Wavelength Scaling Law

When the BSDF is due to microroughness on a surface, you can scale it to other wavelengths very easily. This technique is valid when the scattering is from a polished surface, but not when the scattering is due to contamination or dust on the surface.

The ABg BSDF model used in TracePro (and GUERAP V) has the form

$$BSDF = \frac{A}{B + \beta^g}$$

where

$$\beta \equiv \left| \vec{\beta} - \vec{\beta}_0 \right|$$

To scale the ABg BSDF from one wavelength to another, say from λ_1 to λ_2, we calculate new A and B coefficients, and g remains unchanged,

$$A_2 = A_1 \left(\frac{\lambda_2}{\lambda_1} \right)^{g-4}$$

and

$$B_2 = B_1 \left(\frac{\lambda_2}{\lambda_1} \right)^{g} .$$

Scaling Law for ABg BSDF

The BSDF due to surface microroughness (polished surfaces with $\sigma \ll \lambda$) is proportional to the power spectral density (PSD) of the surface roughness with $1/\lambda^4$ scaling (J.C. Stover, Optical Scattering: Measurement and Analysis, McGraw-Hill, New York (1990), eq. 4.1),

$$BSDF = \frac{1}{\lambda^4} PSD .$$

We postulate that the PSD (and therefore the BSDF) has the form

$$PSD = \frac{a}{b + (cf)^g}$$

where a, b, and c are constants and f = spatial frequency. Noting that $f = \beta / \lambda$, where

$$\beta \equiv \left| \vec{\beta} - \vec{\beta}_0 \right|,$$

then

$$PSD = \frac{a}{b + \left(\frac{c\beta}{\lambda} \right)^g} = \frac{a \left(\frac{\lambda}{c} \right)^g}{a \left(\frac{\lambda}{c} \right)^g + \beta^g}.$$

Using the fact that the BRDF is proportional to the PSD, after doing some algebra, we can write the BSDF as

$$BSDF = K \frac{\frac{a}{c^g} \lambda^{g-4}}{\frac{b}{c^g} \lambda^g + \beta^g}$$

where K is a constant. Letting a&χεντ; = a/c^g, b&χεντ; = b/c^g, we have

$$BSDF = K \frac{a' \lambda^{g-4}}{b' \lambda^g + \beta^g}.$$

For a particular λ, then,

$$A = K a' \lambda^{g-4}$$

and

$$B = b' \lambda^g.$$

The wavelength scaling law for the ABg BSDF is now evident. To scale the ABg BSDF from λ_1 to λ_2, we calculate new A and B coefficients, and g remains unchanged,

$$A_2 = A_1 \left(\frac{\lambda_2}{\lambda_1} \right)^{g-4}$$

and

$$B_2 = B_1\left(\frac{\lambda_2}{\lambda_1}\right)^{\varepsilon}.$$