Reflection Models I

cs348b
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Overview

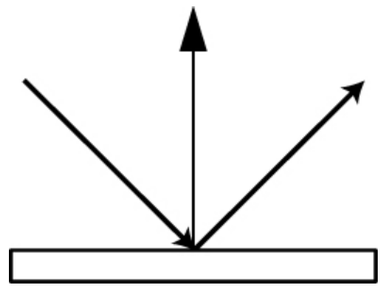
- Types of reflection models
- The BRDF
- The reflection equation
- Ideal reflection and refraction
- Fresnel reflection
- Diffuse reflection

Reflection

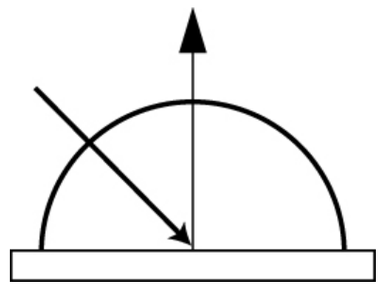
- Properties
  - Spectral distribution
  - Polarization
  - Directional distribution
- Approaches
  - Physical (wave optics, geometric optics, ...)
  - Phenomenological
  - Measured data

Types of Reflection Models

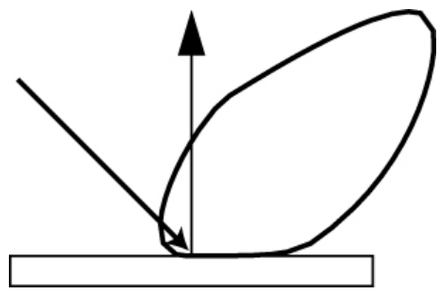
- Ideal Specular



- Ideal Diffuse



- Glossy Specular



Diffuse

Plastic

Metal

Blue Paint

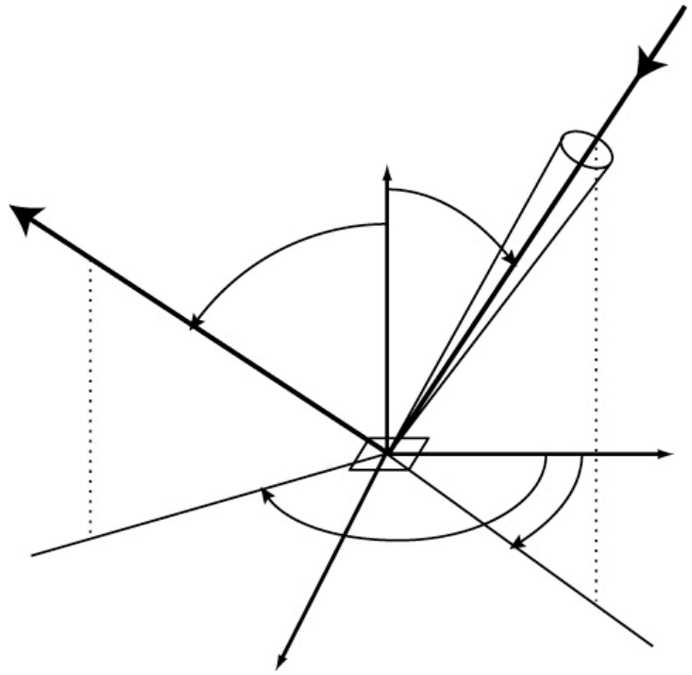
Brushed Metal

Clay

Skin

The BRDF

- Bidirectional reflectance distribution function

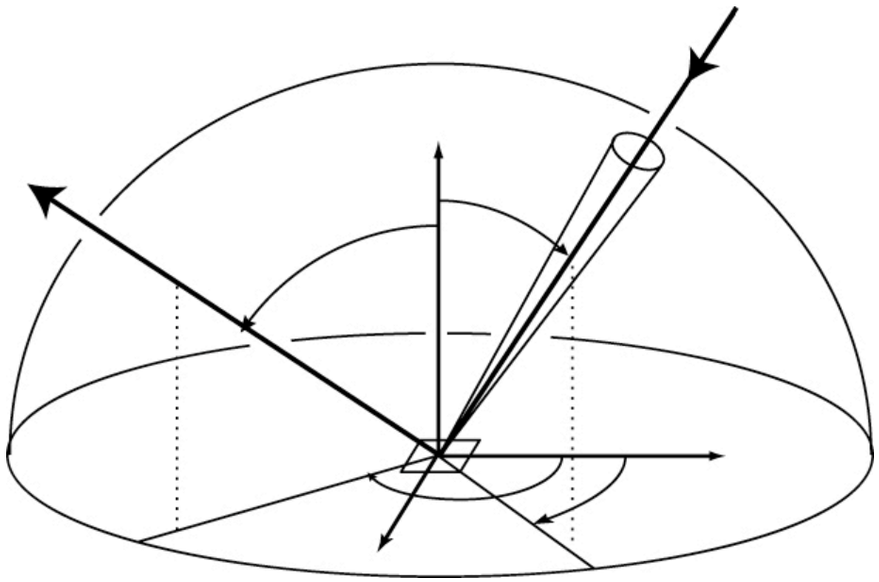


$$f_r(\omega_i \rightarrow \omega_o) = \frac{dL_r(\omega_i \rightarrow \omega_o)}{dE_i(\omega_i)}$$

Key Properties

- Linearity
- Reciprocity
- Energy conservation
- Isotropic vs. anisotropic

The Reflection Equation



$$L(\omega_o) = \int_\Omega f(\omega_i \rightarrow \omega_o) L(\omega_i) \cos\theta_i d\omega_i$$

Reflectance

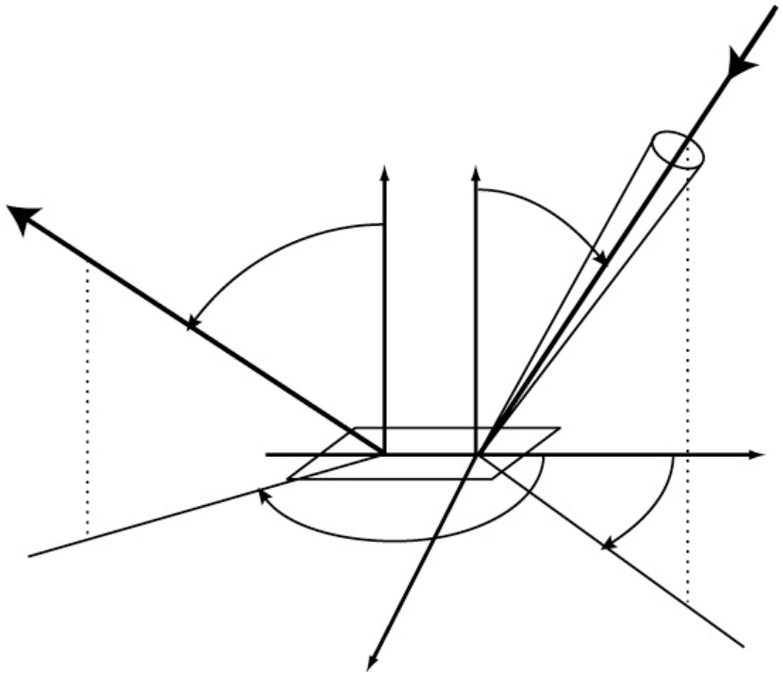
- Ratio of incident power to reflected power

$$\rho(\Omega_i \rightarrow \Omega_o) = \frac{d\Phi_i}{d\Phi_o} = \frac{\int_{\Omega_o} L(\omega_o) \cos\theta_o d\omega_o}{\int_{\Omega_i} L(\omega_i) \cos\theta_i d\omega_i}$$

- 3 possibilities for Ω
  - differential solid angle, solid angle, hemisphere
- Conservation of energy: $0 \leq \rho \leq 1$

The BSSRDF

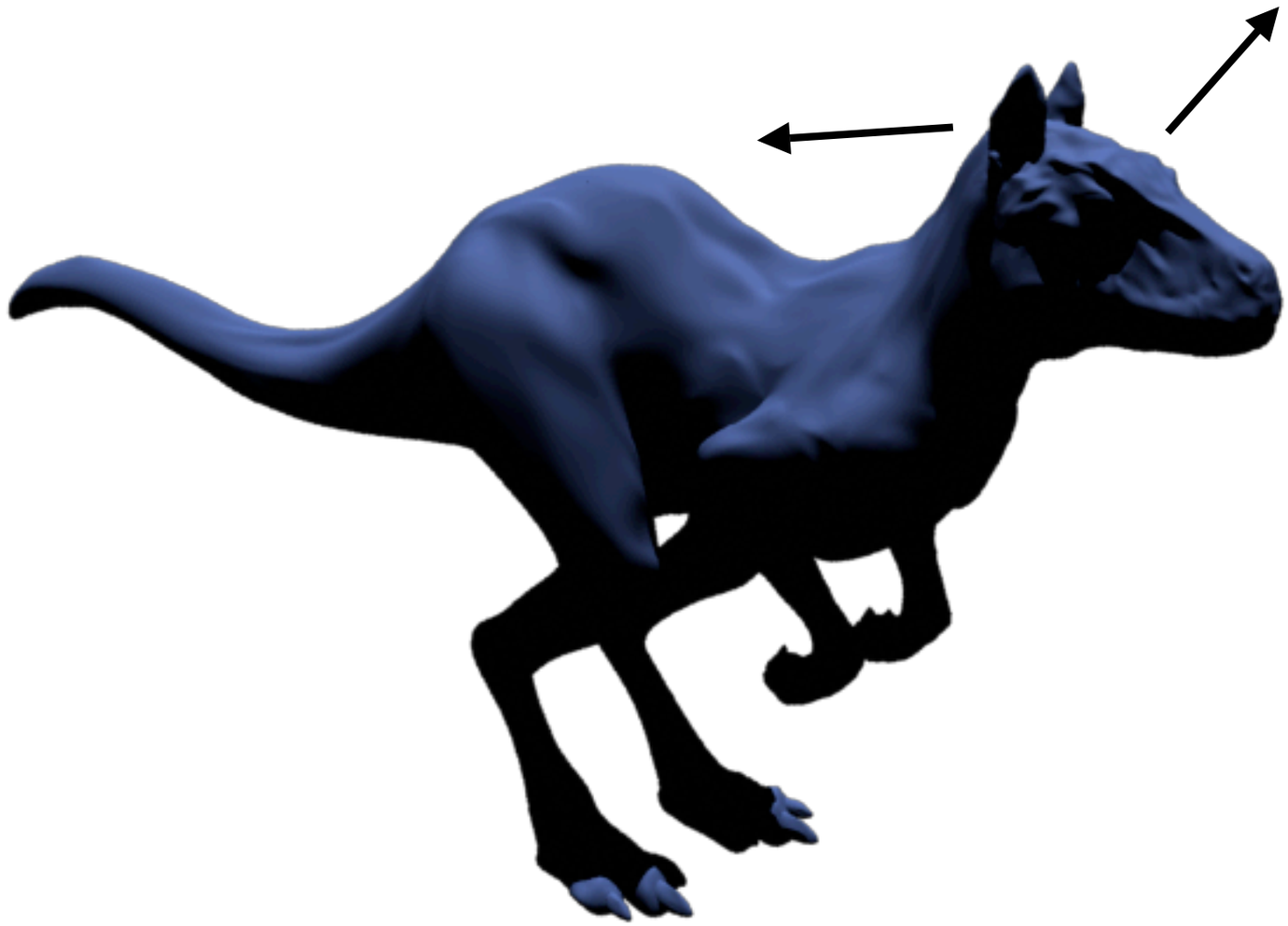
- Bidirectional surface scattering reflectance distribution function



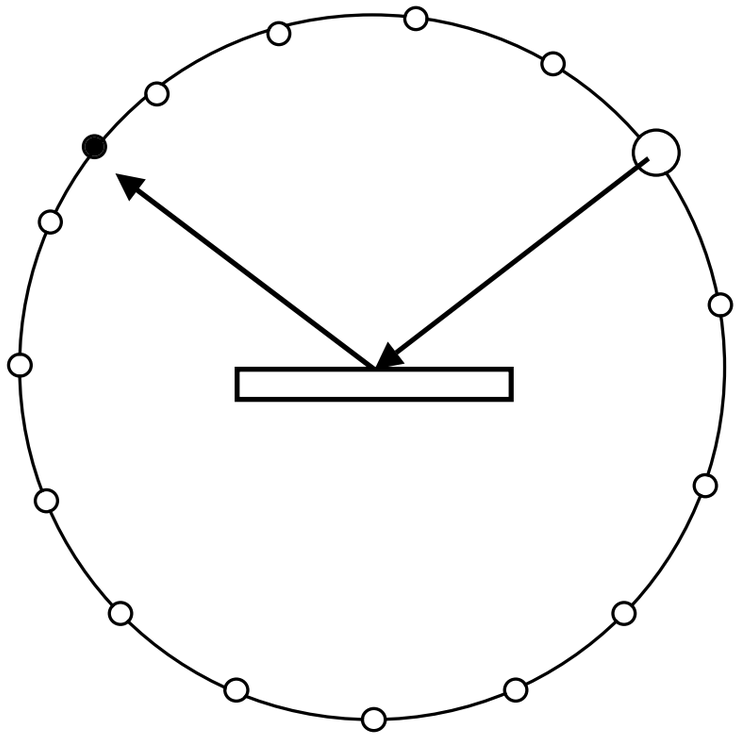
$$S(x_i, \omega_i \rightarrow x_o, \omega_o) = \frac{dL_r(x_i, \omega_i \rightarrow x_o, \omega_o)}{d\Phi_i(x_i, \omega_i)}$$

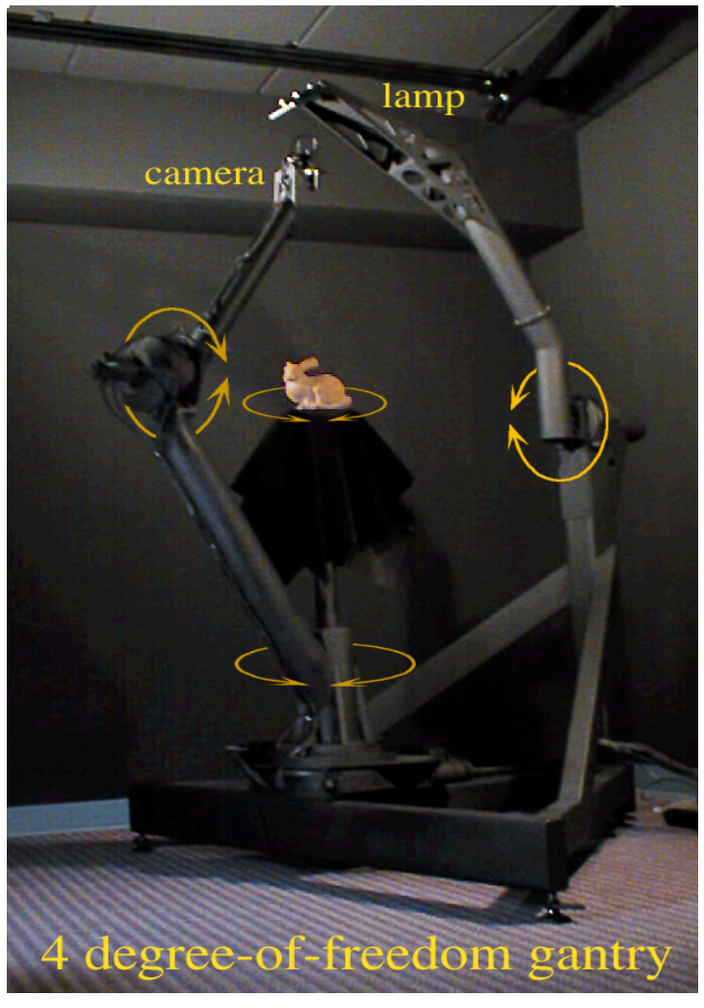
General Scattering Functions

$$S(x_i, \omega_i \rightarrow x_o, \omega_o)$$



Gonioreflectometer





Law of Reflection

$$\theta_i = \theta_o$$
$$\phi_i = \phi_o + \pi$$

- Computing the reflected direction
  - Vector geometry approach
  - BRDF coordinate system

$$f_r(\omega_i \rightarrow \omega_o) = \frac{\delta(\omega_i - \omega_o)}{\cos\theta_i}$$

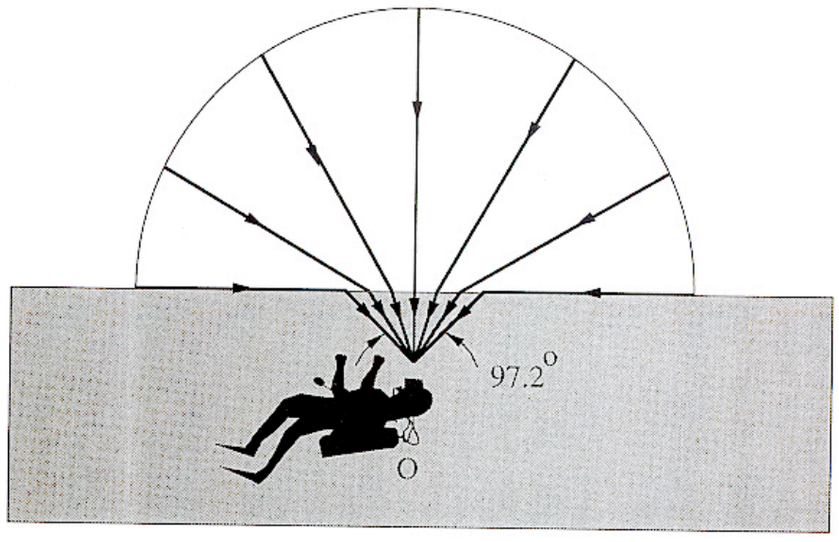
Law of Refraction

- Snell's law $\eta_i \sin\theta_i = \eta_o \sin\theta_o$
  - Can derive from Fermat's Principle...

$$\phi_i = \phi_o + \pi$$

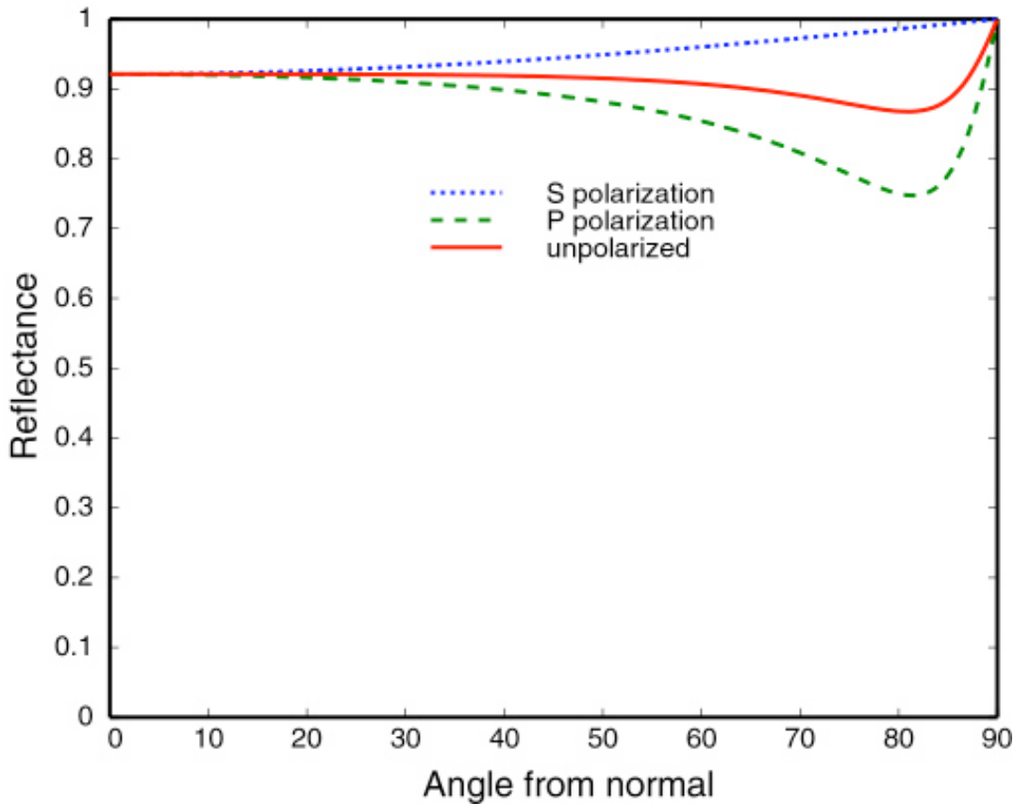
- Total internal reflection if no solution to Snell's law equation

Optical Manhole

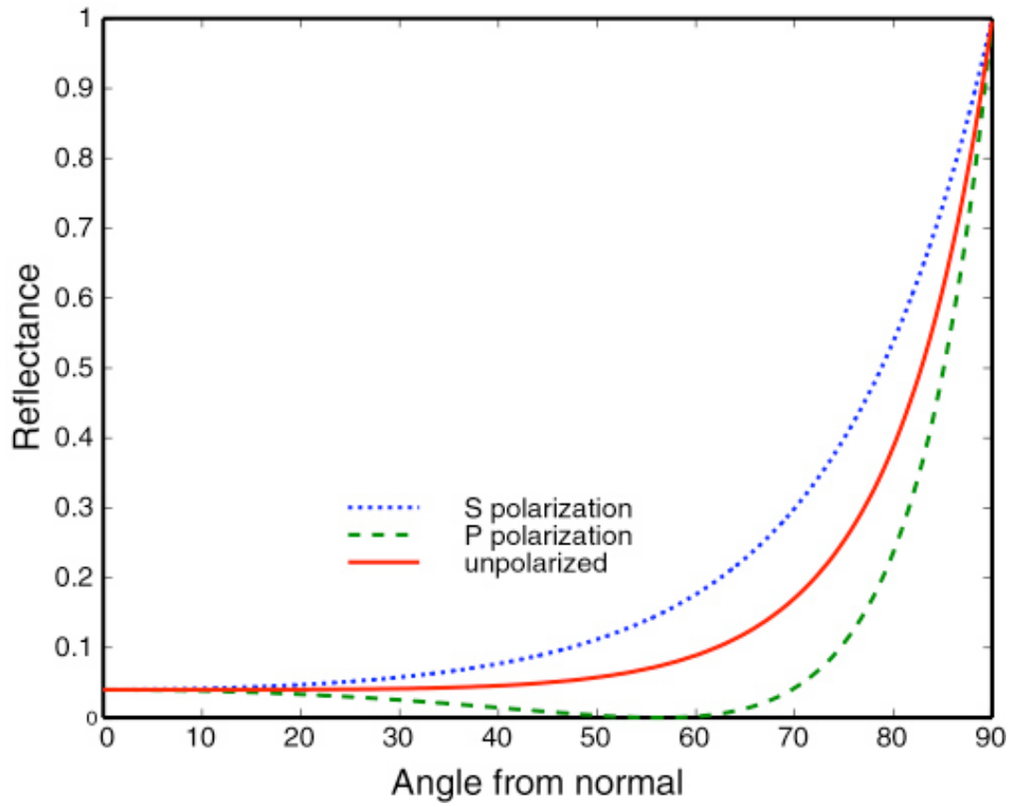


Fresnel Reflectance

Metal (aluminum)



Dielectric (glass)



Schlick: $F(\theta) = F(0) + (1 - F(0))(1 - \cos\theta)^5$

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Fresnel Reflectance in Action

Lafortune, Foo, Torrance, Greenberg, SIGGRAPH 1997

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Ideal Diffuse Reflection

- Assume light is equally scattered in all directions

$$f_r(\omega_i \rightarrow \omega_o) = c$$

- Not physically realizable (but the ideal for matte paint)

$$L_o(\omega_o) = c \cdot E$$