Realization of Improved Solar UV Diffusers

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Background

Global UV irradiance measurement

- **Diffusers** used in global solar UV irradiance measurements.
- Angular response
  - Proportional to the *cosine of the zenith angle* of radiation.
  - **Independent of the azimuth angle.**
- Purely trial-and-error based optimization is time consuming.
Steps of Diffuser optimization

1. Study different diffuser materials.
   • PTFE (Teflon) or quartz?
2. Construct simulation algorithm.
   • Monte Carlo ray tracing
3. Find out material parameters.
   • Compare measurement results with simulations
4. Use algorithm to optimize diffuser geometry.
5. Construct and characterize the diffuser.
Material characterization

Angular response & transmittance

- Beam-expanded HeCd gonio.
- "Bubbled" quartz materials*
  - No phase transition
  - High transmittance
  - Low integrated cosine error

\[
f_2 = \int_{0^\circ}^{85^\circ} \left| \frac{R(\theta)}{R(0) \cos(\theta)} - 1 \right| \sin(2\theta) d\theta \cdot 100 \%
\]

**Overview**

- **Monte Carlo ray tracing algorithm.**
- Rays traced from detector towards the sky.
- Inside the diffuser **
  - Propagation
  - Scattering
  - Absorption
- **Material interfaces**
  - Transmission
  - Reflection

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Diffuser algorithm

Weather dome

- Affects the propagation direction and weight of the particle.
- Angle of the first transmitted ray calculated exactly.
- Transmittance from geometrical series using flat sheet approximation.
Simulation

Parameter sensitivity

- The sensitivity of the angular response to different parameters can be studied.
- For example, studying the effect of spatial misalignment of the diffuser element.
  - By changing the visible area of the diffuser.
  - Small manufacturing tolerances required!
Optimized diffusers

_Fiber diffuser (Schreder)_

- **Flat quartz diffuser**
  11 mm in diameter.
- Integrated cosine error $f_2 = 1.4\%$.
- Simulation results agree after small modification
  - Diameter of the visible area of the diffuser was decreased by 1.3 mm.
  - The angular response of the optical fiber was not characterized.

![Graph showing cosine error vs. incident angle](Image)
Optimized diffusers

Brewer diffuser

• **Flat quartz diffuser**
  22 mm in diameter.
• Integrated cosine error $f_2 = 1.3\%$.
  • Significant improvement over the standard diffuser!
• More on this in the talk by Allard and Joop.
Realization of Improved UV Diffusers

Conclusions

- **Monte Carlo algorithm** for optimizing solar UV diffusers was developed.
  - Can guide the diffuser design process.
  - Useful for parameter studies (manufacturing tolerances!)
- ""Bubbled"" quartz diffusers have variety of attractive features.
  - Transmittance, angular response, no phase transition, etc.
- **Two new of entrance optics** were constructed in the project.
  - Simple planar quartz diffuser elements.
  - Measured integrated cosine error around 1.4 %.
Outlook

or how to proceed?

- **Surface roughness?**
  - Alters the angular response at large incident angles.
- **Potential problems**
  - *Azimuthal dependence*
  - *Harder to simulate*
- **Shaped diffusers?**
  - E.g. Spherical front surface.
  - **Potential problems**
  - *Manufacturing cost, quality and tolerances.*

What about this bit?