]. The material candidates are measured for the diffuse transmittance profiles. The best material is selected and the transmittance profile is used to derive material parameters to be used with Monte Carlo analysis and Zemax design program to design the final diffusers. Two versions will be designed – one for Brewer spectroradiometers and the other one to be used with spectroradiometers utilizing a fiber bundle in their entrance optics.

The ready diffusers are characterized for cosine response. It is also tested that they obey inverse square law [3]. The new quartz based materials may have advantages over the traditional PTFE. The transmittance of the PTFE depends on temperature whereas quartz should be more stable [4]. It may also be possible to use quartz diffusers outside without the protecting dome.

[1] Julian Gröbner, "Improved entrance optic for global irradiance measurements with a Brewer spectrophotometer," Appl. Opt. 42, 3516 – 3521 (2003).

[2] Bettina Barton et al, "Characterization of new optical diffusers used in high irradiance UV radiometers," Poster presented in the 11th International Conference on New Developments and Applications in Optical Radiometry (NEWRAD 2011), Maui, Hawaii, September 19 – 23, 2011.

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[4] Lasse Ylianttila and Josef Schreder, "Temperature effects on PTFE diffusers," Opt. Mater. 27, S1811-1814 (2005).