Investigating the Light Scattering Properties of LIGO Materials

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Background

The Core Optics Support (COS) subsystem is responsible for controlling light noise in LIGO interferometers.

COS controls scattered light noise and reflected ghost beams from Core Optics Components (COC) by using Beam dumps and baffles.

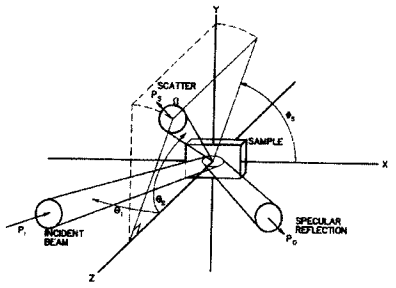
Beam dumps and baffles should be made of highly absorbent and low scattering material.

Bidirectional Reflectance Distribution Function (BRDF)

$$\text{BRDF} = \frac{\text{differential radiant intensity of scattered light (W/sr)}}{\text{radiant flux of incident light (W)}}$$

$$= \frac{dPs/d\Omega}{Pi \cos \theta s}$$

Geometry for definition of BRDF



BRDF requirements for beam dumps and baffles

The BRDF for the beam dump should be $< 1.7 \times 10^{-2}$ sr^{-1} and that of a beam baffle should be $\leq 3.9 \times 10\text{-}2$ sr^{-1}.

The reflectivity for the beam dump should be $<1.2 \times 10^{-2}$ whereas that of a beam baffle does not matter.

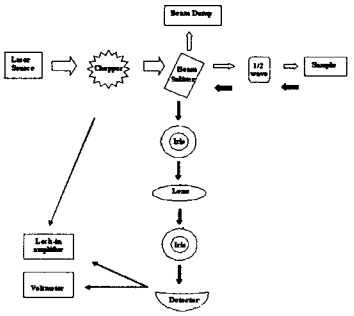
For LIGO, we need...

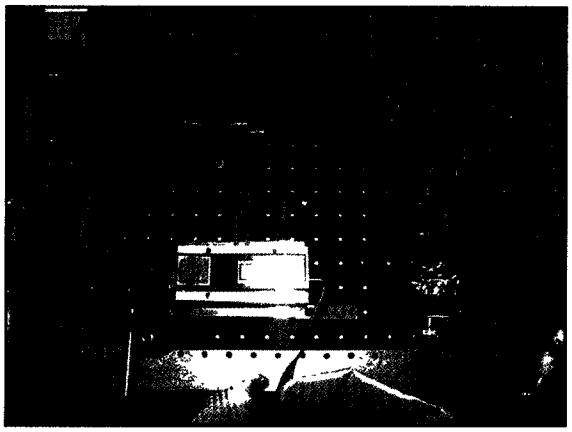
Backscatter Distribution Function

$$BSDF(\theta) = \frac{dPs / d\Omega}{Pi\ RT}$$

Methods

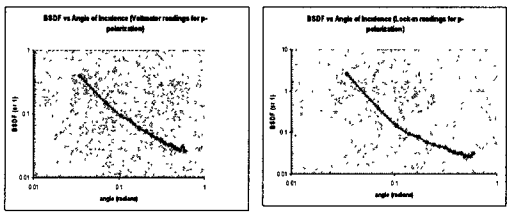
Set-up



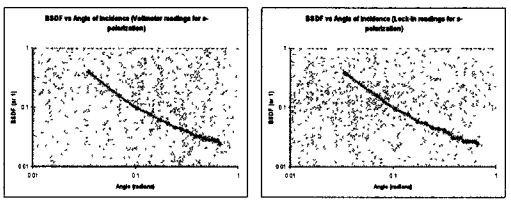


Results

BSDF vs Angle of Incidence for p-polarization



BSDF vs Angle of Incidence for s-polarization



Conclusion

Good candidate for a beam baffle:

BSDF readings were less than 3.9×10^{-2} for angles greater than 20^0 .

Reflectivity does not matter for a beam baffle .

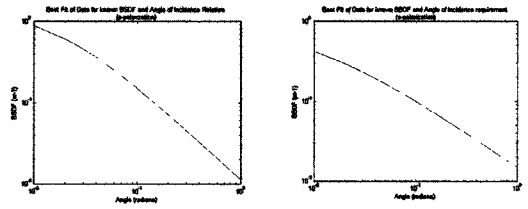
However...

BSDF readings were higher than the requirement of that of a beam dump.

Reflectivity was also high.

Estimation of angle of incidence to meet Beam dump requirement

BSDF = a / (b+ θ^q)



So,

For p-polarized incident beam, the sample needs to be tilted at 55.004^0 to meet the BSDF requirement of the beam dump.

For s-polarized beam, the sample needs to be tilted at 55.577^0 to meet the requirement.

I believe...

A good start for an effective study of scattering of materials.

A BSDF measuring apparatus has been designed and built successfully which can be valuable for further study of different samples and would contribute in attaining the required sensitivity of the LIGO interferometers

Additional Suggestions

More sensitive detector

Study of a diffuse scatterer for reference

Study of other LIGO material samples for comparison of BSDF

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