Francisco Ganacim <ganacim@impa.br>

3D Visualization

... with ray tracing

Elementos

- mundo
- câmera
- objetos
- materiais
- fontes de luz
- meio

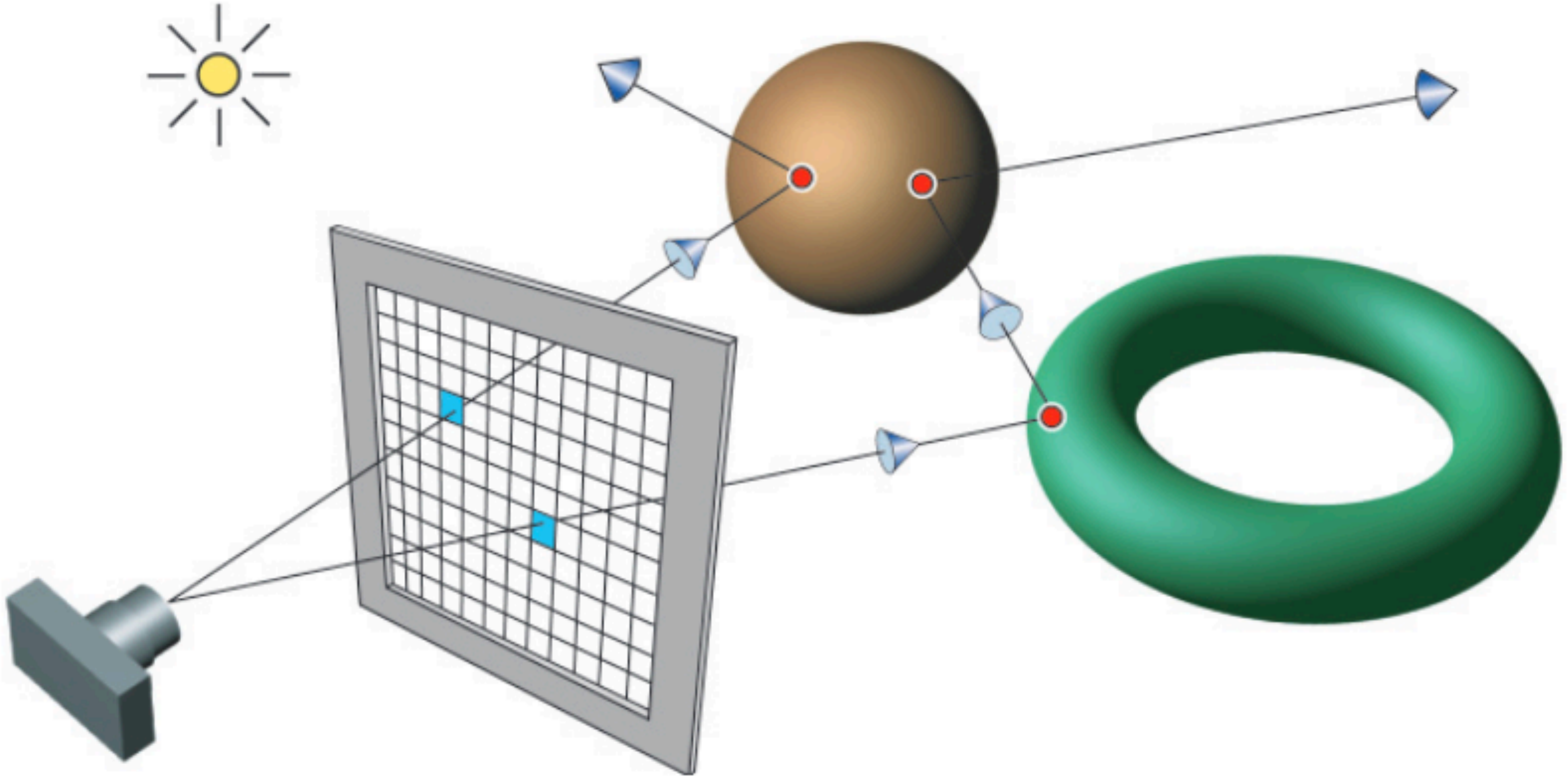
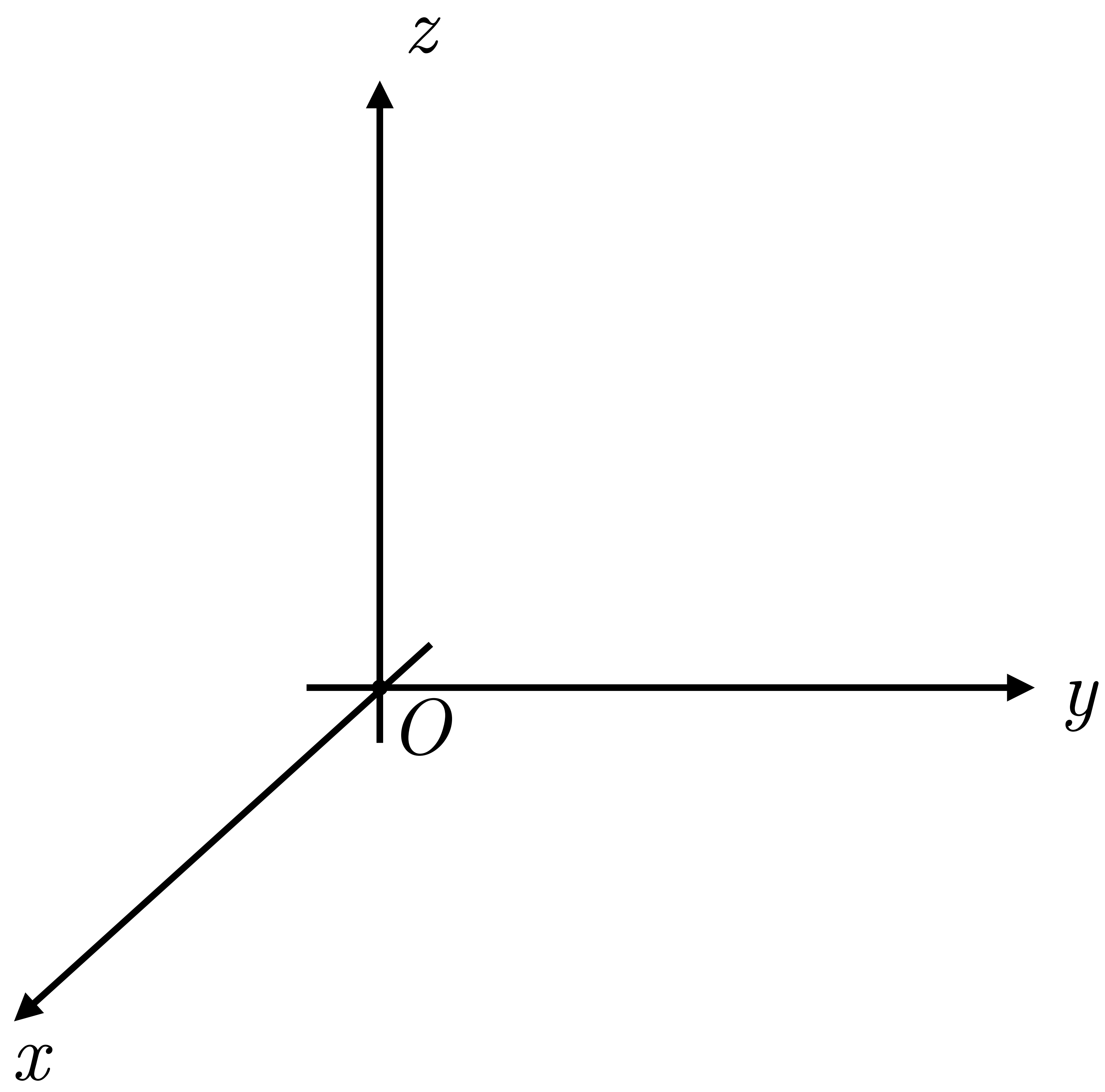


Figure 1. The ray-tracing process.

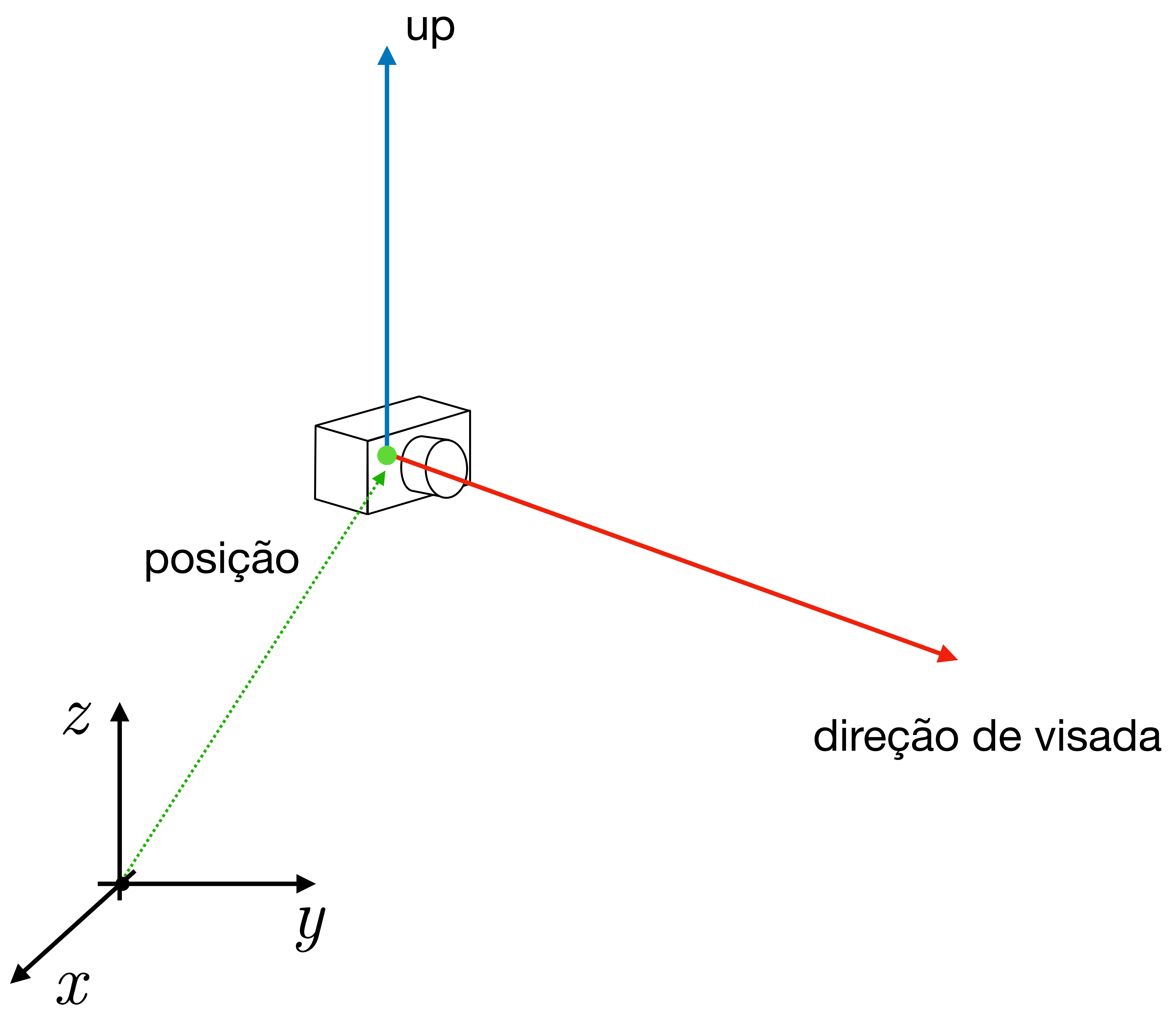
Mundo

- define um referencial de coordenadas
- define uma orientação
- podemos definir um background ou
- uma luz ambiente



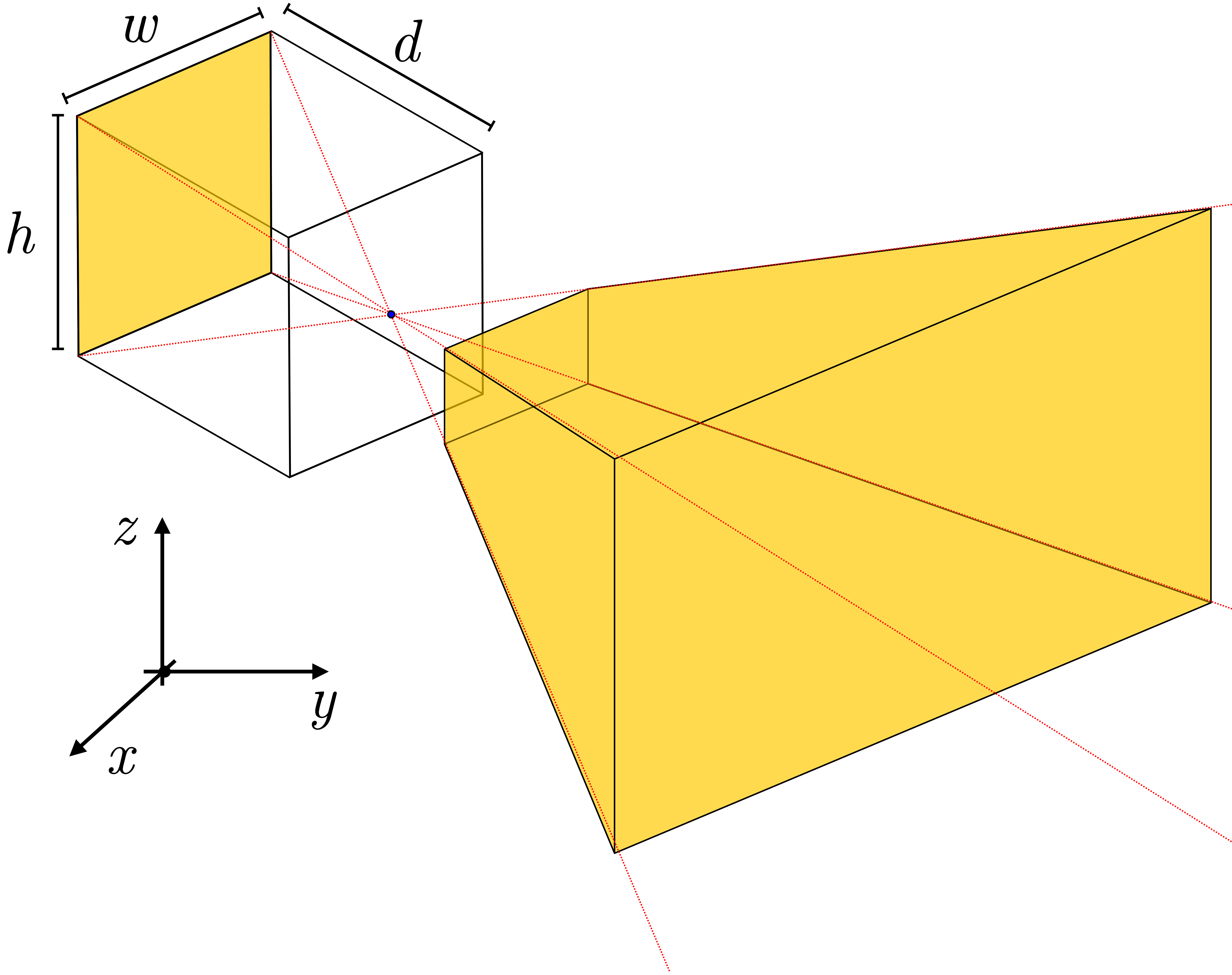
Camera

parâmetros extrínsecos



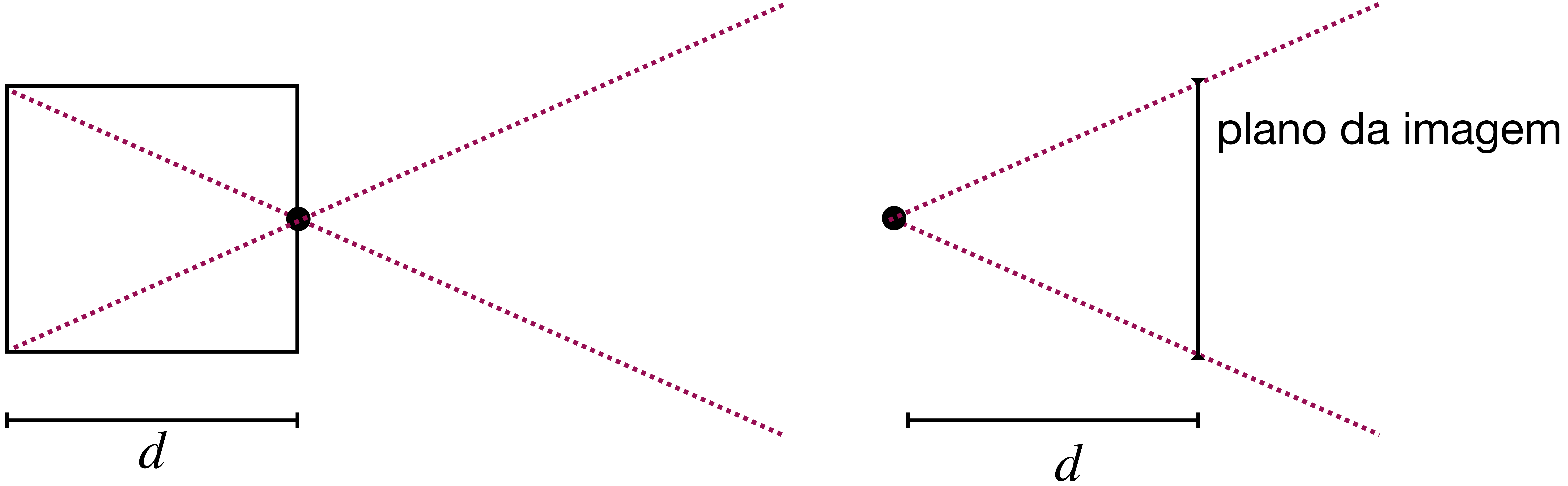
Camera

parâmetros intrínsecos

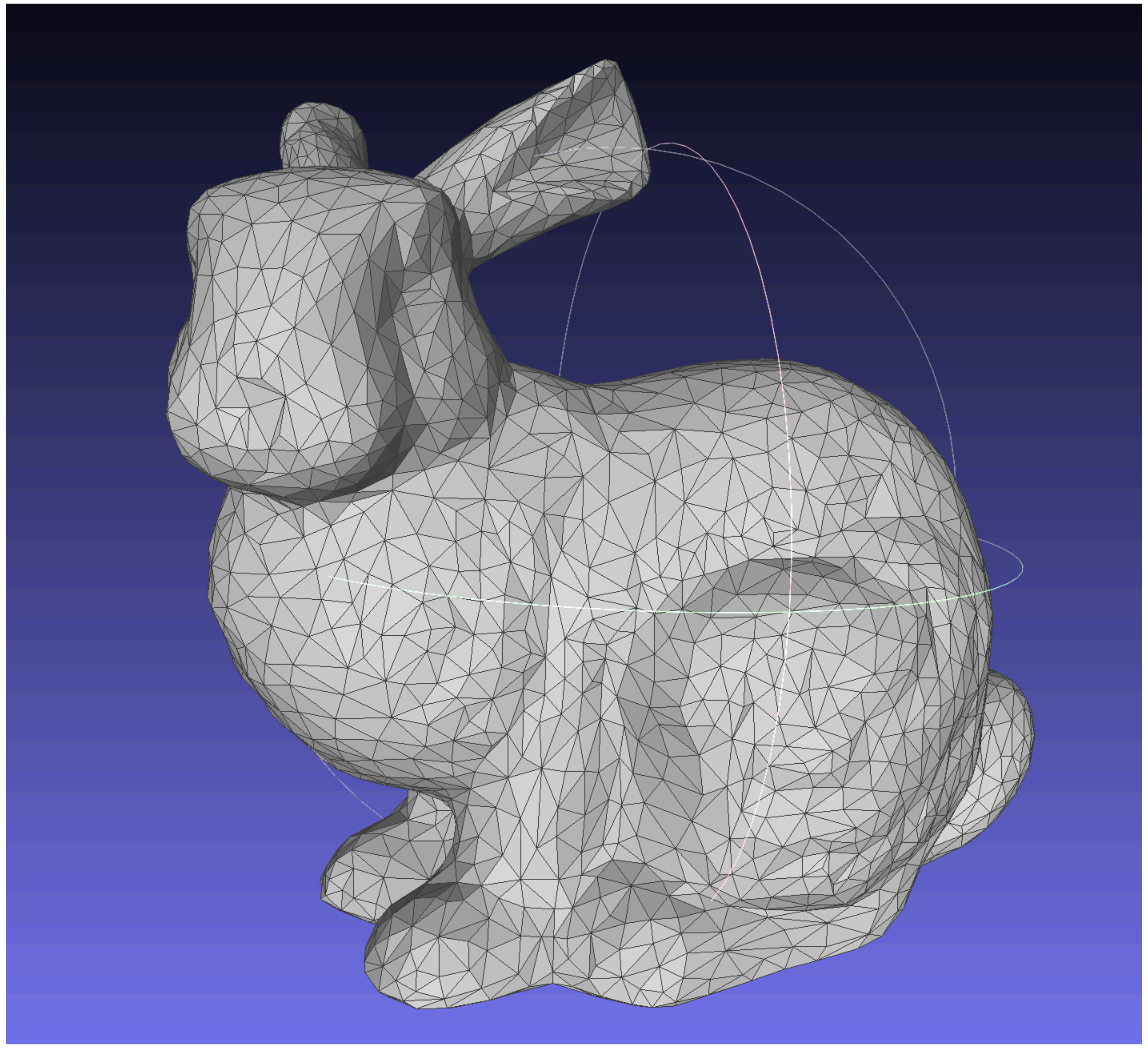


Camera

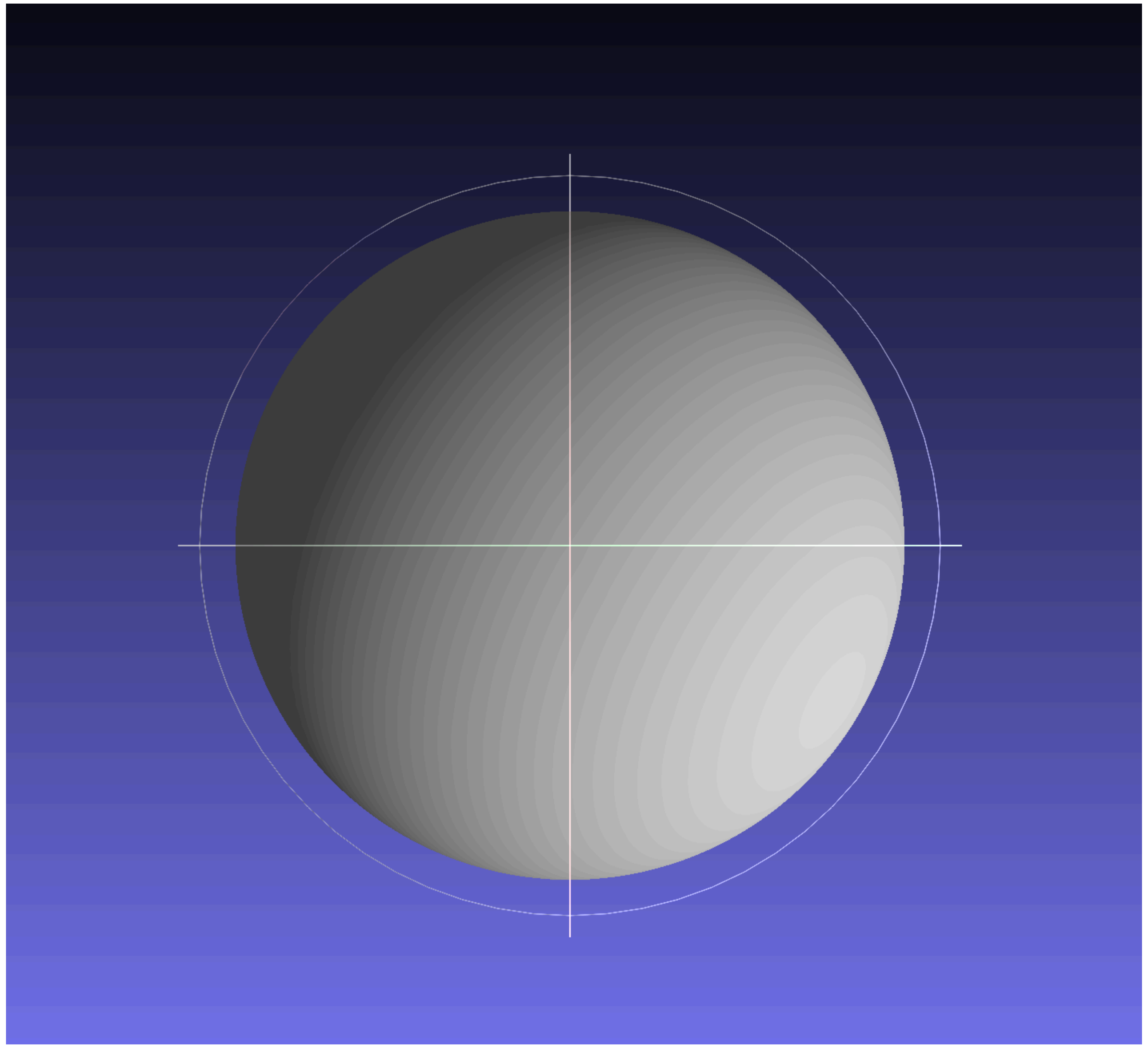
parâmetros intrínsecos



Objetos



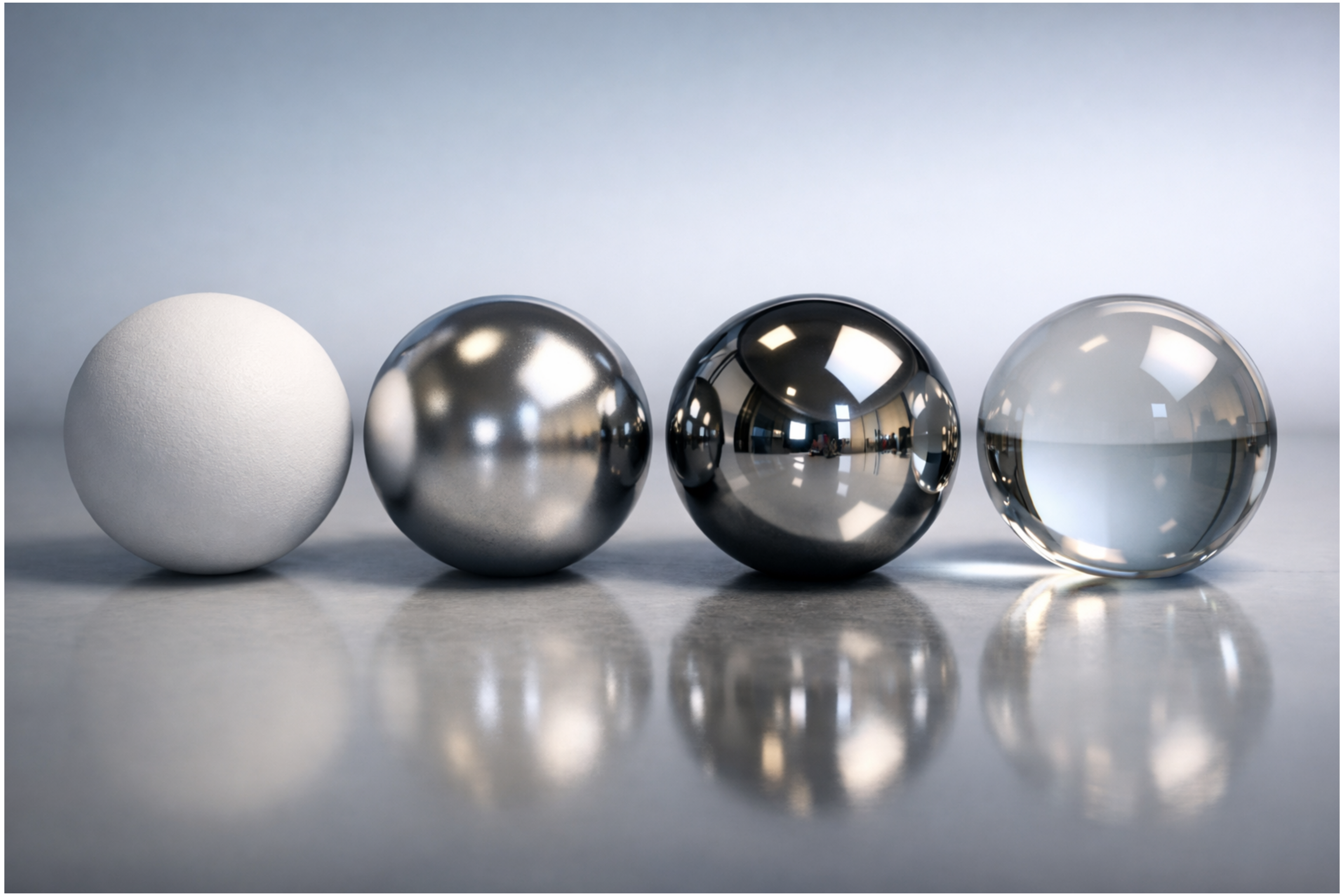
malha de triângulos



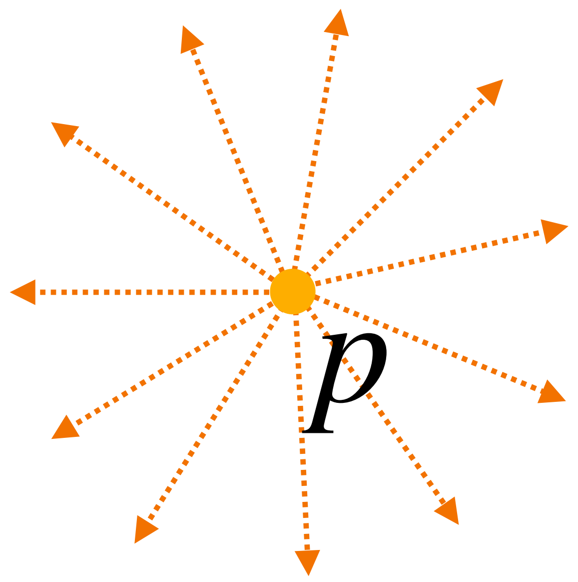
$$f(x, y, z) = x^2 + y^2 + z^2 - 1 \leq 0$$

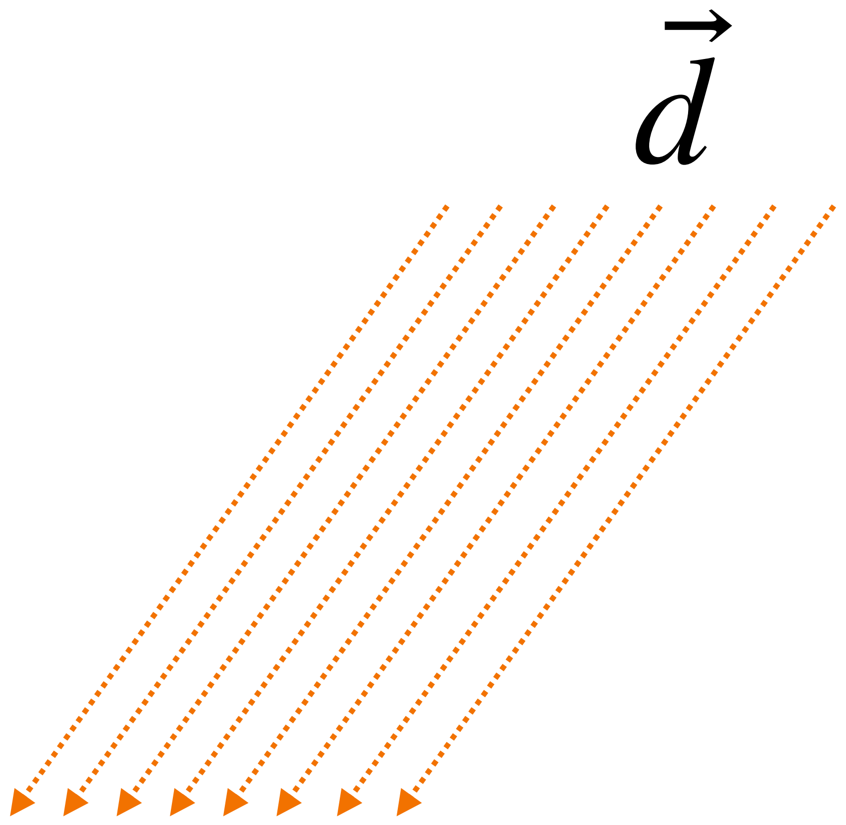
funções implícitas

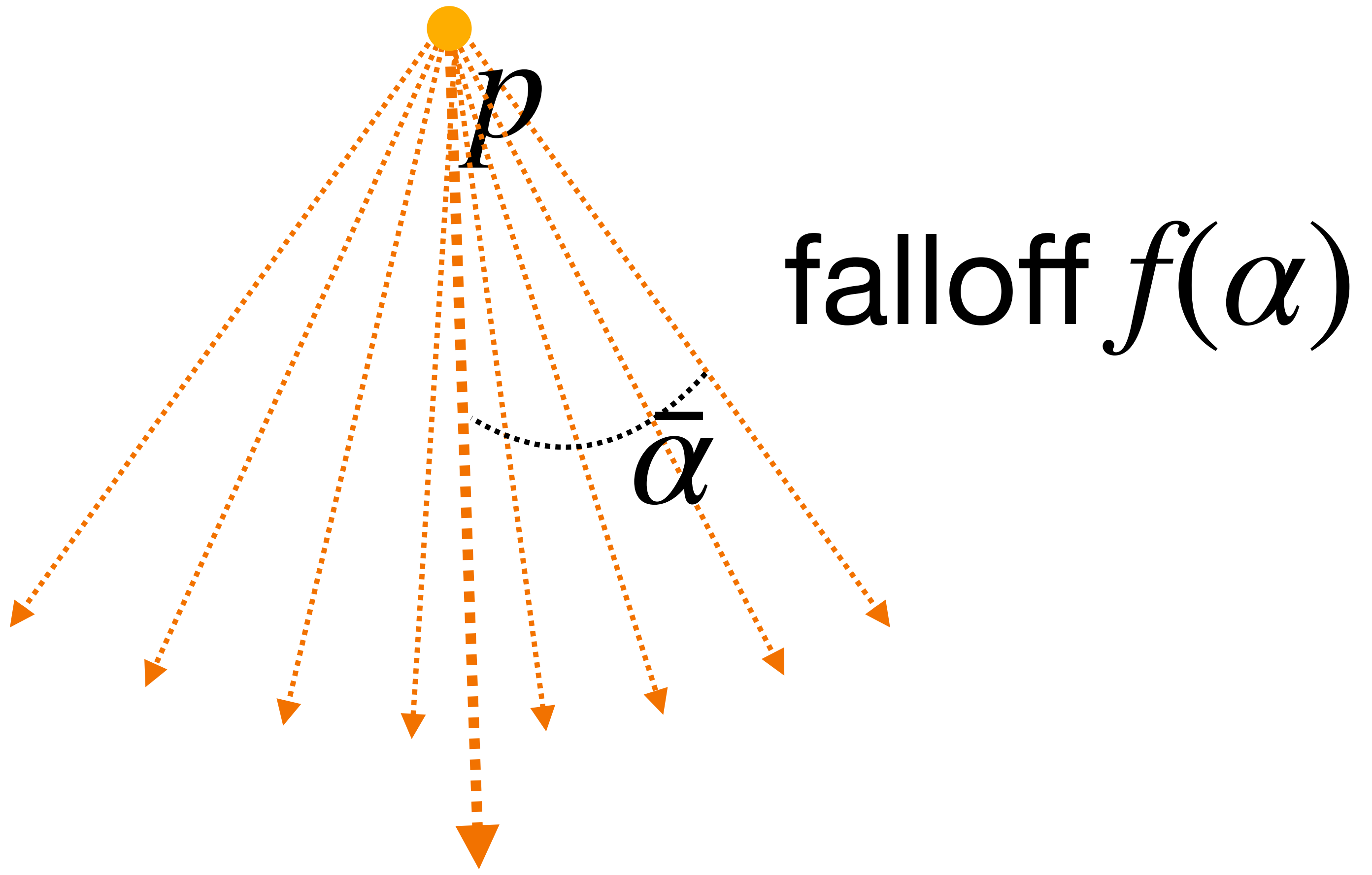
Materiais



Fontes de Luz

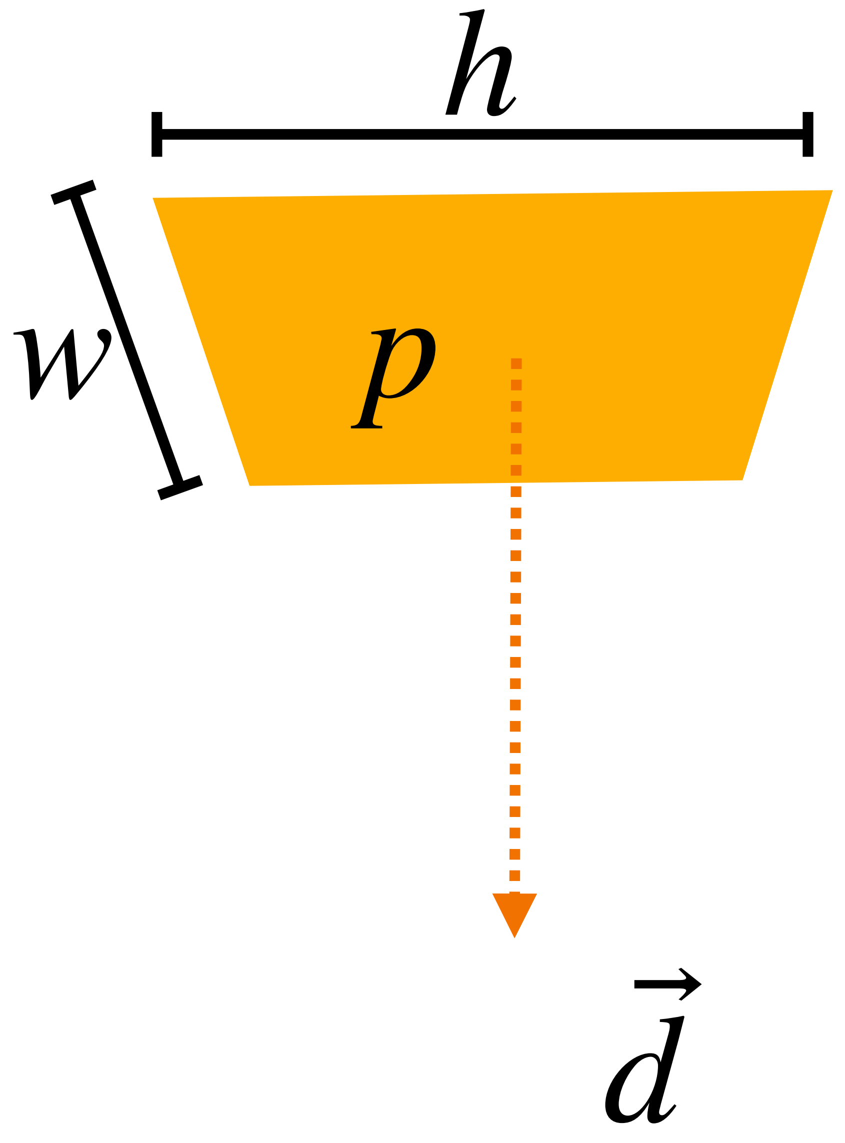






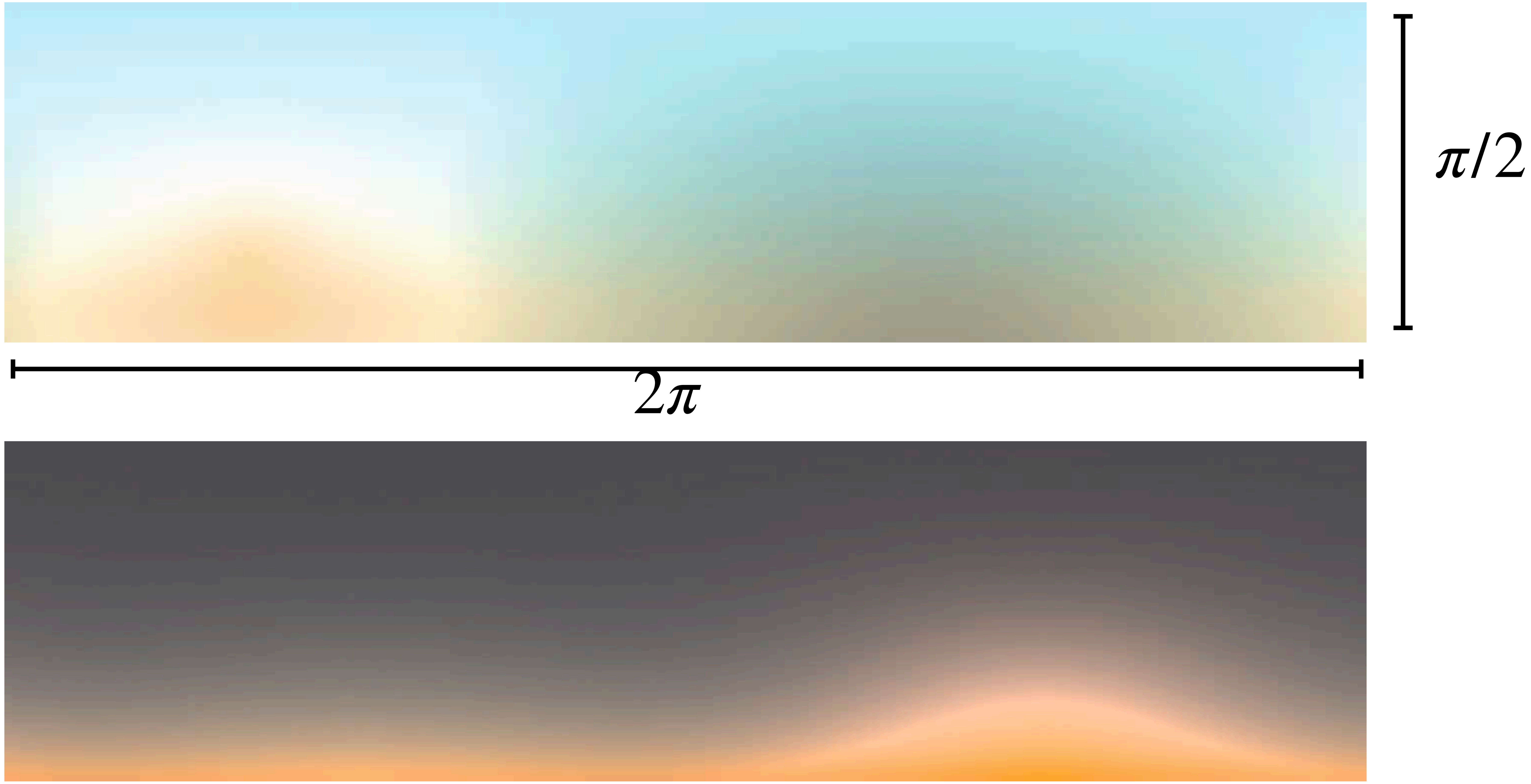
Physically Based Rendering, 3ed

Area Light



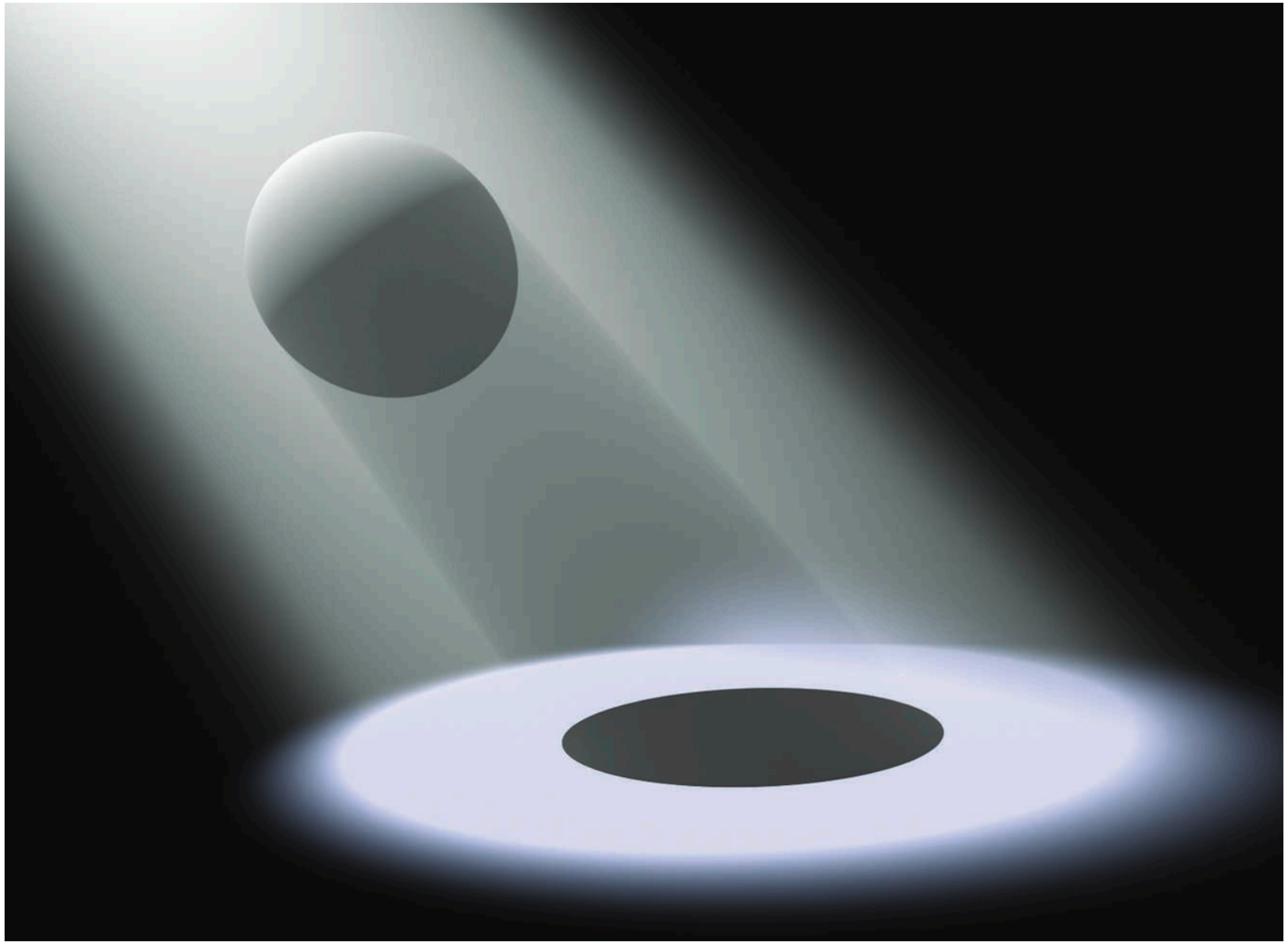
Physically Based Rendering, 3ed

Environment Mapping



Physically Based Rendering, 3ed

Participação do Meio



Physically Based Rendering, 3ed

Câmera Virtual

definindo o referencial

Usaremos os seguintes parâmetros:

1. e : posição
2. l : ponto a ser visto
3. up : direção “para cima” provisória

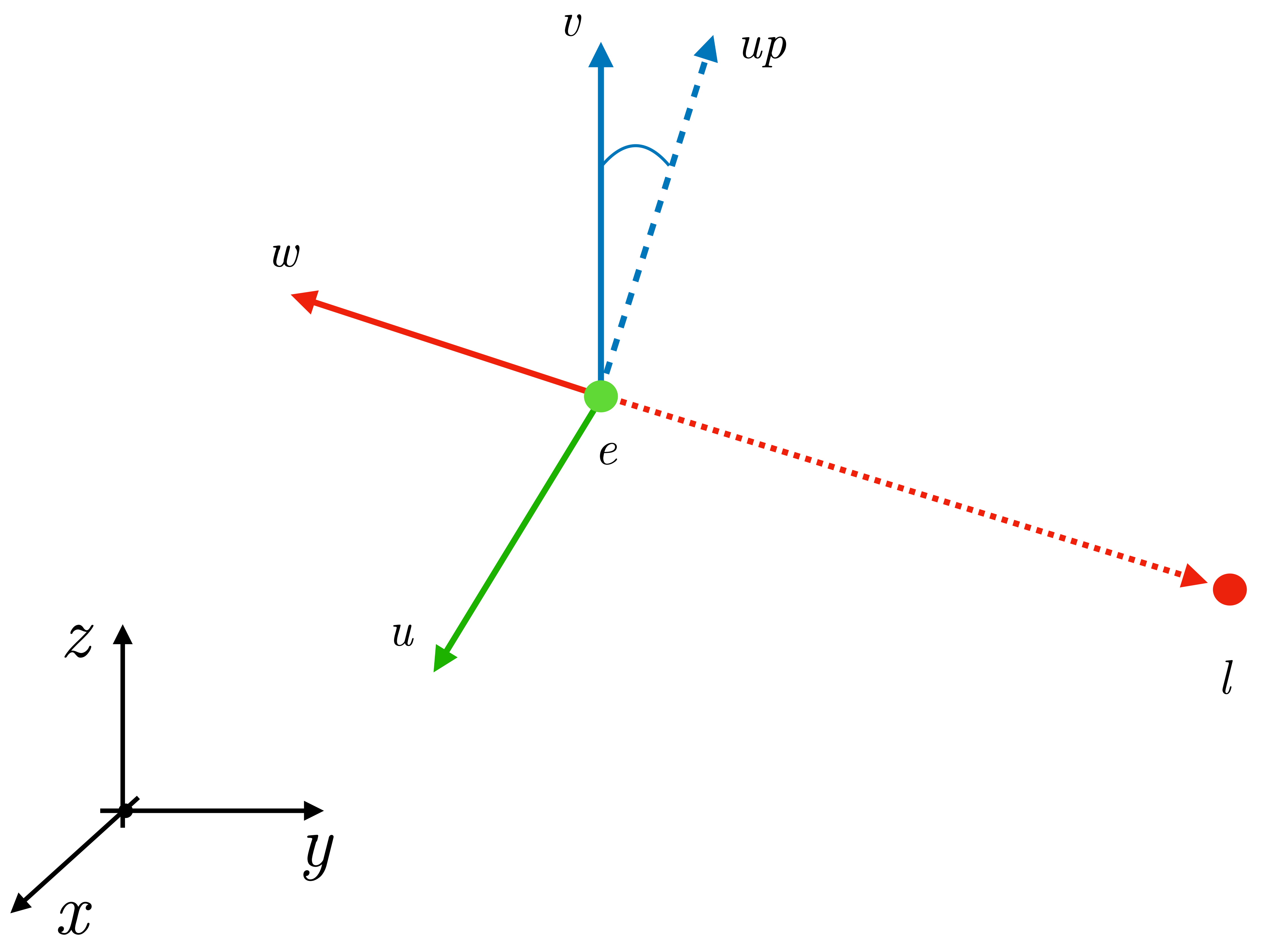
Temos

$$up = \text{normalize}(up)$$

$$w = \text{normalize}(e - l)$$

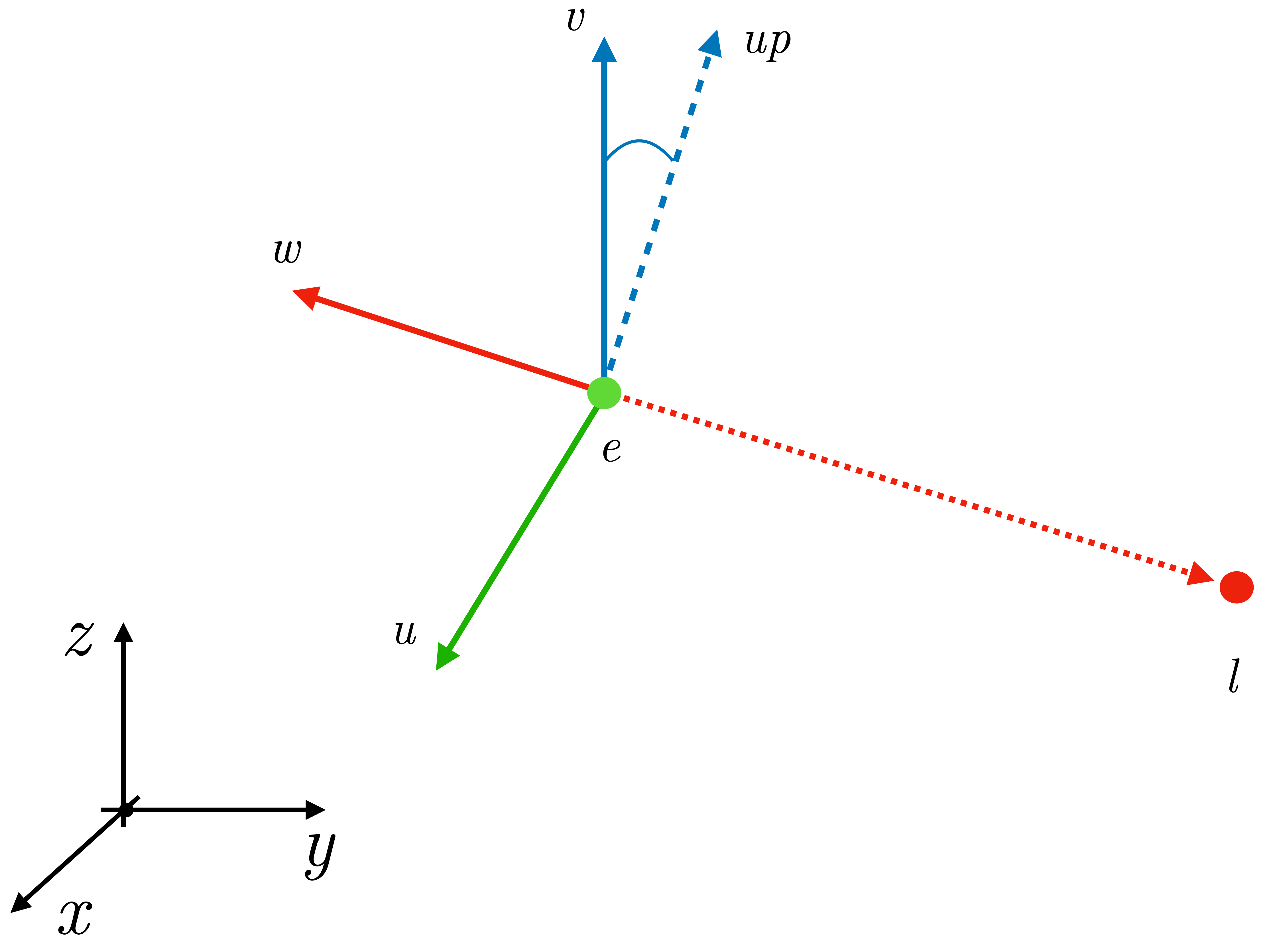
$$u = up \times w$$

$$v = w \times u$$



Câmera Virtual

plano da imagem

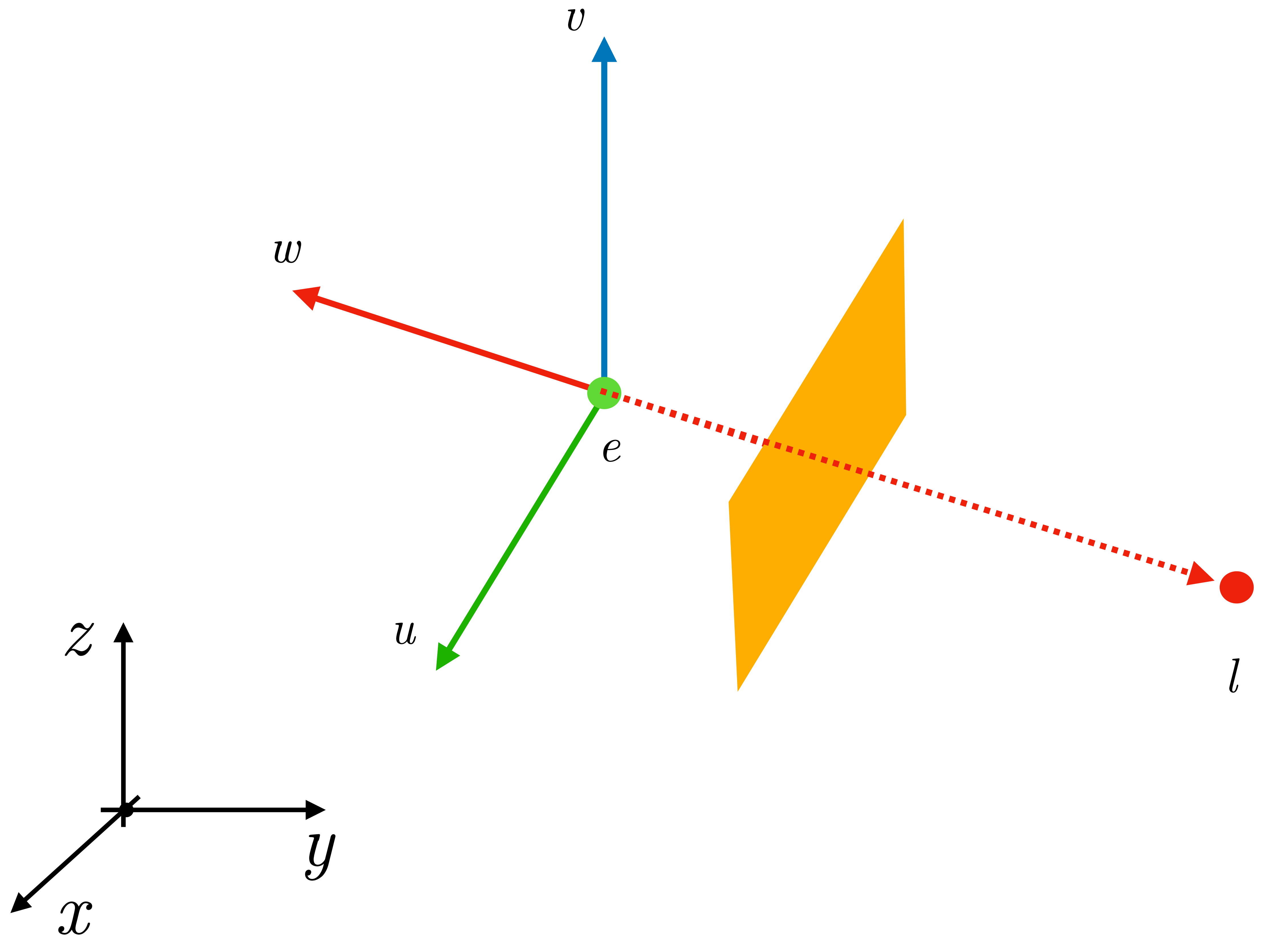


Câmera Virtual
plano da imagem

Queremos definir o *filme.*

Temos os seguintes parâmetros:

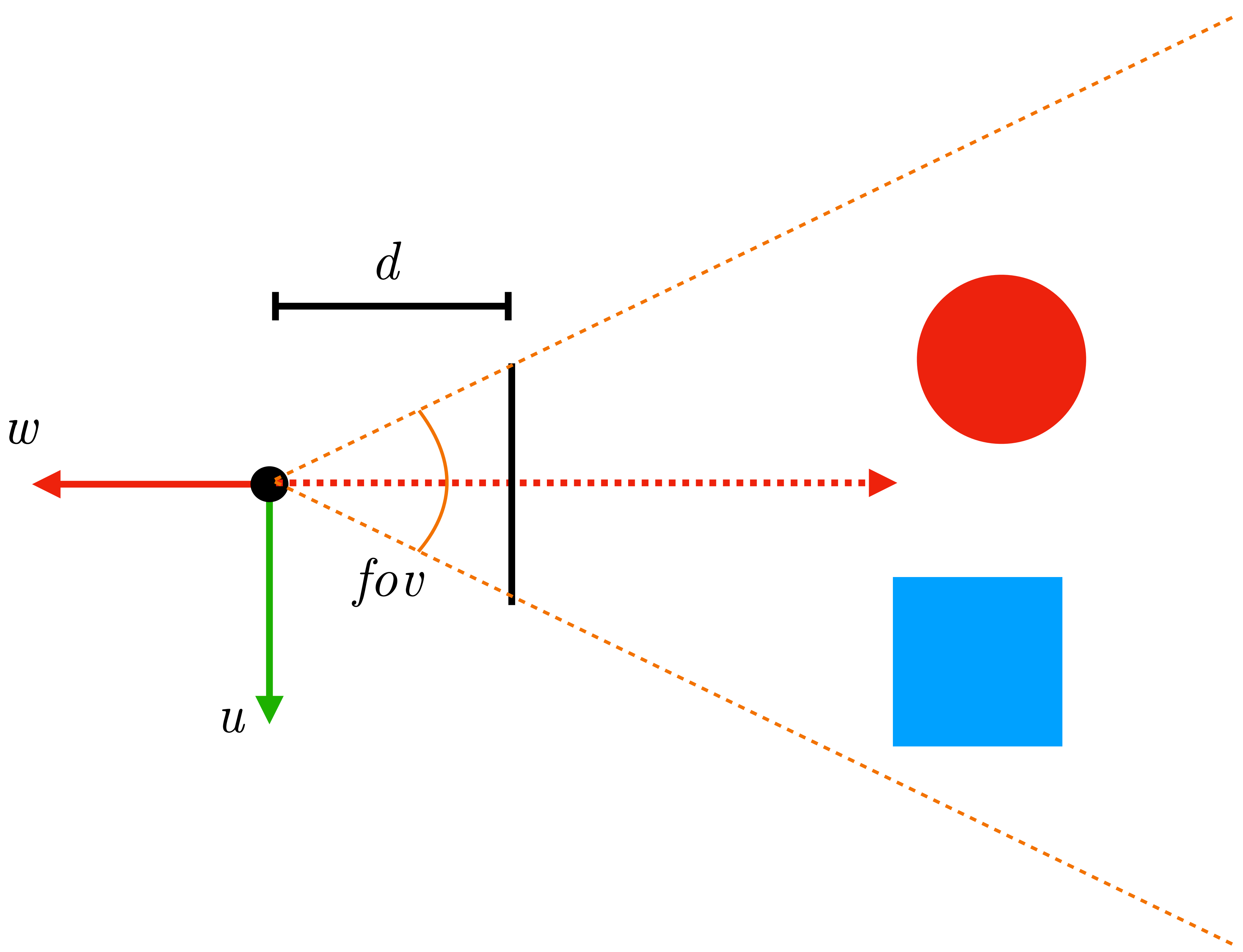
1. fov : abertura horizontal
2. resolução da imagem

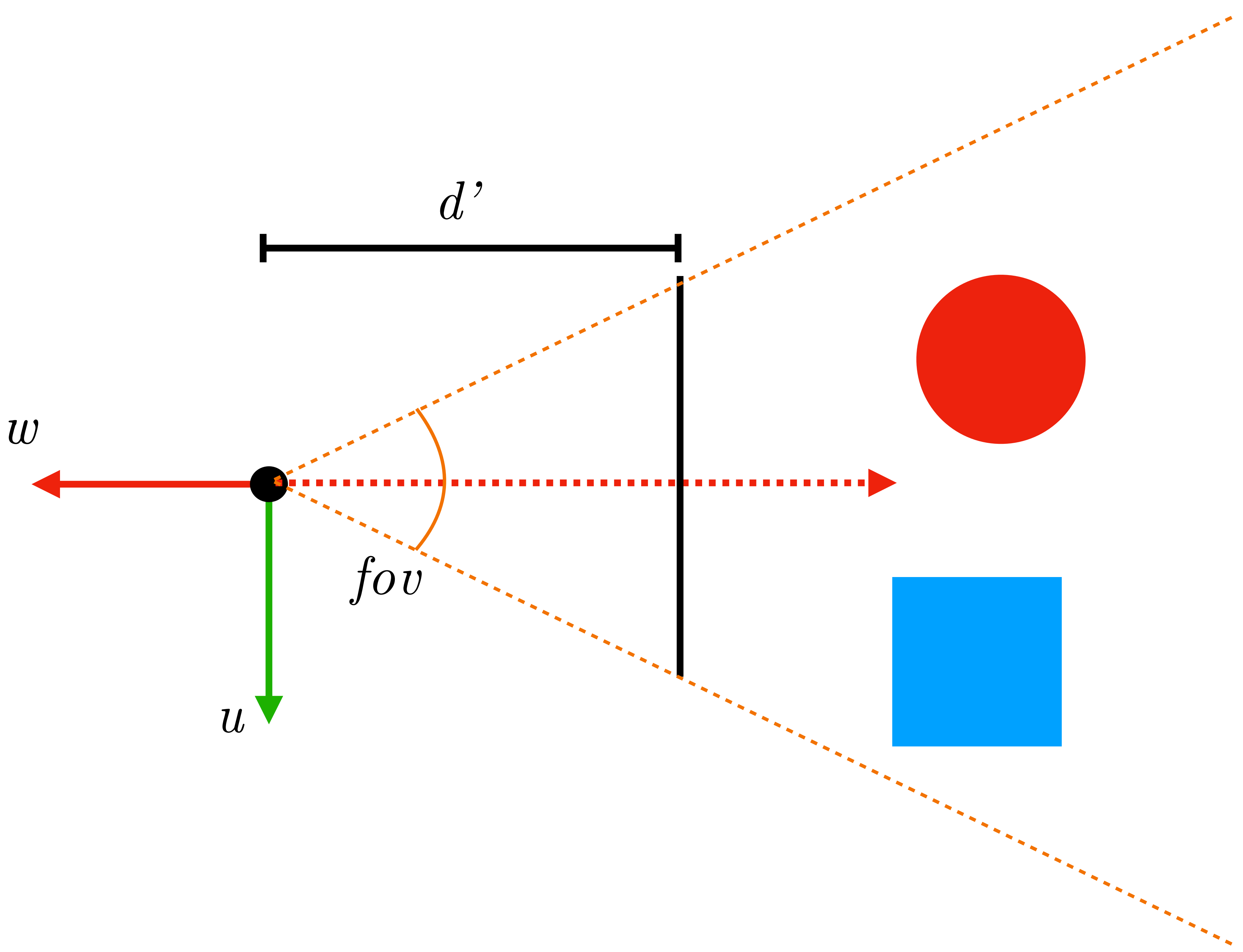


Câmera Virtual

plano da imagem

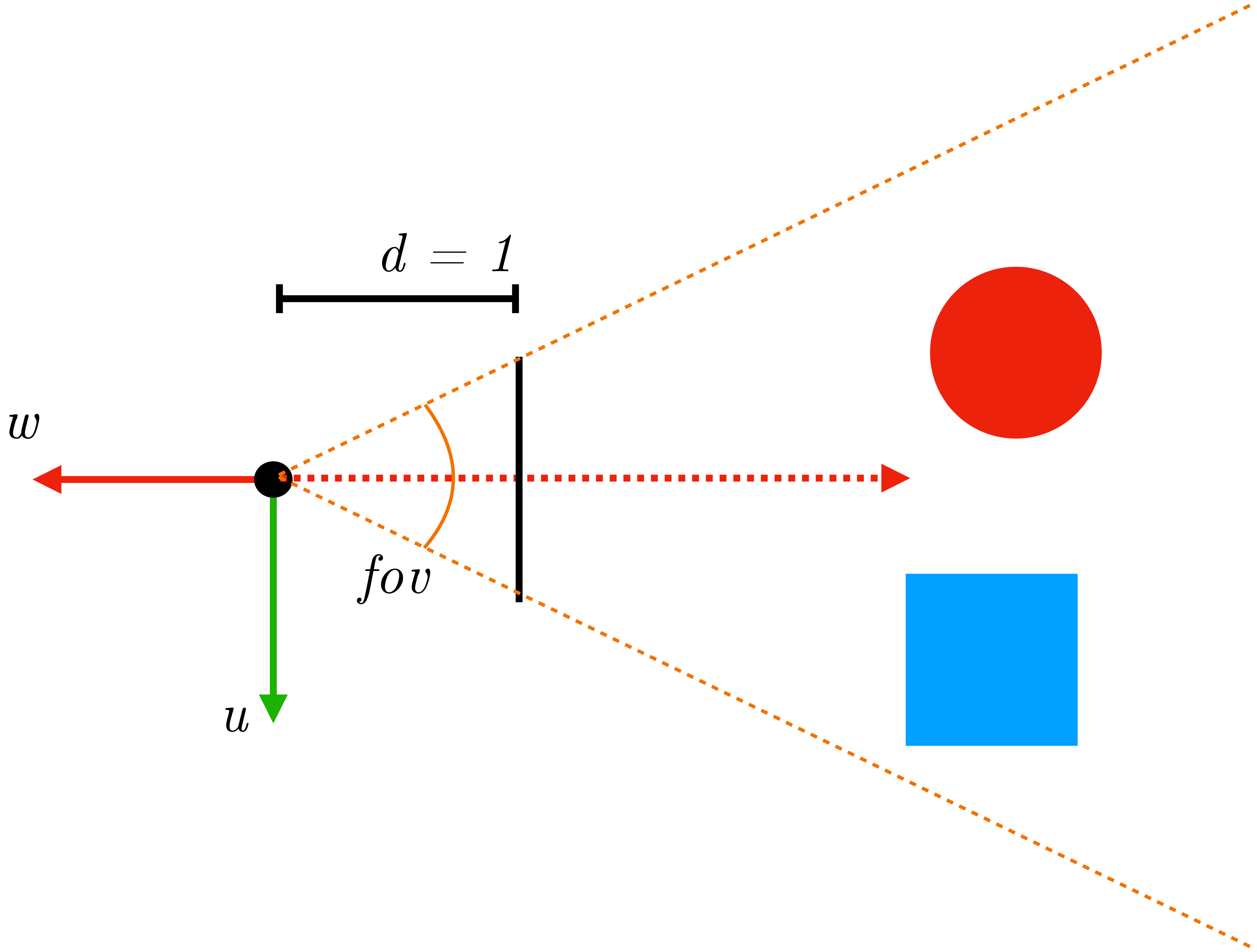
mudando d para d' temos a mesma imagem





Câmera Virtual

plano da imagem



Temos:

1. Imagem é $H \times W$
2. $d = 1$

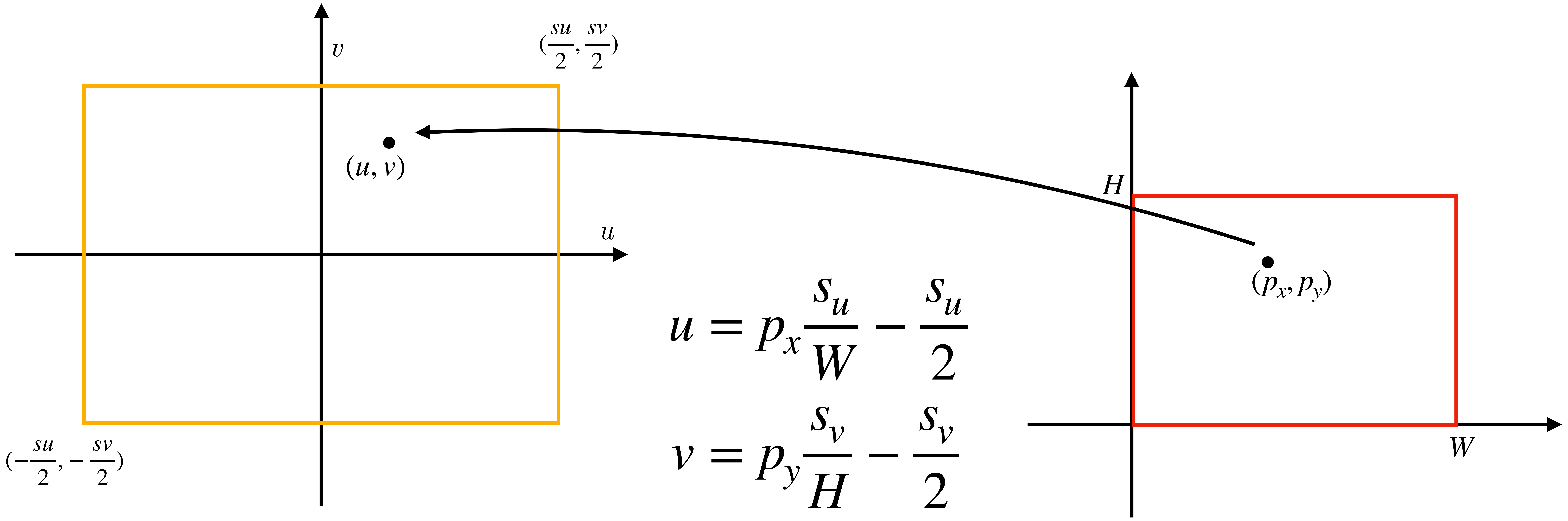
Calculamos :

$$ar = \frac{H}{W}$$

$$s_u = 2\tan(fov/2)$$

$$s_v = s_u * ar$$

Câmera Virtual



$$u = p_x \frac{s_u}{W} - \frac{s_u}{2}$$

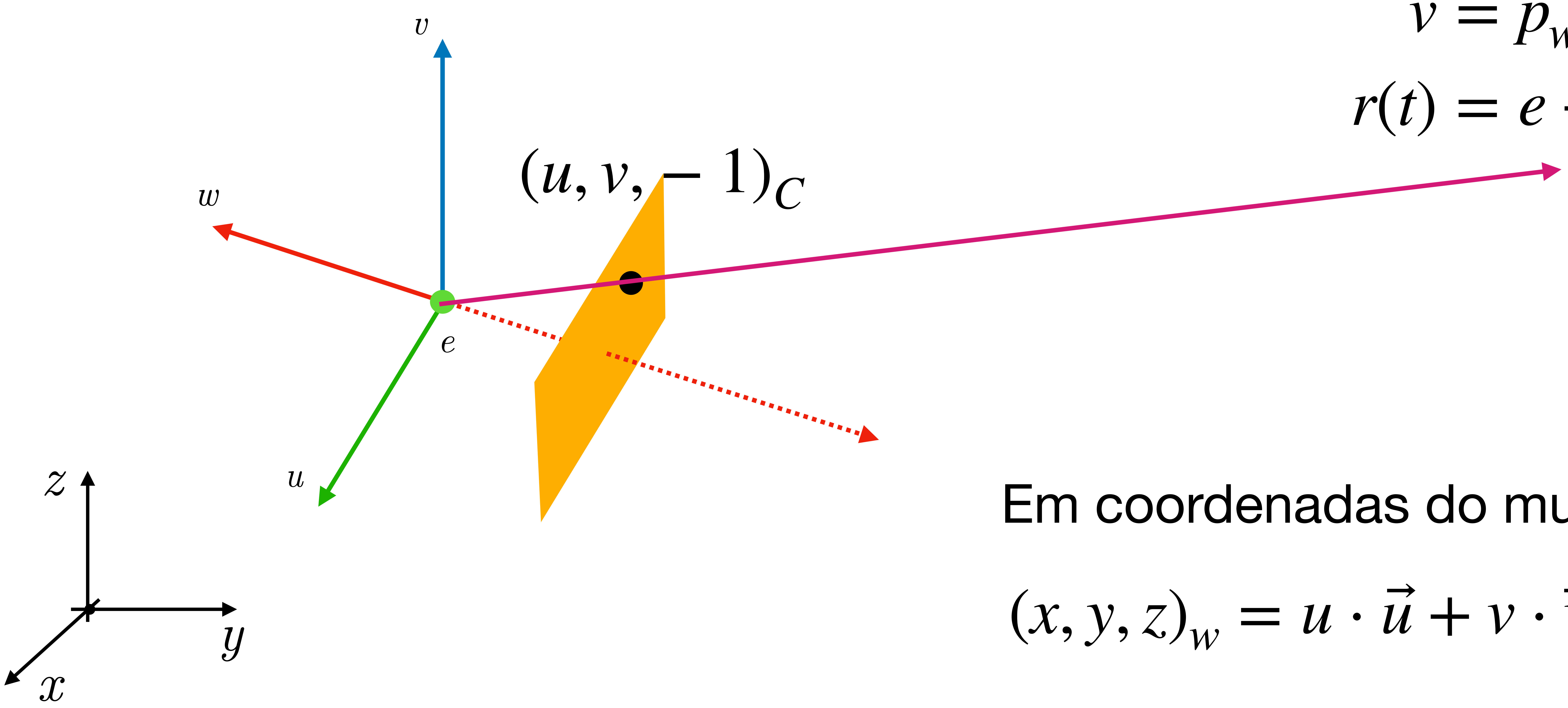
$$v = p_y \frac{s_v}{H} - \frac{s_v}{2}$$

$$w = -1$$

Calculando raios

$$v = p_w - e$$

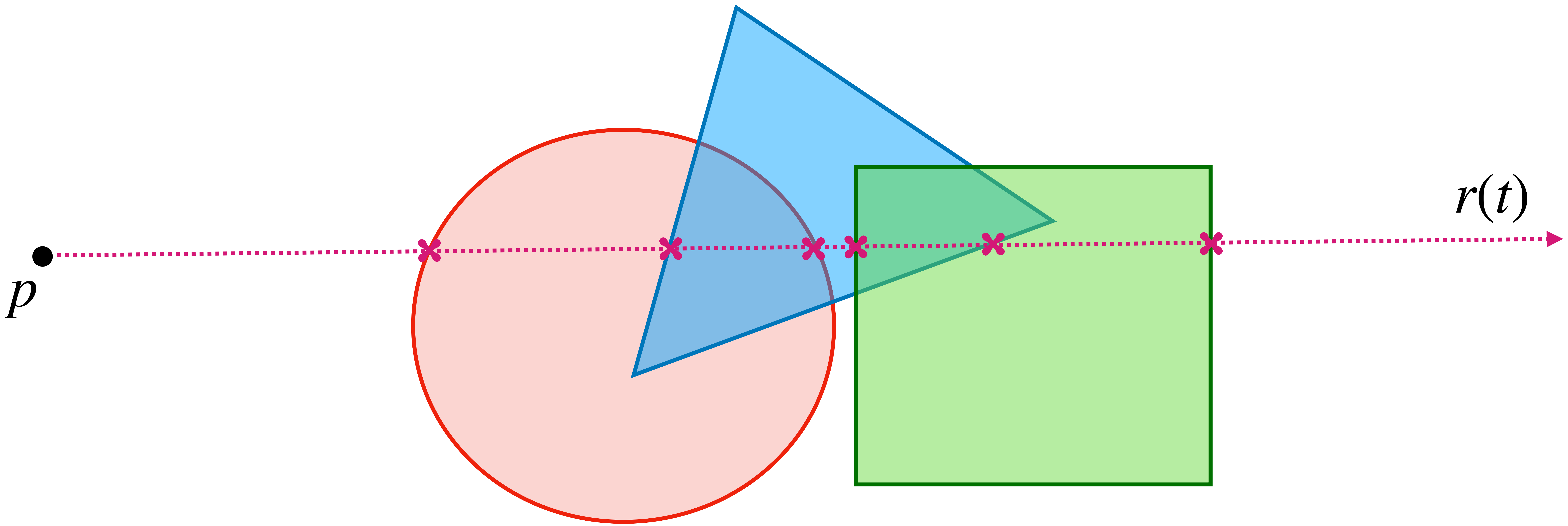
$$r(t) = e + v \cdot t$$



Em coordenadas do mundo

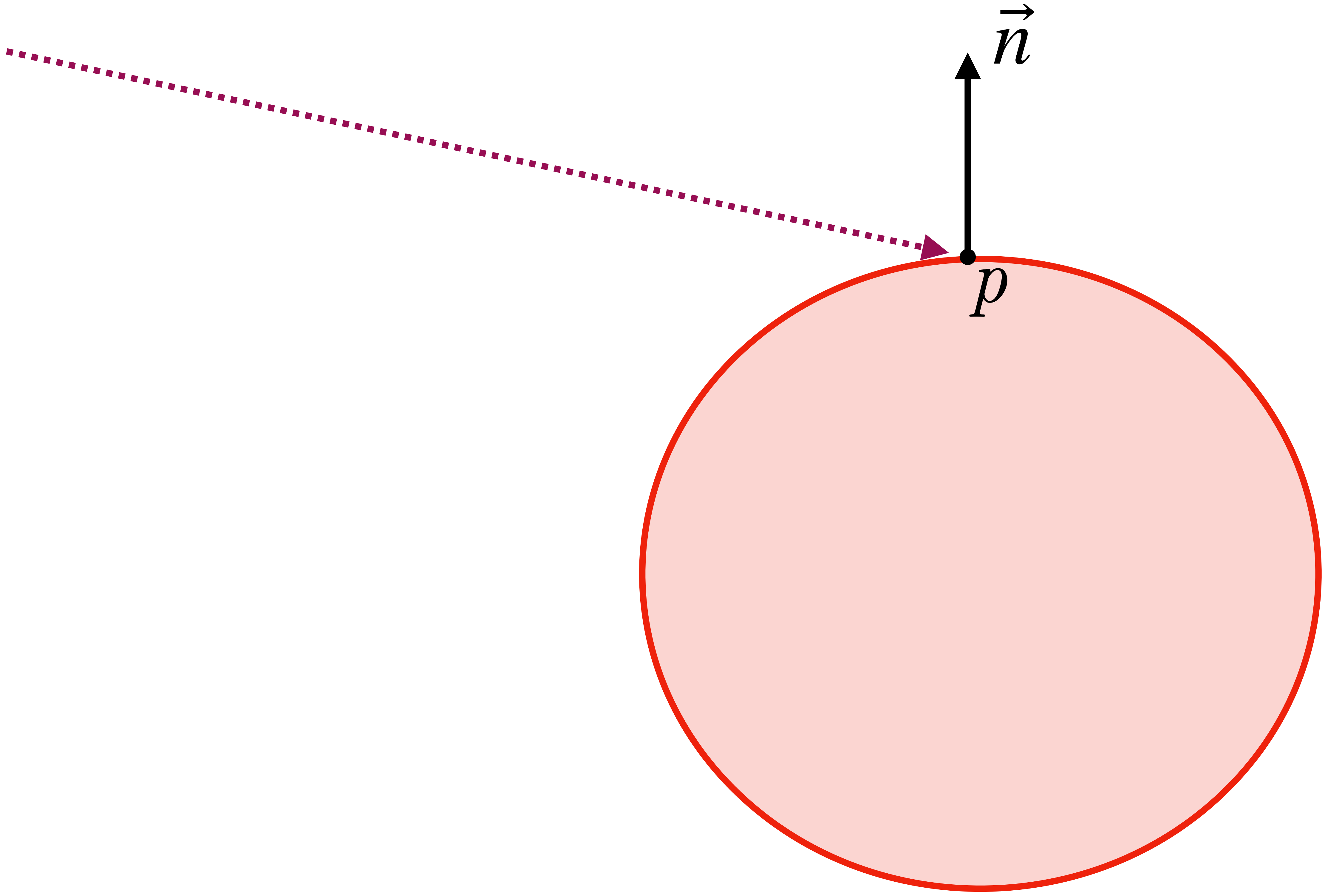
$$(x, y, z)_w = u \cdot \vec{u} + v \cdot \vec{v} - 1 \cdot \vec{w}$$

Intersecção de raio e objetos



Objetos

Precisamos saber encontrar $\vec{n}$ para p no objeto

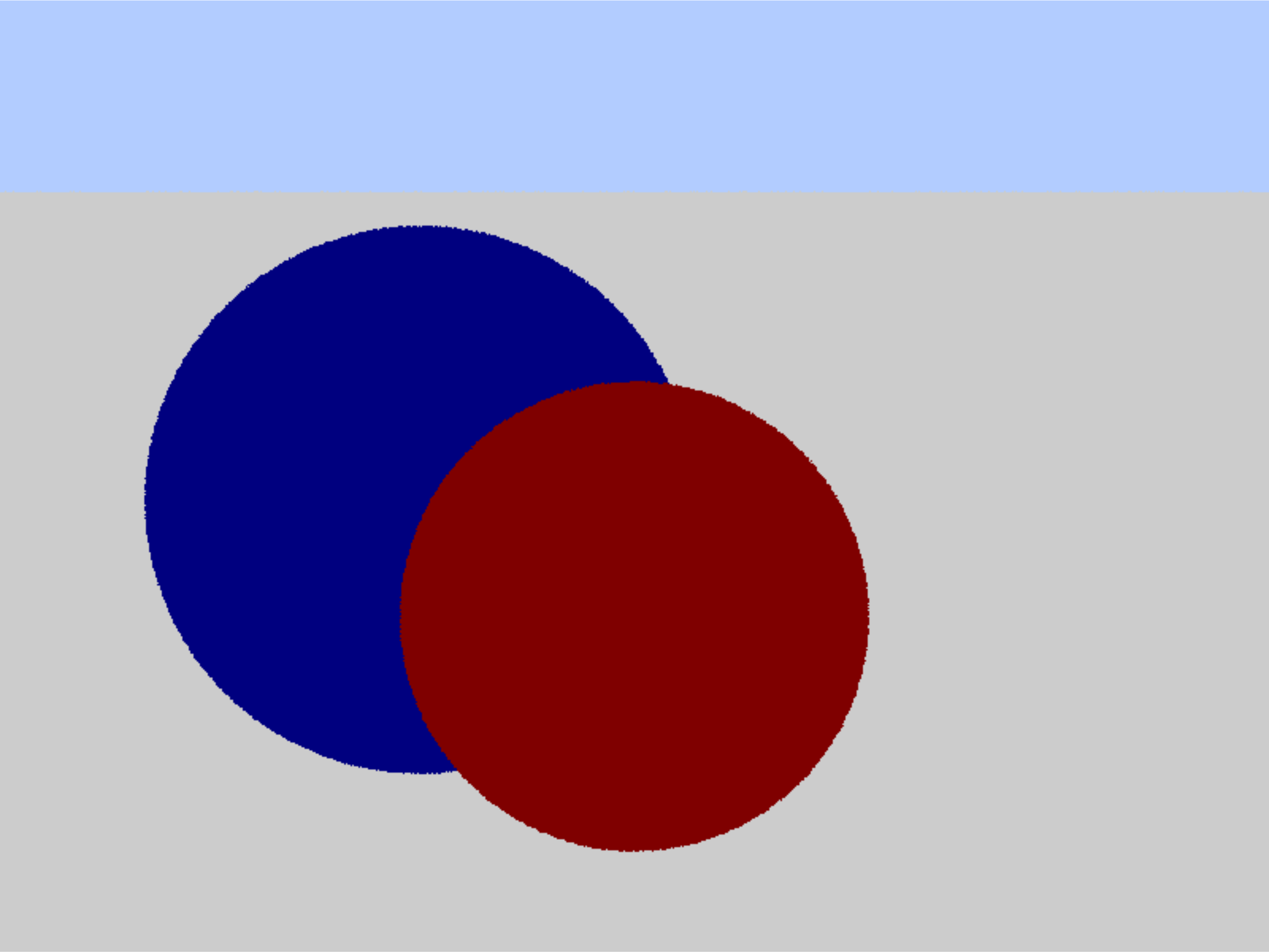


Se o modelo é implícito, então

$$\vec{n} = \frac{\nabla F(p)}{|\nabla F(p)|}$$

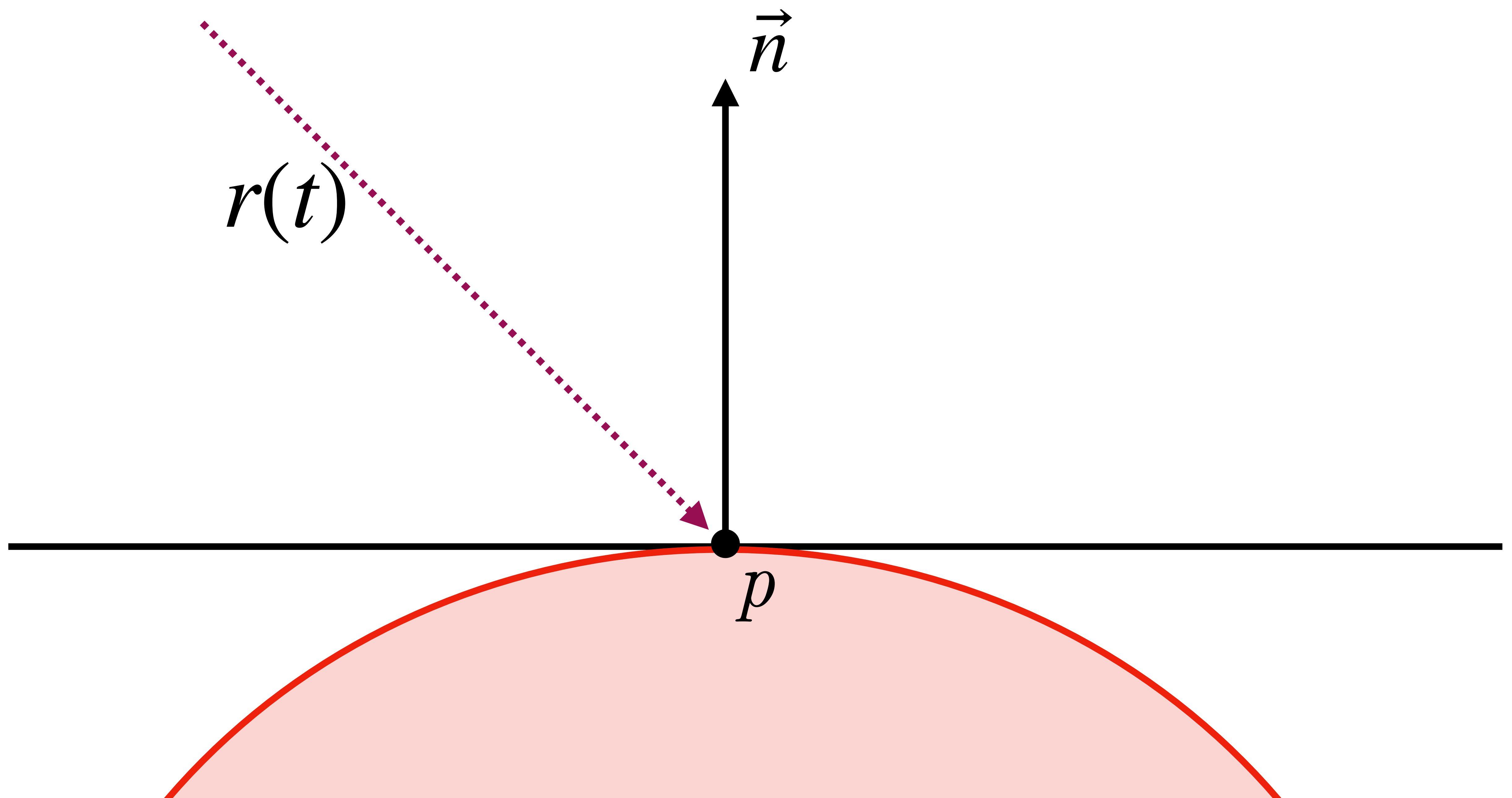
Por convenção $\vec{n}$ deve apontar para **fora**

Primeira versão do render



Interação entre materiais e luz

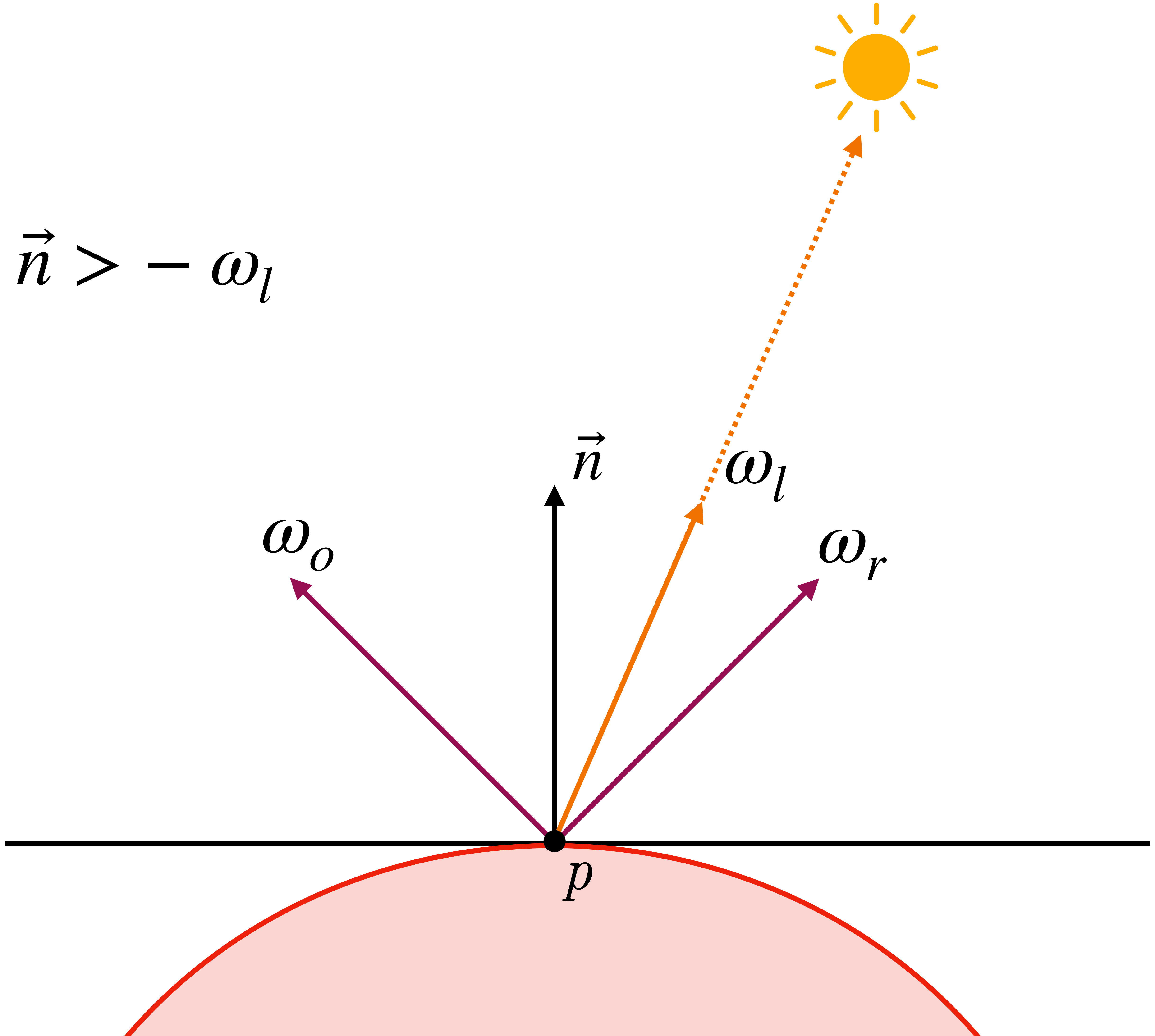
modelos de iluminação locais



Interação entre materiais e luz

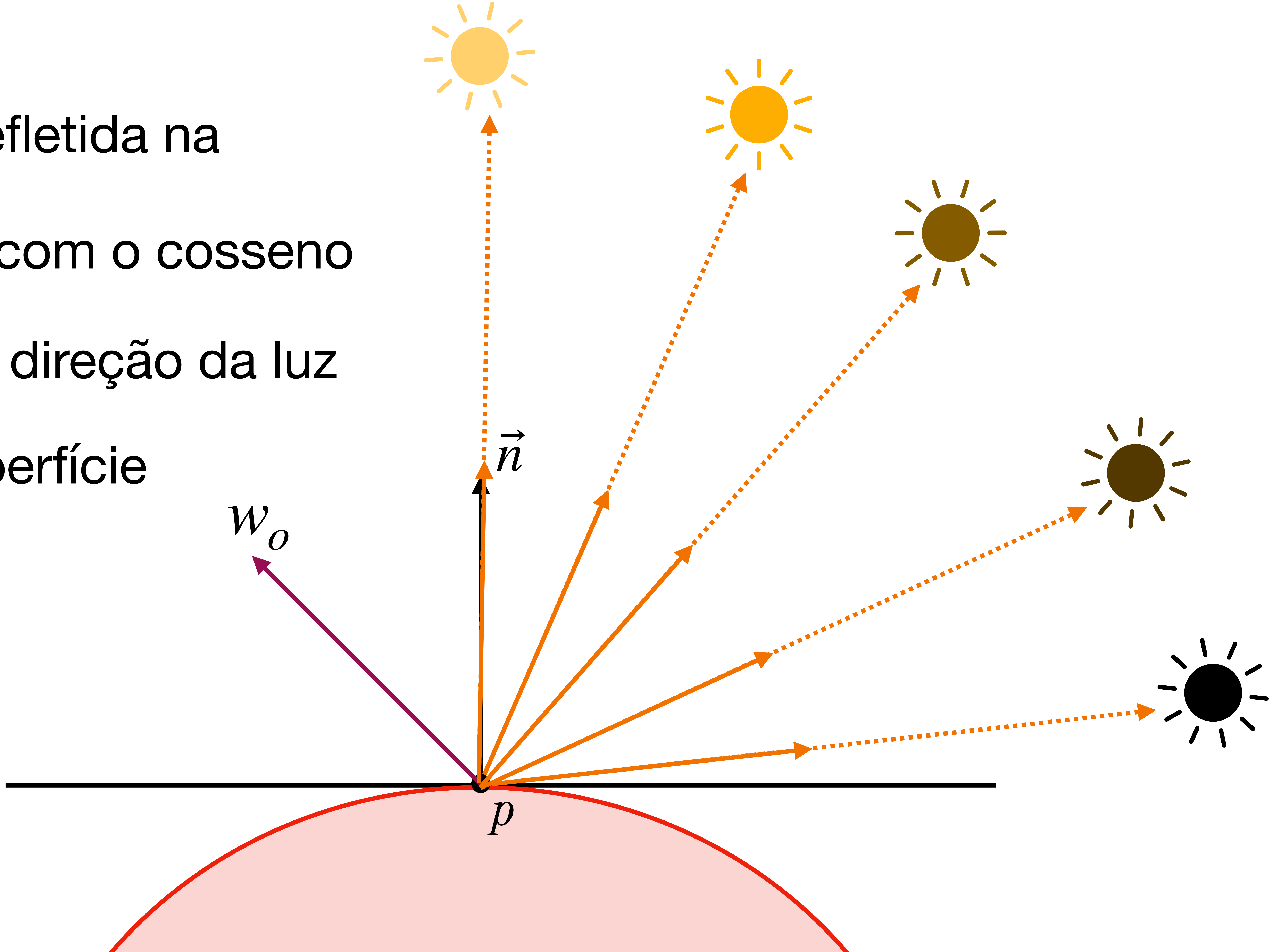
modelos de iluminação locais

$$\omega_r = 2 < \omega_l, \vec{n} > - \omega_l$$

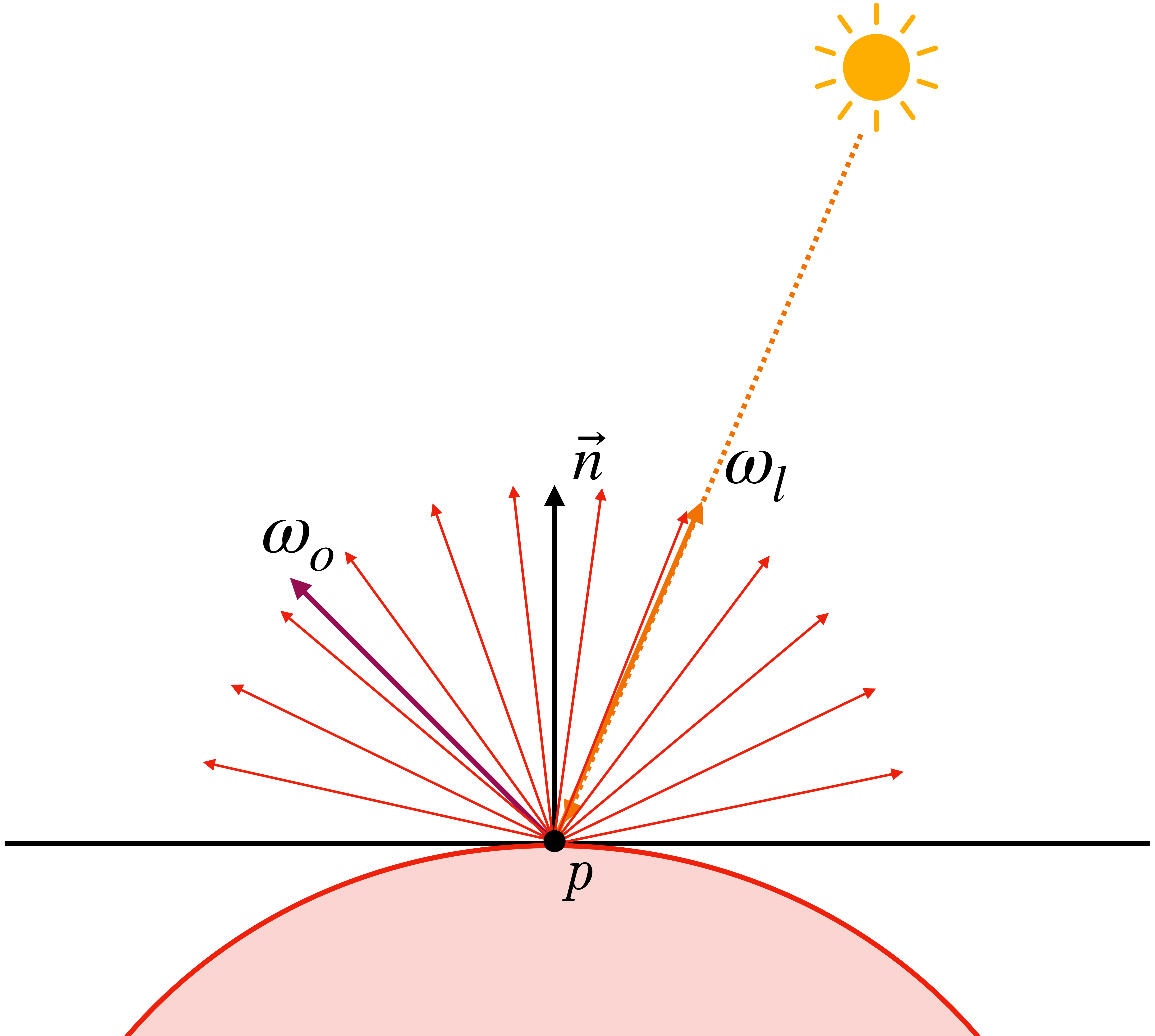


Lei de Lambert

A luminosidade refletida na direção ω_o decai com o cosseno do ângulo entre a direção da luz e a normal da superfície

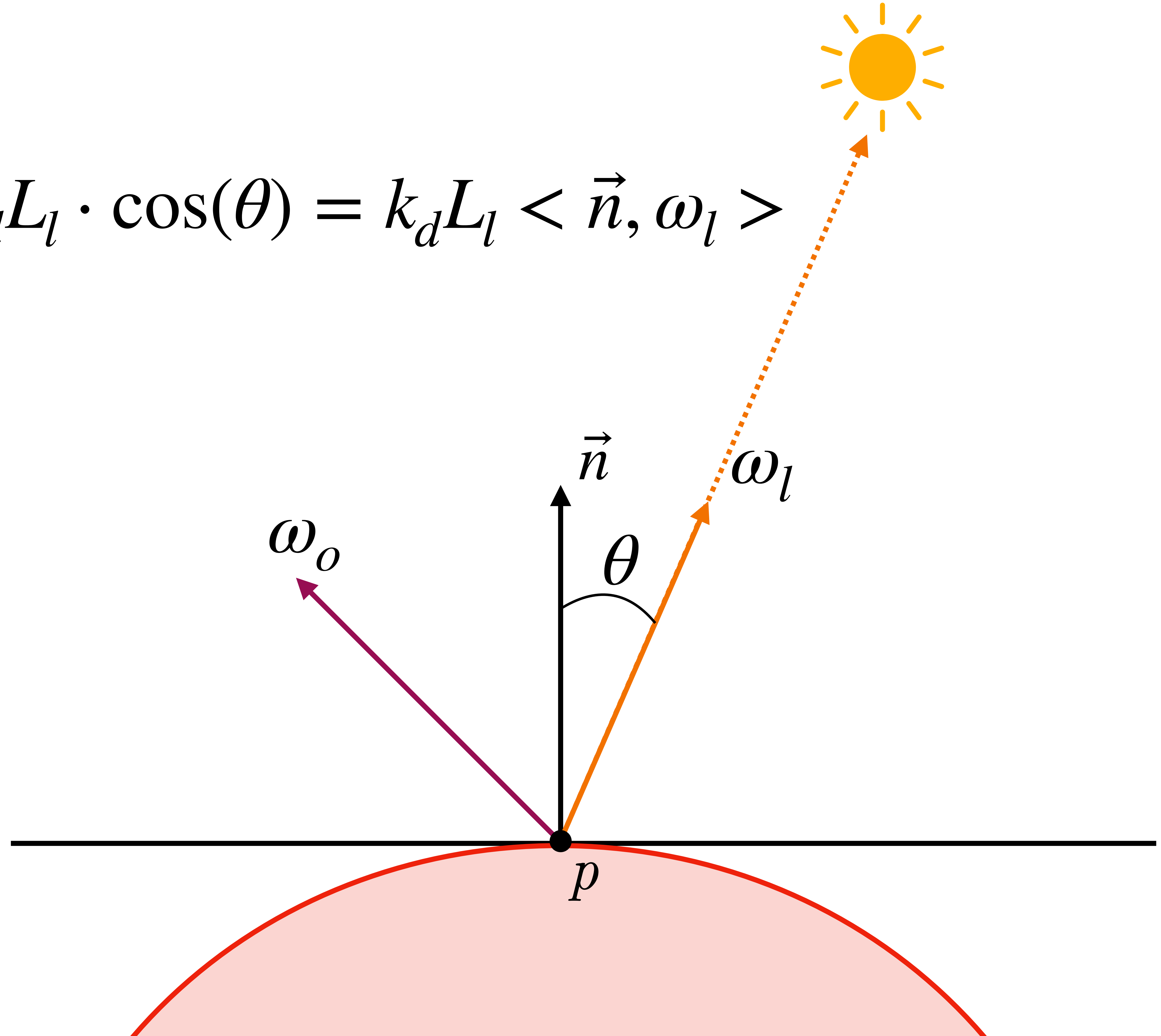


Reflexão difusa

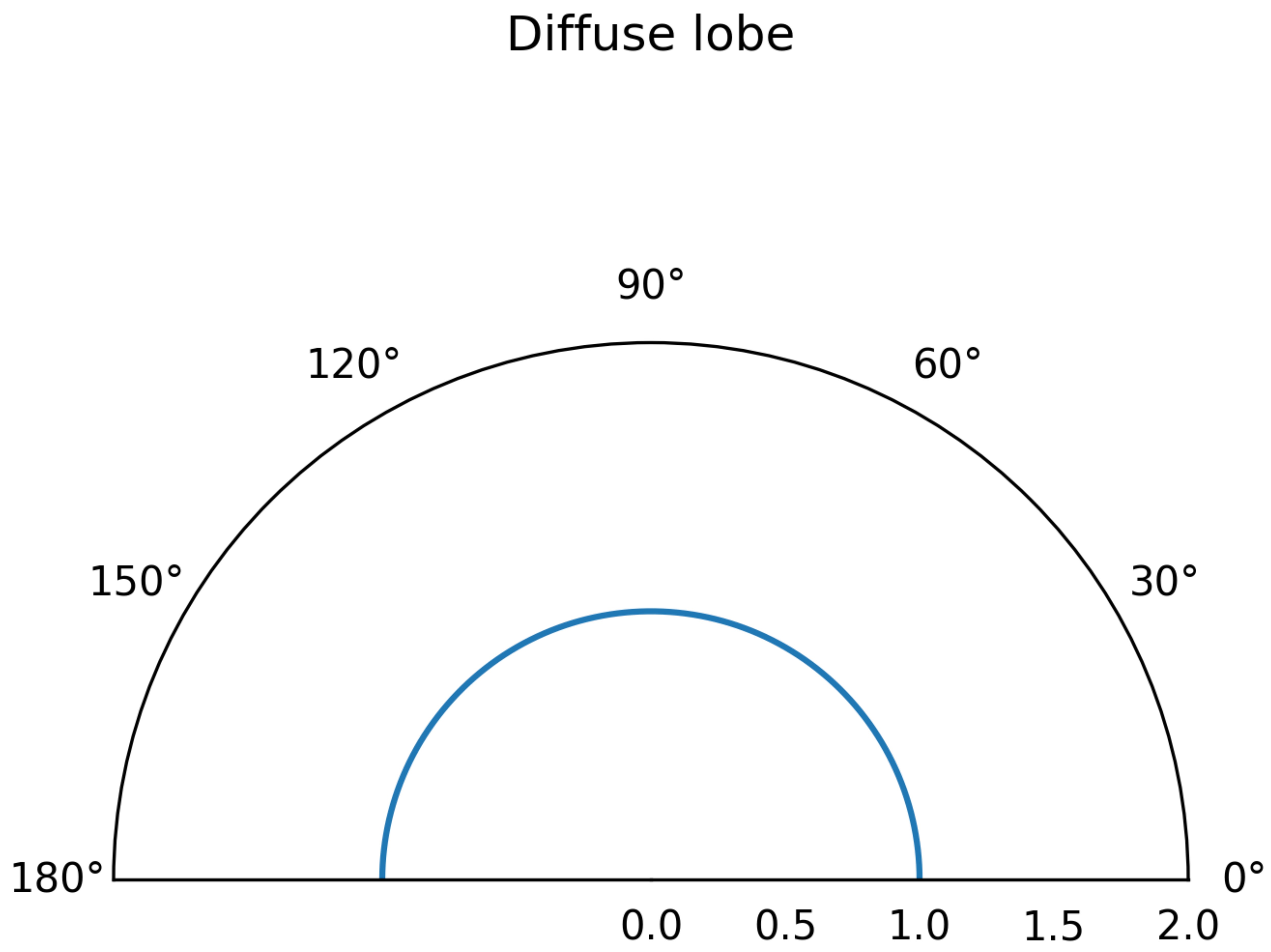


Reflexão difusa

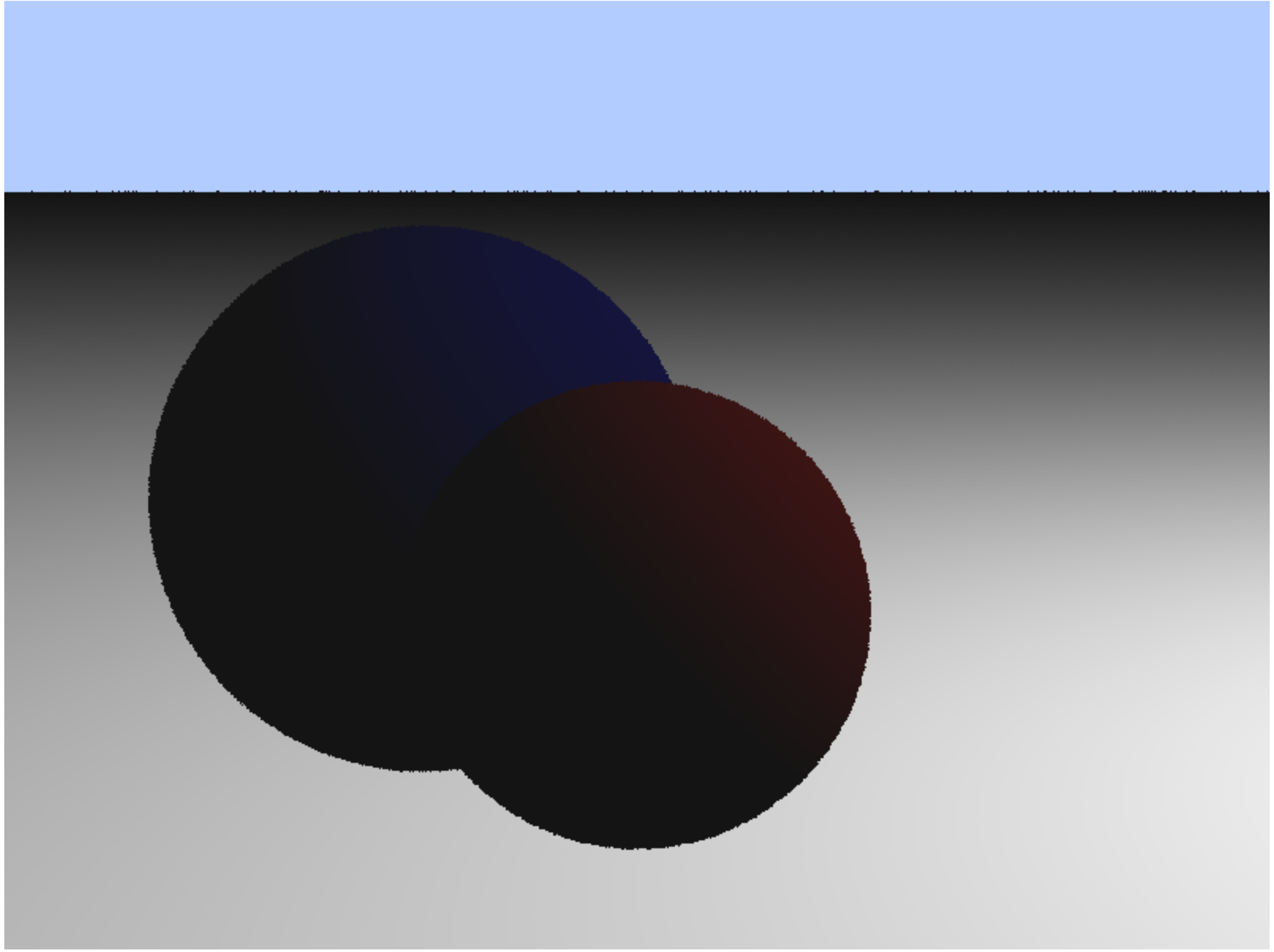
$$L(p, \omega_o) = k_d L_l \cdot \cos(\theta) = k_d L_l < \vec{n}, \omega_l >$$



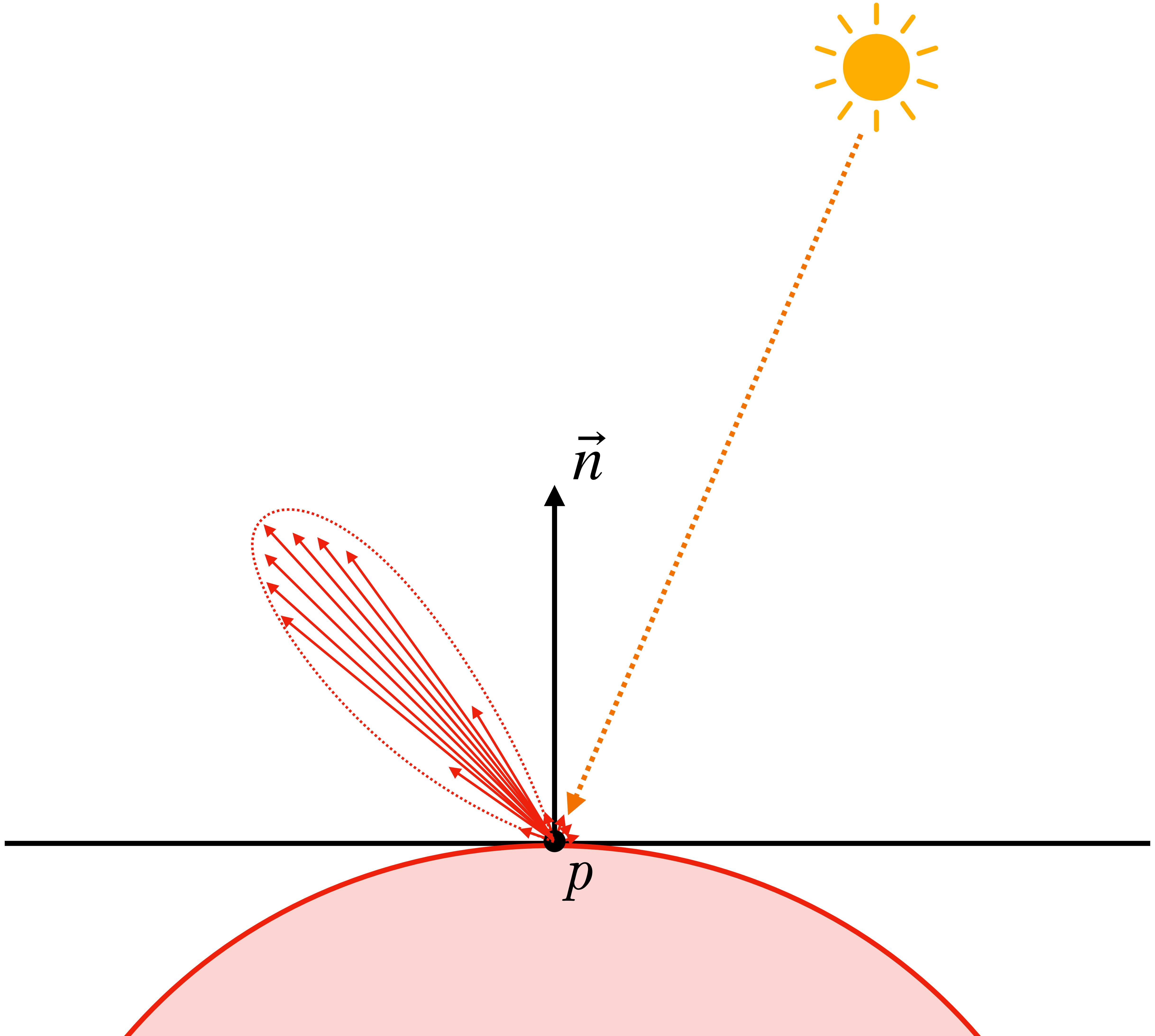
Distribuição Difusa



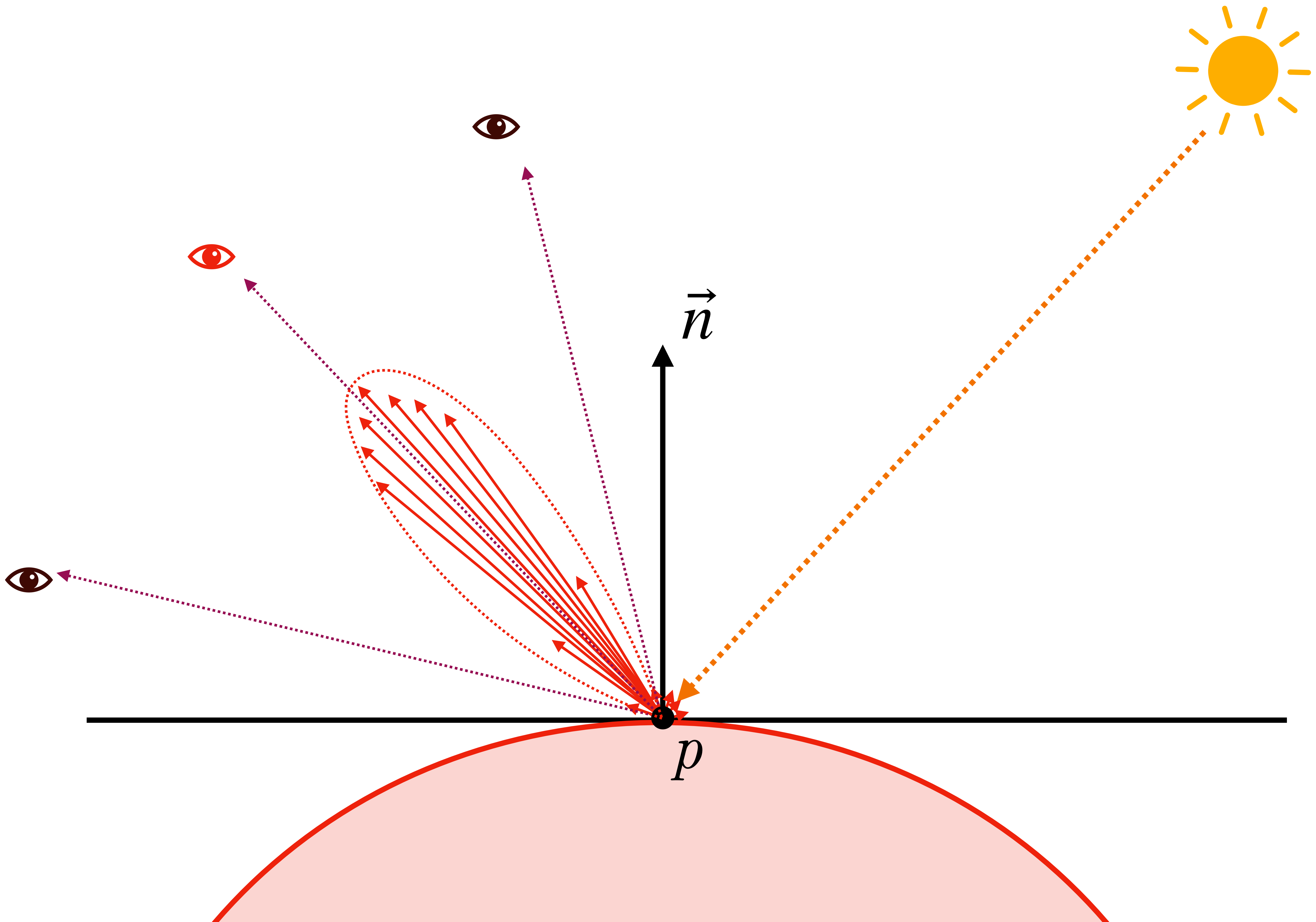
Exemplo de render



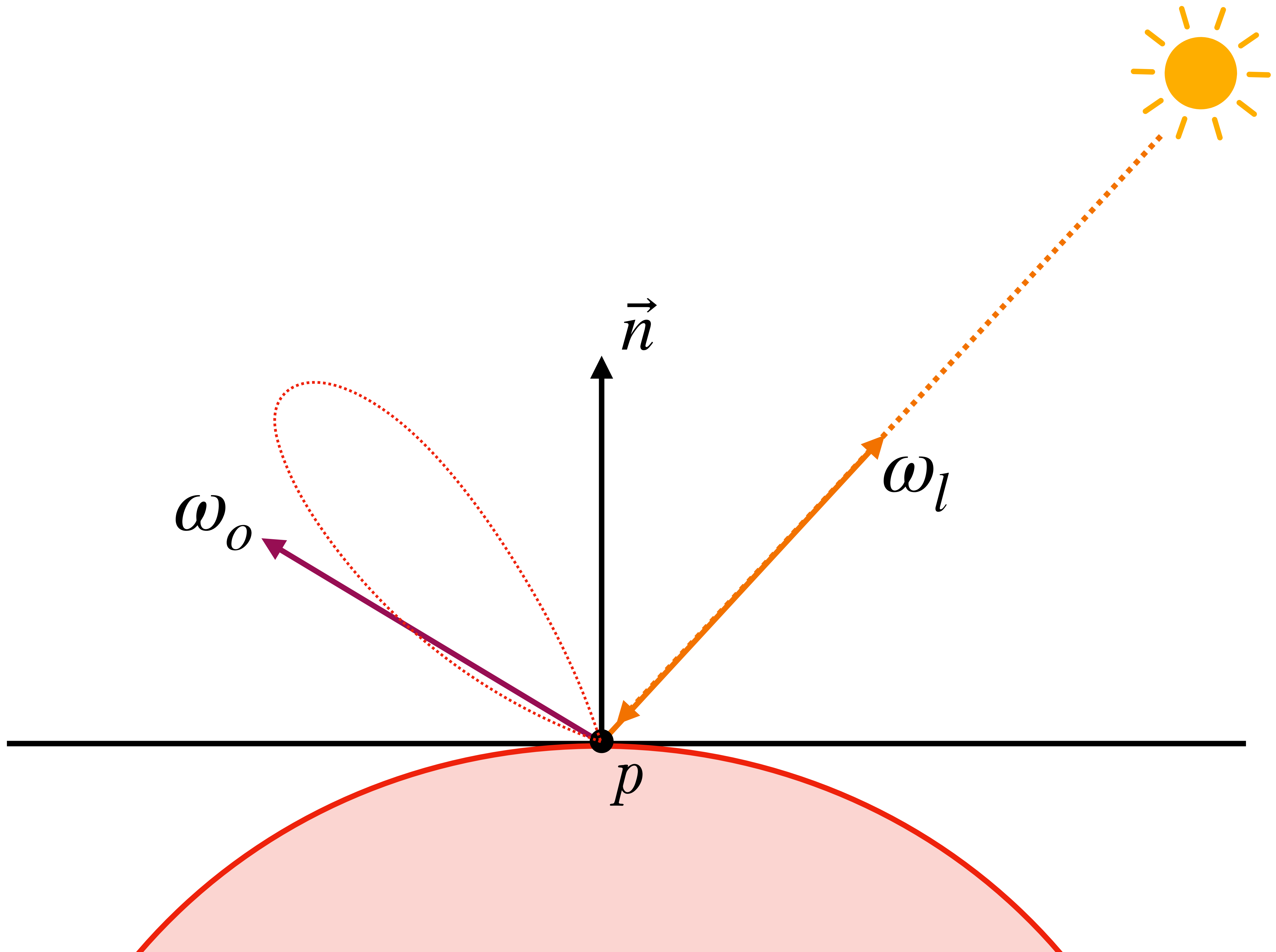
Reflexão especular



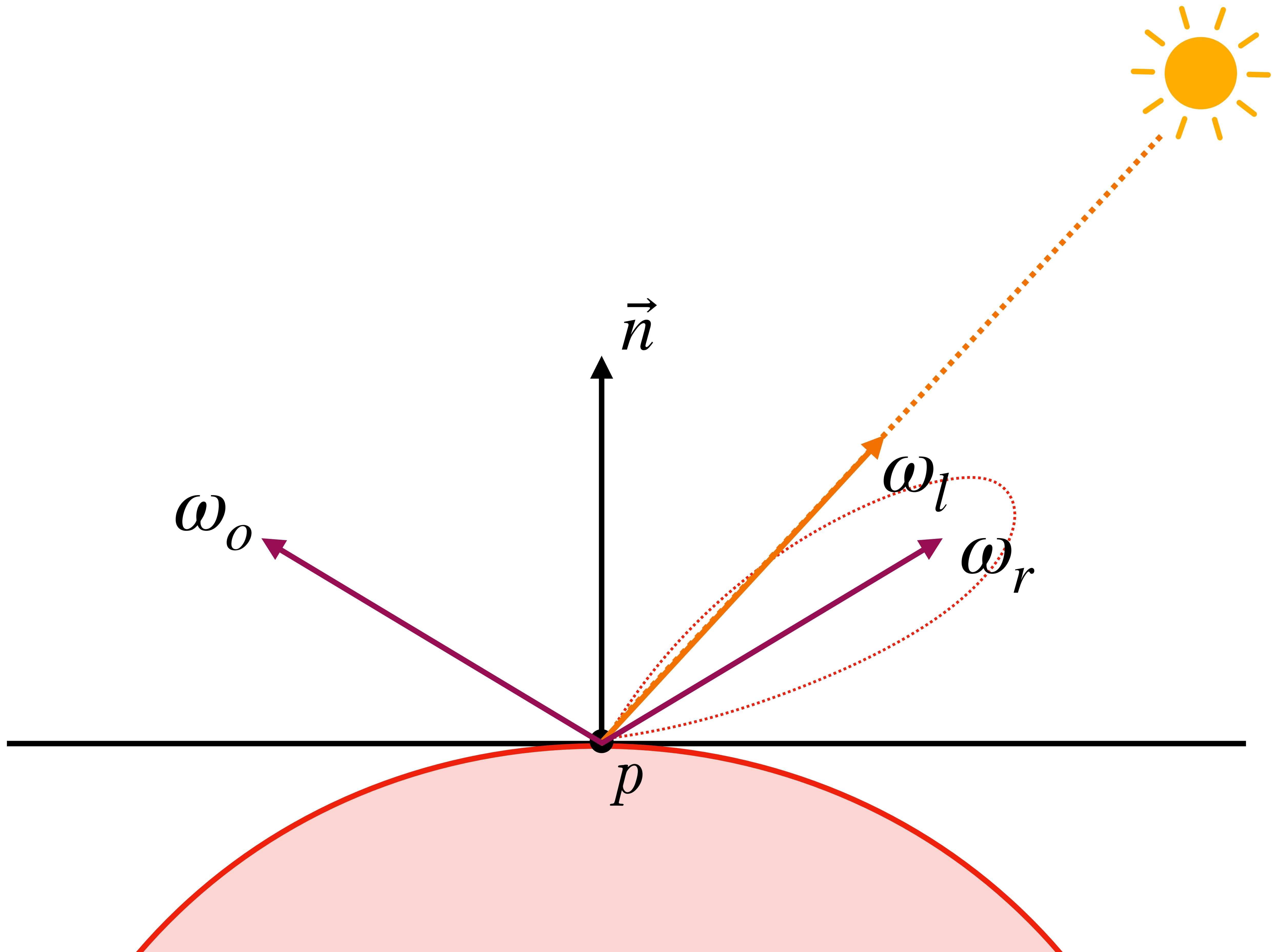
Reflexão especular



Reflexão especular



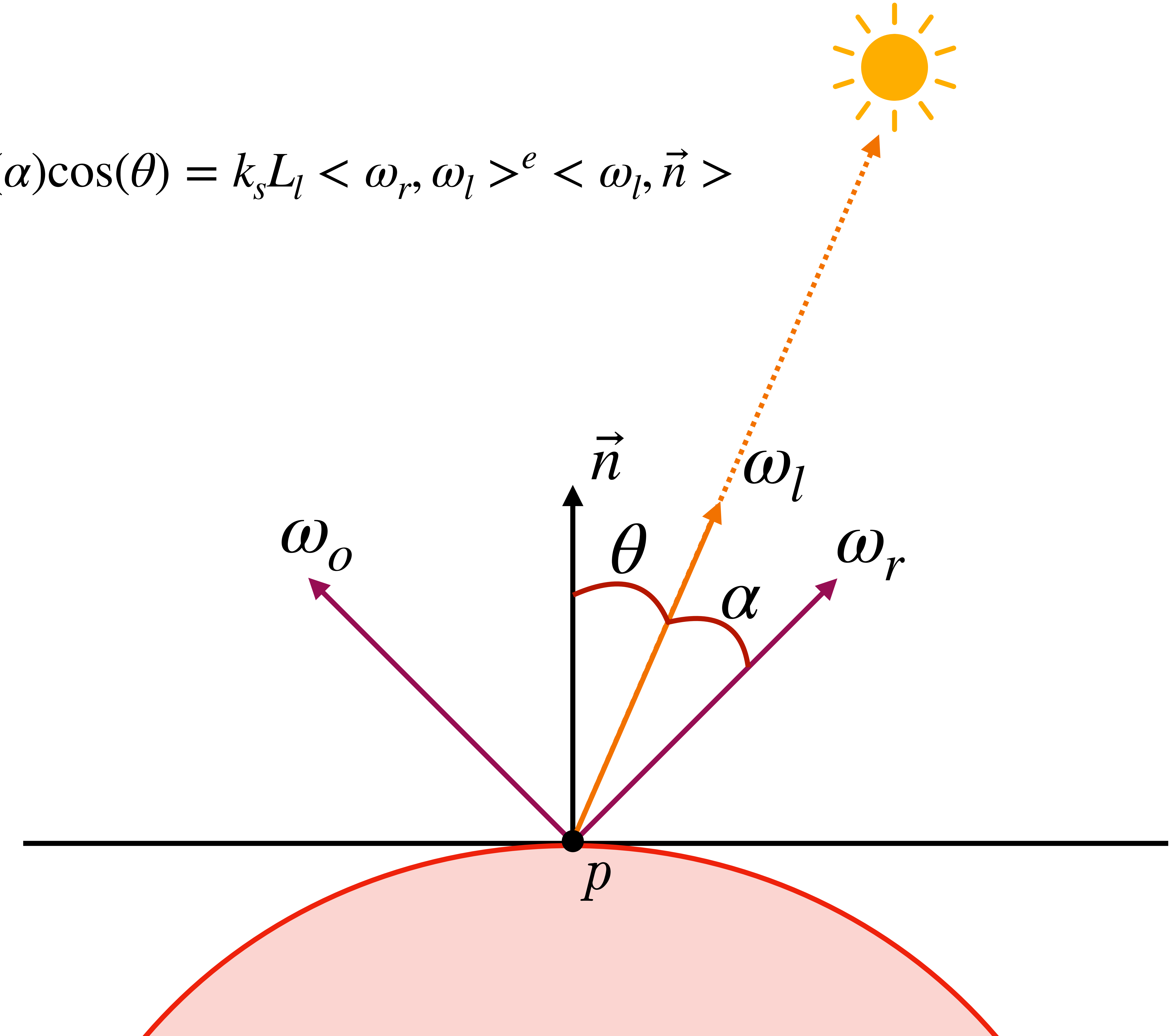
Reflexão especular



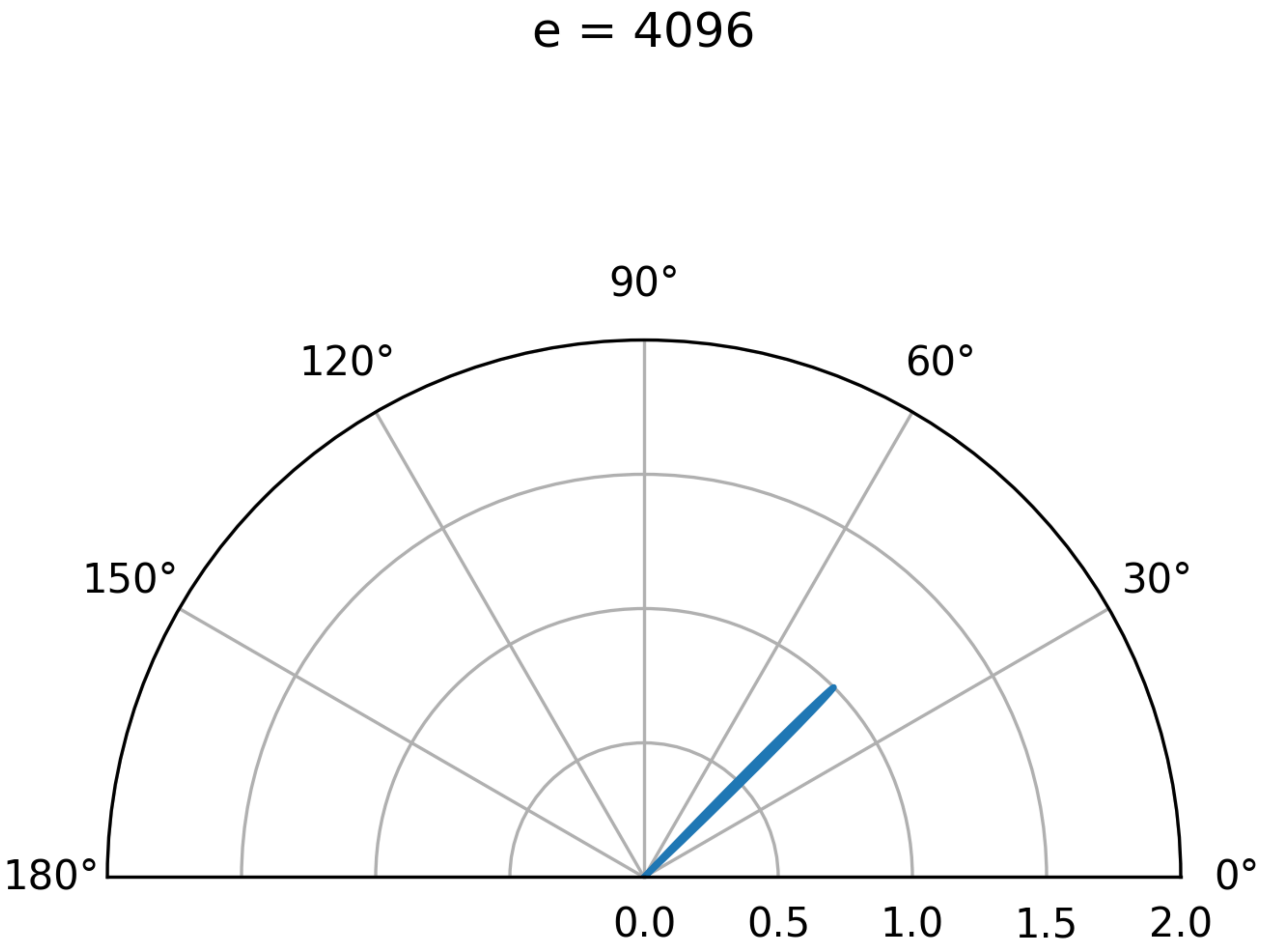
Reflexão especular

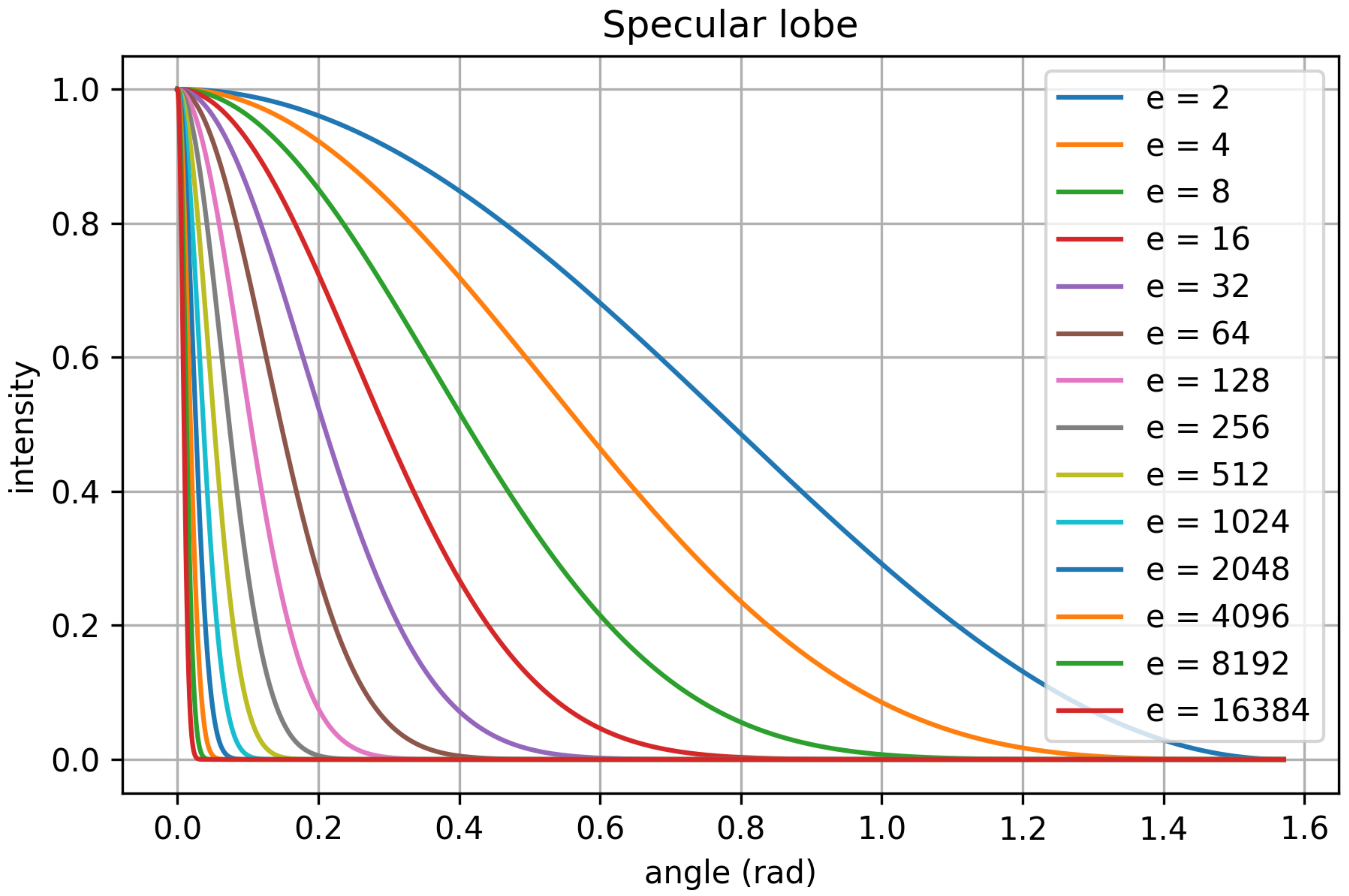
$$L(p, \omega_o) = k_s L_l \cdot \cos^e(\alpha)\cos(\theta) = k_s L_l < \omega_r, \omega_l >^e < \omega_l, \vec{n} >$$

onde $e \geq 0$

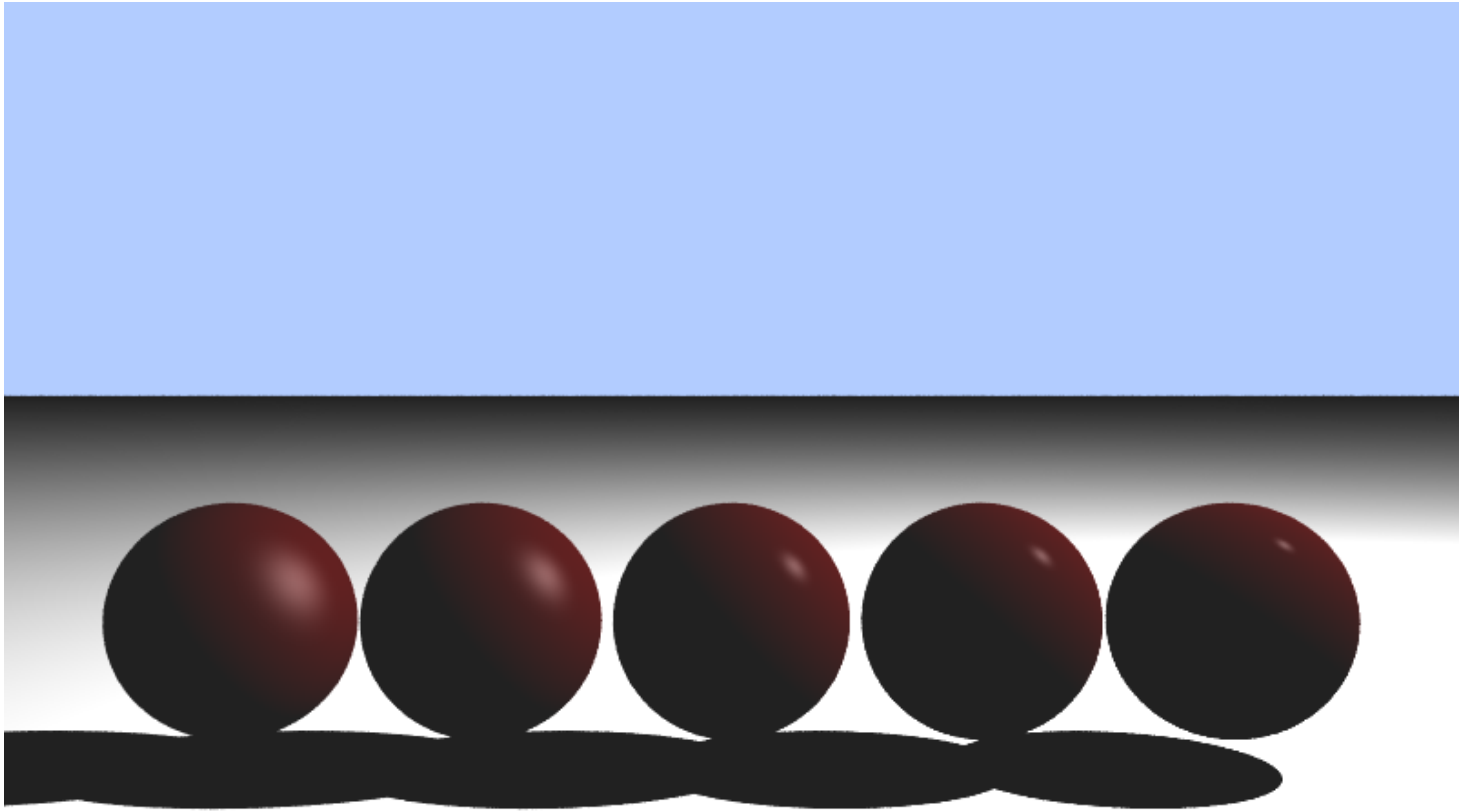


Decaimento especular





Exemplo de render



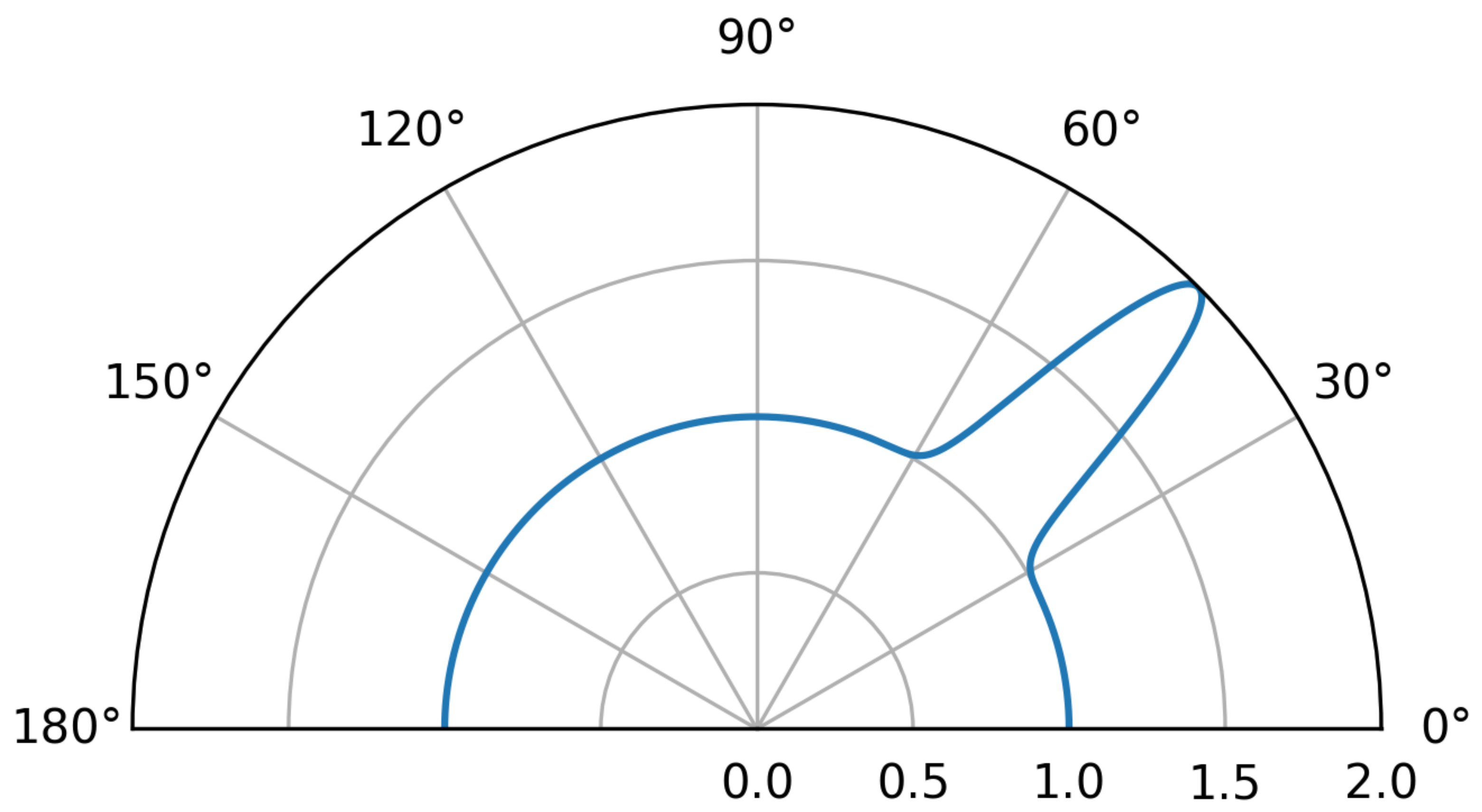
$e =$ 8 16 64 128 256

Modelo: Amb. + Difuso + Especular

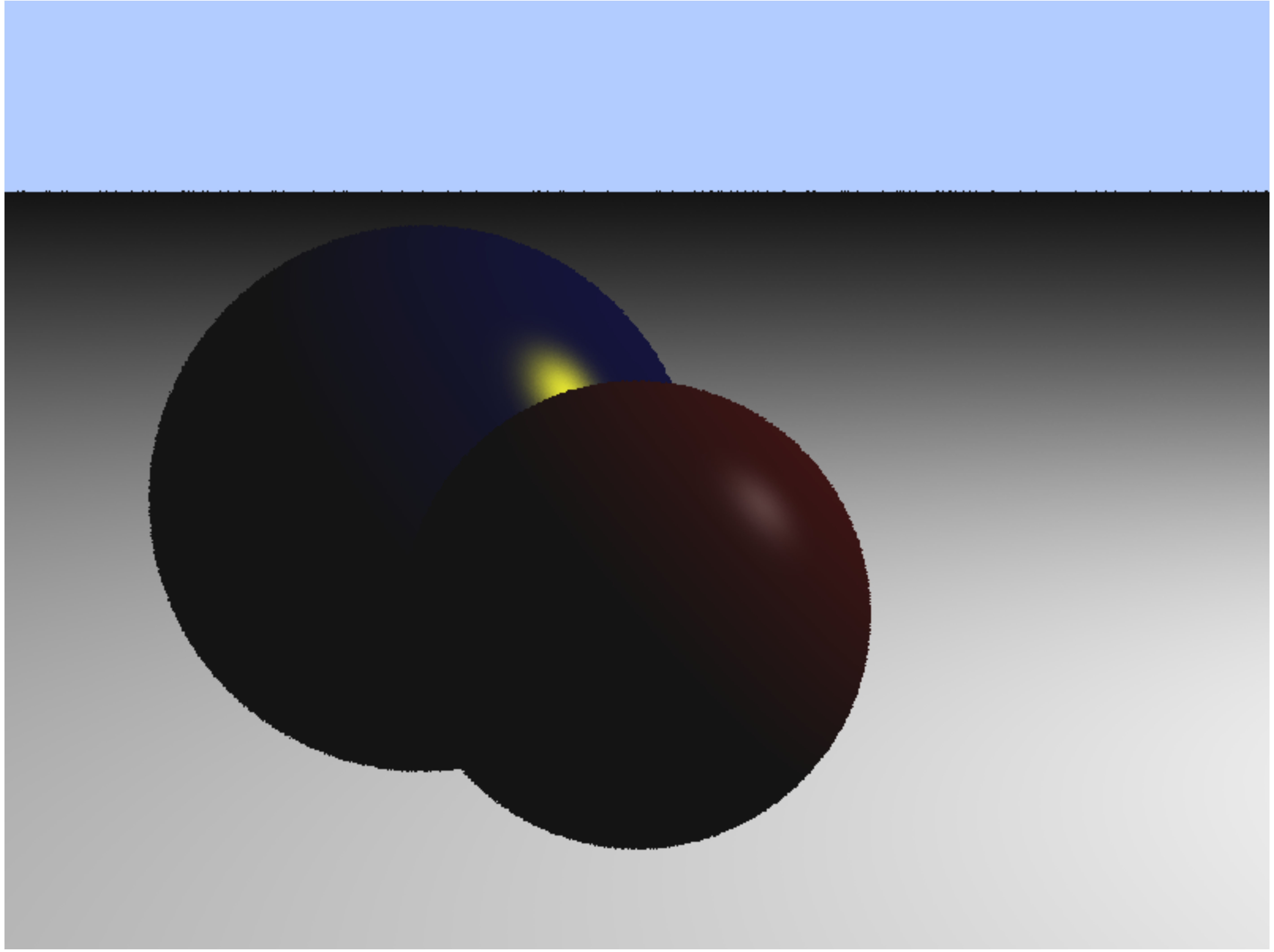
$$L(p,\omega_o) = k_a L_a + k_d \sum_{i=1}^{n} L_i < \omega_i, \vec{n} > + k_s \sum_{j=1}^{n} L_j < \omega_r, \omega_j >^e < \omega_j, \vec{n} >$$

$$= k_a L_a + \sum_{i=1}^{n} L_i (k_d + k_s < \omega_r, \omega_i >^e \,) < \omega_i, \vec{n} >$$

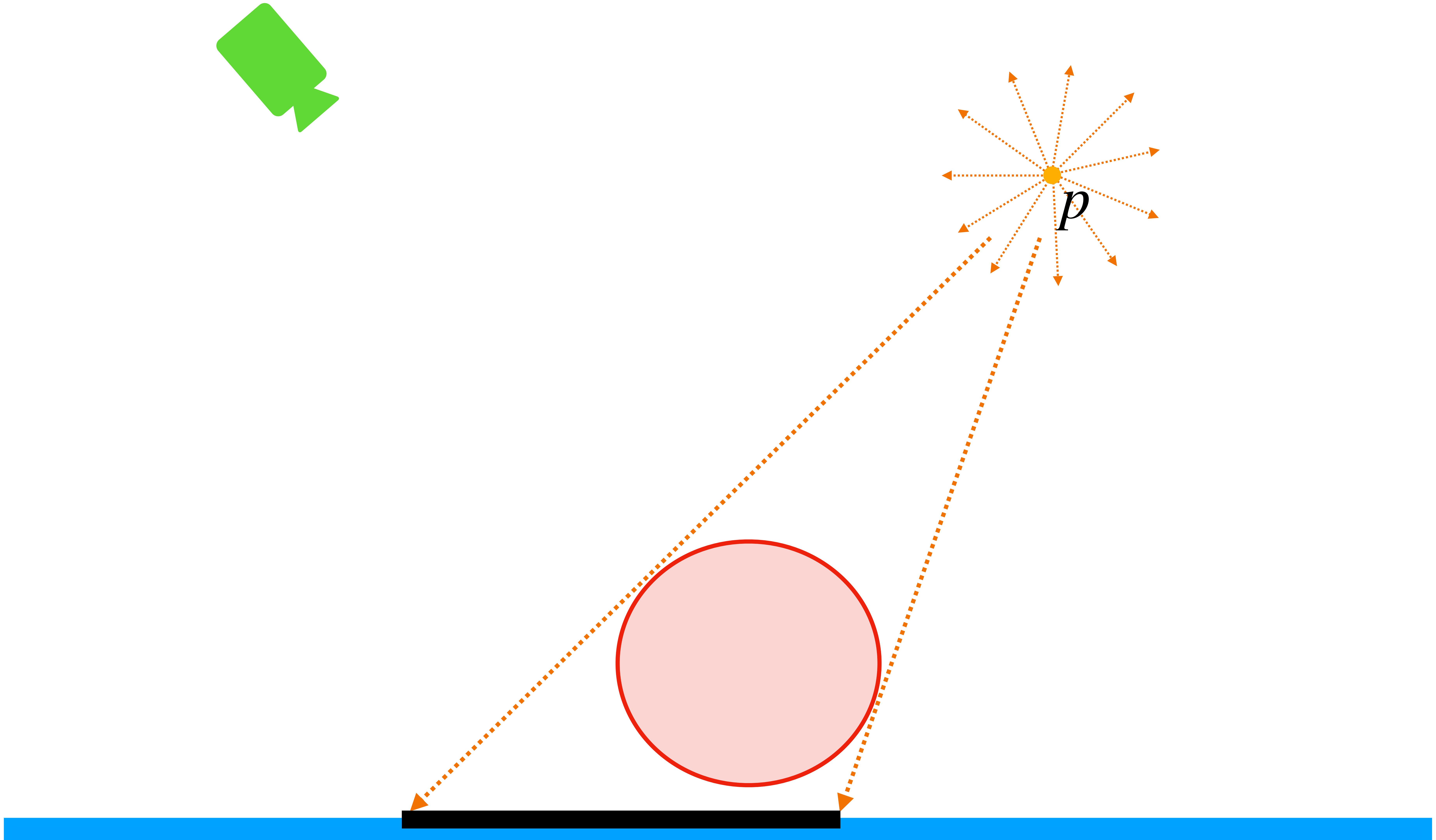
d + e = 128



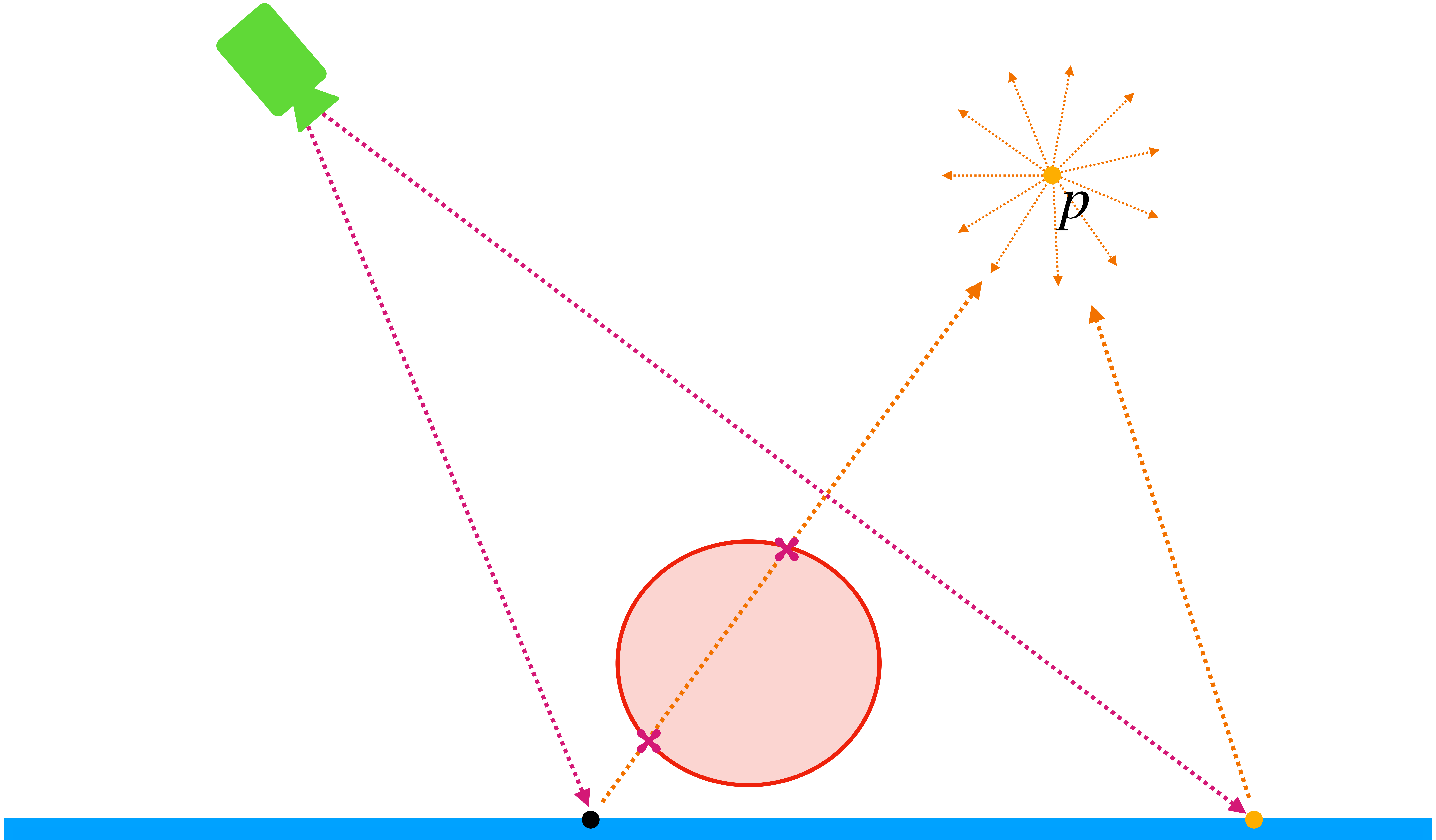
Exemplo de render



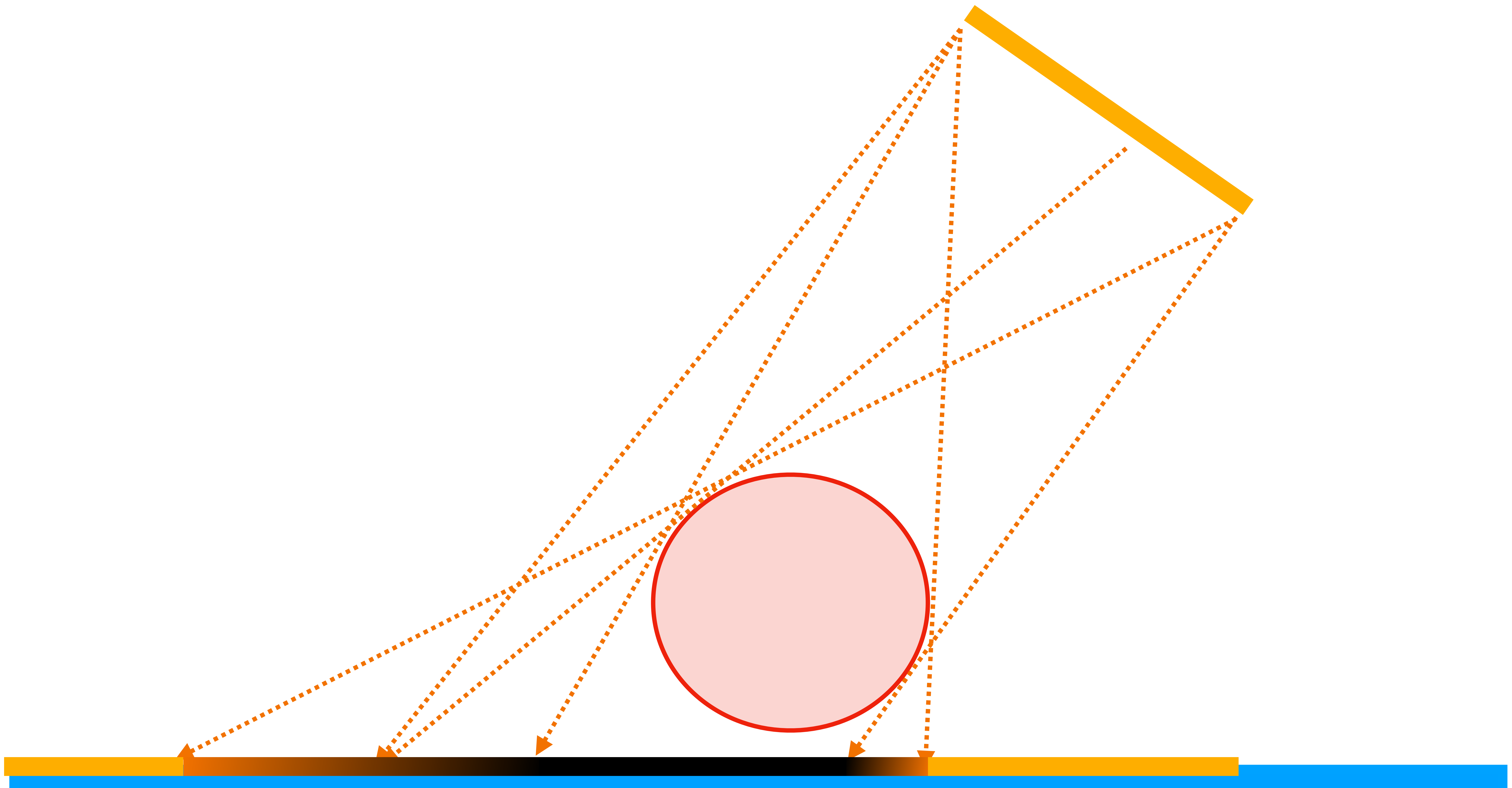
Sombra



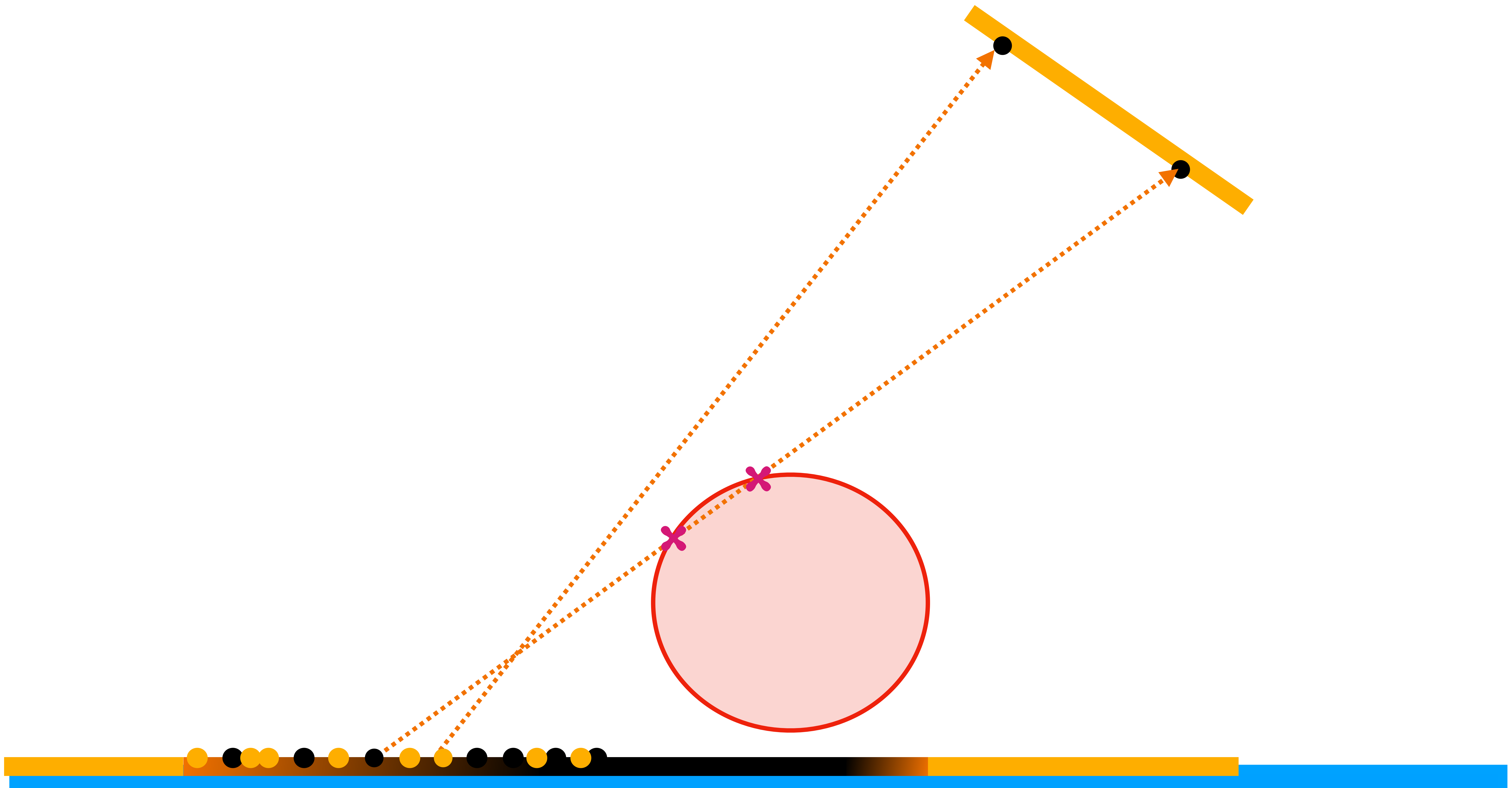
Sombra



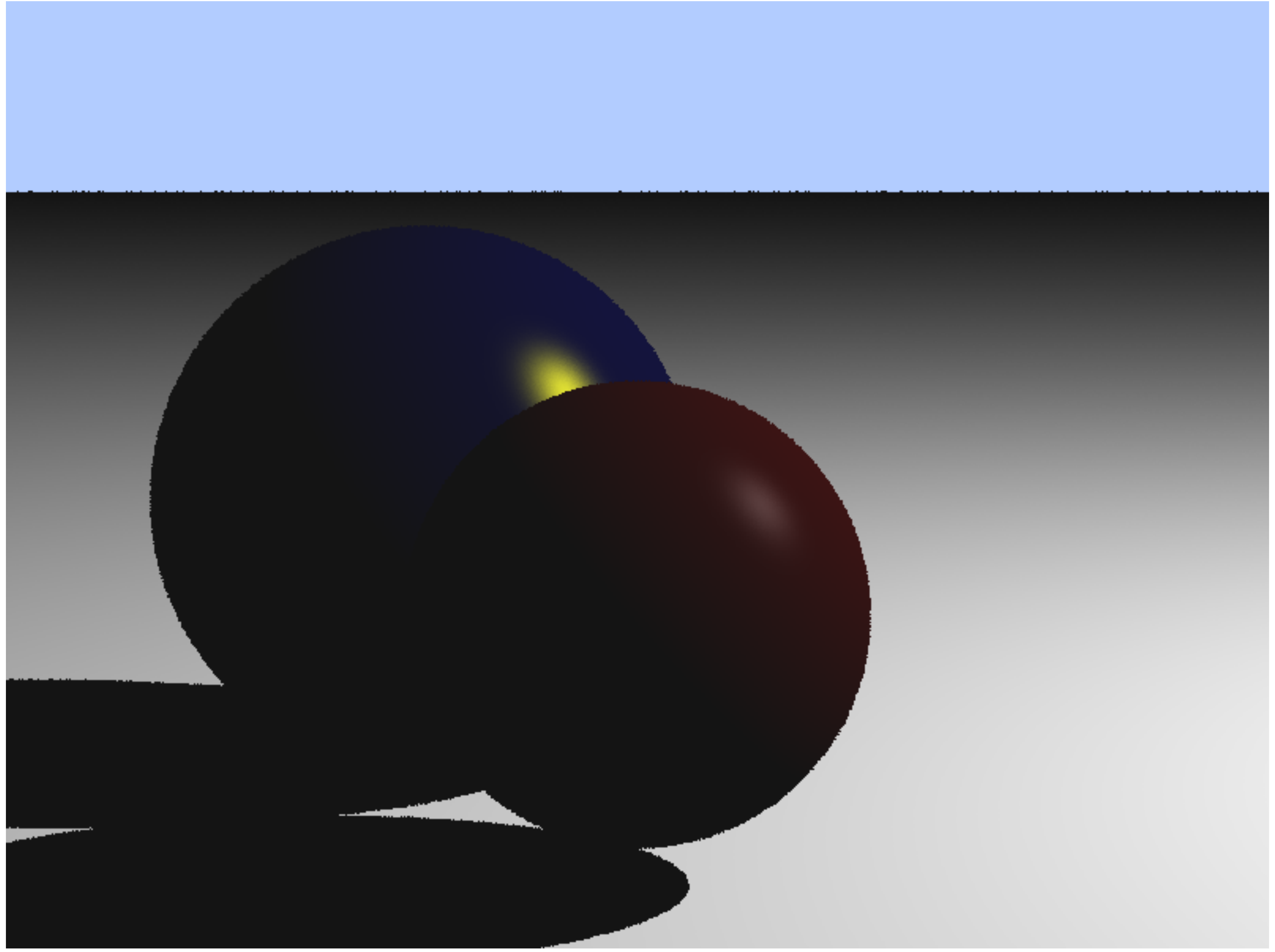
Area Light

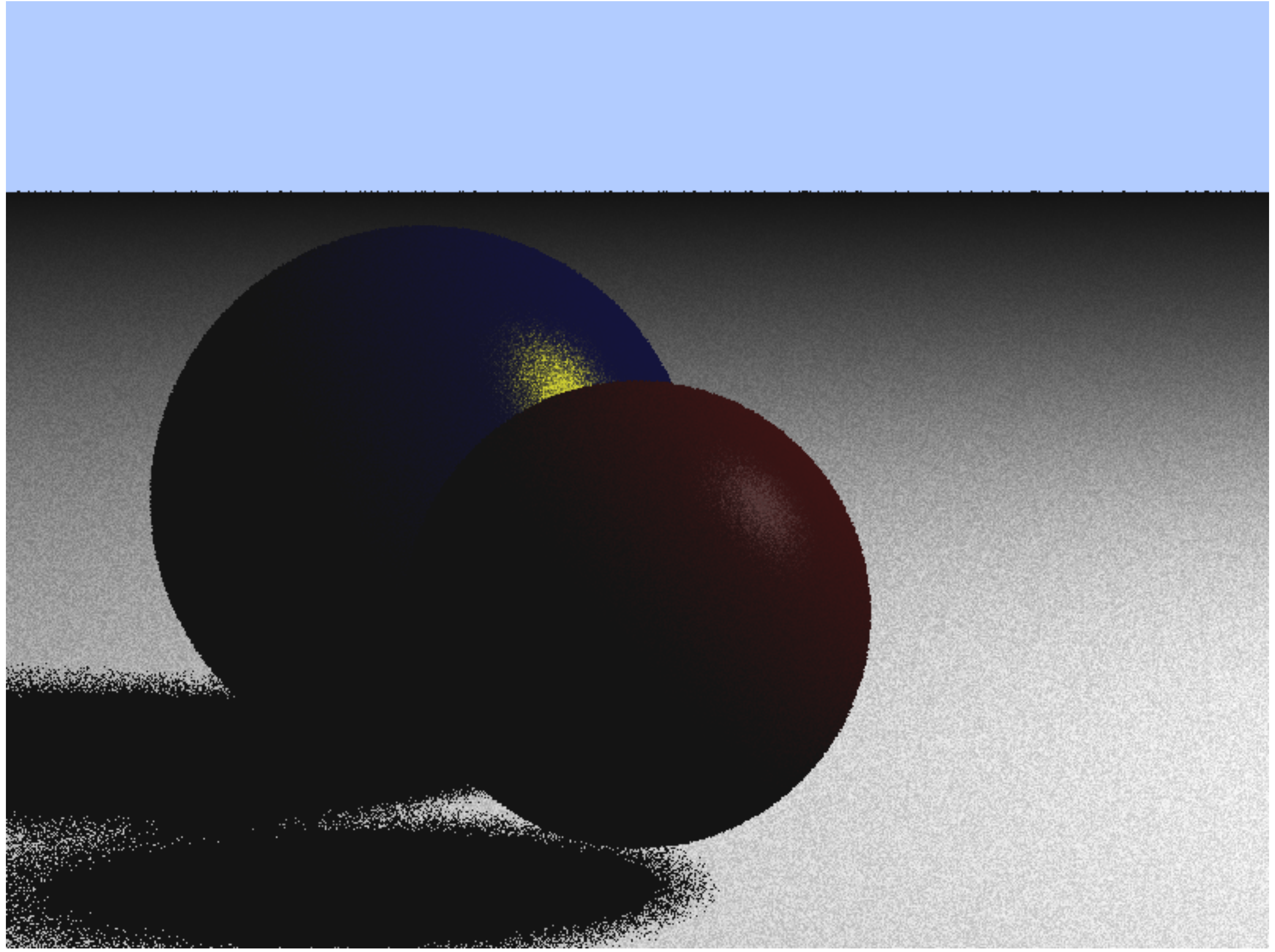


Area Light

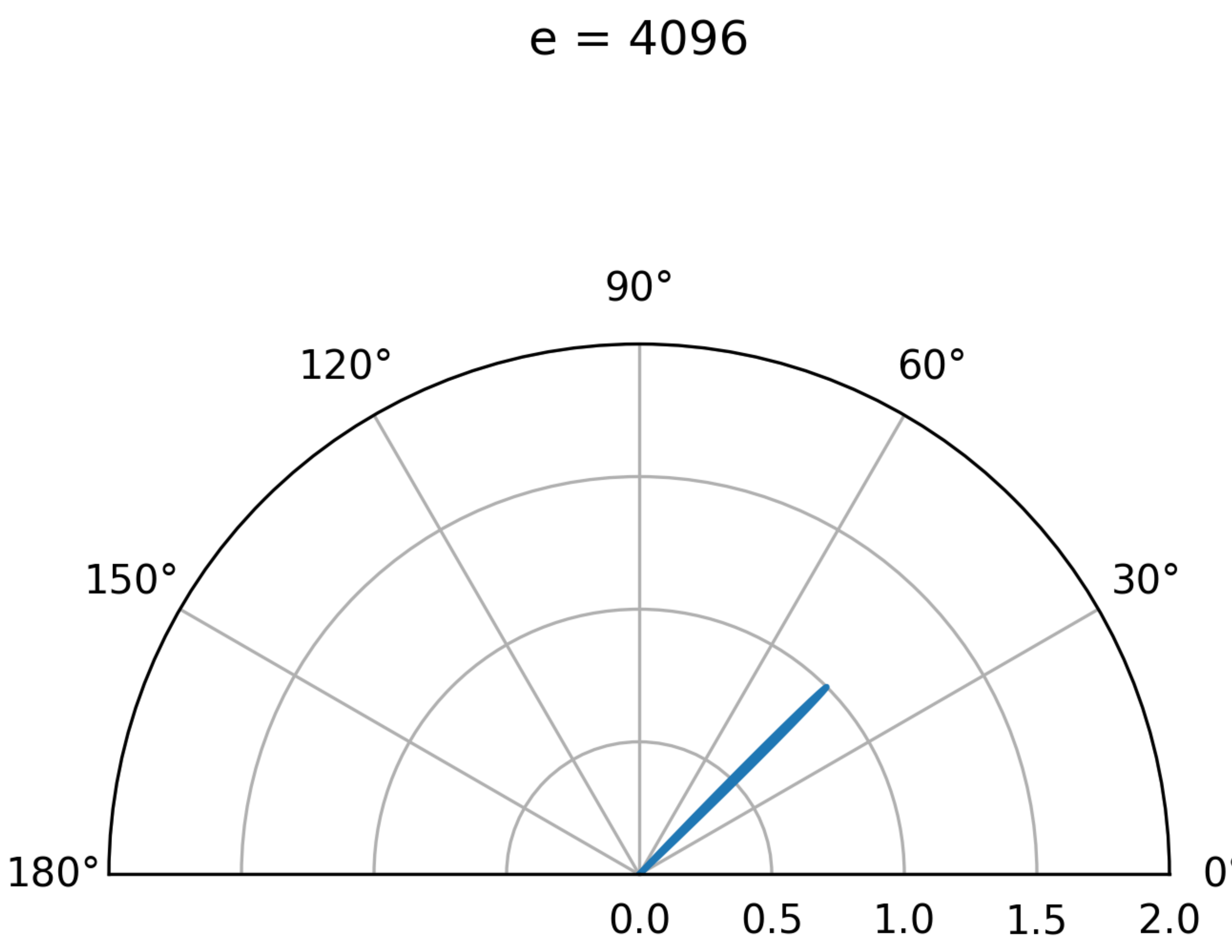


Exemplo

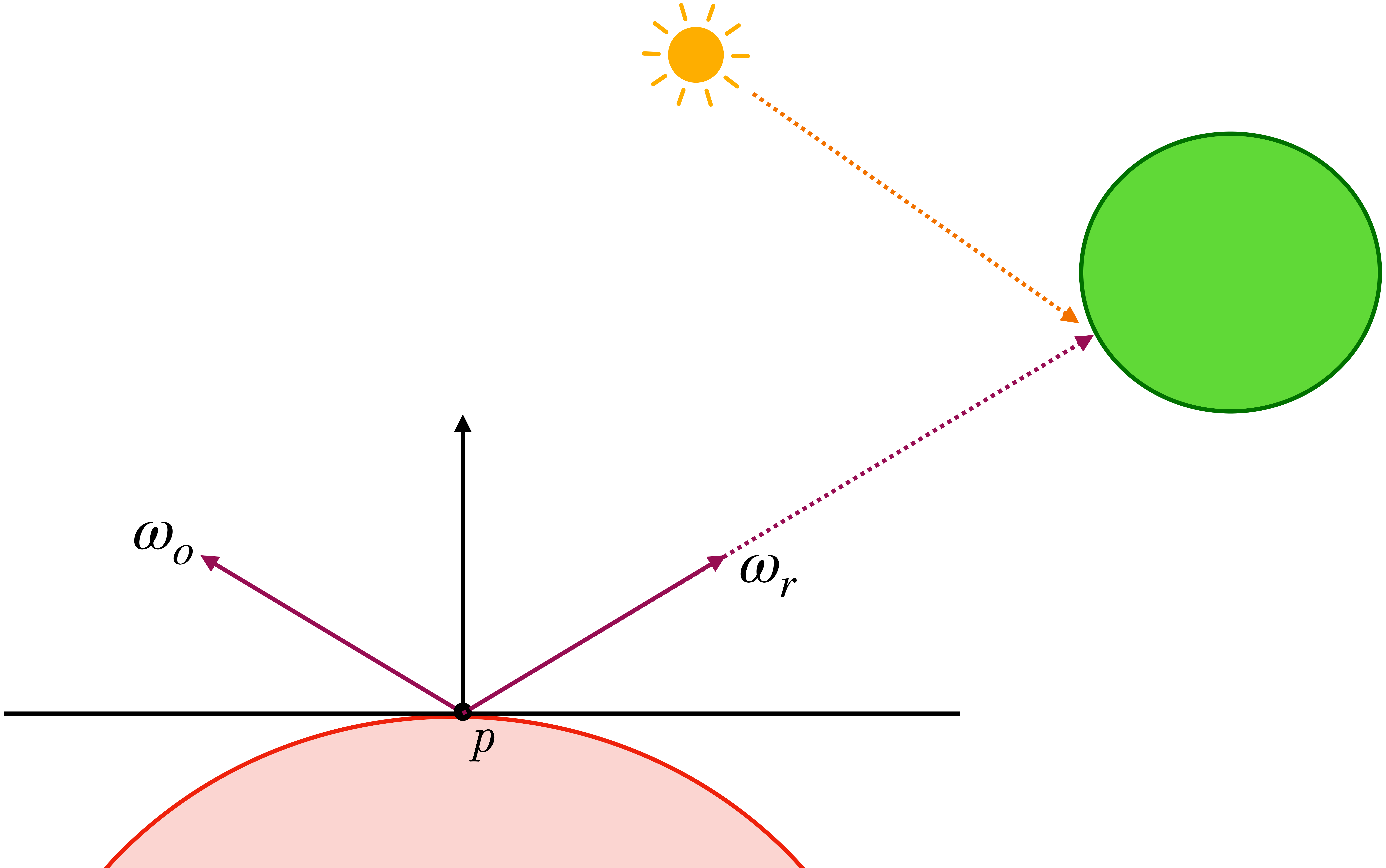




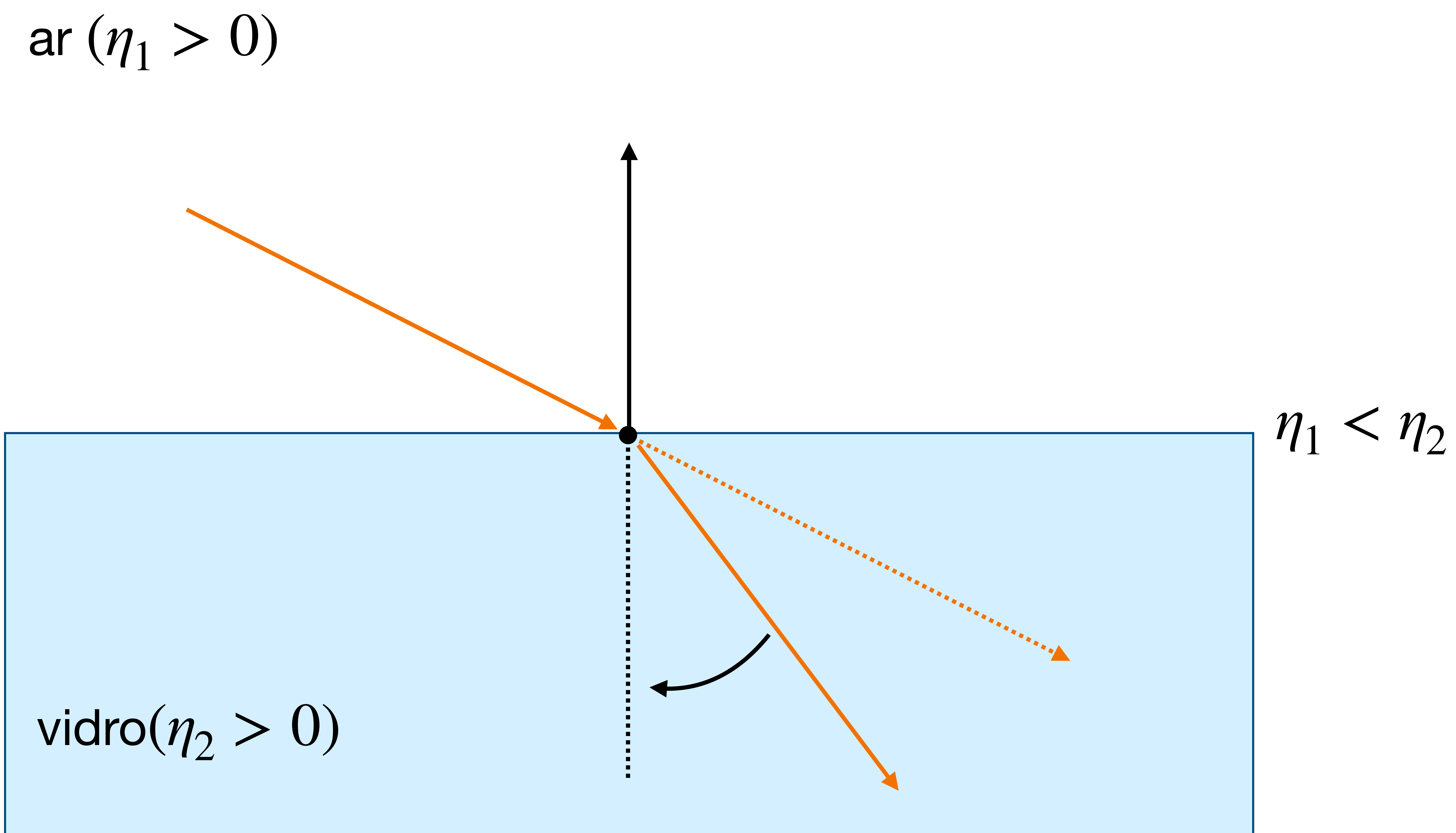
Reflexão e Transmissão de Luz



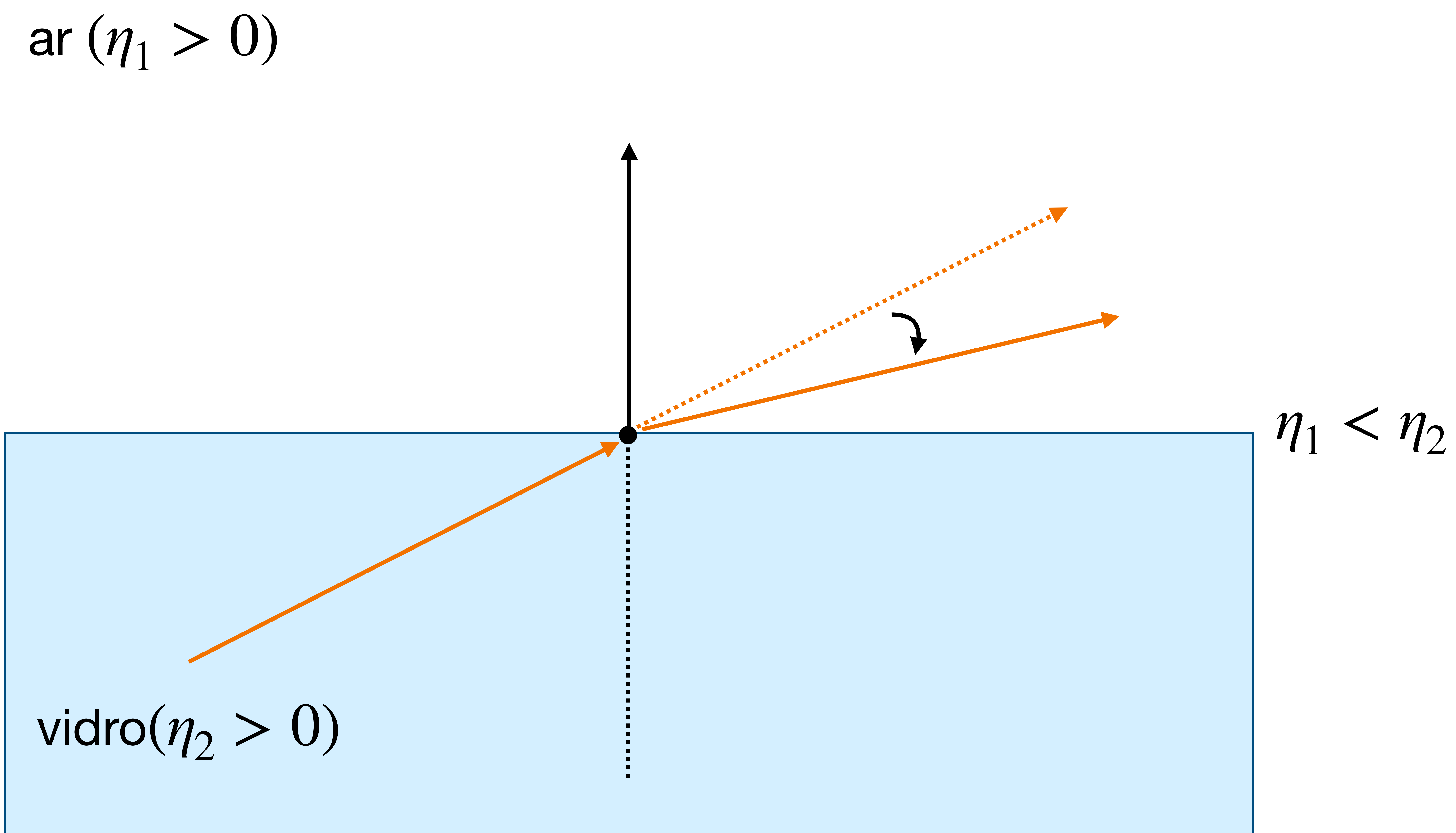
Reflexão



Transmissão



Transmissão

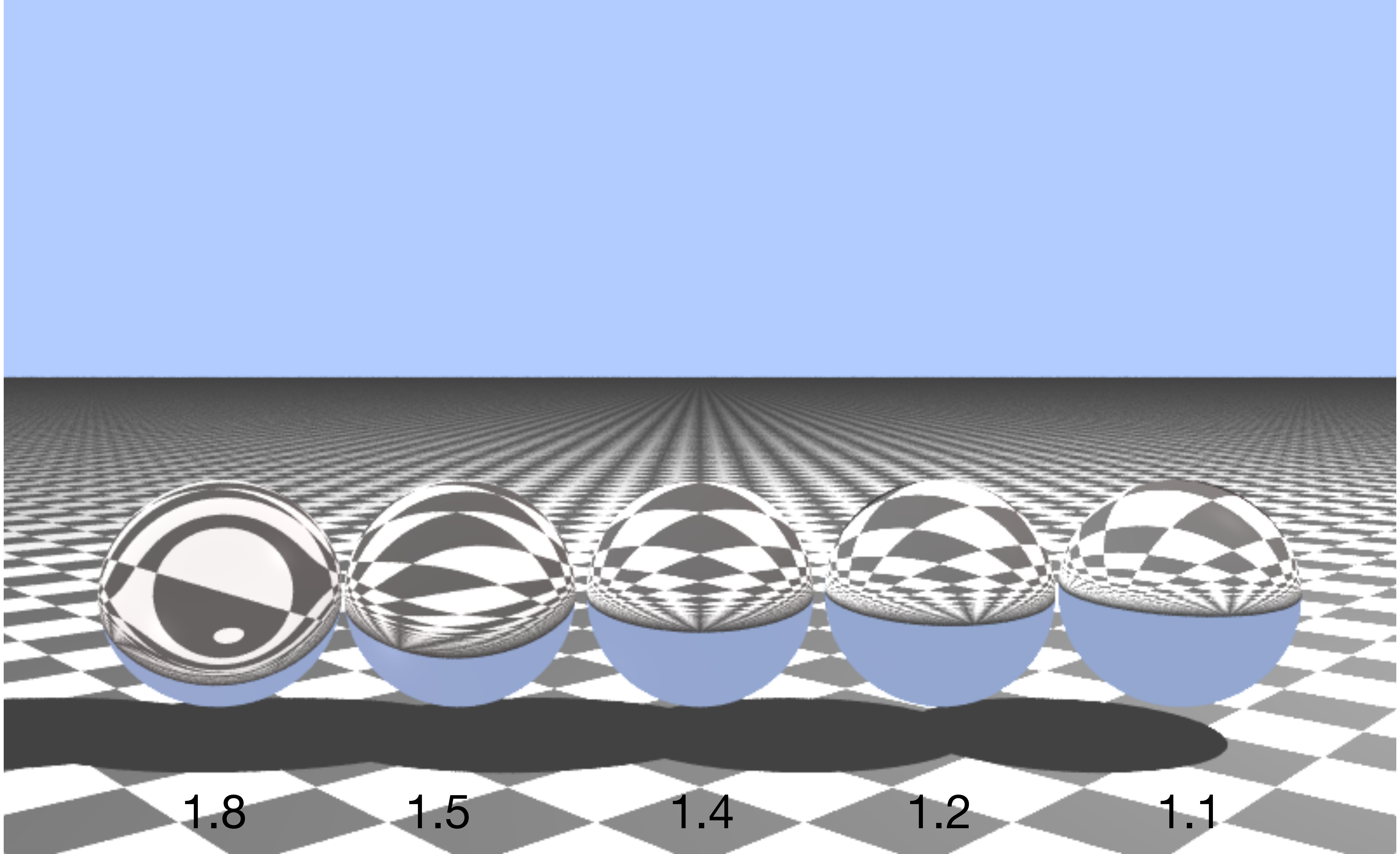


Transmissão

$$L(p, \omega_o) = k_r L(p, \omega_r) + k_t L(p, \omega_t)$$

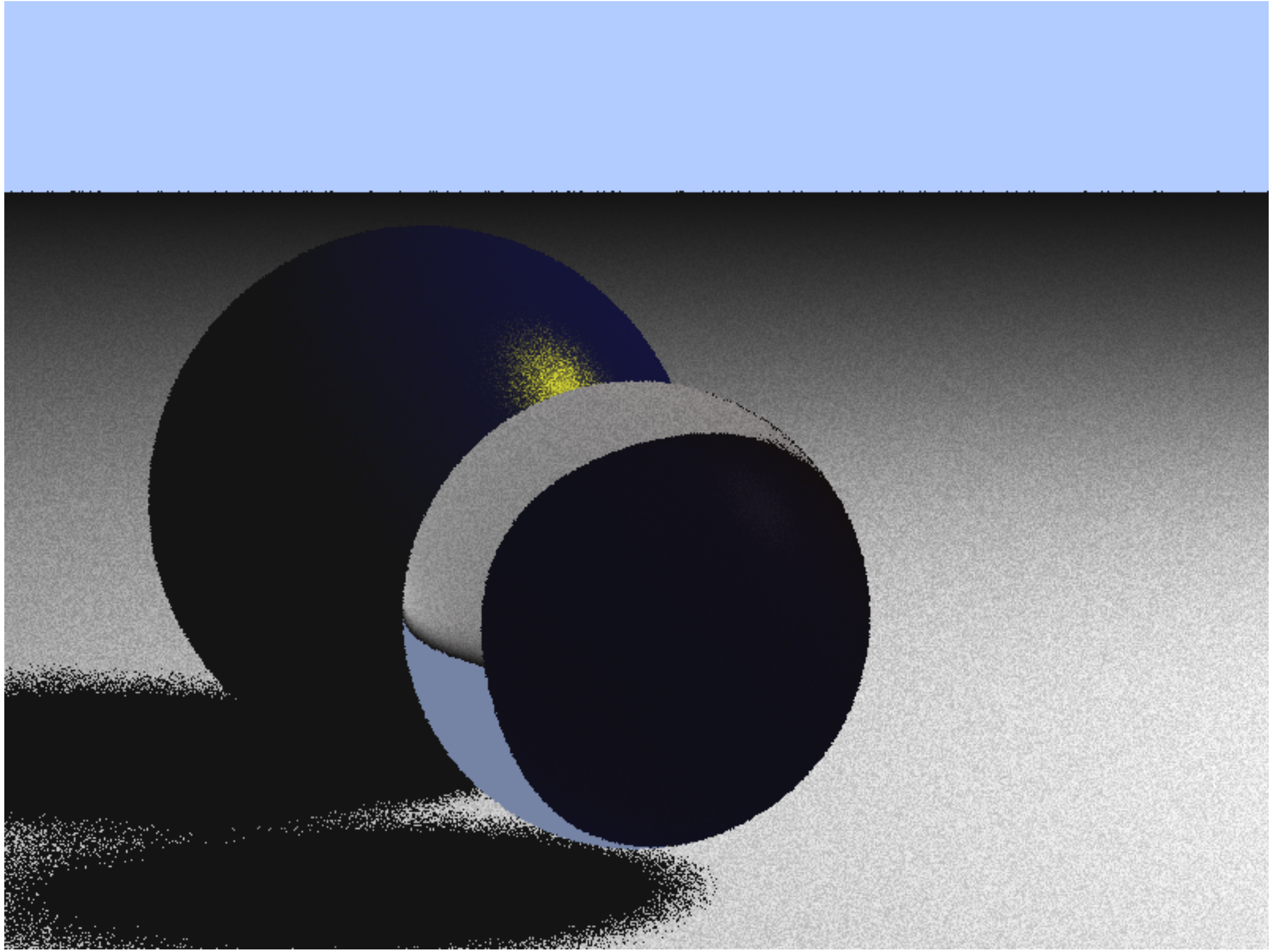
Reflections and Refractions in Ray Tracing, Bram de Greve 2006

Exemplo

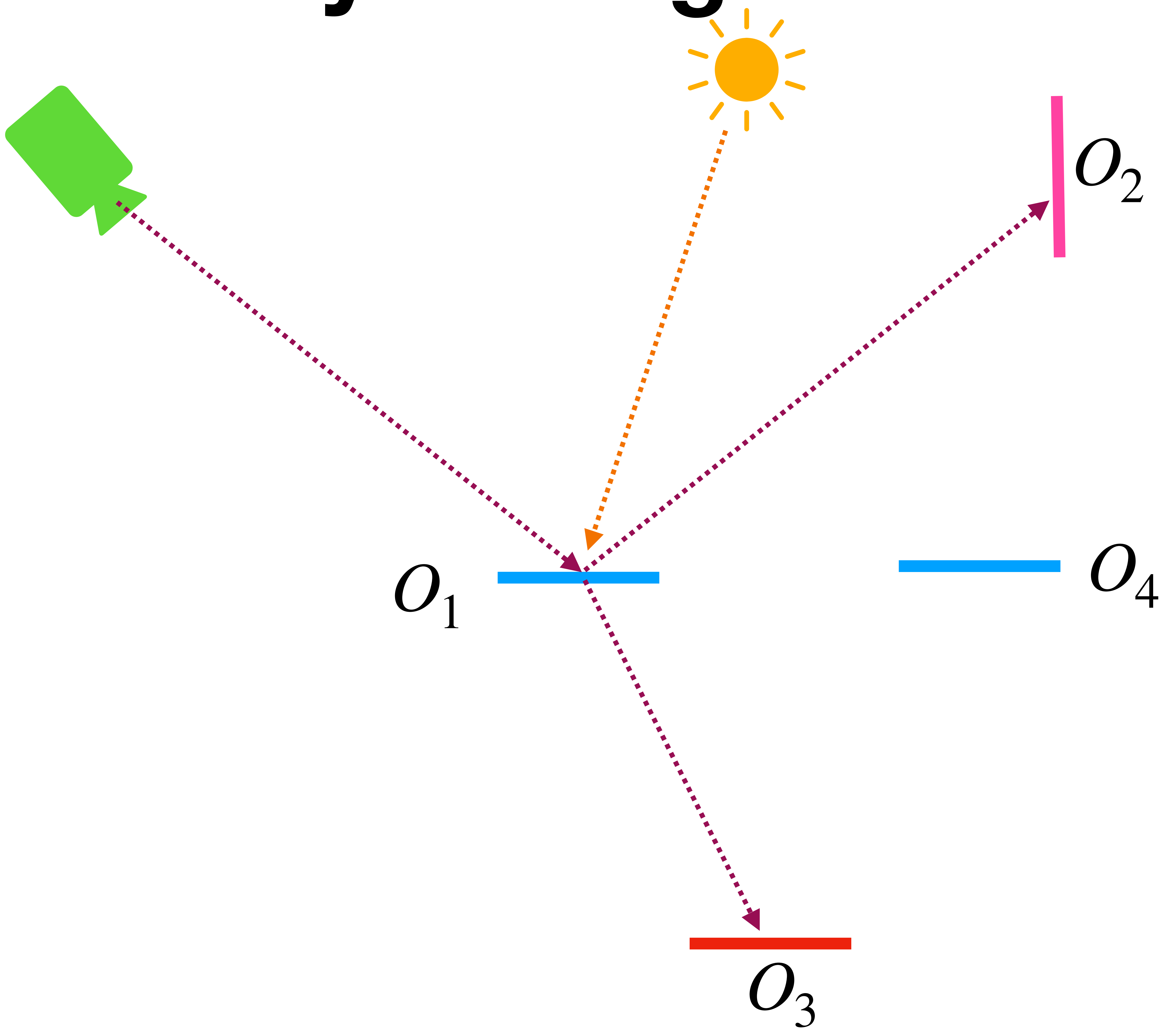


$\eta =$ 1.8 1.5 1.4 1.2 1.1

Exemplo

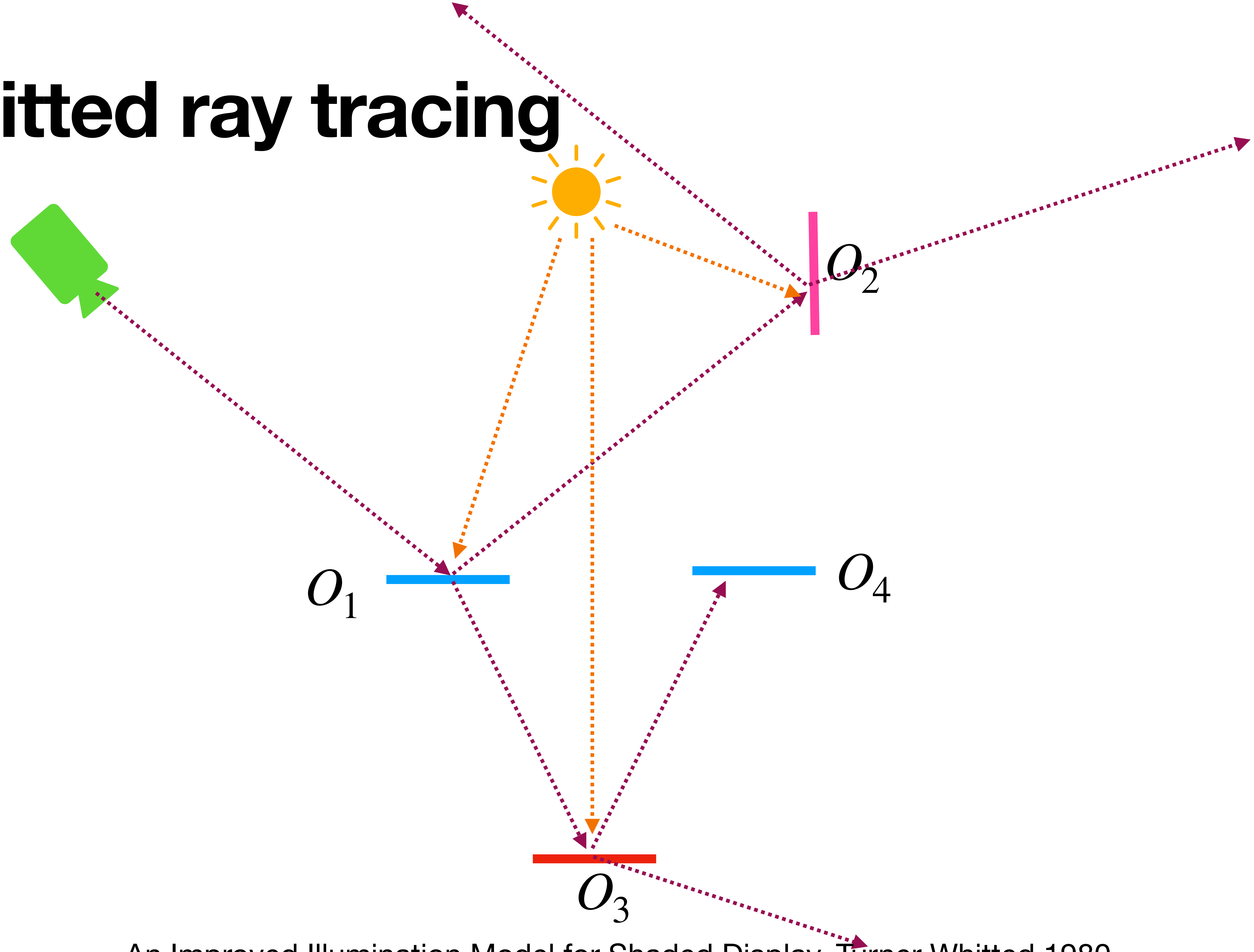


Whitted ray tracing



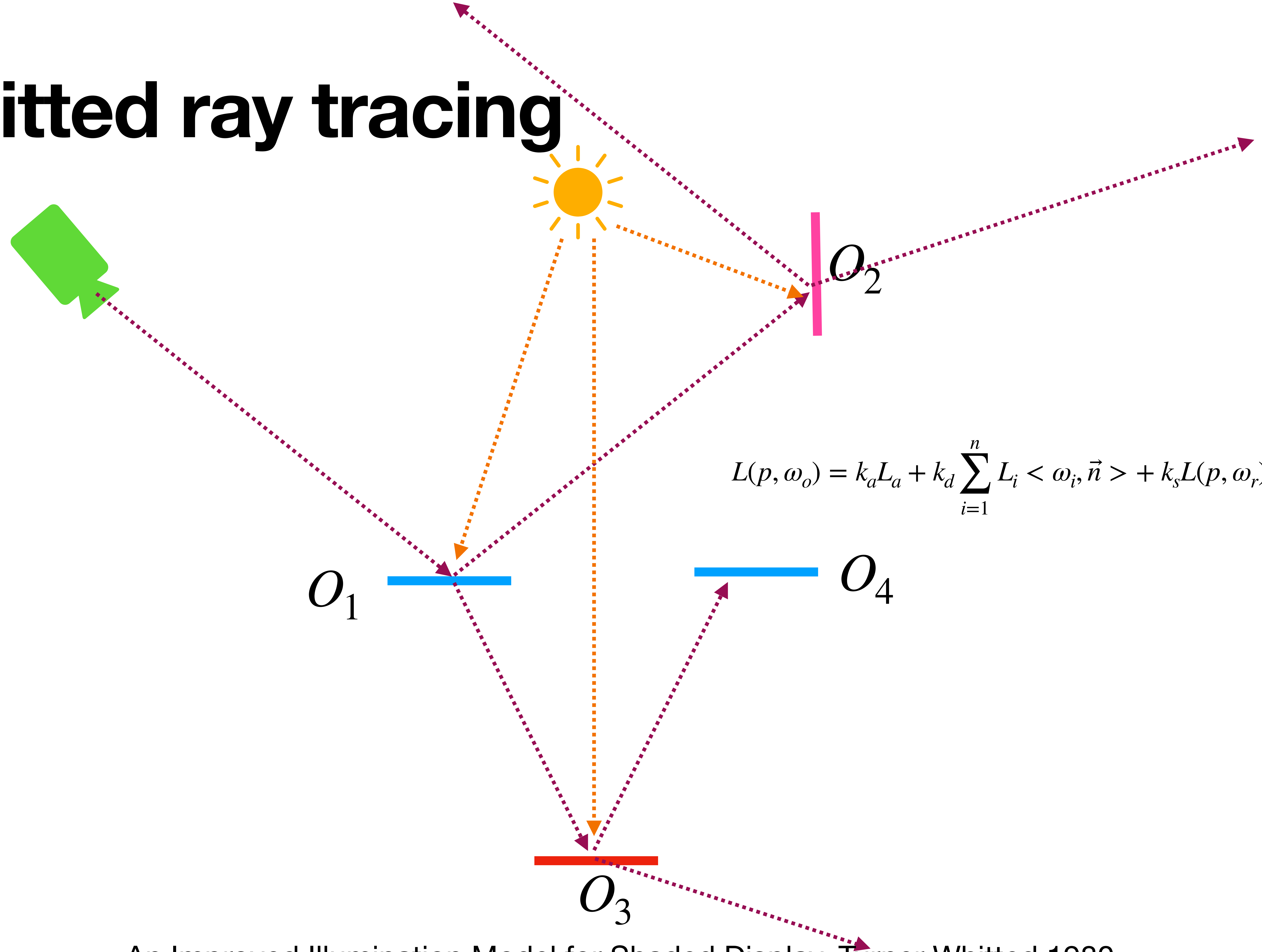
An Improved Illumination Model for Shaded Display, Turner Whitted 1980

Whitted ray tracing



An Improved Illumination Model for Shaded Display, Turner Whitted 1980

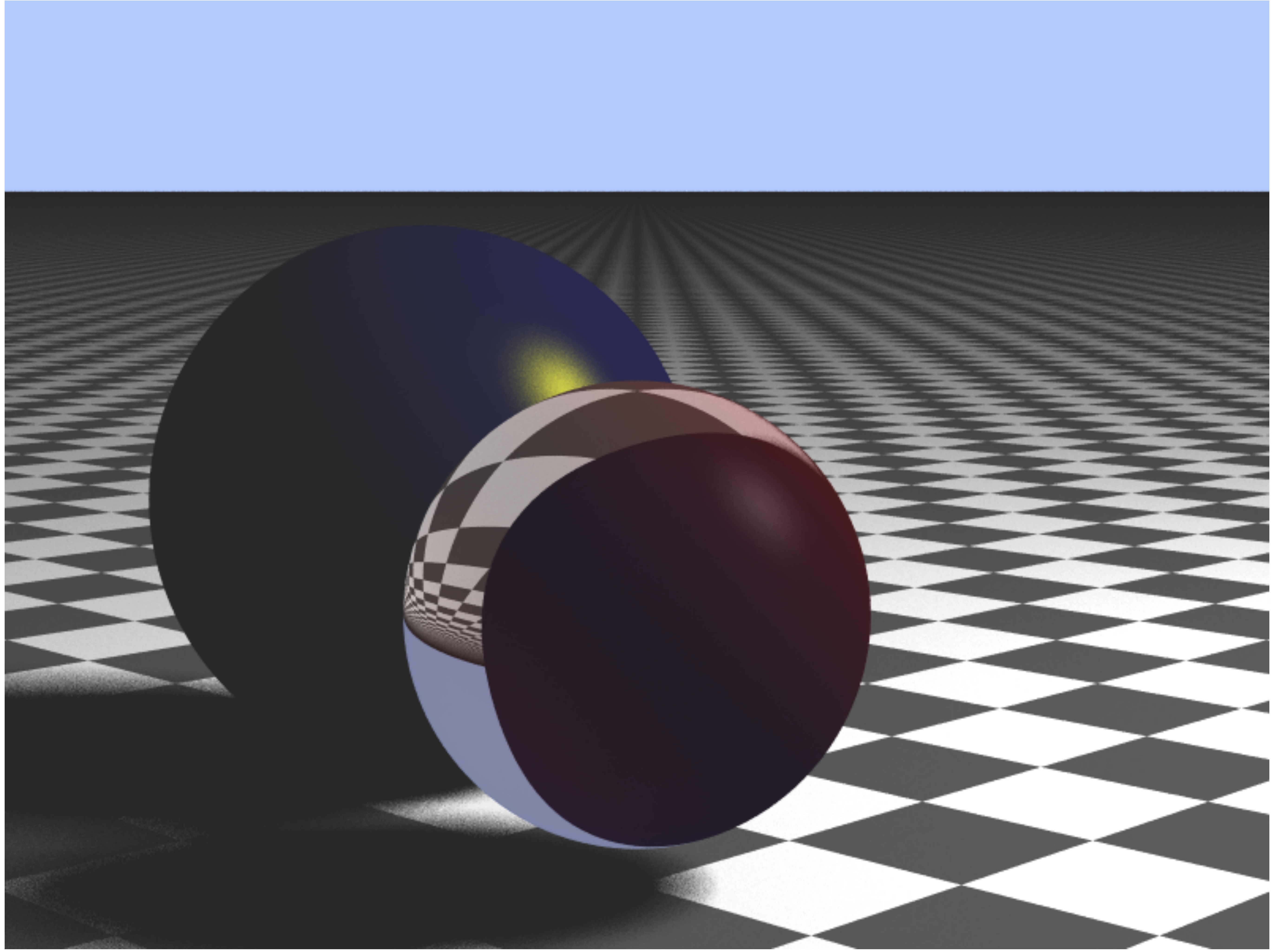
Whitted ray tracing



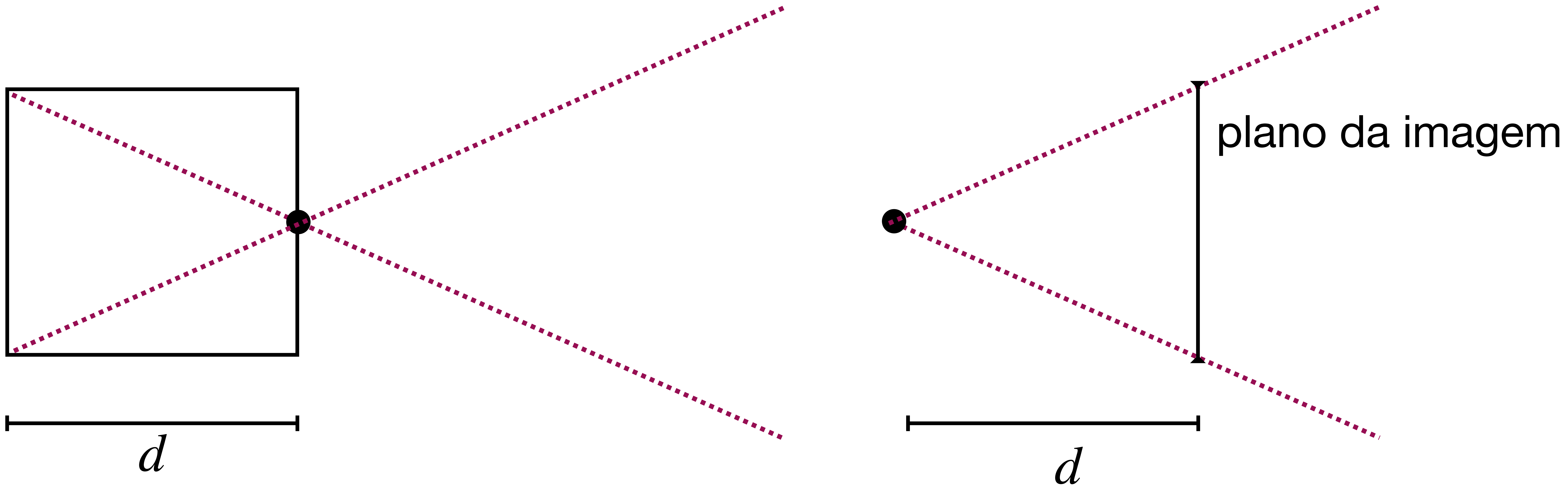
$$L(p, \omega_o) = k_a L_a + k_d \sum_{i=1}^{n} L_i < \omega_i, \vec{n} > + k_s L(p, \omega_r) + k_t L(p, \omega_t)$$

An Improved Illumination Model for Shaded Display, Turner Whitted 1980

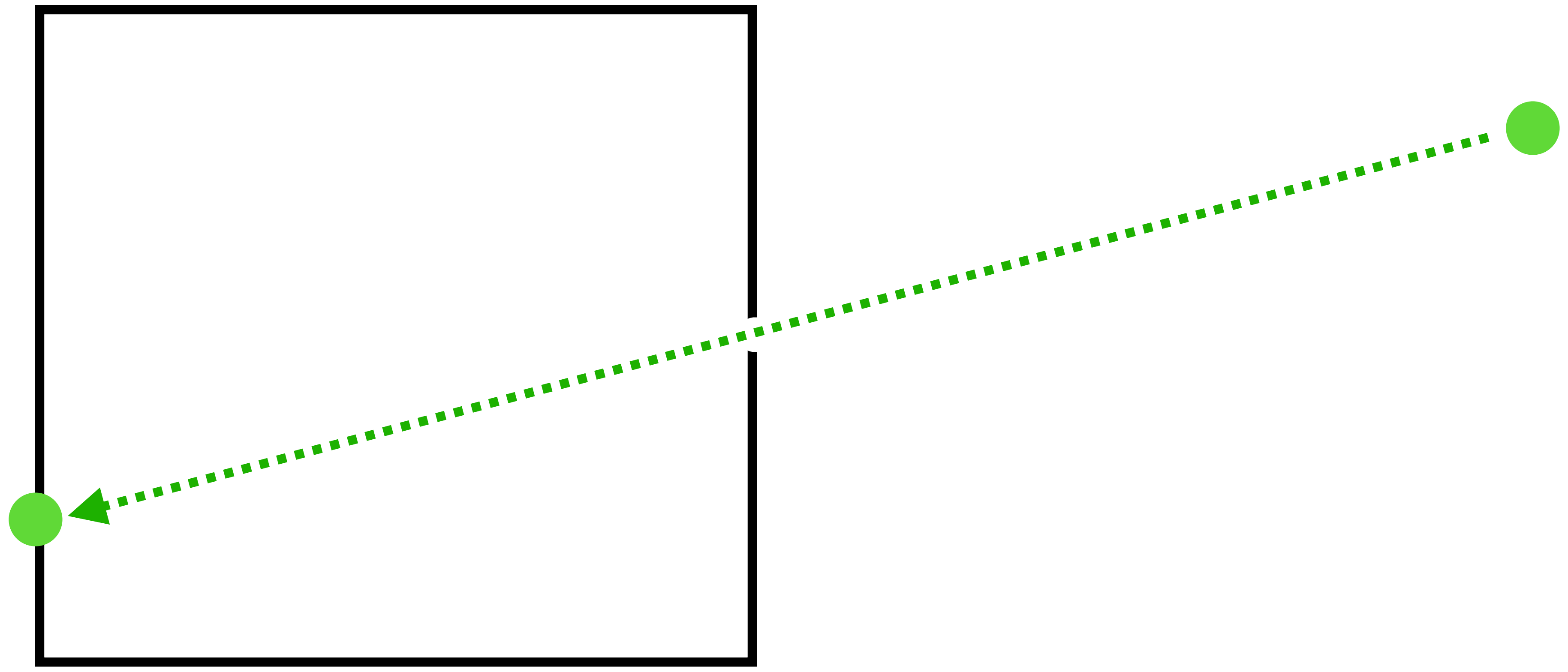
Exemplo



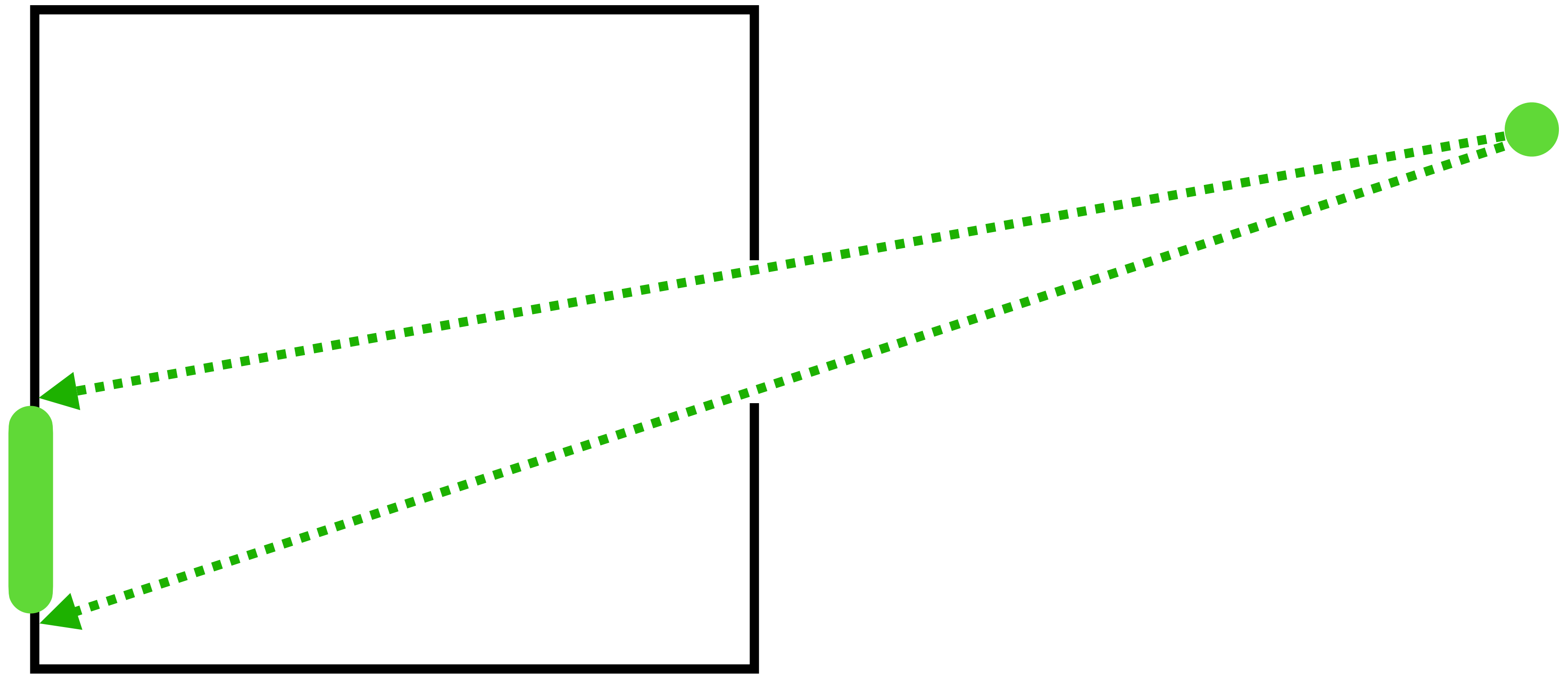
Profundidade de campo



Profundidade de campo

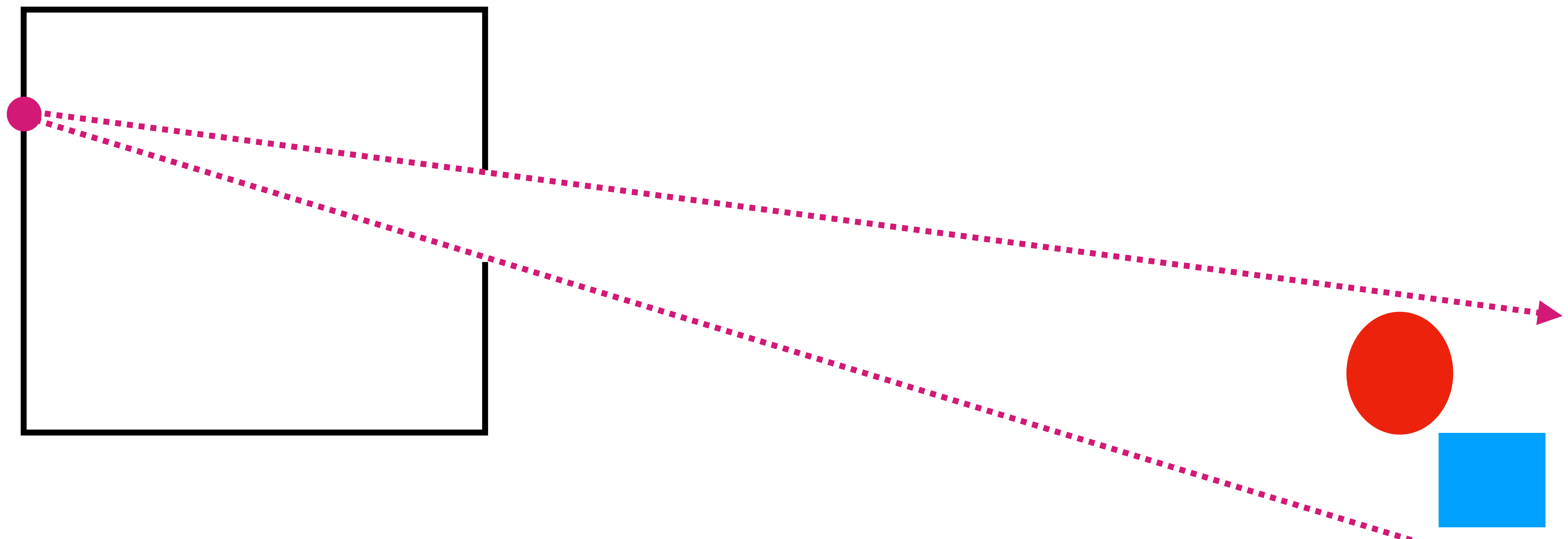


pinhole “ideal"



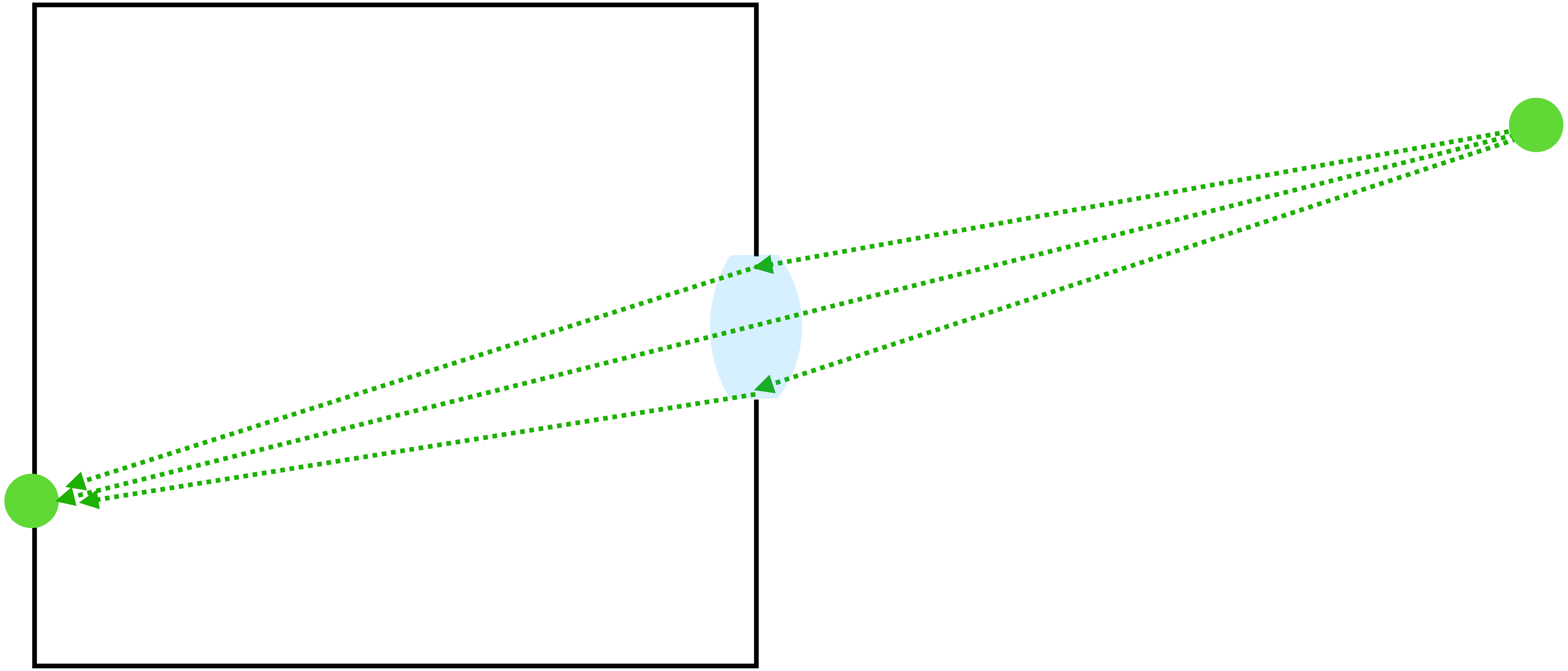
pinhole com abertura > 0

Profundidade de campo

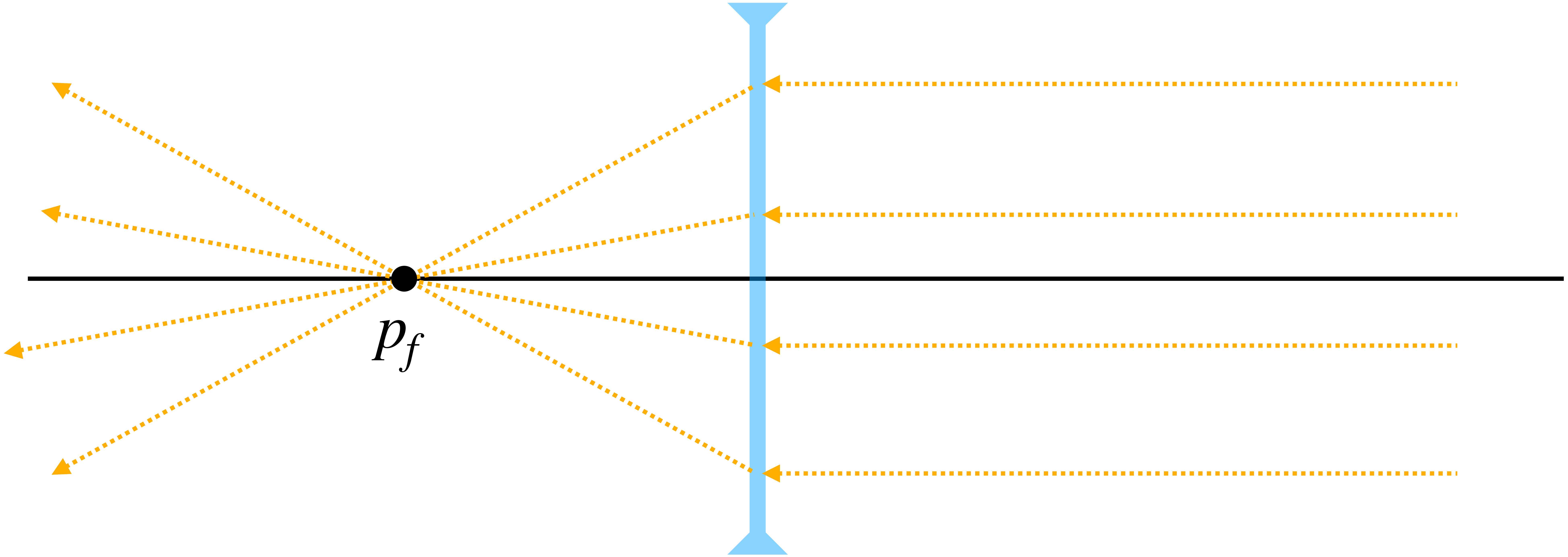


pinhole com abertura > 0

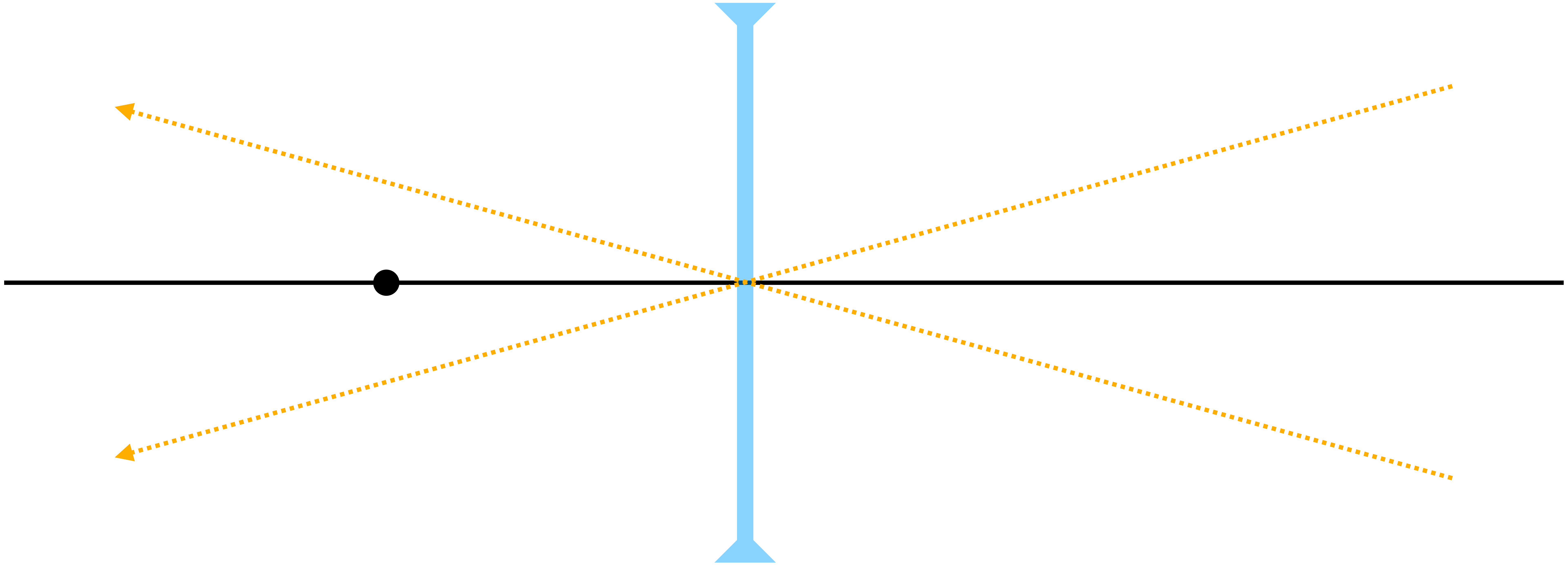
Profundidade de campo



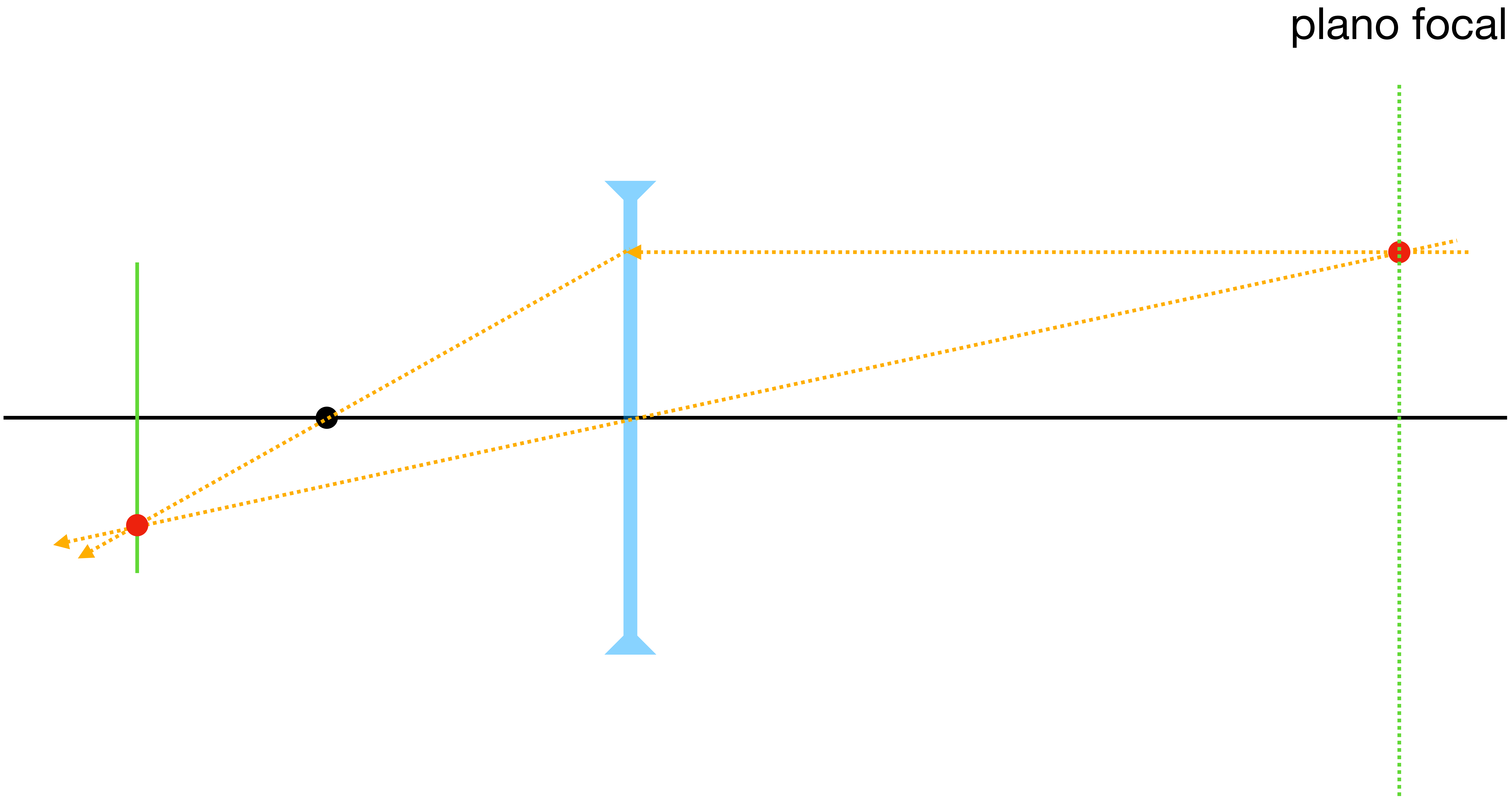
Profundidade de campo



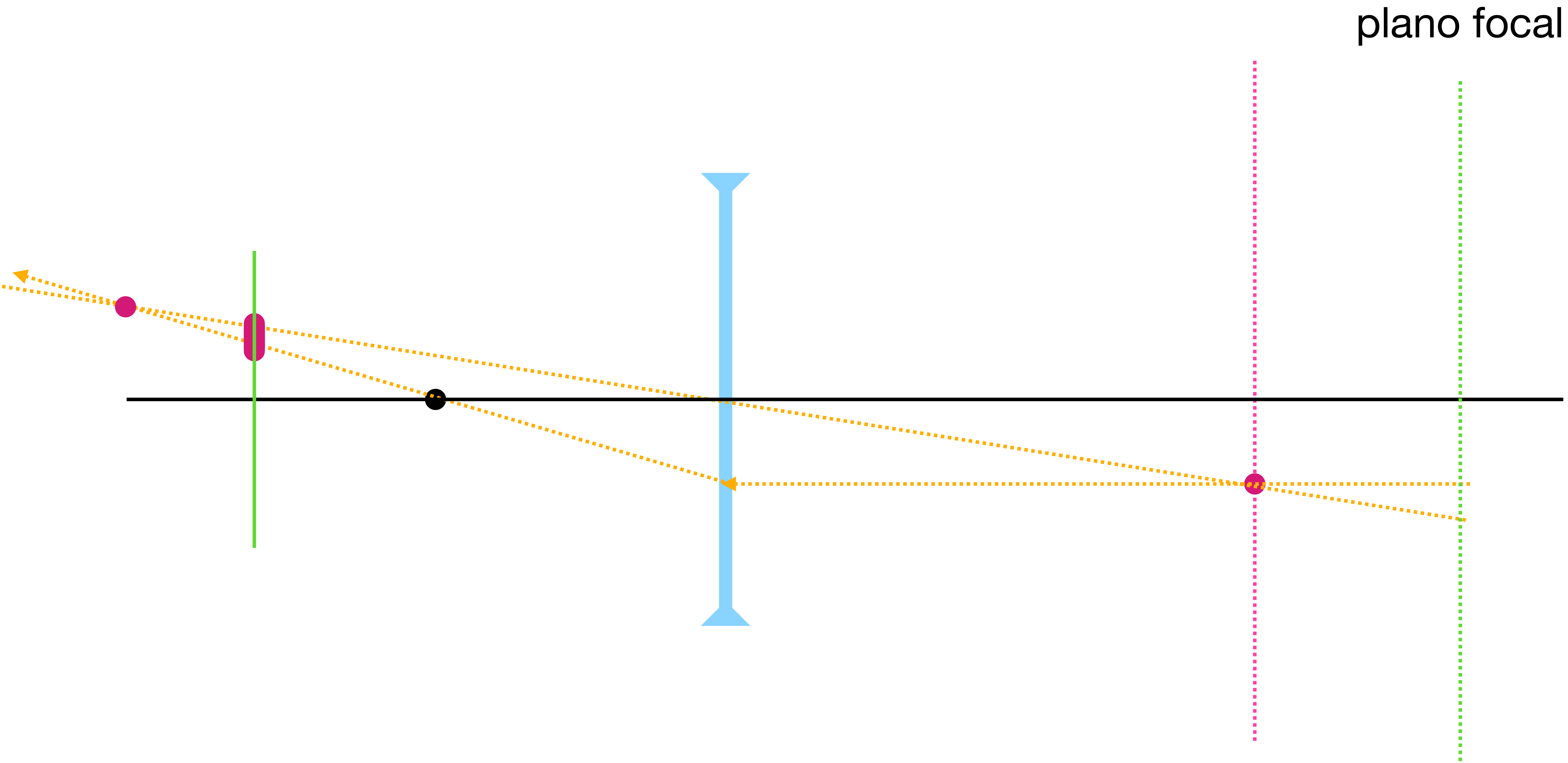
Profundidade de campo



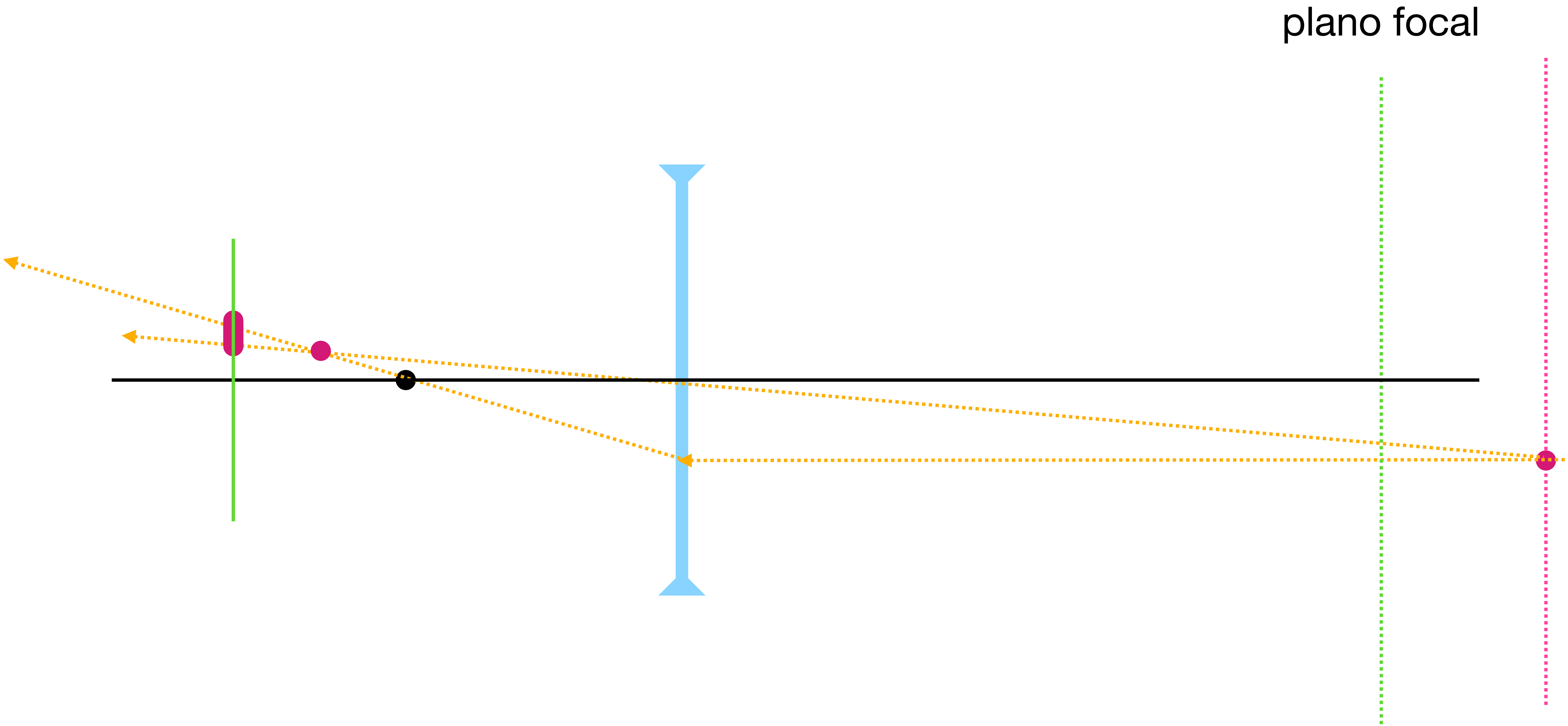
Profundidade de campo



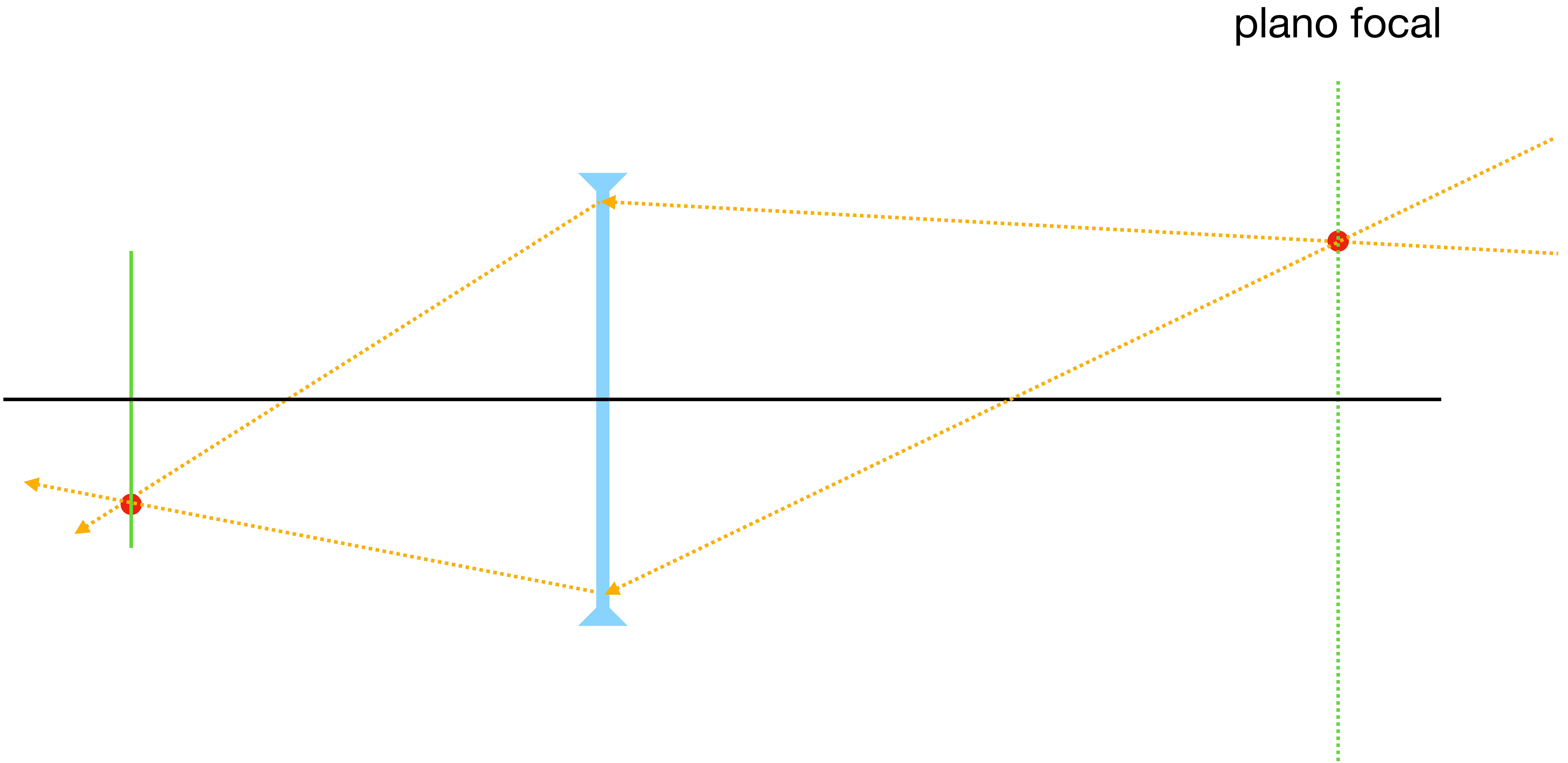
Profundidade de campo



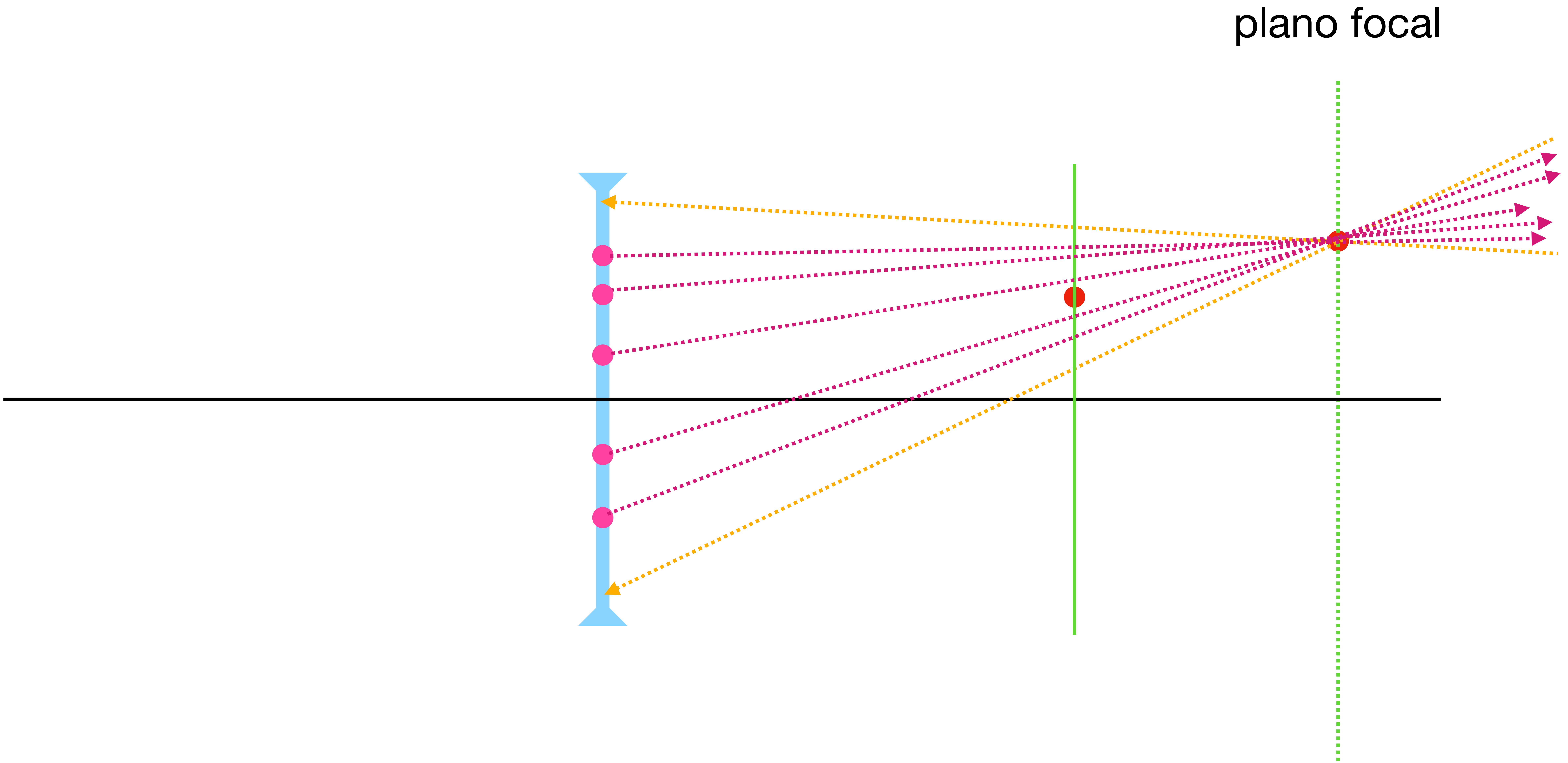
Profundidade de campo



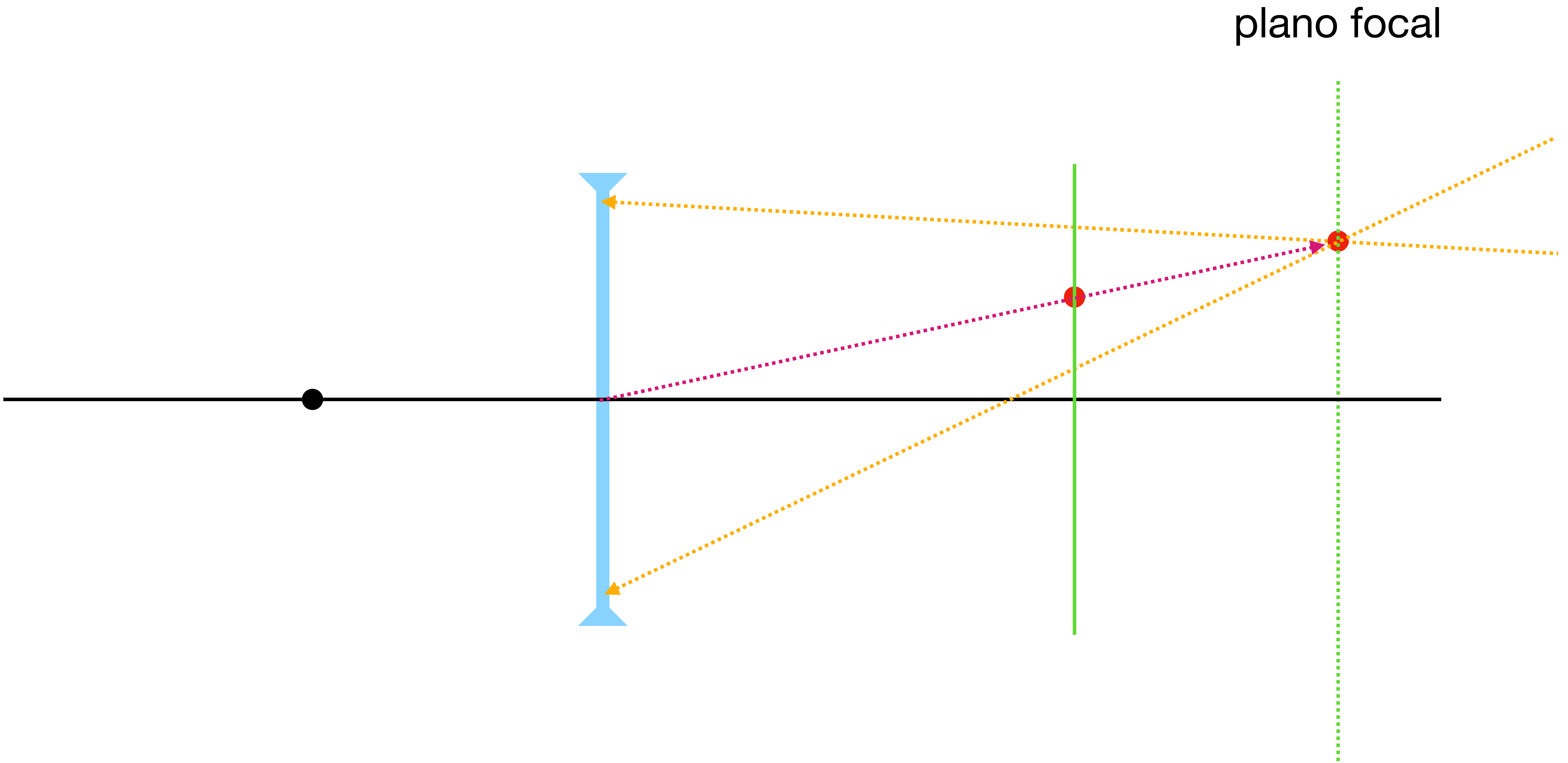
Profundidade de campo



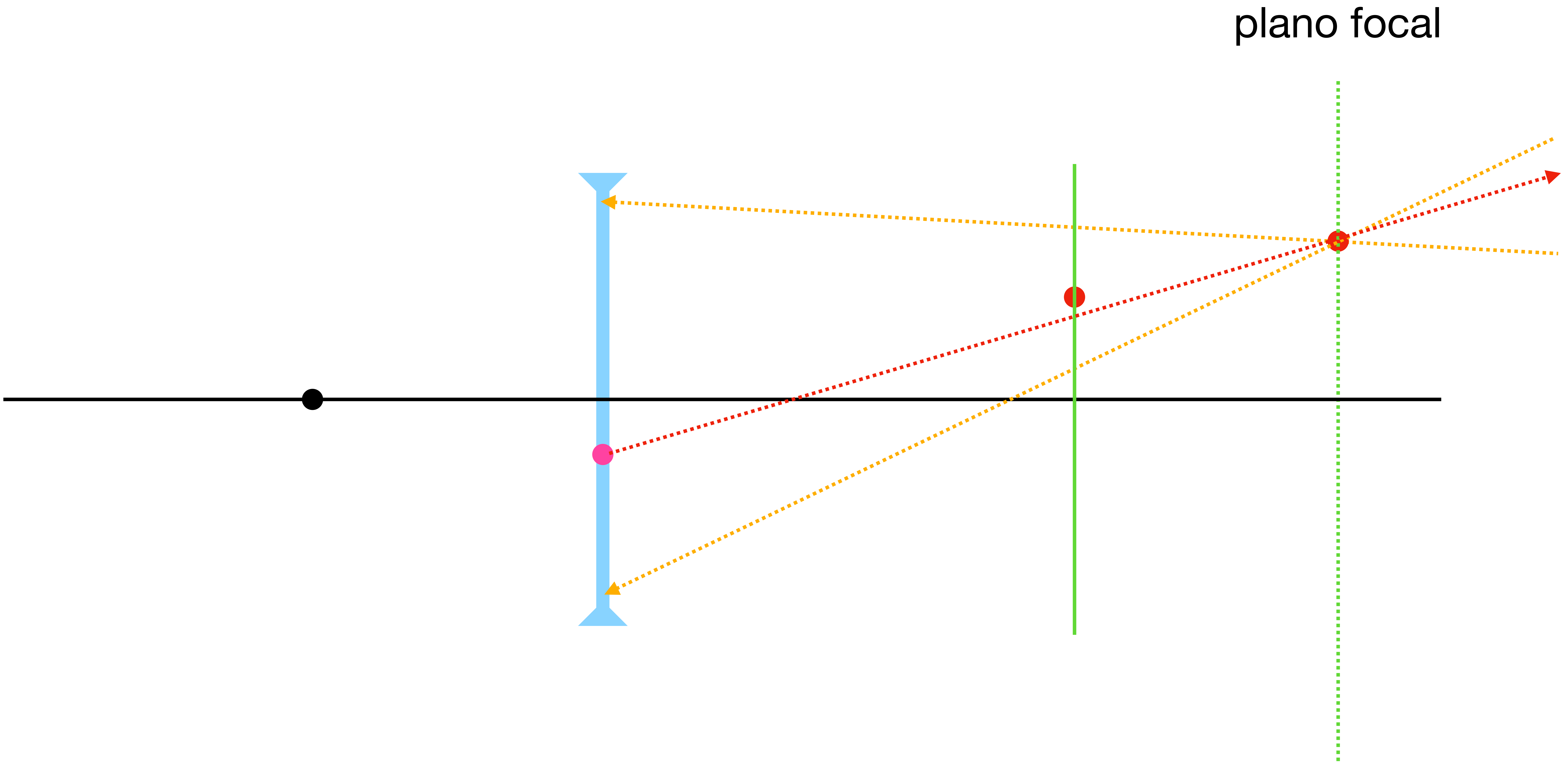
Profundidade de campo



Profundidade de campo



Profundidade de campo



Profundidade de campo

escolha f (fixo para a câmera) e r o raio da lente

$p_s = (u, v, 1)$ ponto no sensor (amostra)

$p_f = (f * u, f * v, f)$ ponto projetado no plano focal

$e_l = (u_e, v_e, 0)$ ponto amostrado na lente $(u_e^2 + v_e^2 < r^2)$

toma $r(t) = p + tv$ onde

$v = [p_p]_W - [e_l]_W$

$p = [e_l]_W$

repita para várias amostras