Lighting and shading

Raghavendra G S

Rendering equation

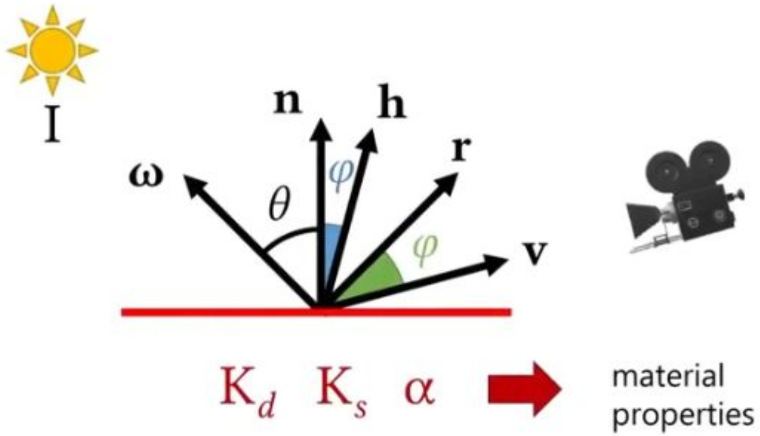
Jim Kajiya came up with a generalization of the illumination models in the 80s

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_\Omega L_i(\boldsymbol{\omega}_i) \cos\theta_i \ f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \ d\boldsymbol{\omega}_i$$

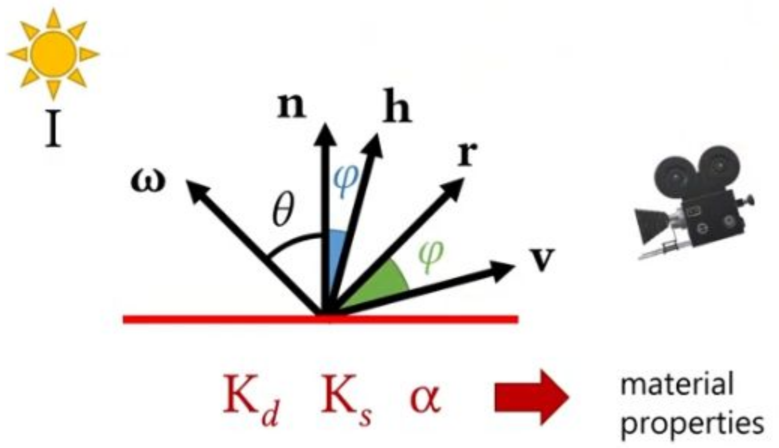
Recall Blinn/Phong Model

$$C = I\left(\cos\theta\, K_d + K_s(\cos\varphi)^{\alpha}\right)$$



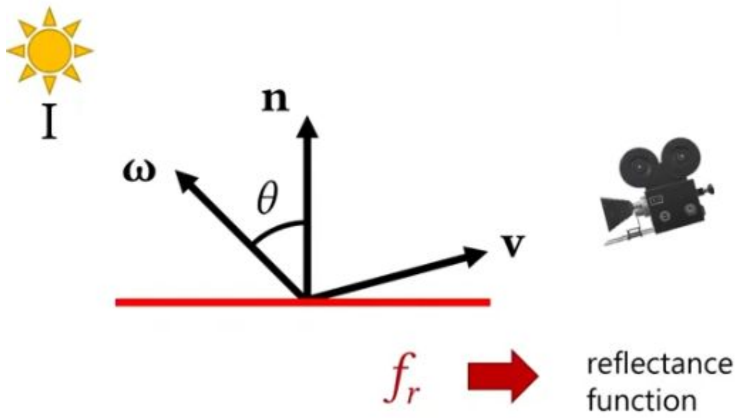
Recall Blinn/Phong Model

$$C = I\cos\theta\left(K_d + K_s\frac{(\cos\varphi)^{\alpha}}{\cos\theta}\right)$$



Reflectance function

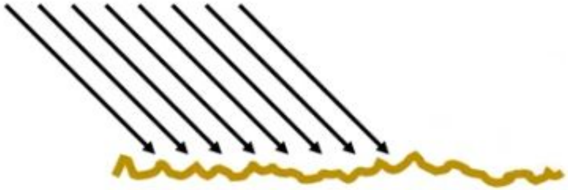
$$C = I \cos\theta \; f_r(\boldsymbol{\omega}, \mathbf{v})$$



Reflections

Zoomed in view

Zoomed in view



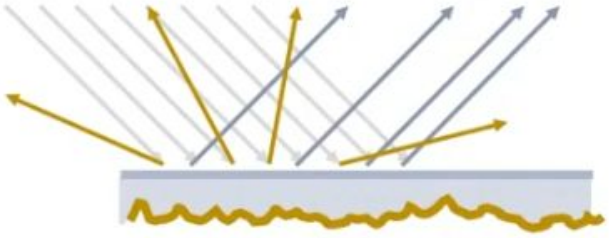
Zoomed in view

Zoomed in view

Zoomed in view

Zoomed in view

Zoomed in view

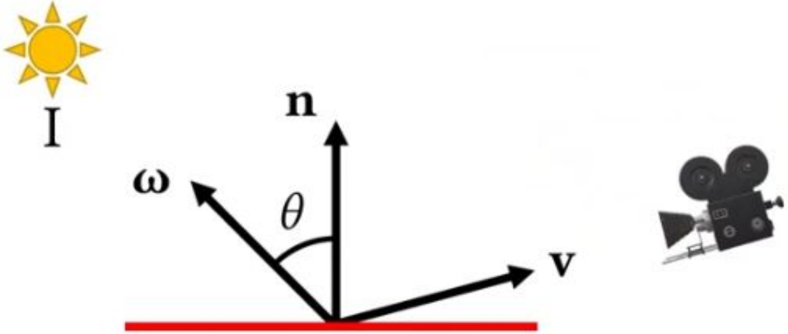


Zoomed in view

BDRF

$$f_r(\boldsymbol{\omega},\mathbf{v})$$

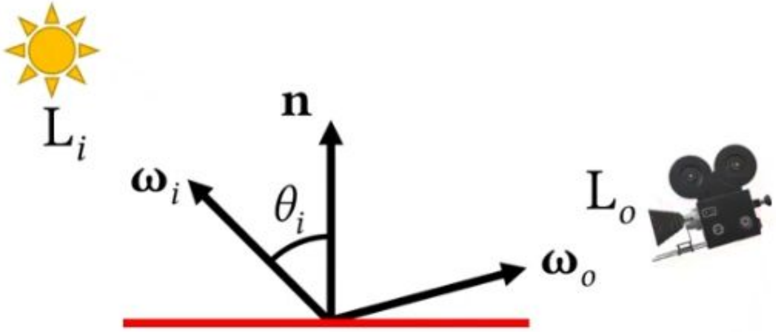
Bidirectional Reflectance
Distribution Function (BRDF)



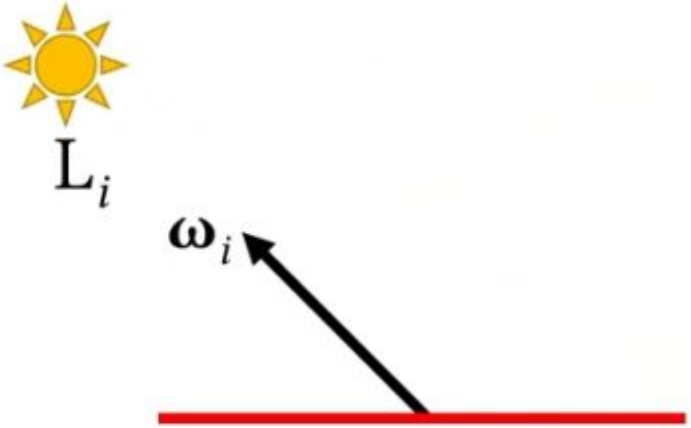
BDRF

$$f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)$$

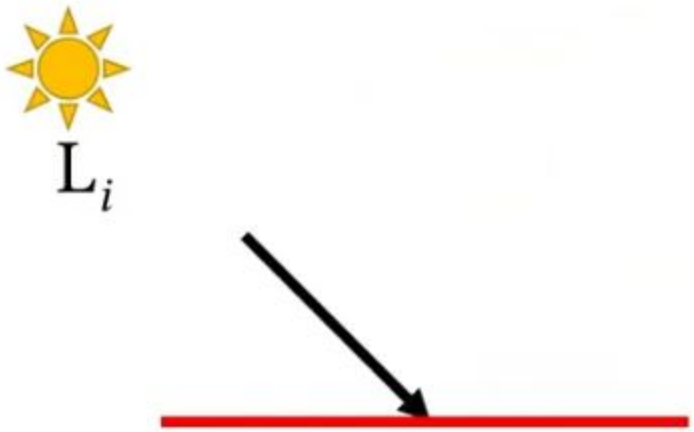
Bidirectional Reflectance
Distribution Function (BRDF)



BDRF



BDRF

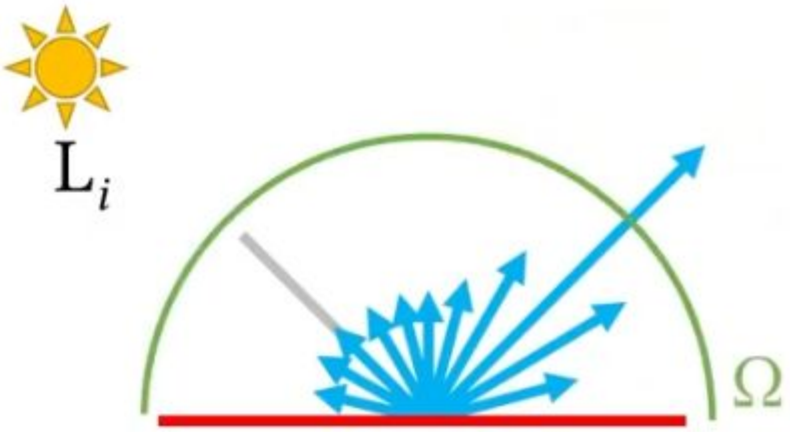


BDRF

BDRF

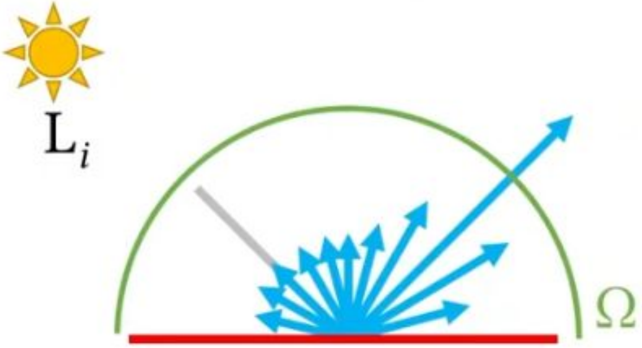
BDRF

BDRF



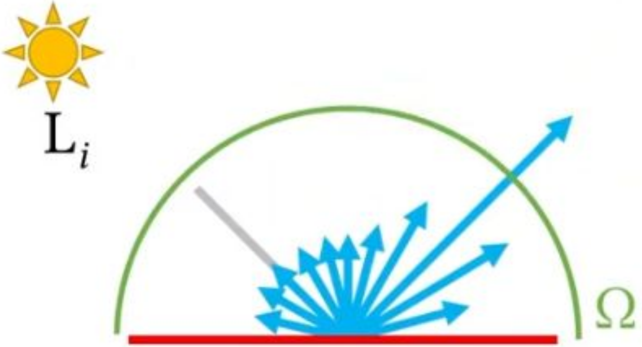
BDRF

$$\int_{\Omega} f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_o$$



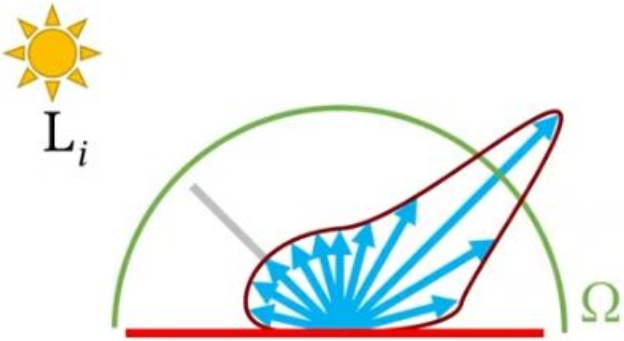
BDRF

$$\int_{\Omega} f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)\ d\boldsymbol{\omega}_o \le 1$$



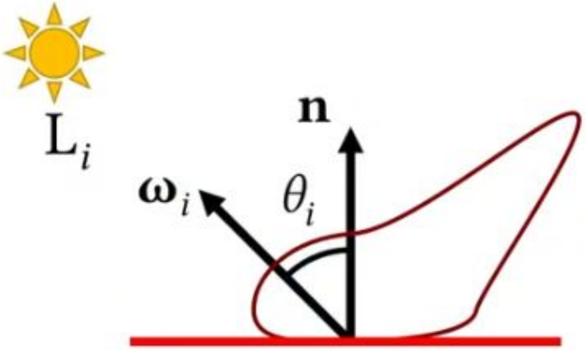
BDRF

$$\int_{\Omega} f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)\ d\boldsymbol{\omega}_o \leq 1$$

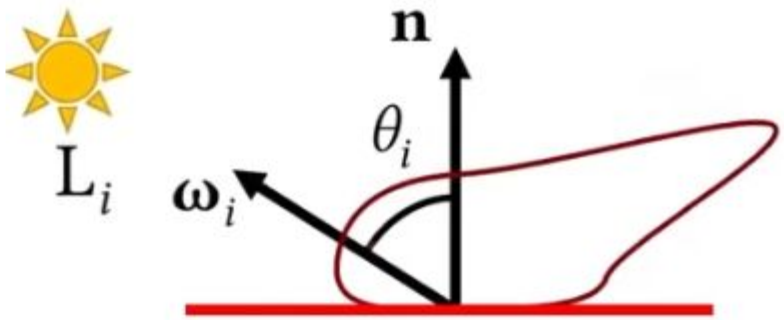


BDRF

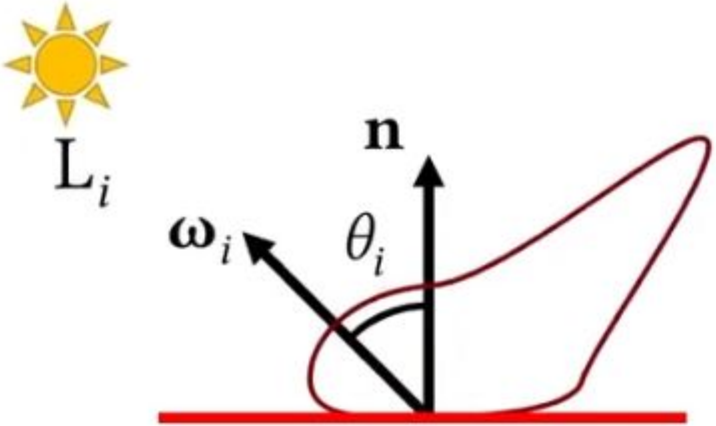
$$\int_{\Omega} f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_o \leq 1$$



BDRF

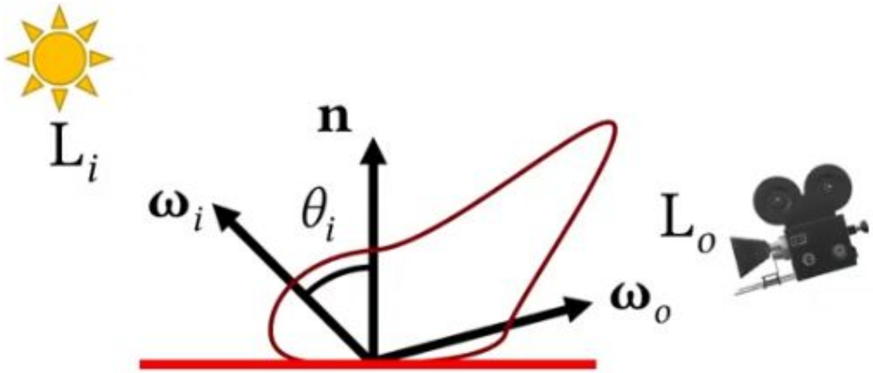


BDRF



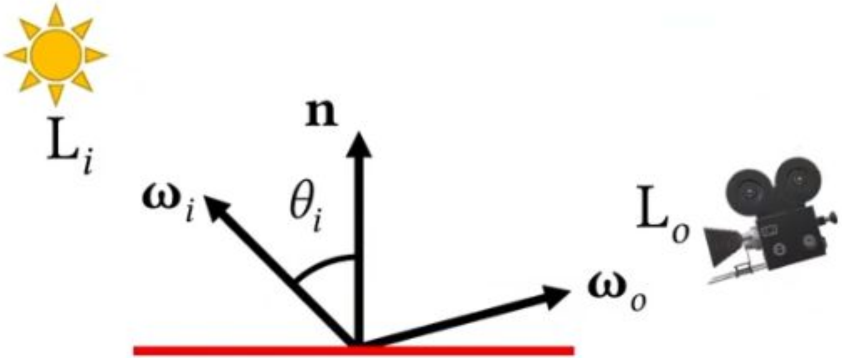
BDRF

$$\int_{\Omega} f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_o \; \leq 1$$



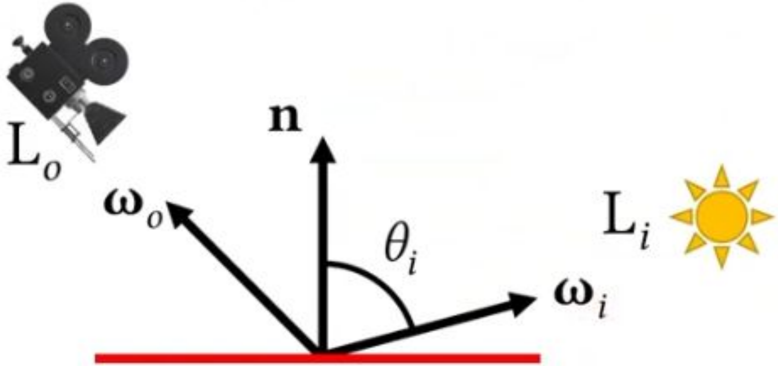
BDRF

$$f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) = f_r(\boldsymbol{\omega}_o, \boldsymbol{\omega}_i)$$



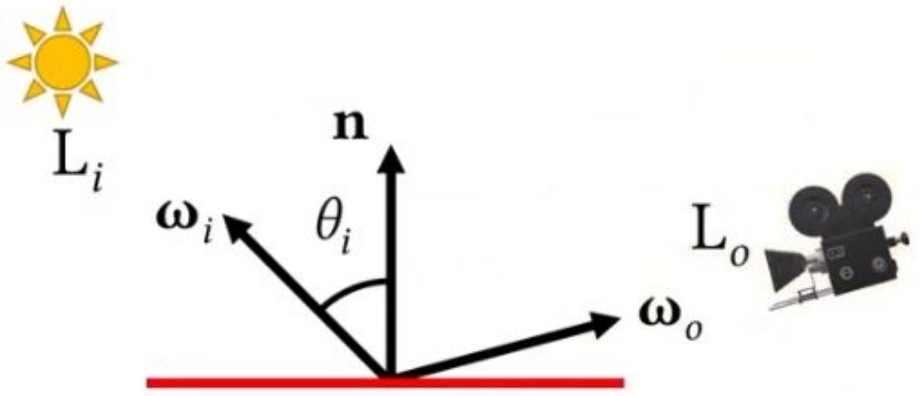
BDRF

$$f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) = f_r(\boldsymbol{\omega}_o, \boldsymbol{\omega}_i)$$



Rendering equation

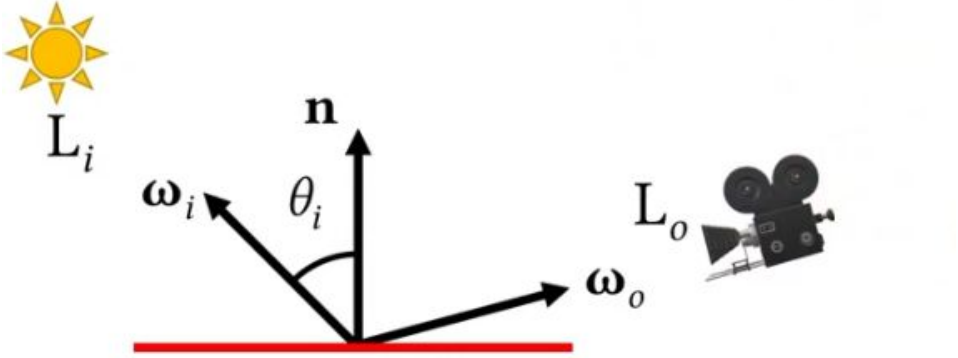
$$L_o(\boldsymbol{\omega}_o) = L_i(\boldsymbol{\omega}_i) \cos\theta_i \, f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)$$



Rendering equation

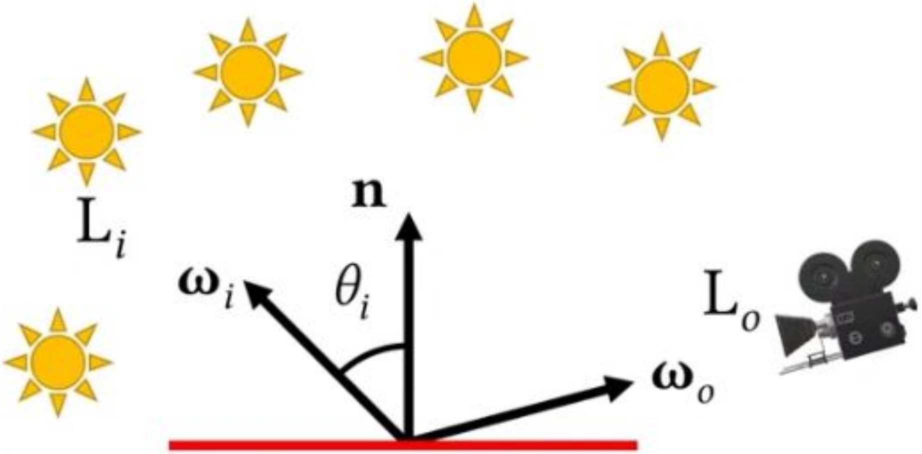
$$C = I\cos\theta \; f_r(\boldsymbol{\omega}, \mathbf{v})$$

$$L_o(\boldsymbol{\omega}_o) = L_i(\boldsymbol{\omega}_i)\cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)$$



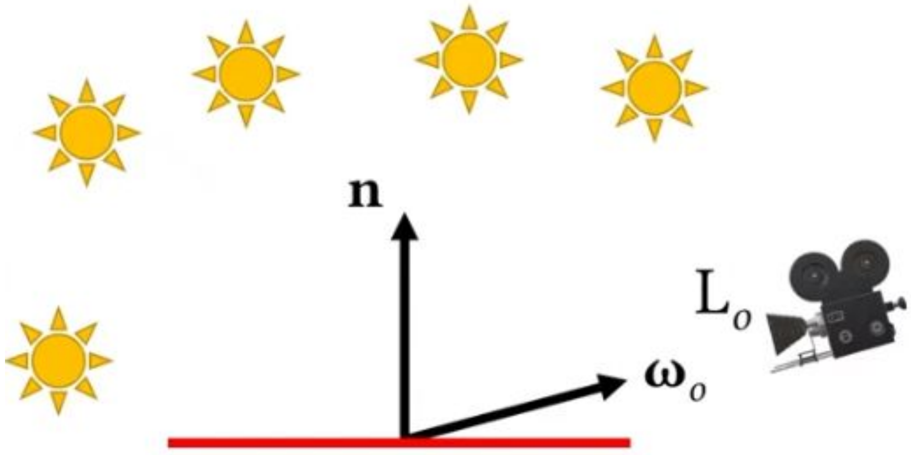
Rendering equation

$$L_o(\boldsymbol{\omega}_o) = L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)$$



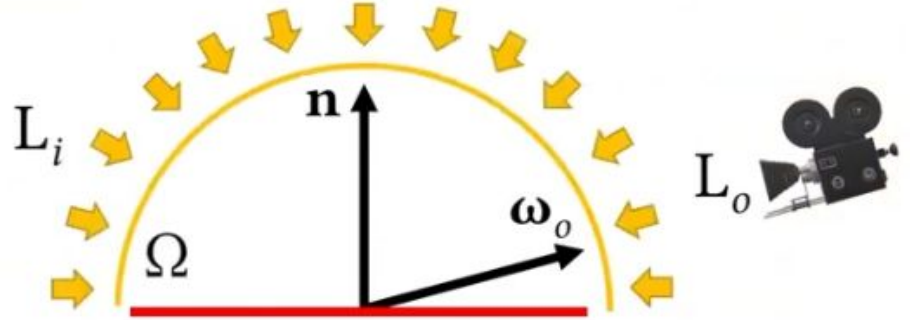
Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \sum_i L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)$$



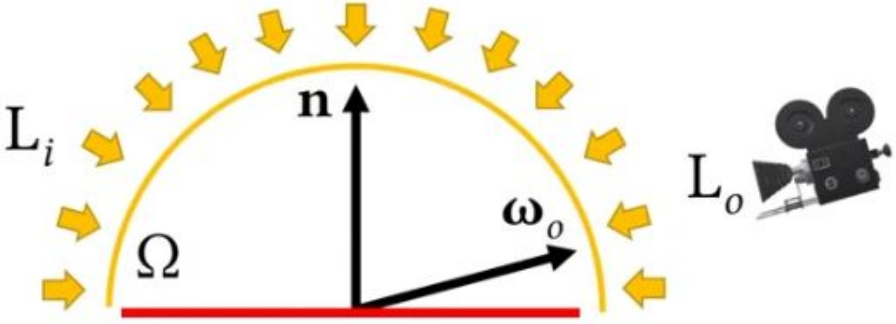
Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \sum_i L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o)$$



Rendering equation

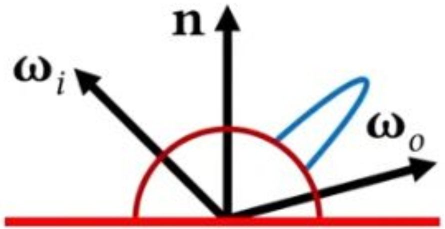
$$L_o(\boldsymbol{\omega}_o) = \int_\Omega L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \;\; d\boldsymbol{\omega}_i$$



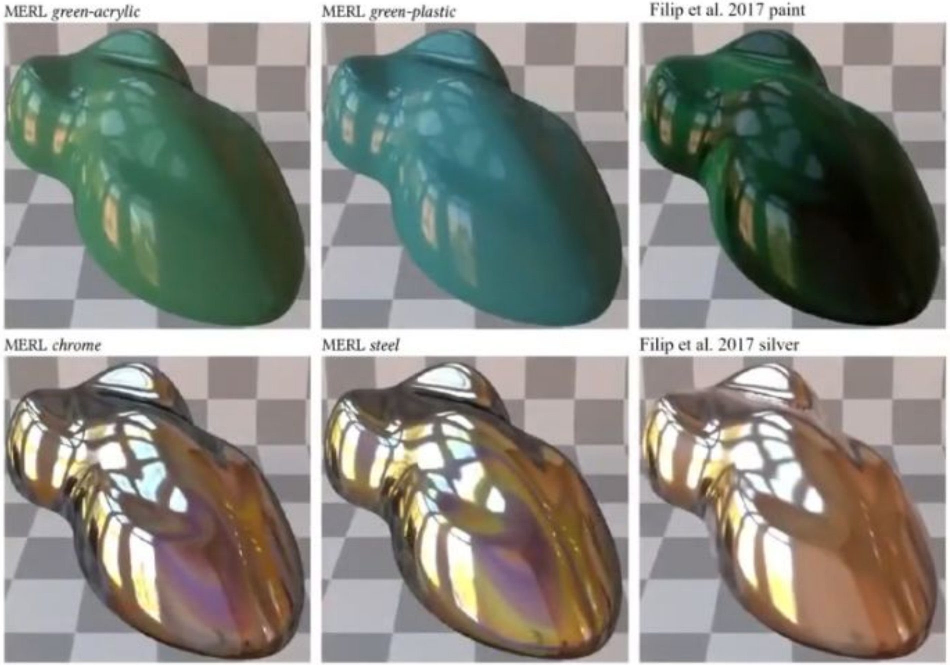
Rendering equation - Blinn/Phong

$$L_o(\boldsymbol{\omega}_o) = \int_\Omega L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Blinn/Phong: $$f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) = \mathrm{K}_d + \mathrm{K}_s \frac{(\cos\varphi_i)^\alpha}{\cos\theta_i}$$



Measured BRDF



Jiri Filip, Radomir Vávra and Frank J. Maile. "BRDF measurement of highly-specular materials using a goniometer." SCCG '17 (2017).

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{\Omega} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{\Omega} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_\Omega L_{sky}(\boldsymbol{\omega}_i) \cos\theta_i \, f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_\Omega L_{sky}(\boldsymbol{\omega}_i) \cos\theta_i \, f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

$$+ L_{sun}(\boldsymbol{\omega}_{sun}) \cos\theta_{sun} \, f_r(\boldsymbol{\omega}_{sun}, \boldsymbol{\omega}_o)$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{\Omega} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{\Omega} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_\Omega L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{\Omega} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

$$L_i(\boldsymbol{\omega}_i) = L_{lights}(\boldsymbol{\omega}_i) + L_{objects}(\boldsymbol{\omega}_i)$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{\Omega} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

$$L_i(\boldsymbol{\omega}_i) = L_{direct}(\boldsymbol{\omega}_i) + L_{indirect}(\boldsymbol{\omega}_i)$$

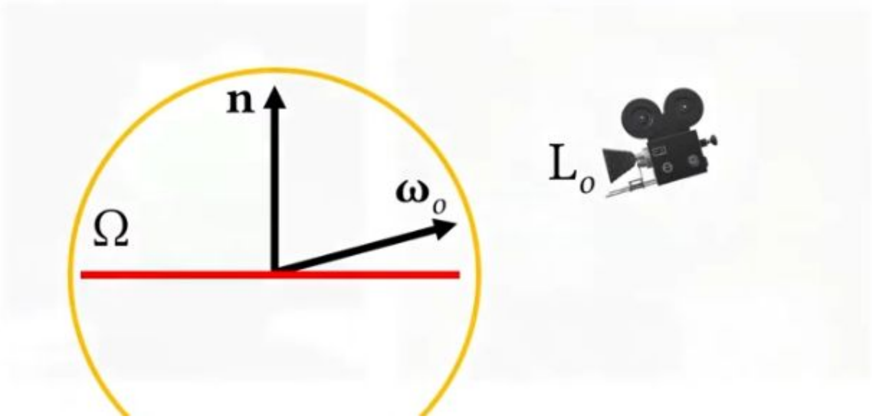
Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_\Omega L_{direct}(\boldsymbol{\omega}_i) \cos\theta_i \, f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i + \int_\Omega L_{indirect}(\boldsymbol{\omega}_i) \cos\theta_i \, f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{S^2} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_s(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

$$+ L_{emission}(\boldsymbol{\omega}_o)$$



Rendering equation

$$L_o(\boldsymbol{\omega}_o) = \int_{S^2} L_i(\boldsymbol{\omega}_i) \cos\theta_i \; f_s(\boldsymbol{\omega}_i, \boldsymbol{\omega}_o) \; d\boldsymbol{\omega}_i$$

$$+ L_{emission}(\boldsymbol{\omega}_o)$$

Character Creator 3

Catherine Watts