

FILE:SCATSCLE.TEX

TO: W.Althouse

FROM: R. Weiss (April 17,1989)

CONCERNING: Scaling of the identified scattering noise with tube parameters

I thought it would useful to assemble the scaling relations for the scattering noise identified in KST and RW documents on scattering in one place. The scaling relations are useful in estimating the influence of tube length and radius changes on scattering should scattering become a dominant noise. The symbols used are the following:

$h(f)$, the scattering noise equivalent limiting gravitational wave amplitude spectral density;

λ , the optical wavelength;

λ_g , the gravitational wave wavelength;

L , the interferometer arm length;

R , the tube radius;

l_1 , the distance to the first baffle from an interferometer mirror;

θ , the grazing angle;

θ_0 , the grazing angle with 80db of attenuation in the 4 km tube;

R_{eff} , the effective reflectivity including both absorption and diffuse scattering loss;

A , the attenuation by multiple encounters with the tube walls.

1) Backscattering by baffles

a) No output mode filter

$$h(f) \approx \frac{\lambda^{3/4} L^{1/4}}{R^{1/2} l_1^{1/2}}$$

b) with output mode filter

$$h(f) \approx \frac{\lambda^{3/4}}{R^{1/2} L^{1/4}}$$

2) Diffraction aided reflection

a) No output mode filter

$$h(f) \approx \frac{\lambda^{7/4} L^{7/4}}{\lambda_g R^{5/2}} \ln \left(\frac{L \theta_0}{4R} \right)$$

b) with output mode filter

$$h(f) \approx \frac{\lambda^2 L^2}{\lambda_g R^3}$$

3) Attenuation of multiple reflections in the tube

$$A = (R_{eff})^{\left(\frac{\theta L}{2R}\right)}$$