Reflection Models

Previous lectures

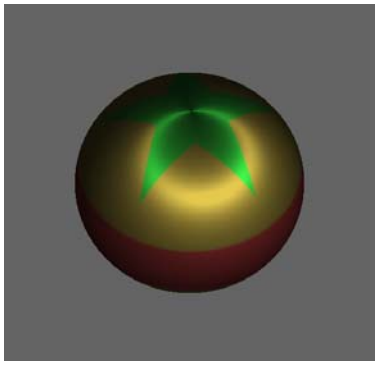
- **Ideal materials: mirrors, glass, matte**
- **Glossy materials**

Today

- **Anisotropic reflection**
- **Subsurface reflection; translucent materials**

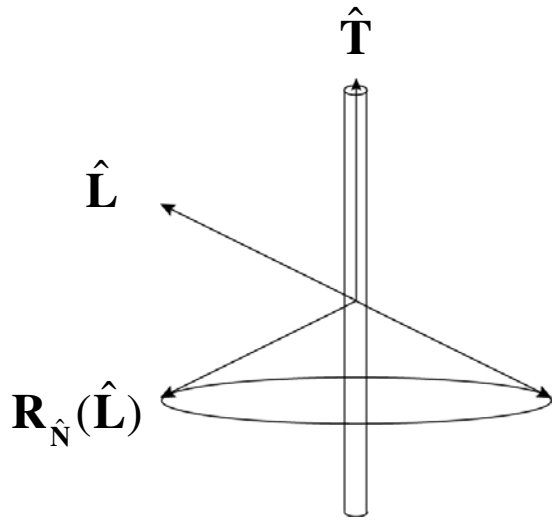
Anisotropic Reflection Model

Anisotropic Reflection

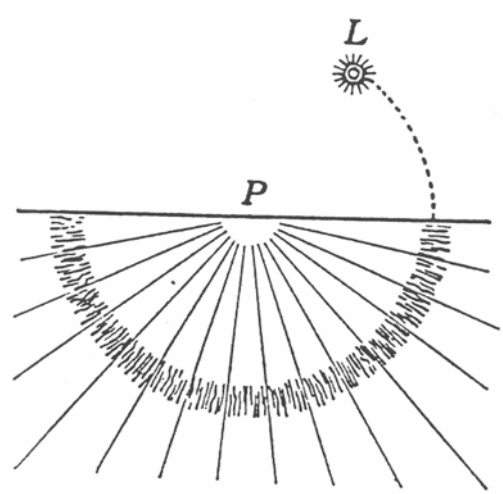


Quarterhorse

Reflection from a Cylinder

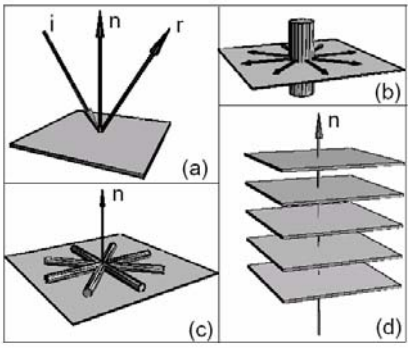


Anisotropic Reflection



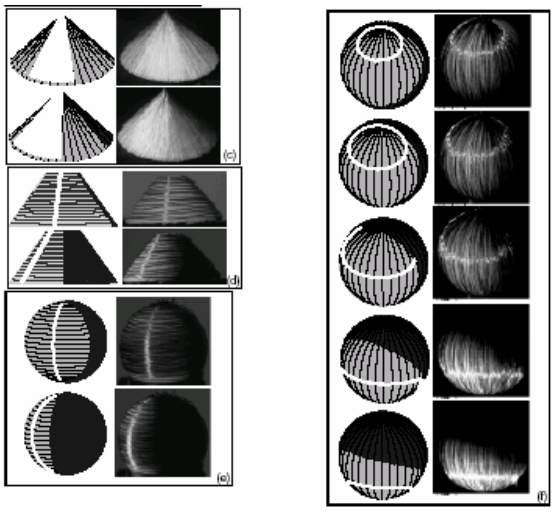
Shape of Anisotropic Highlights

Fibers tangent to the plane defined by the halfway vector reflect light



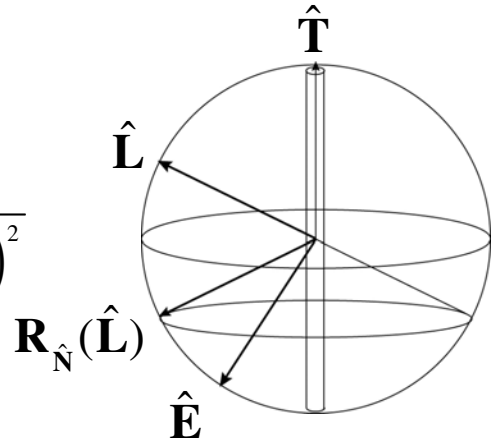
From Lu, Koenderink, Kappers

Shape of Anisotropic Highlights



From Lu, Koenderink, Kappers

Kajiya-Kay Model



Diffuse

$$\sin\theta_L = \sqrt{1-\left(\hat{\mathbf{T}}\bullet\hat{\mathbf{L}}\right)^2}$$

Specular

$$\cos^s\left(\theta_E-\theta_L\right)=\left(\cos\theta_E\cos\theta_L+\sin\theta_E\sin\theta_L\right)^s$$

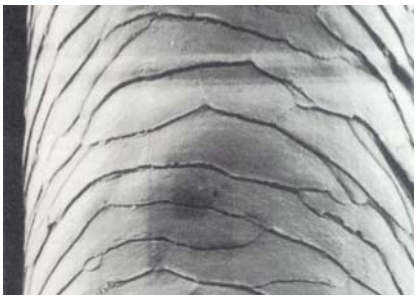
Herbert

Previous Work

Measurements for cosmetics industry

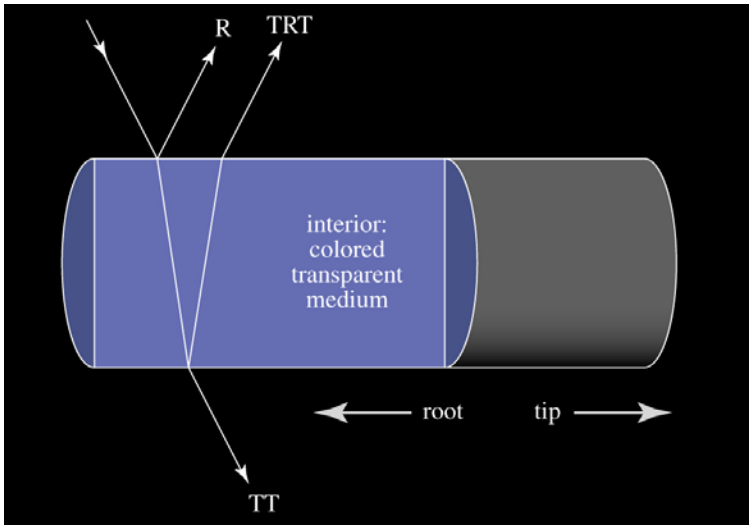
- **[Stamm 1977; Bustard & Smith 1994]**

Structure of fiber surface

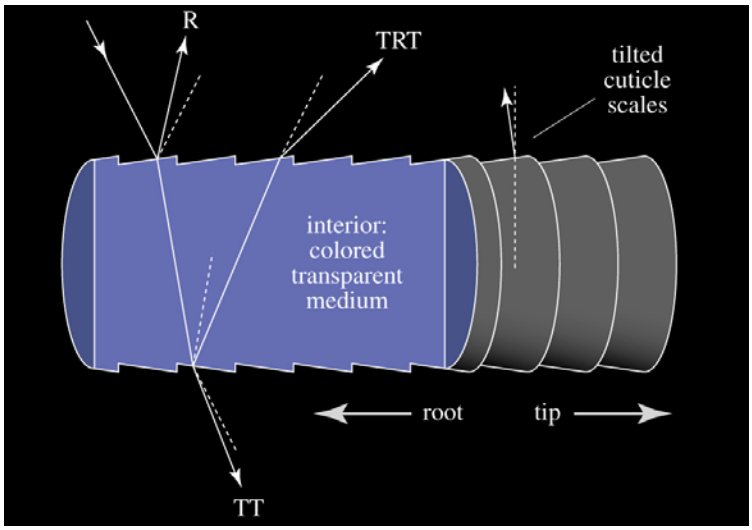


[Robbins '94]

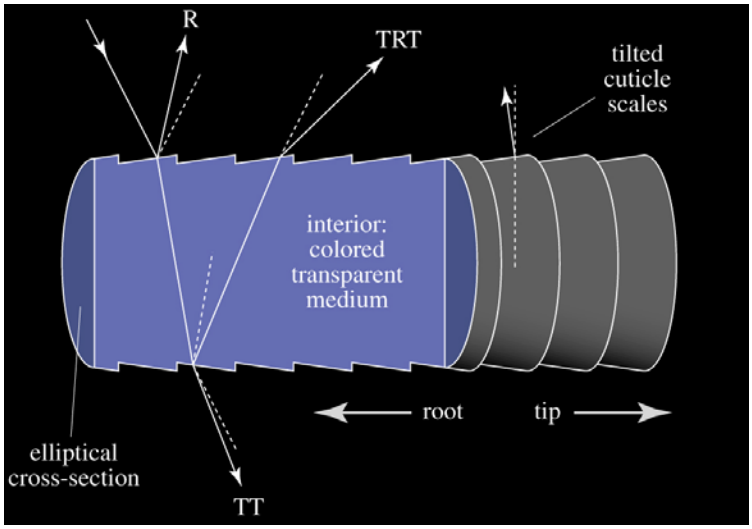
Fiber Model



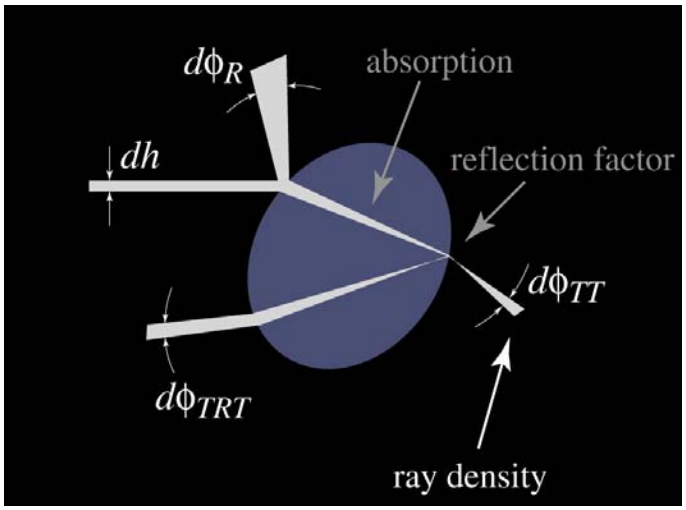
Fiber Model



Fiber Model

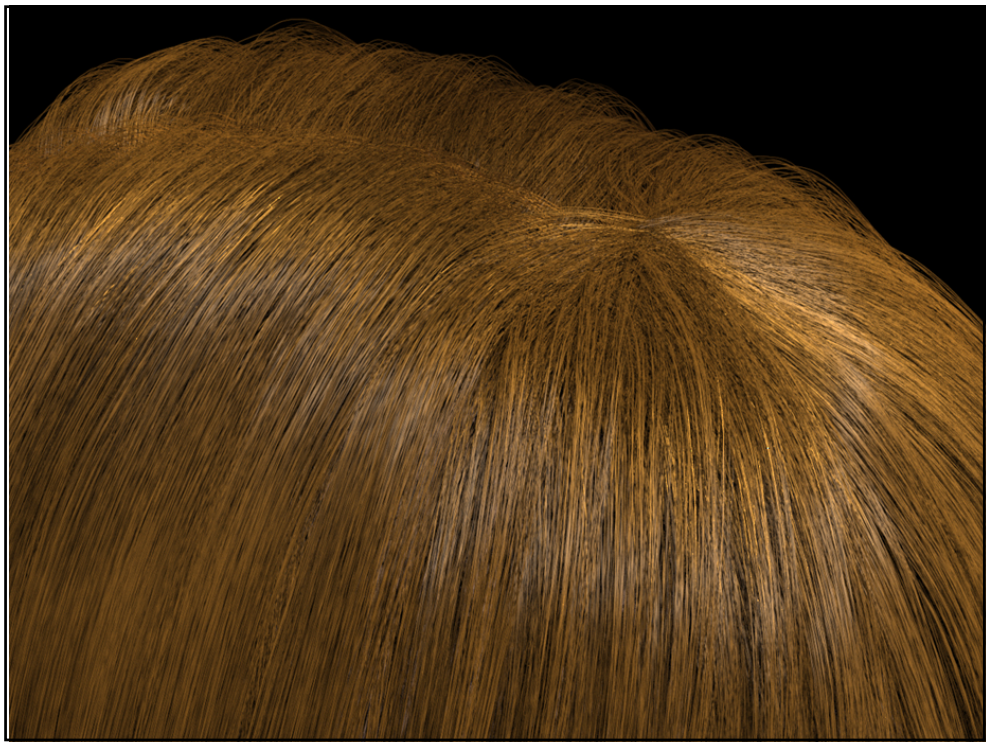


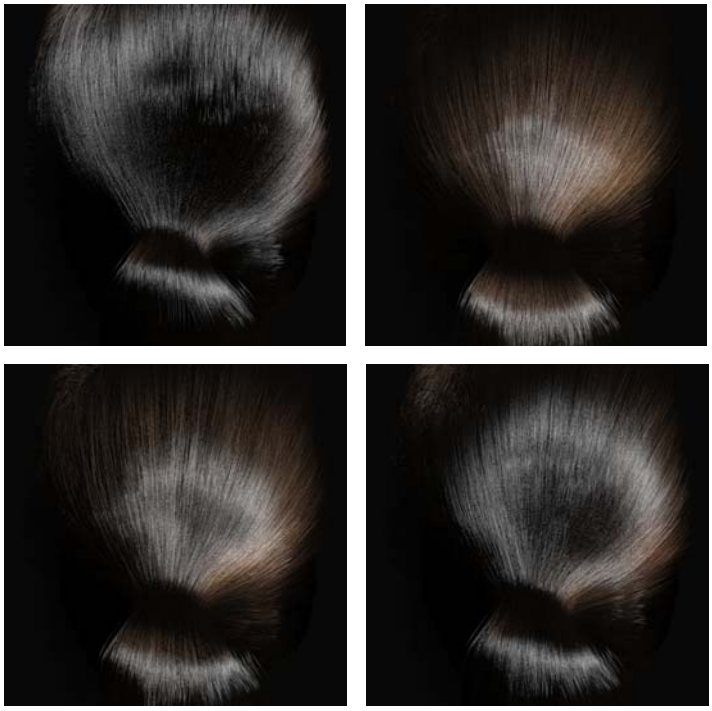
Caustics



Hair Appearance

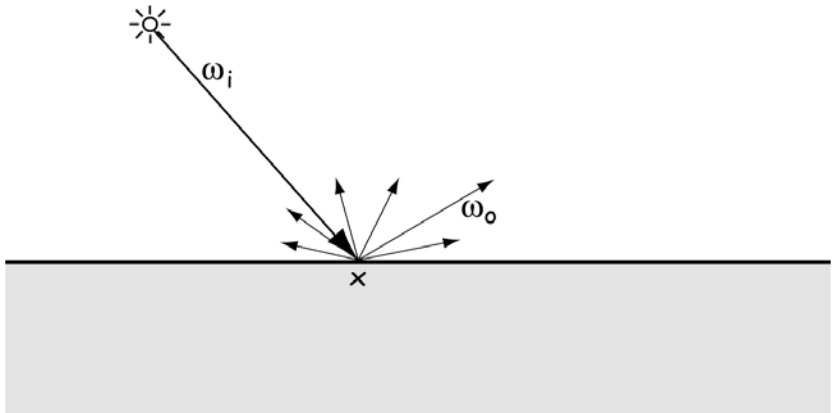
Hair Appearance





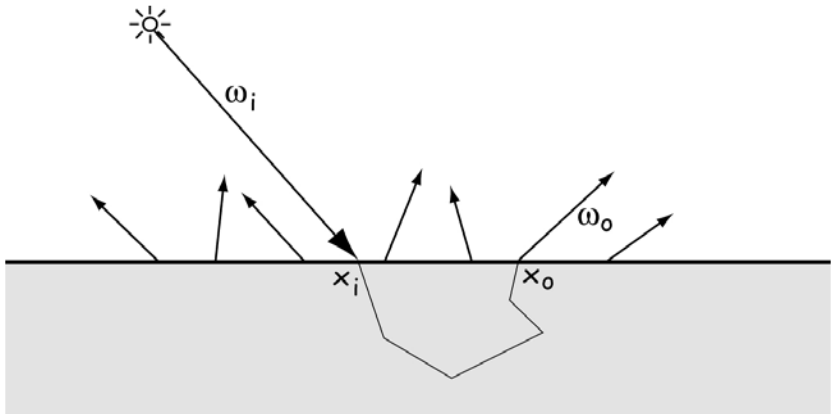
Subsurface Reflection

Traditional Reflection Models: BRDF



$$f_r(x,\omega_i,\omega_o) \equiv \frac{dL_r(x,\omega_o)}{dE_i(x,\omega_i)}$$

Subsurface Scattering: BSSRDF



$$S(x_i,\omega_i;x_o,\omega_o) \equiv \frac{dL_r(x_o,\omega_o)}{d\Phi_i(x_i,\omega_i)}$$

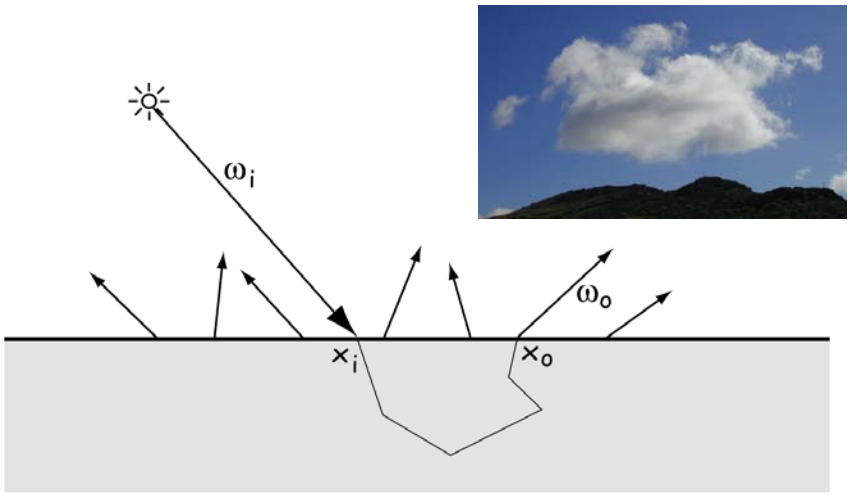
Translucent Materials: Jade

Translucent Materials: Marble

Translucent Materials: Skin

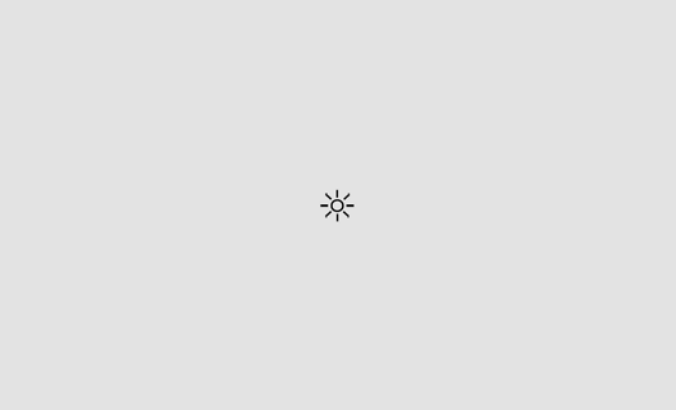
Translucent Materials: Leaves

How?

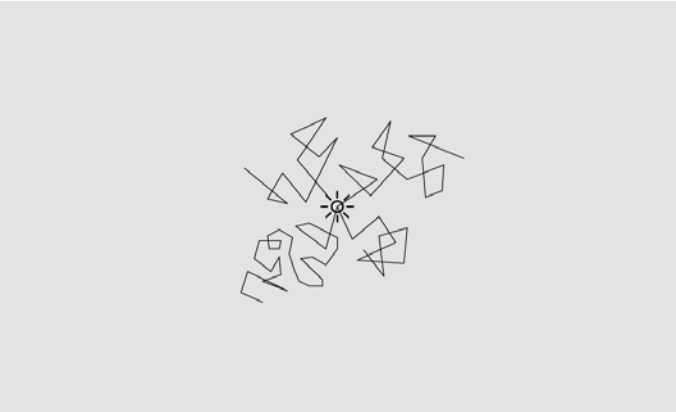


$$S(x_i, \omega_i, x_o, \omega_o) \qquad \frac{dL(x_o, \omega_o)}{d\Phi(x_i, \omega_i)}$$

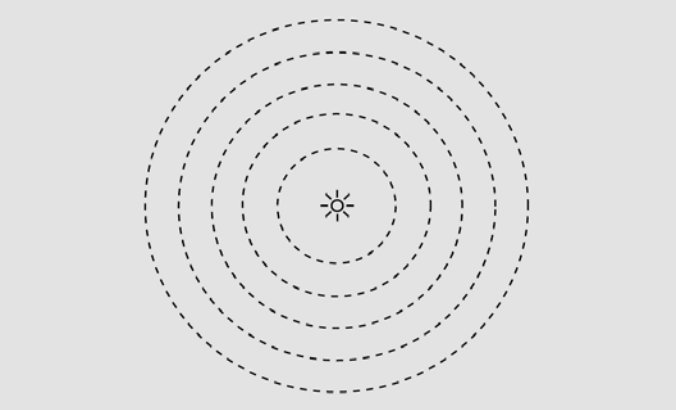
Highly Scattering Media



Highly Scattering Media

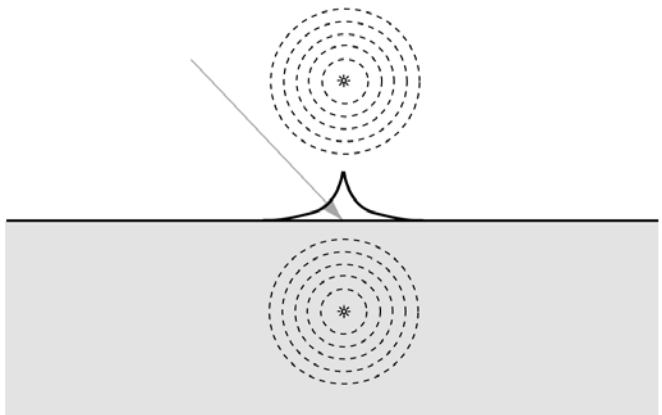


Diffusion Approximation



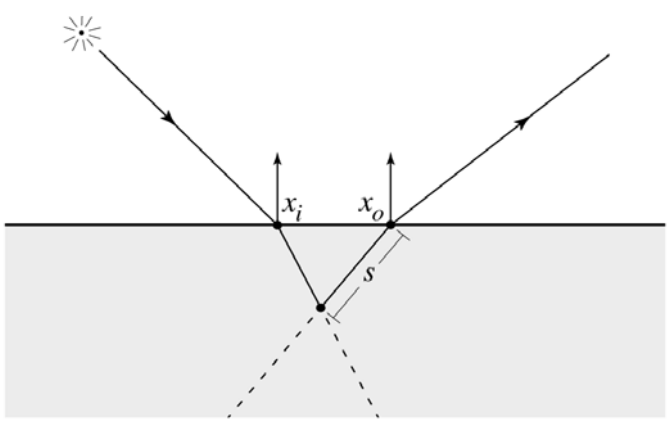
$$\phi(r) = \Phi \frac{e^{-kr}}{r}$$

Dipole Diffusion Approximation

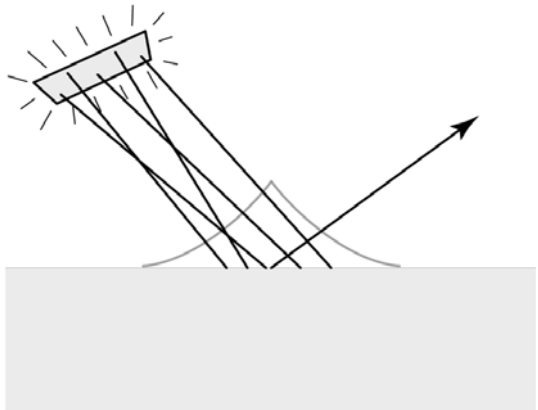


$$R_d(r) = -\frac{\vec{\mathbf{N}} \bullet (\nabla \phi_1(r) - \nabla \phi_2(r))}{\Phi_i}$$

Single Scattering



Evaluating the BSSRDF



$$L_r(x_o, \omega_o) = \int_A \int_\Omega S(x_i, \omega_i; x_o, \omega_o) L_i(x_i, \omega_i) \cos\theta_i \, d\omega_i \, dA$$

Marble: BDRF versus BSSDRF

BRDF

BSSRDF

Marble: MCRT vs BSSRDF

MCRT

BSSRDF

Skim Milk

Whole Milk

Diffuse Milk

A Face (BSSRDF Model)

A Face (BRDF Approximation)