

CS6630 Realistic Image Synthesis

Photon Mapping Subsurface scattering

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Photon Mapping overview

Origins in radiosity

- 2-pass methods
- “final gather”

Basic photon mapping

- Photon tracing
- density estimation
- multiple maps

Methods that build on PM

- progressive PM
- virtual point lights
- volume photon map
- beams, etc. in volumes
- vertex connection

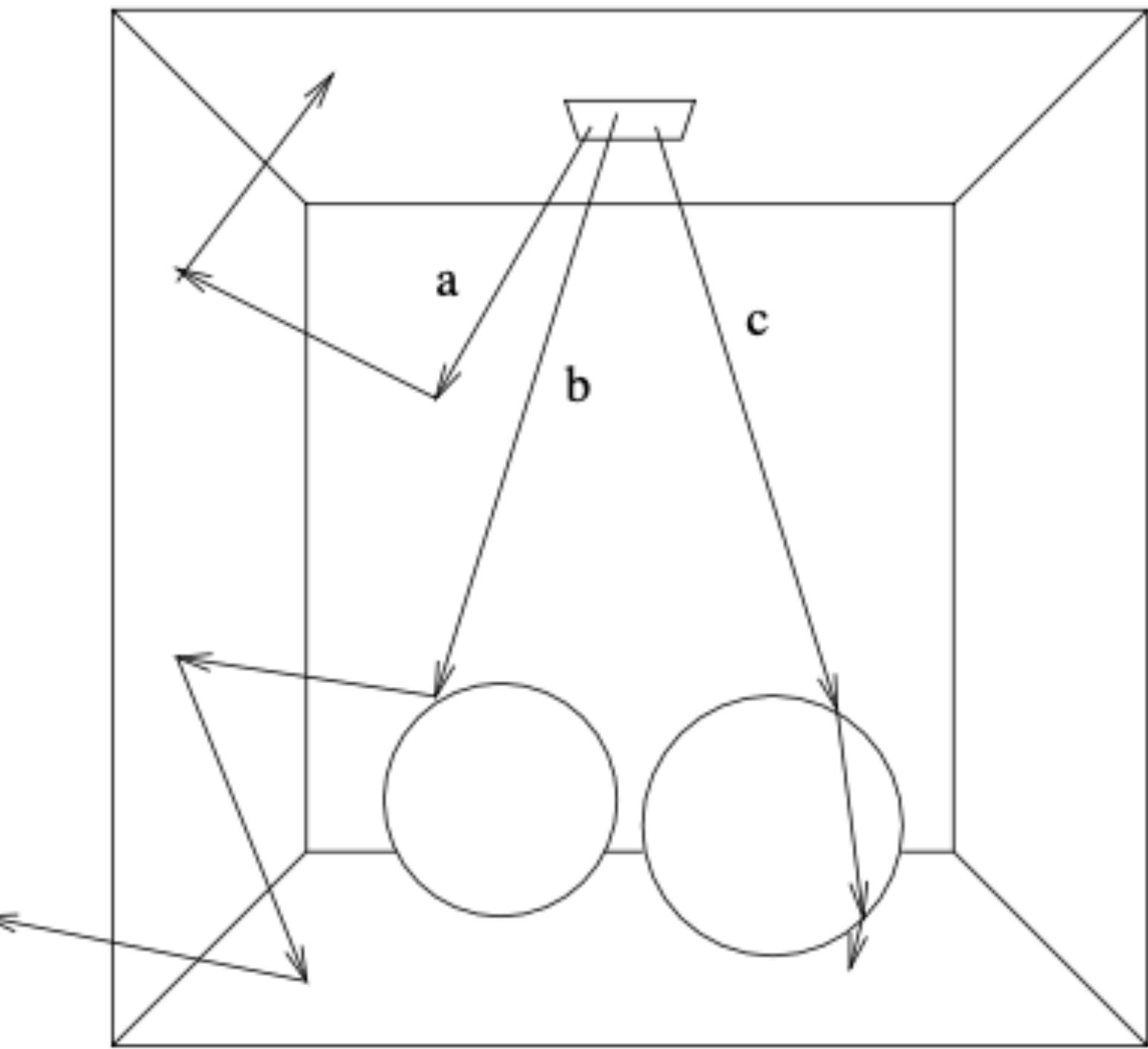
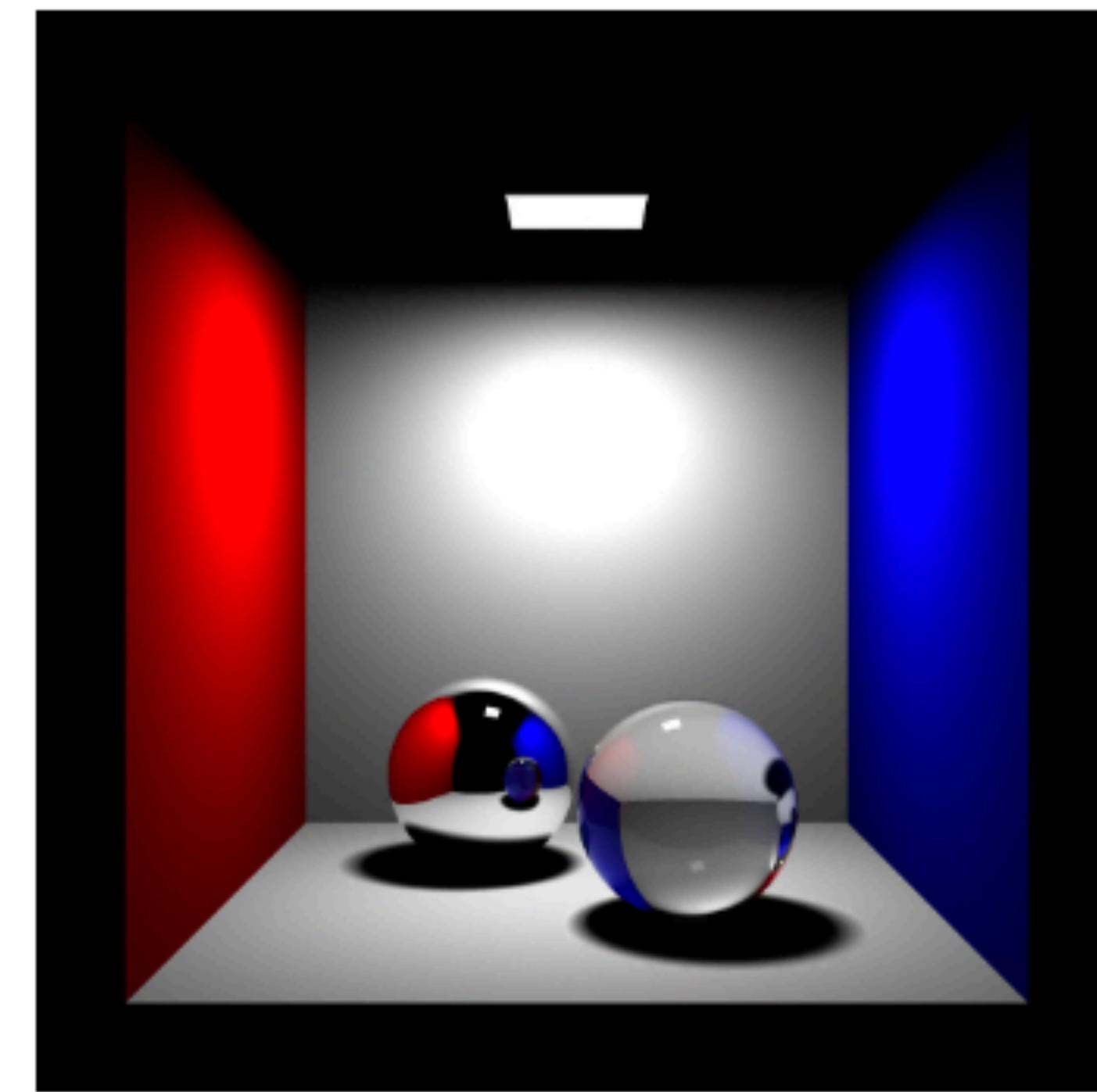
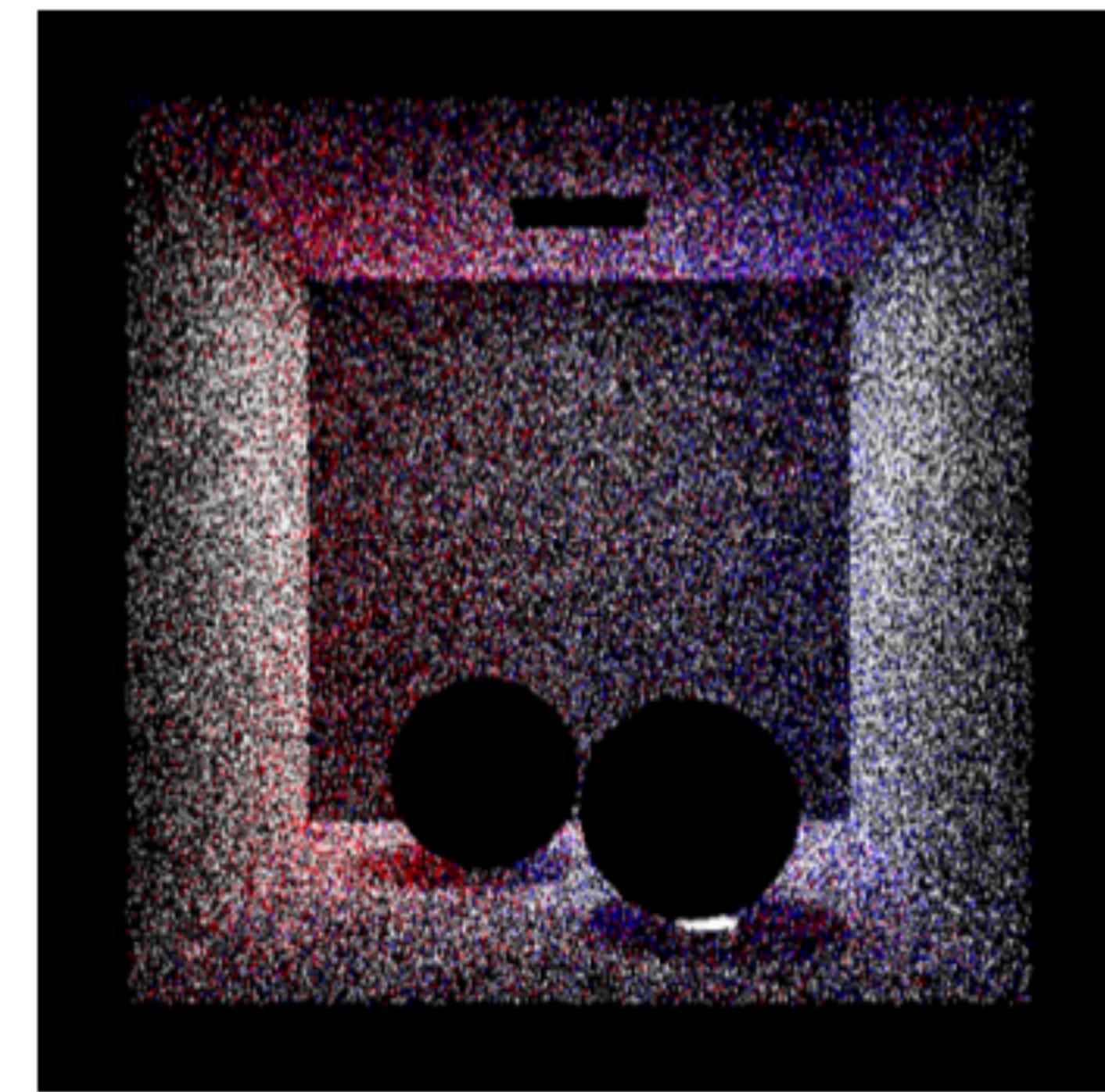


Figure 3: Photon paths in a scene (a “Cornell box” with a chrome sphere on left and a glass sphere on right): (a) two diffuse reflections followed by absorption, (b) a specular reflection followed by two diffuse reflections, (c) two specular transmissions followed by absorption.



(a)



(b)

Figure 4: “Cornell box” with glass and chrome spheres: (a) ray traced image (direct illumination and specular reflection and transmission), (b) the photons in the corresponding photon map.

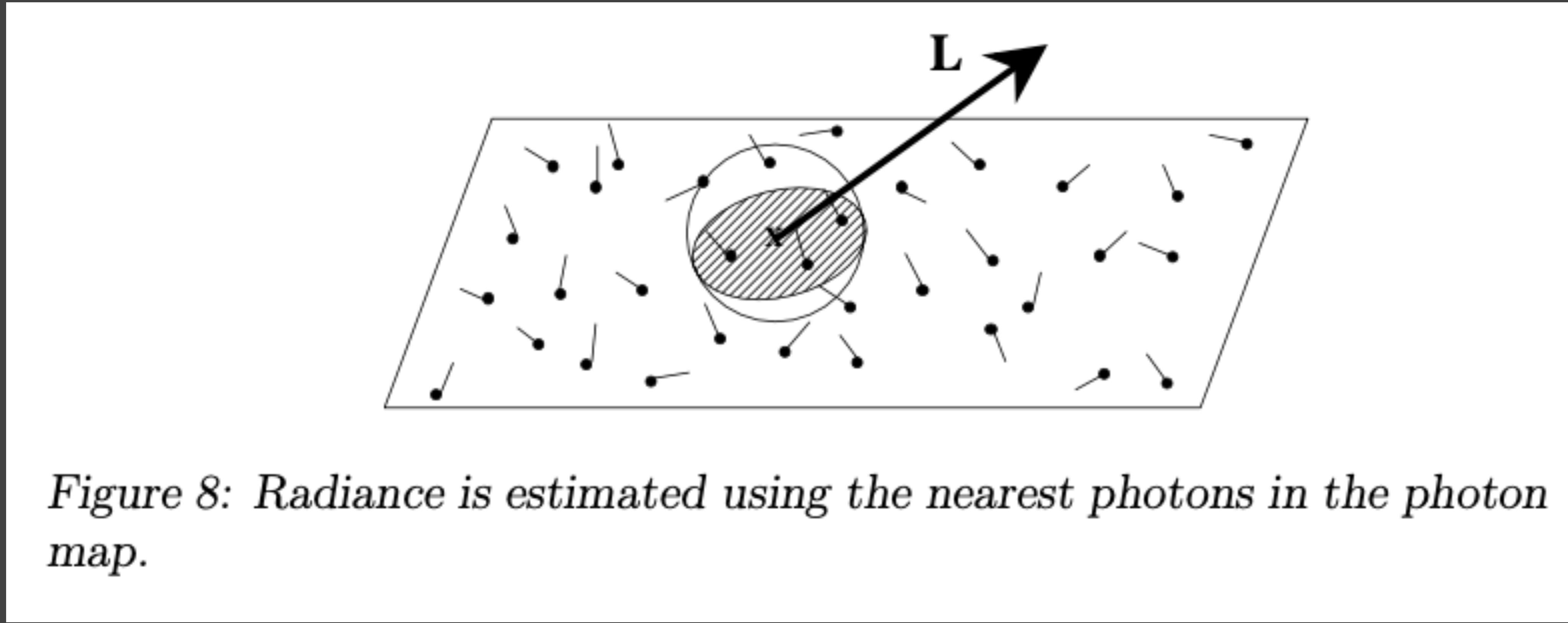
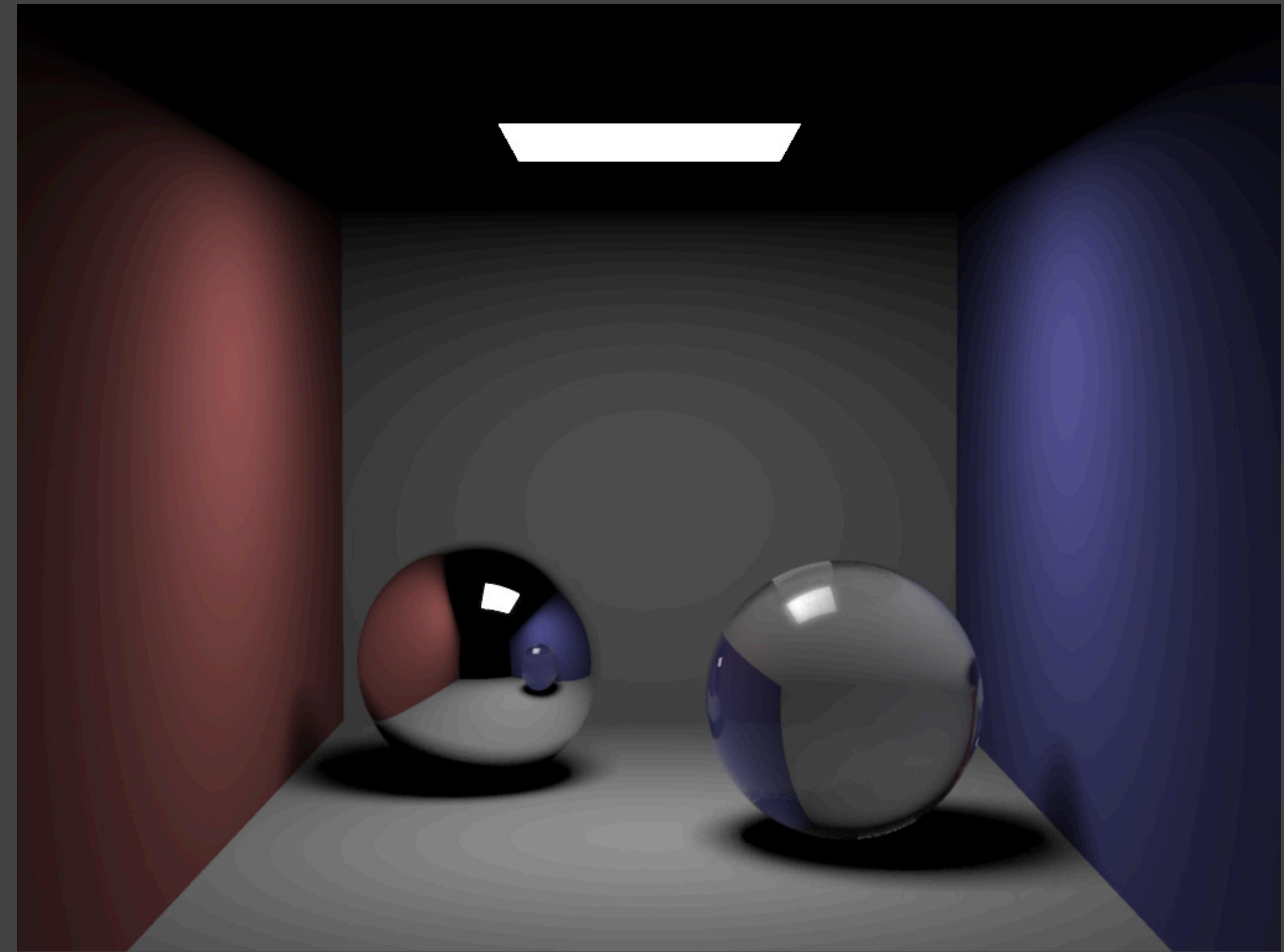
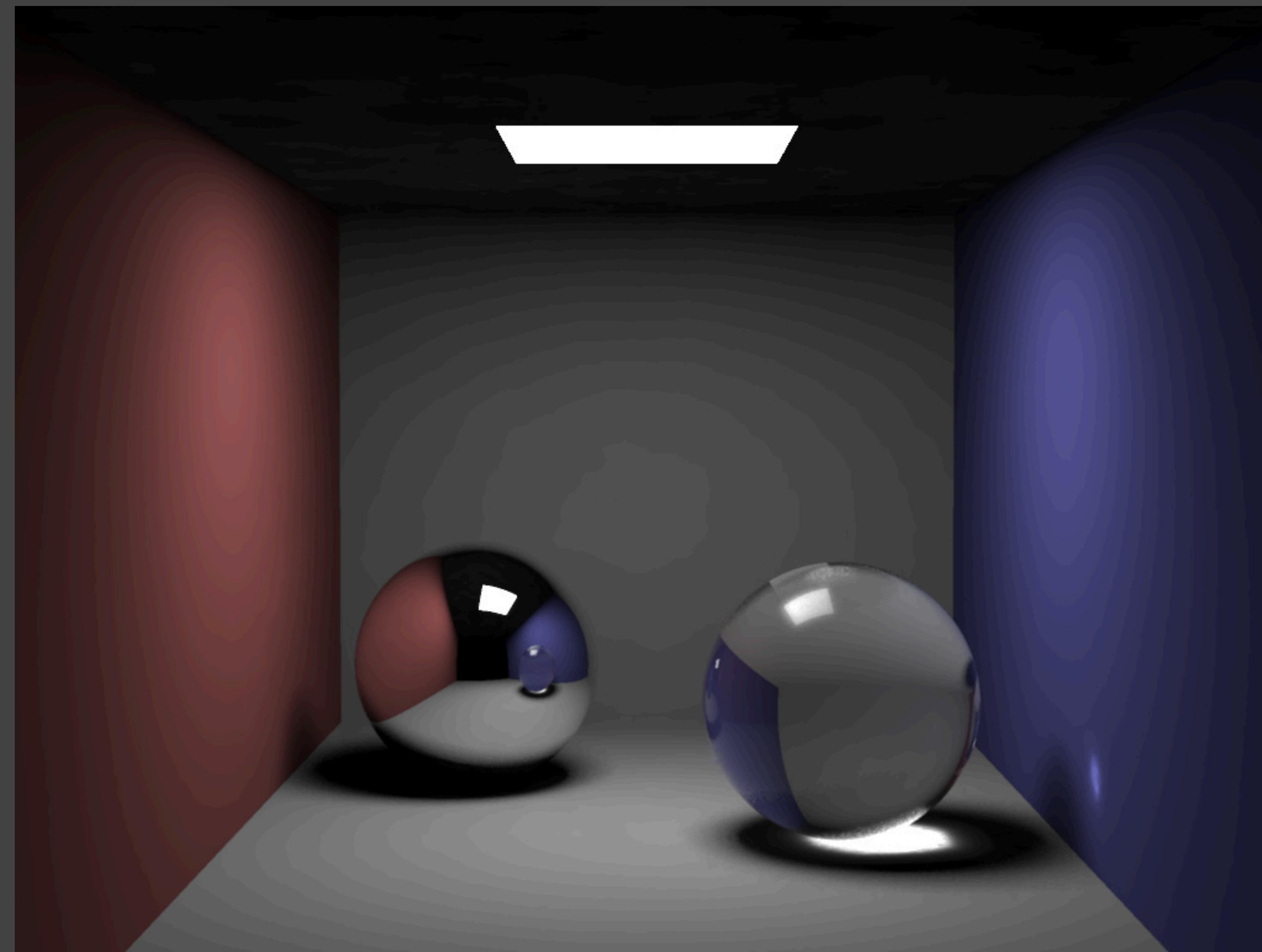


Figure 8: Radiance is estimated using the nearest photons in the photon map.

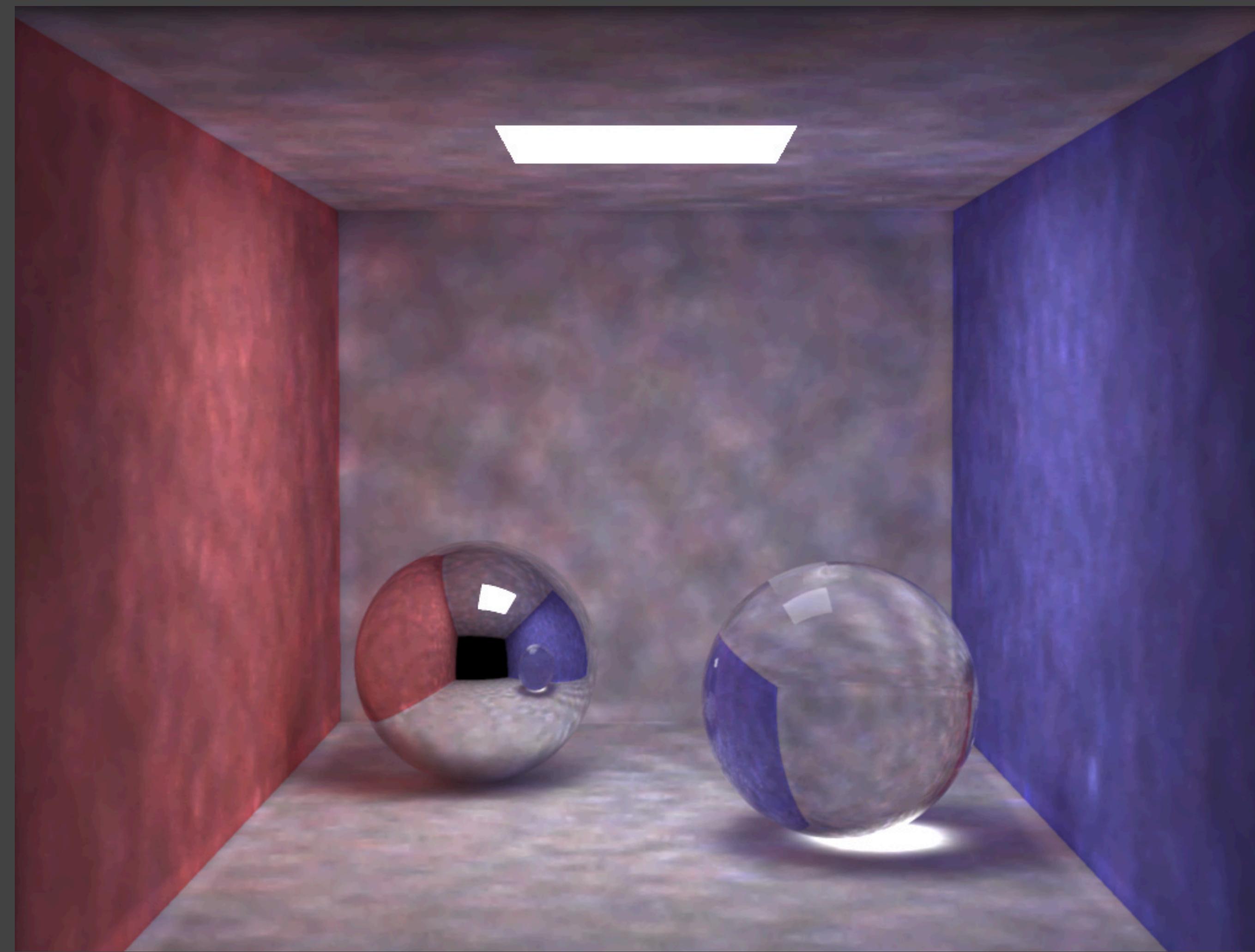
Henrik Wann Jensen, Photon Mapping SIGGRAPH course 2008



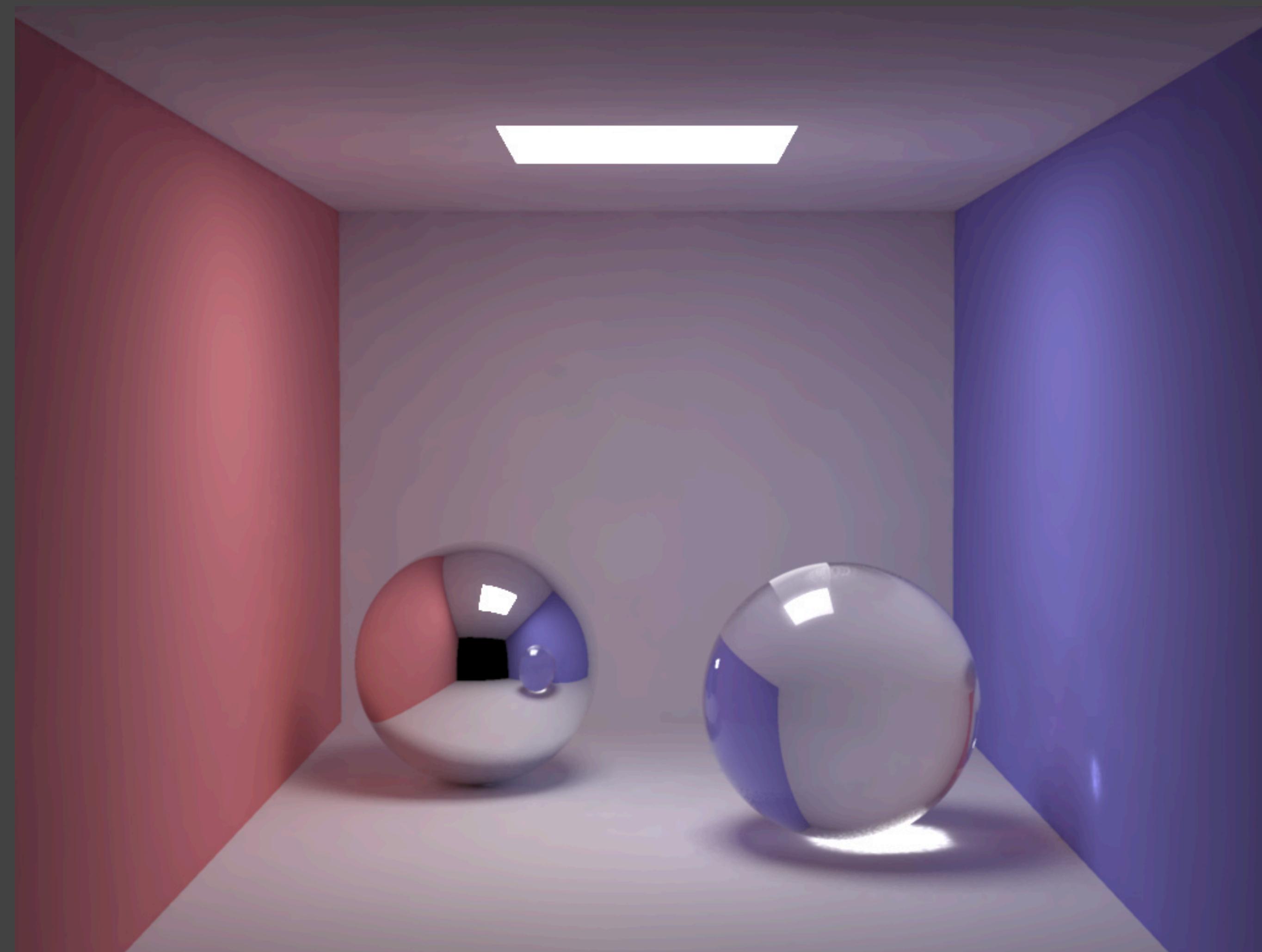
direct only



direct plus caustics from map



indirect illumination via direct photon map lookup



indirect illumination using gather

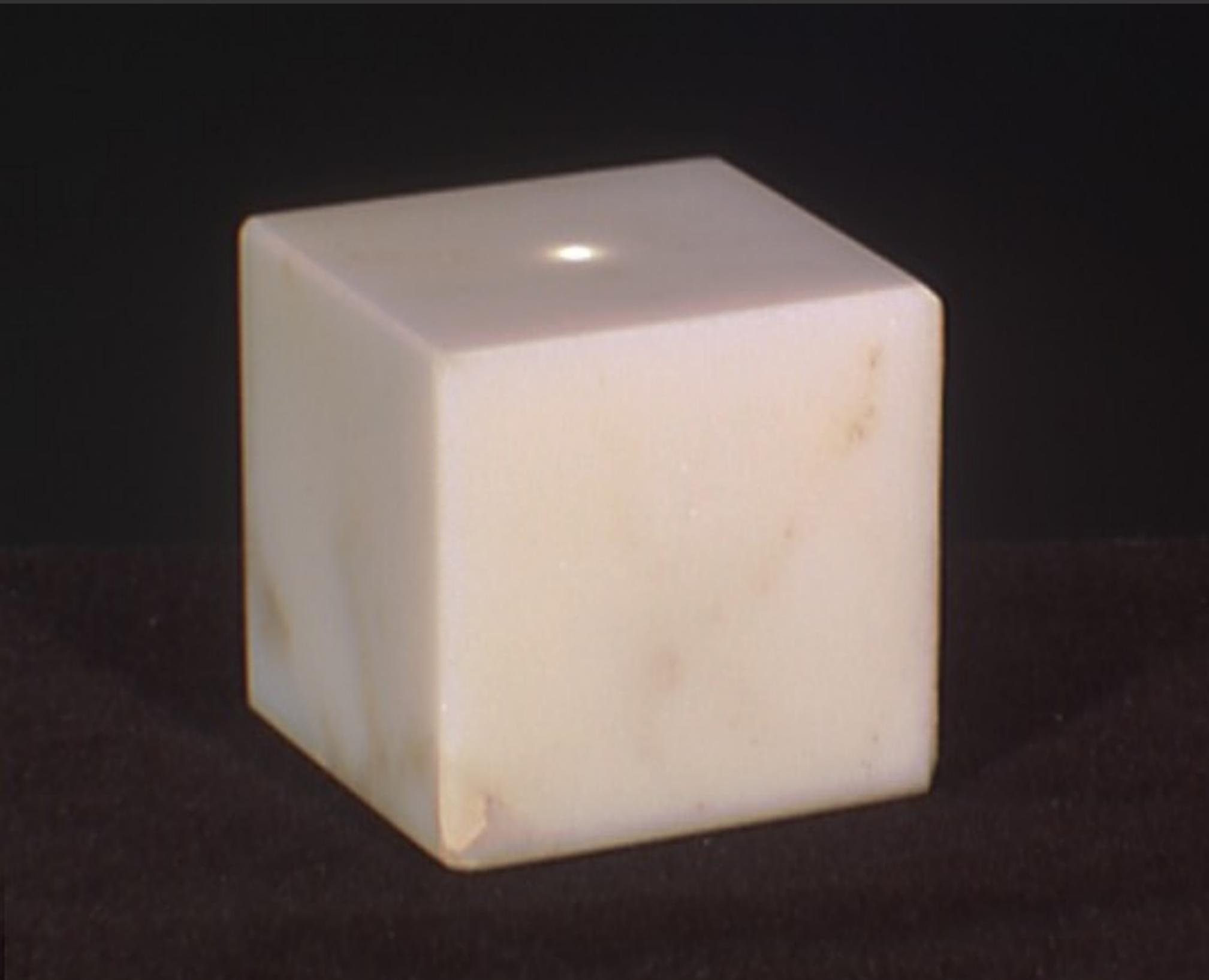
subsurface scattering

Subsurface scattering in statuary marble



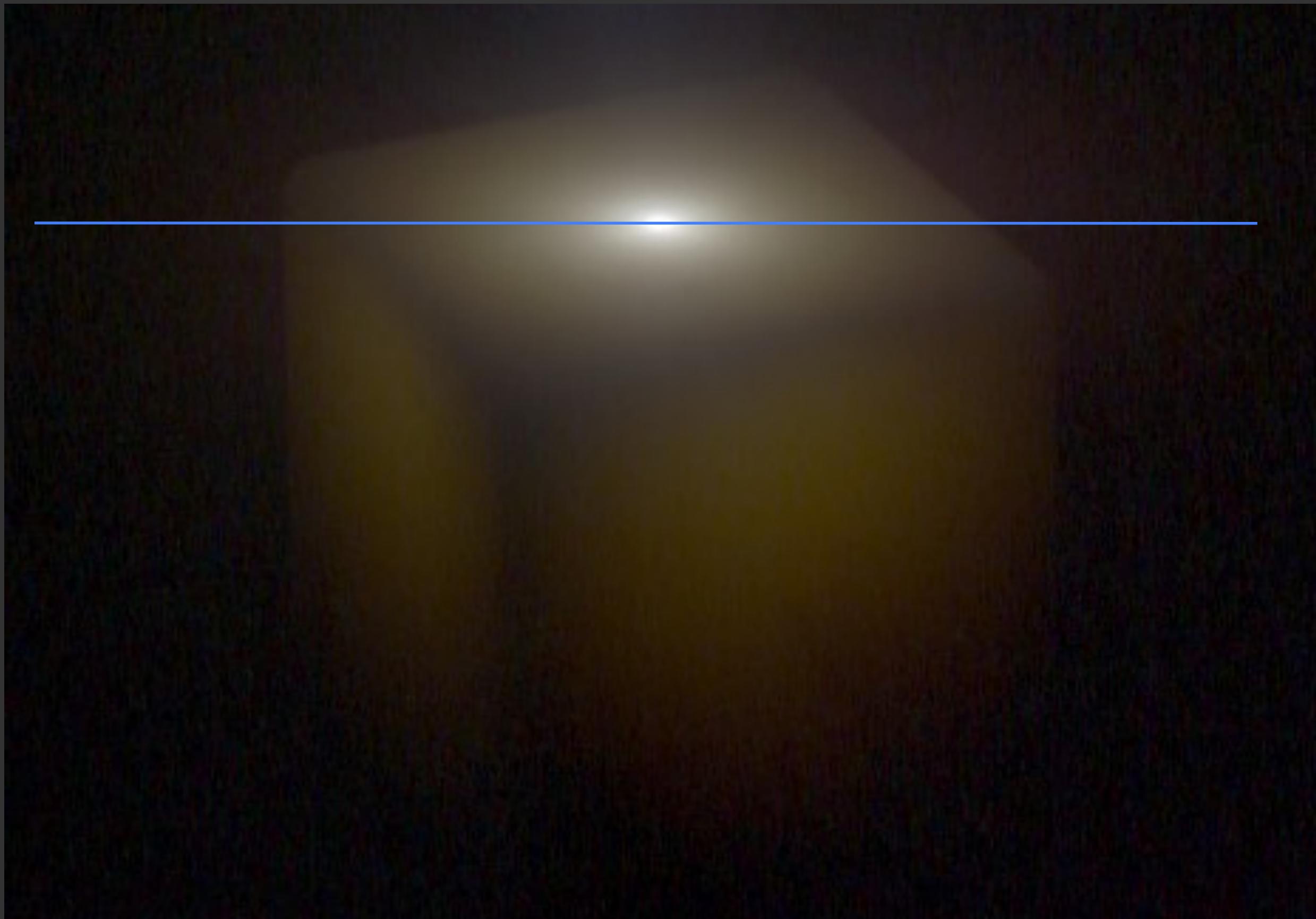
Marc Levoy

Marble sample



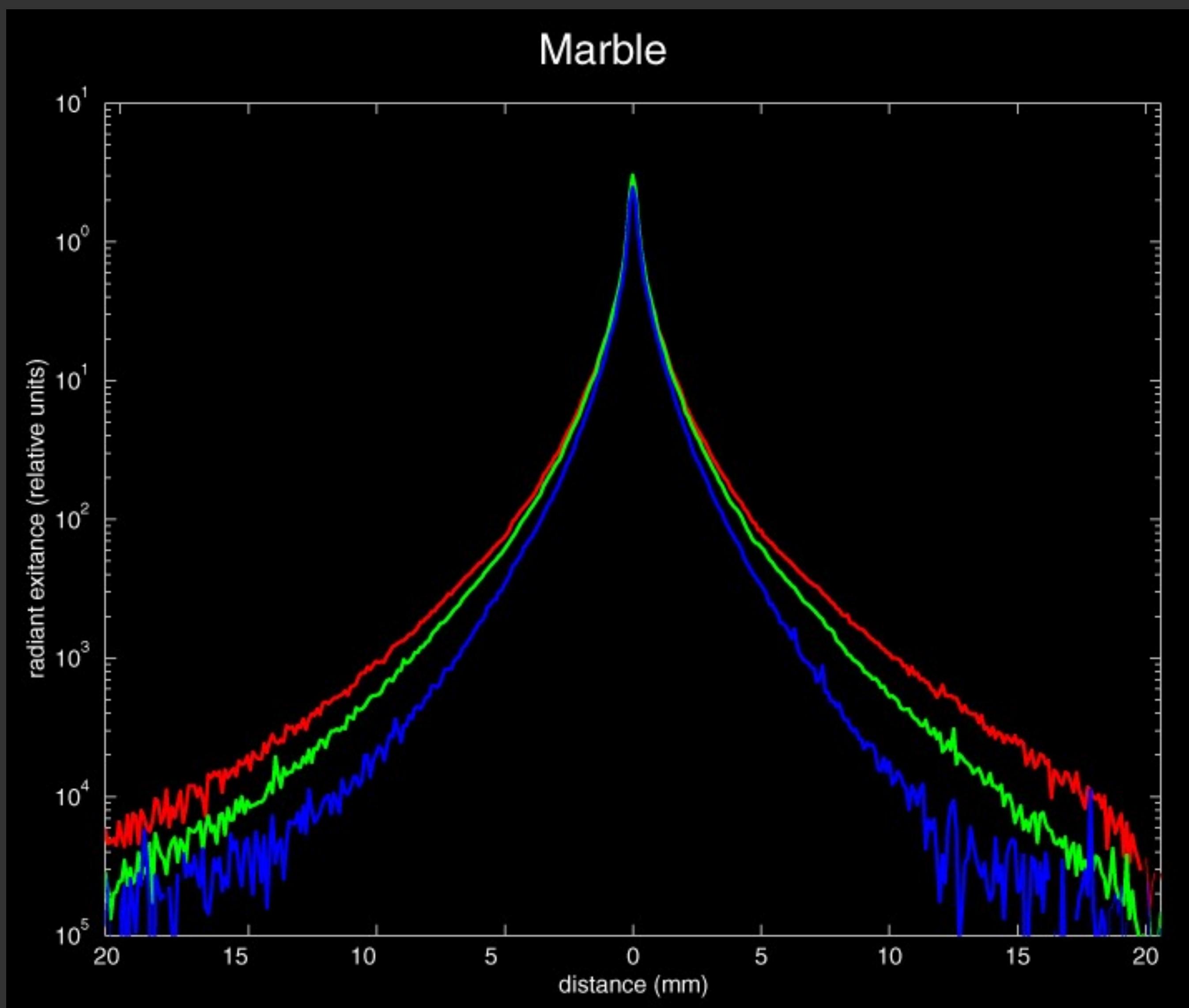
40mm cube of statuary marble

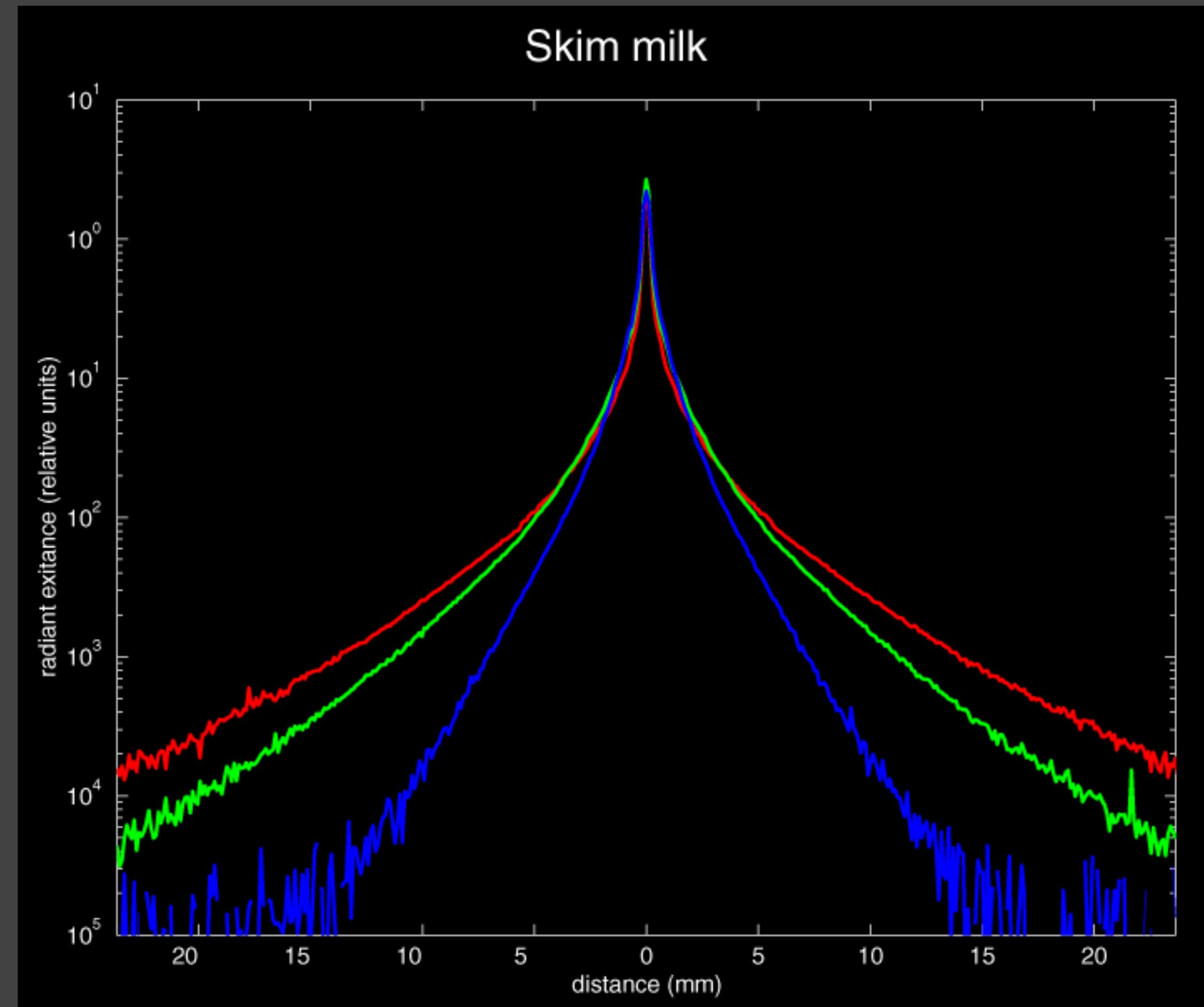
HDR photograph

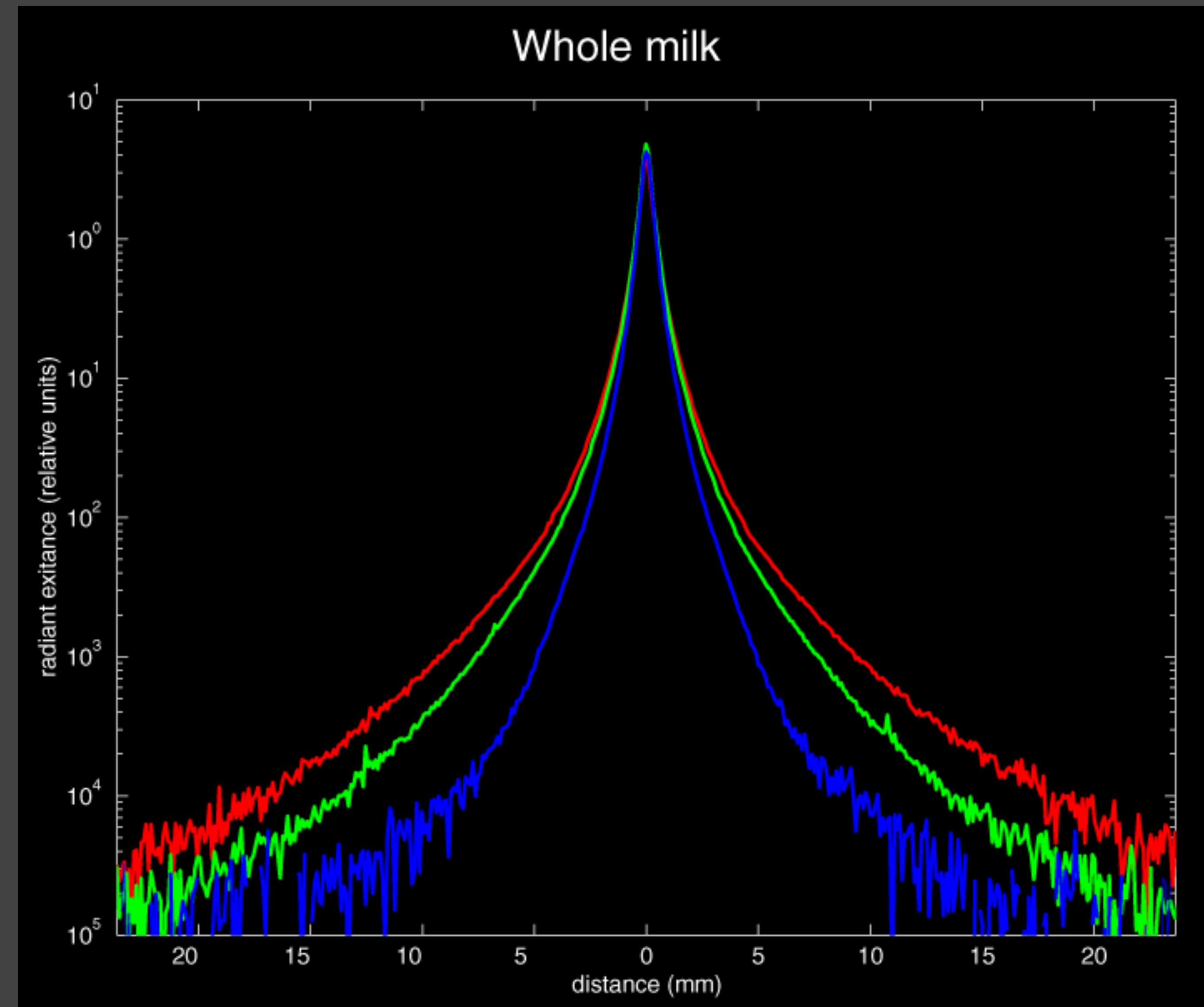


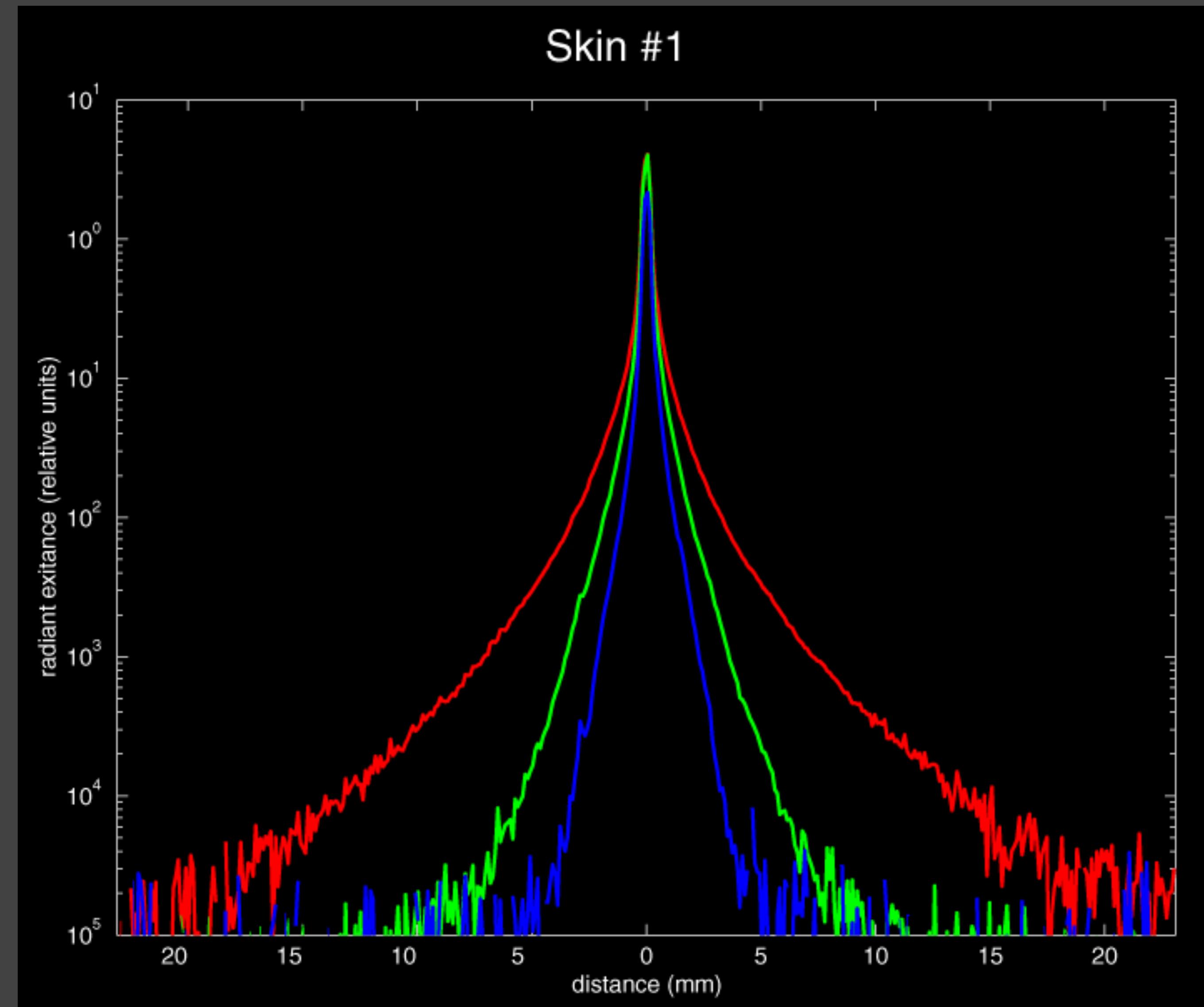
(log scaled image)

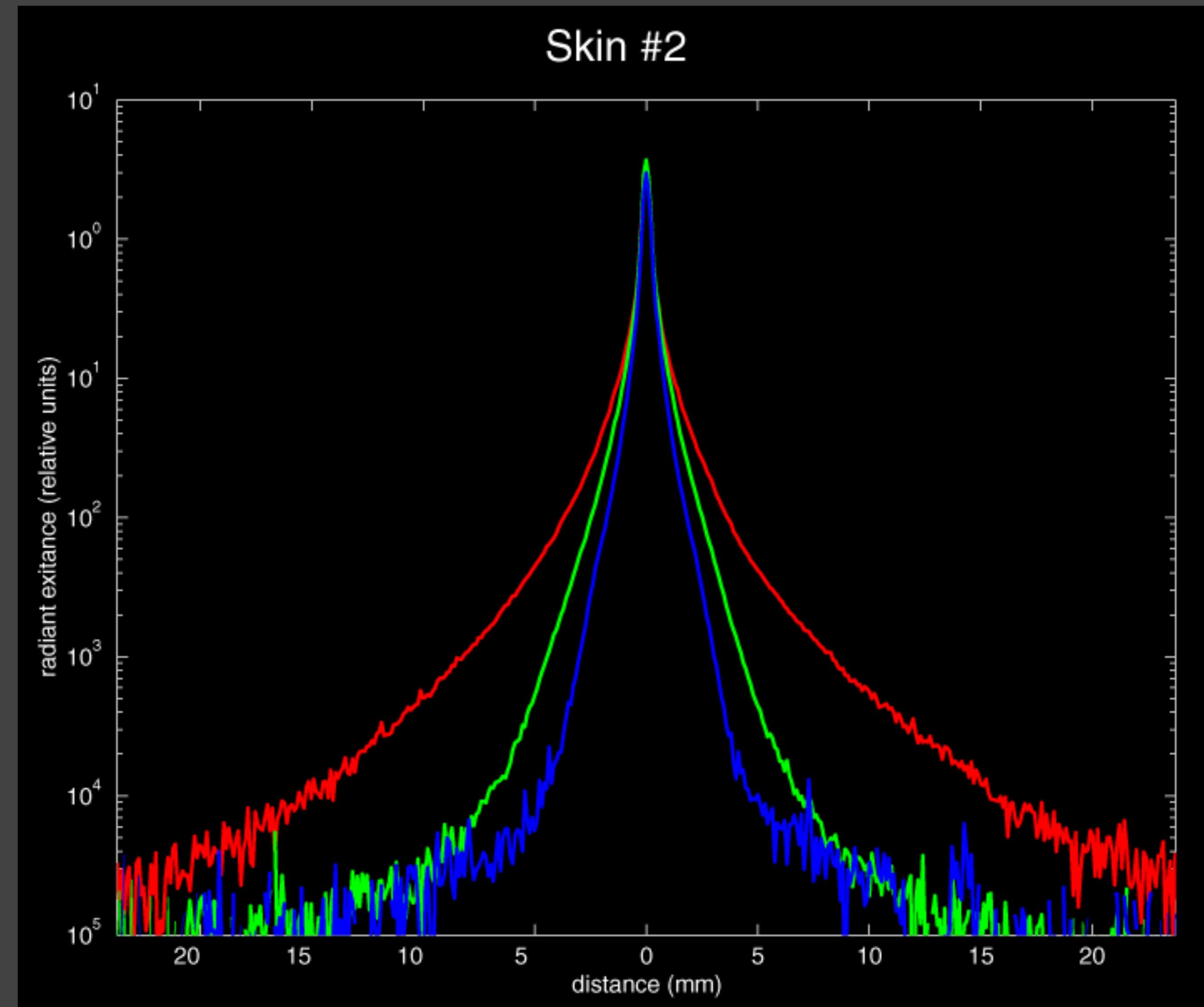
Marble



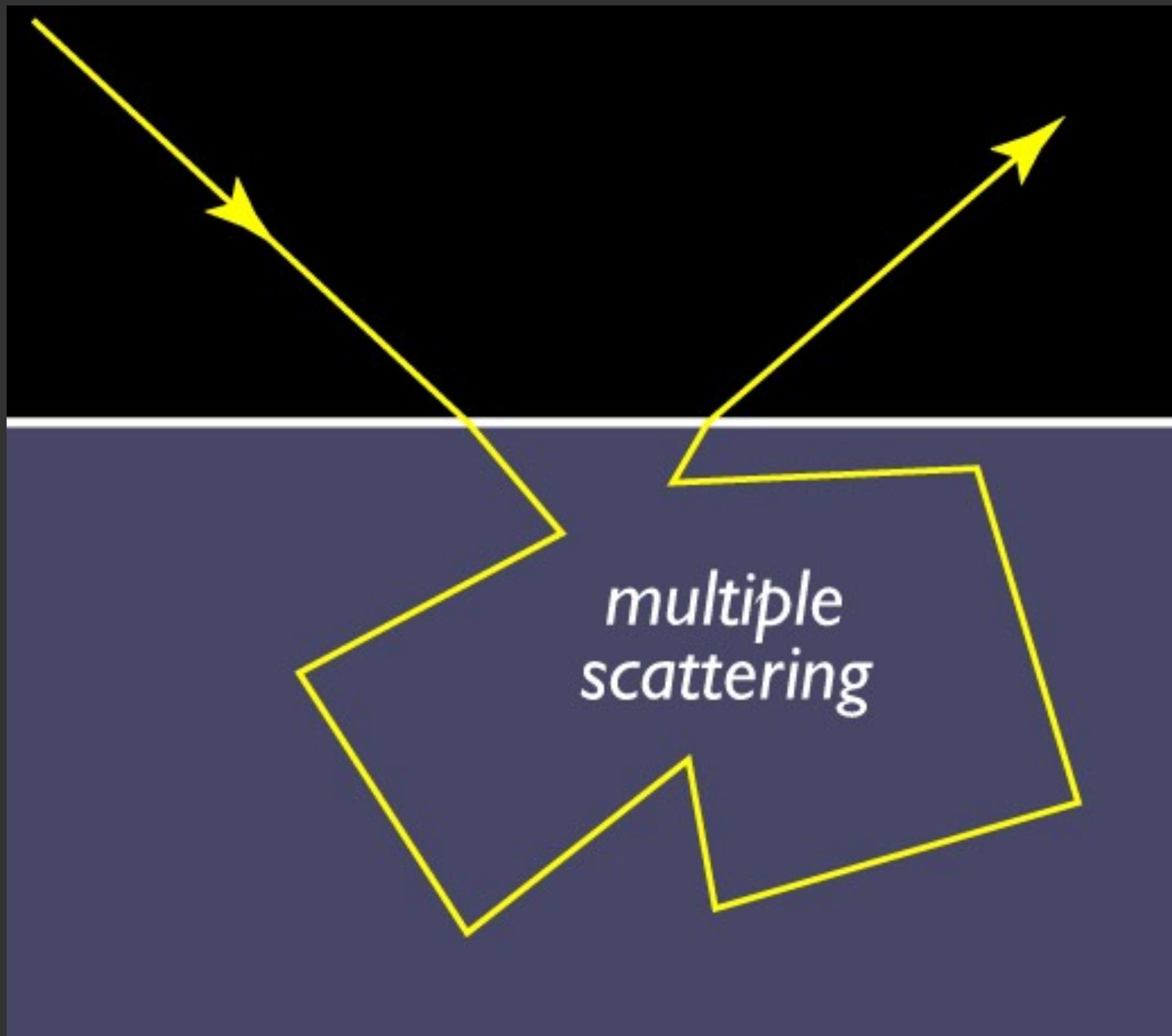








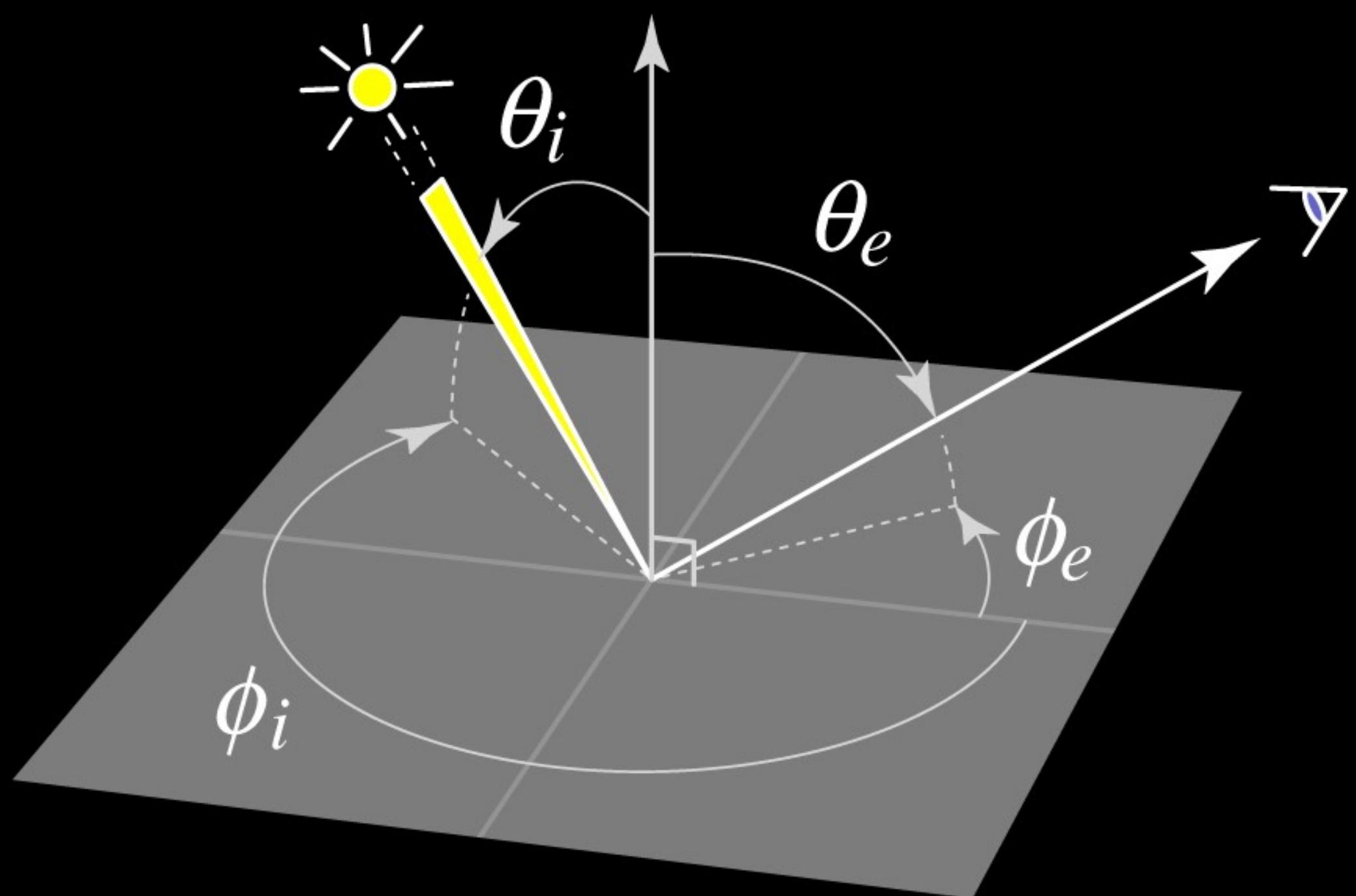
Subsurface volume scattering



Light diffusion

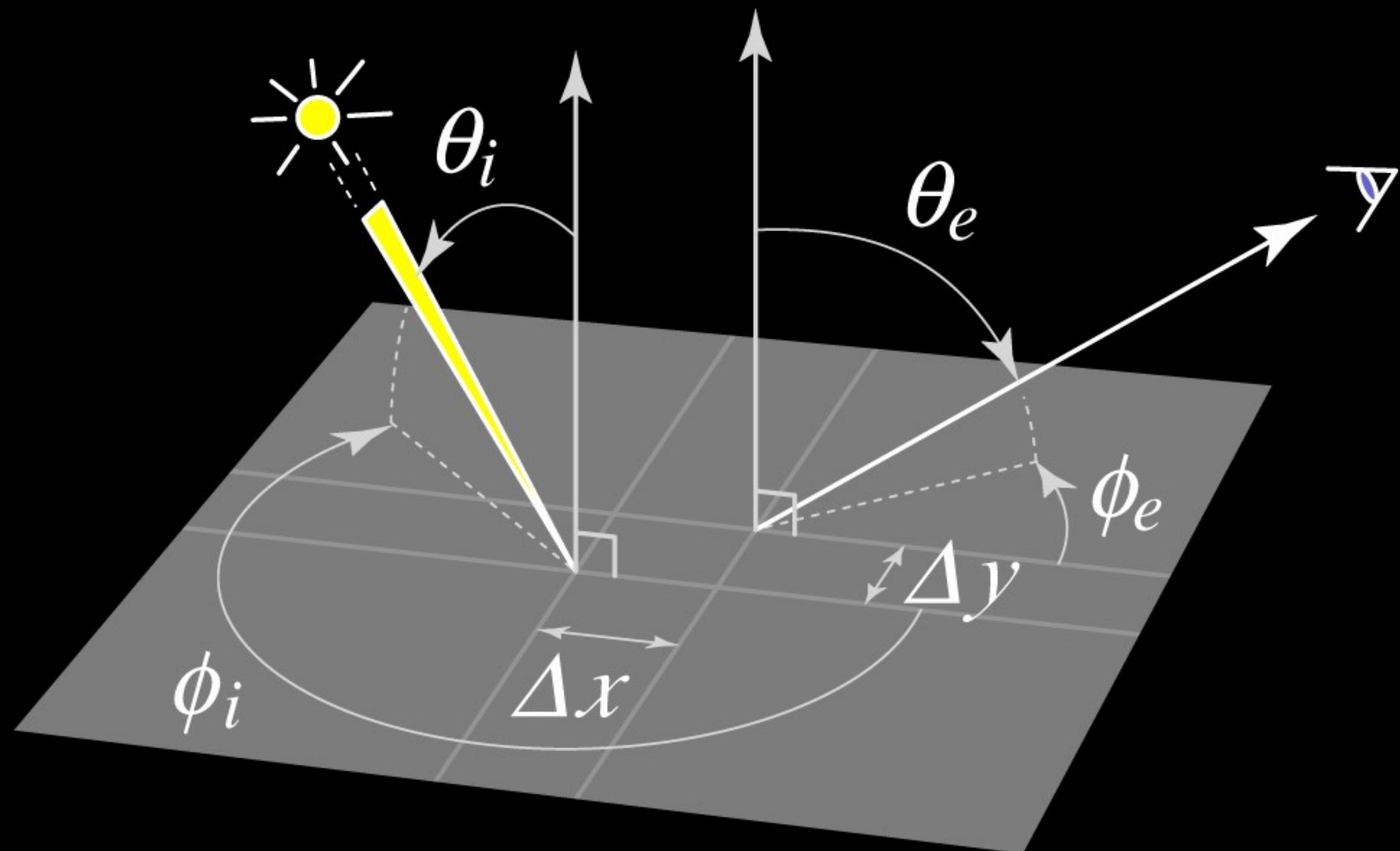


BRDF



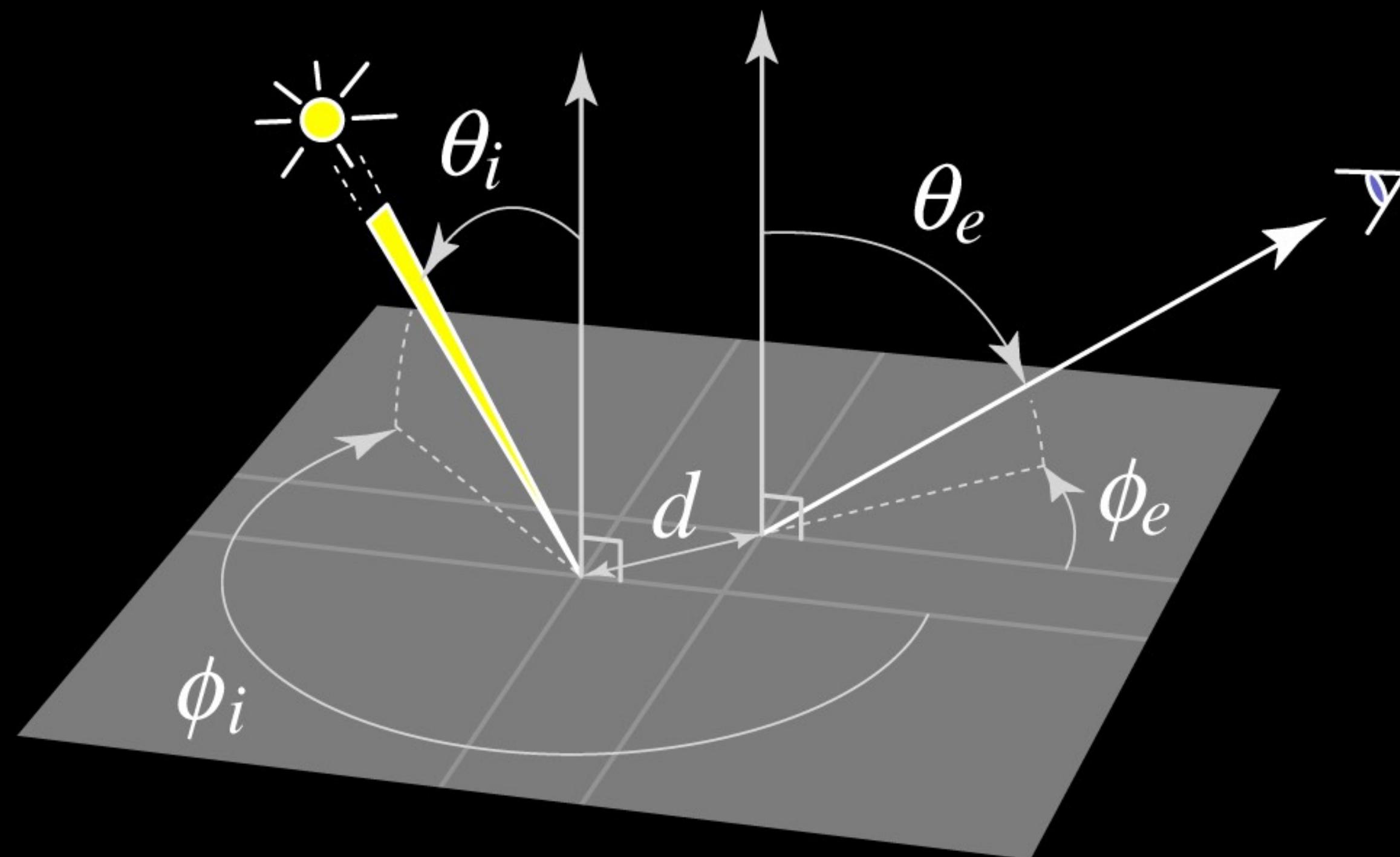
$$f_r(\theta_i, \phi_i, \theta_e, \phi_e)$$

BSSRDF



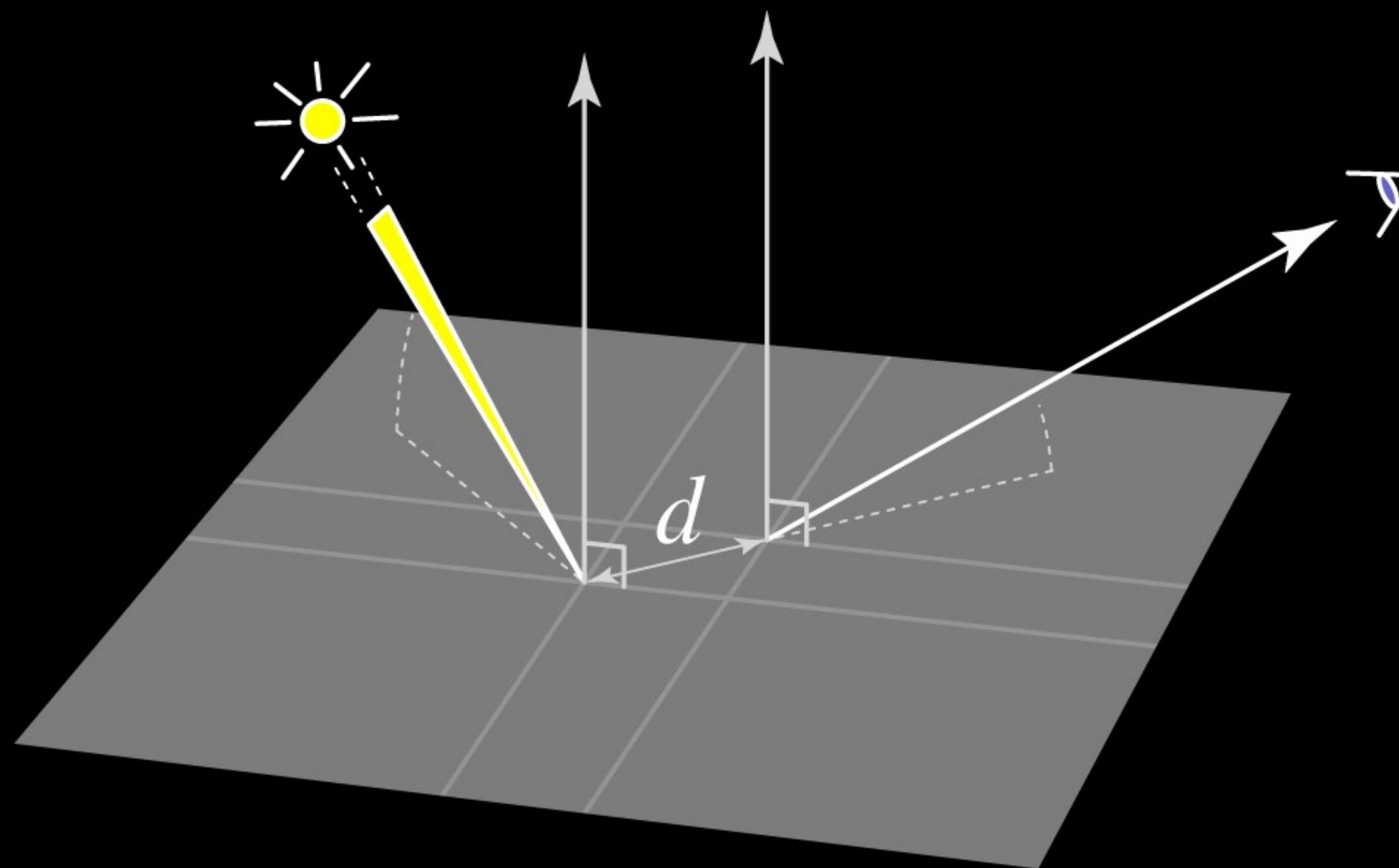
$$S(\theta_i, \phi_i, \theta_e, \phi_e, \Delta x, \Delta y)$$

BSSRDF: isotropic



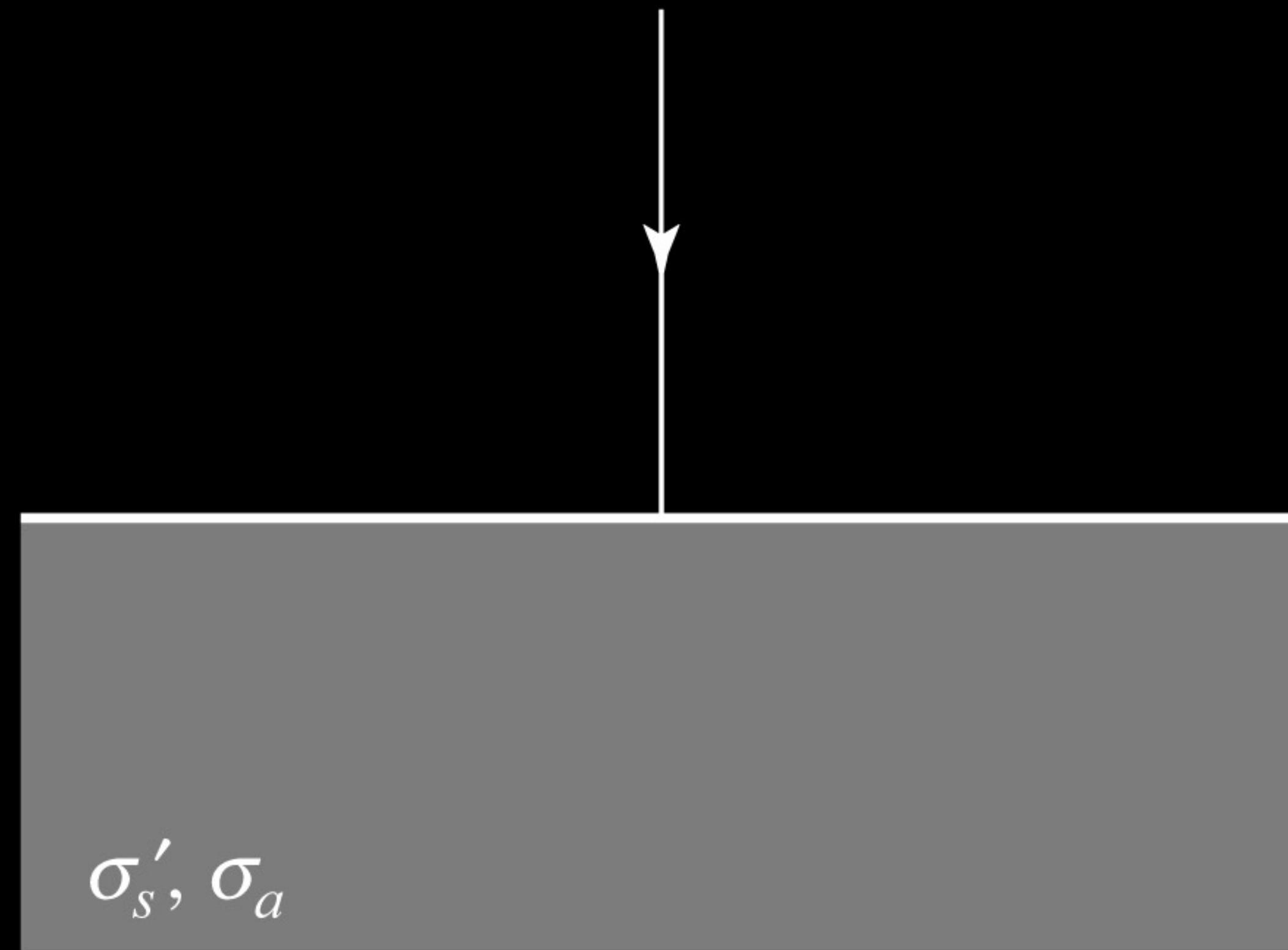
$$S(\theta_i, \phi_i, \theta_e, \phi_e, d)$$

BSSRDF: Lambertian

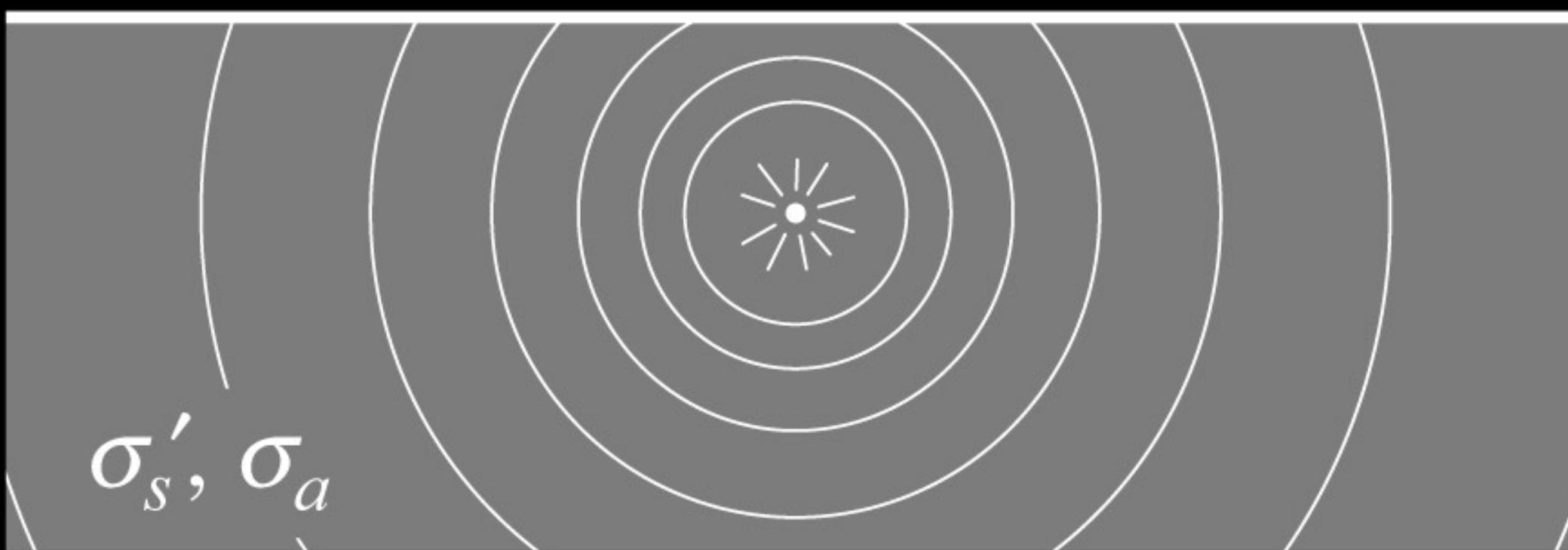


$$R_d(d)$$

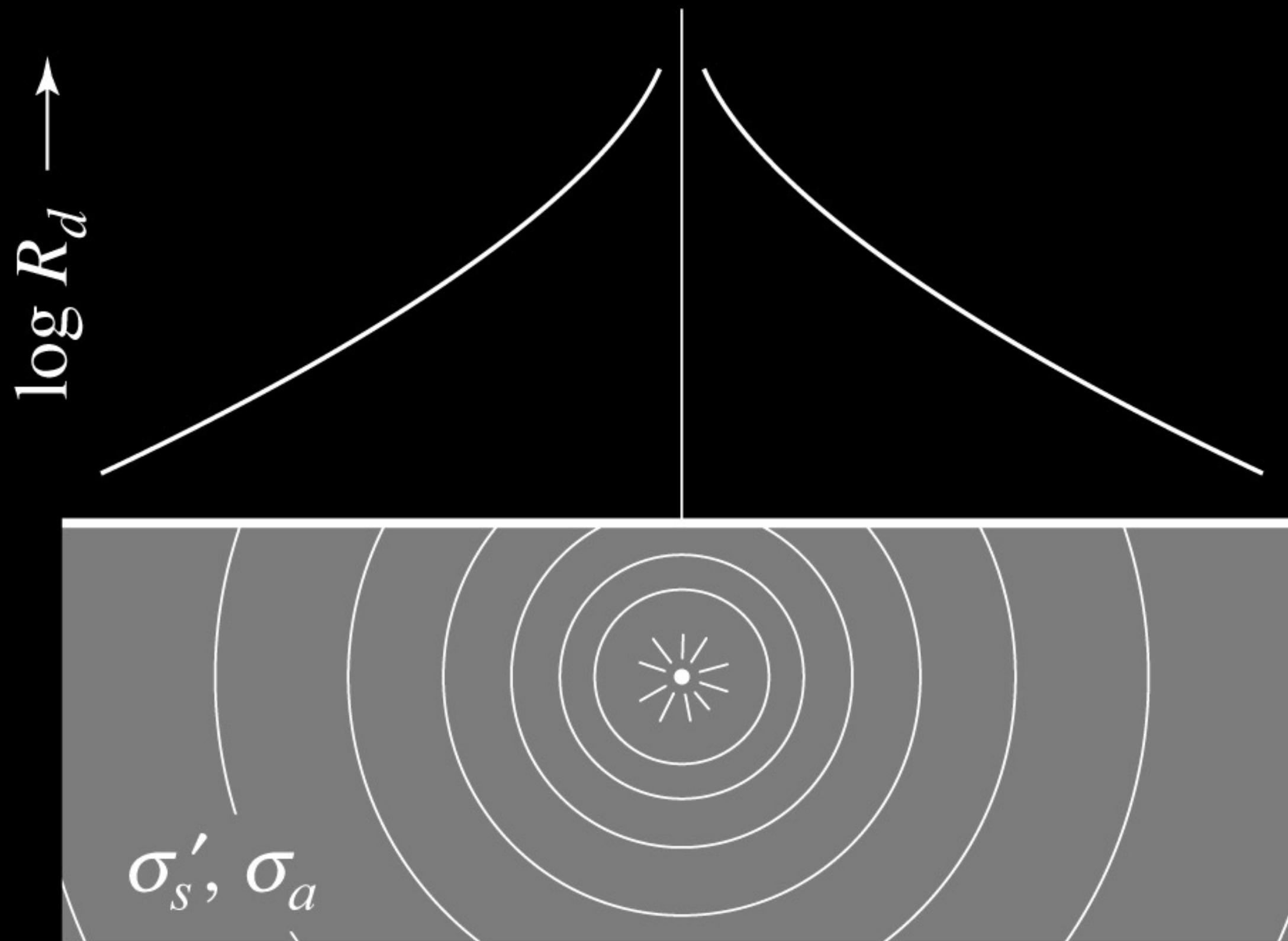
Diffusion approximation



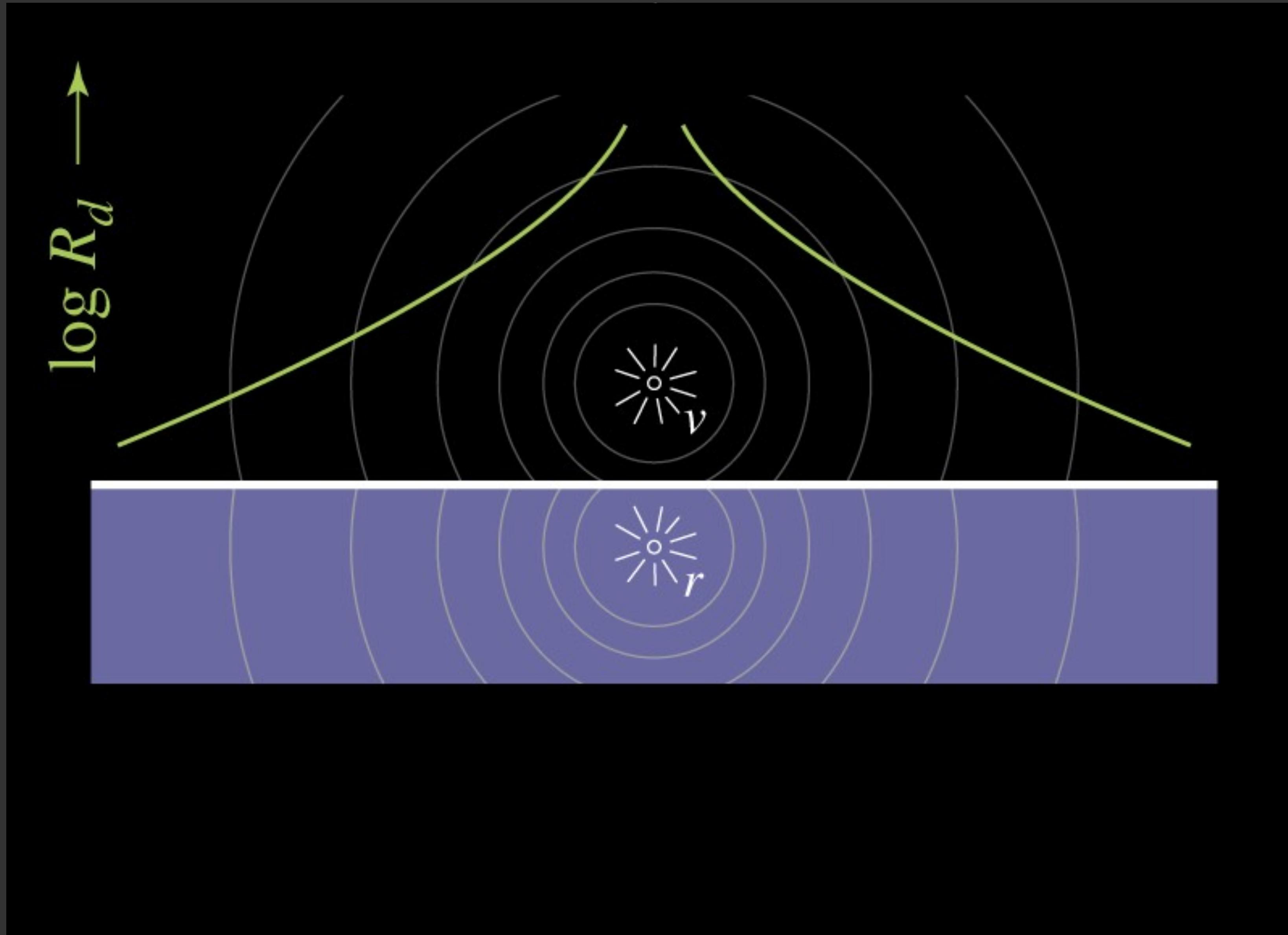
Diffusion approximation



Diffusion approximation



Dipole approximation





[Jensen, Marschner, Levoy & Hanrahan 2001]



Diffuse “milk”

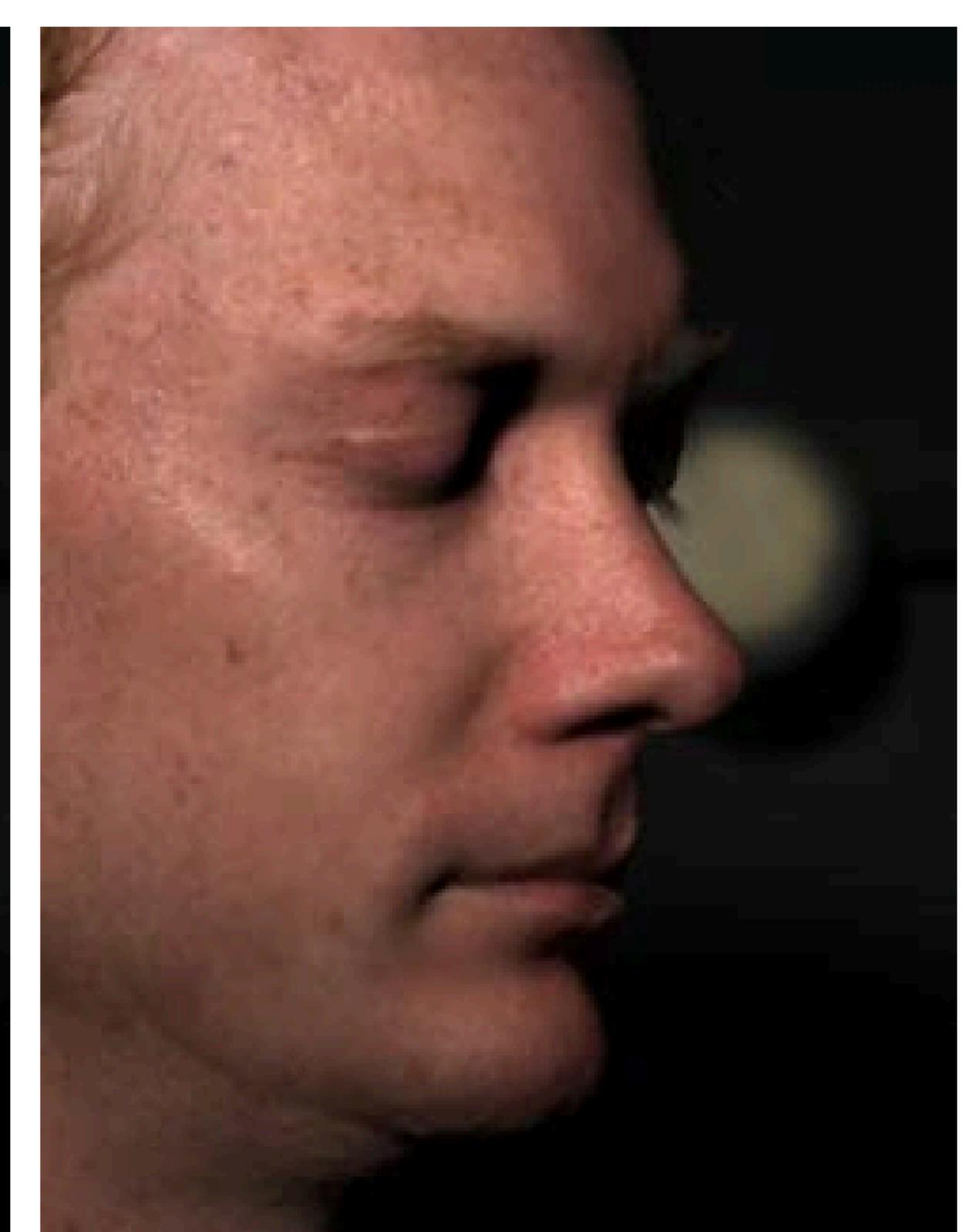
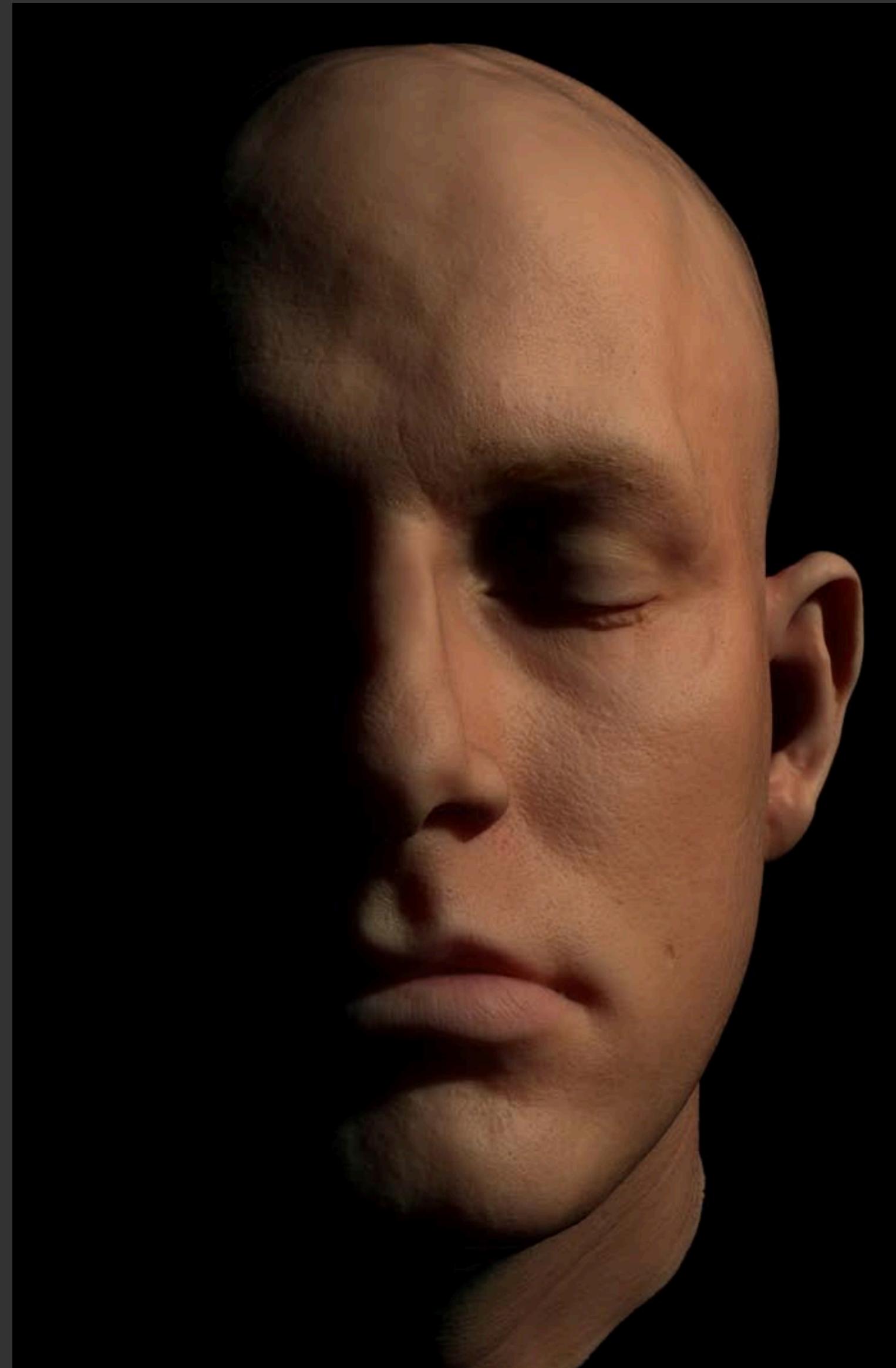


Skim milk



Whole milk

Better models for skin



Photograph

Rendering

Measurement-based skin reflectance model [Weyrich et al. 2006]

Multilayer diffusion [Donner & Jensen 2005]

Improved accuracy



Quantized diffusion [D'Eon & Irving 2011]



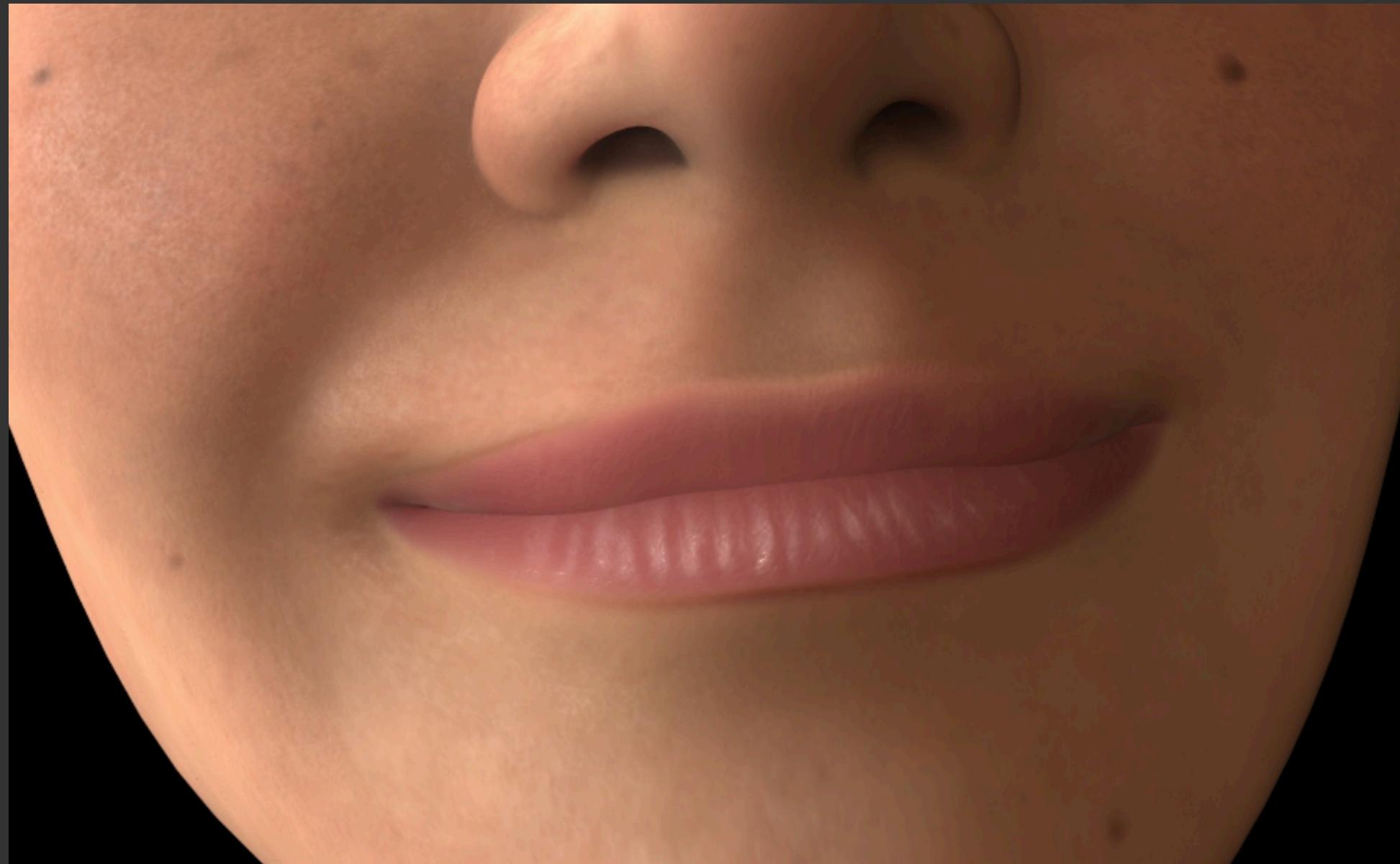
Multilayer diffusion
[Donner & Jensen 2005]



Directional dipole [Frisvad et al. 2009]



Faster translucency



hierarchical evaluation
[Jensen & Buhler et al. 2002]

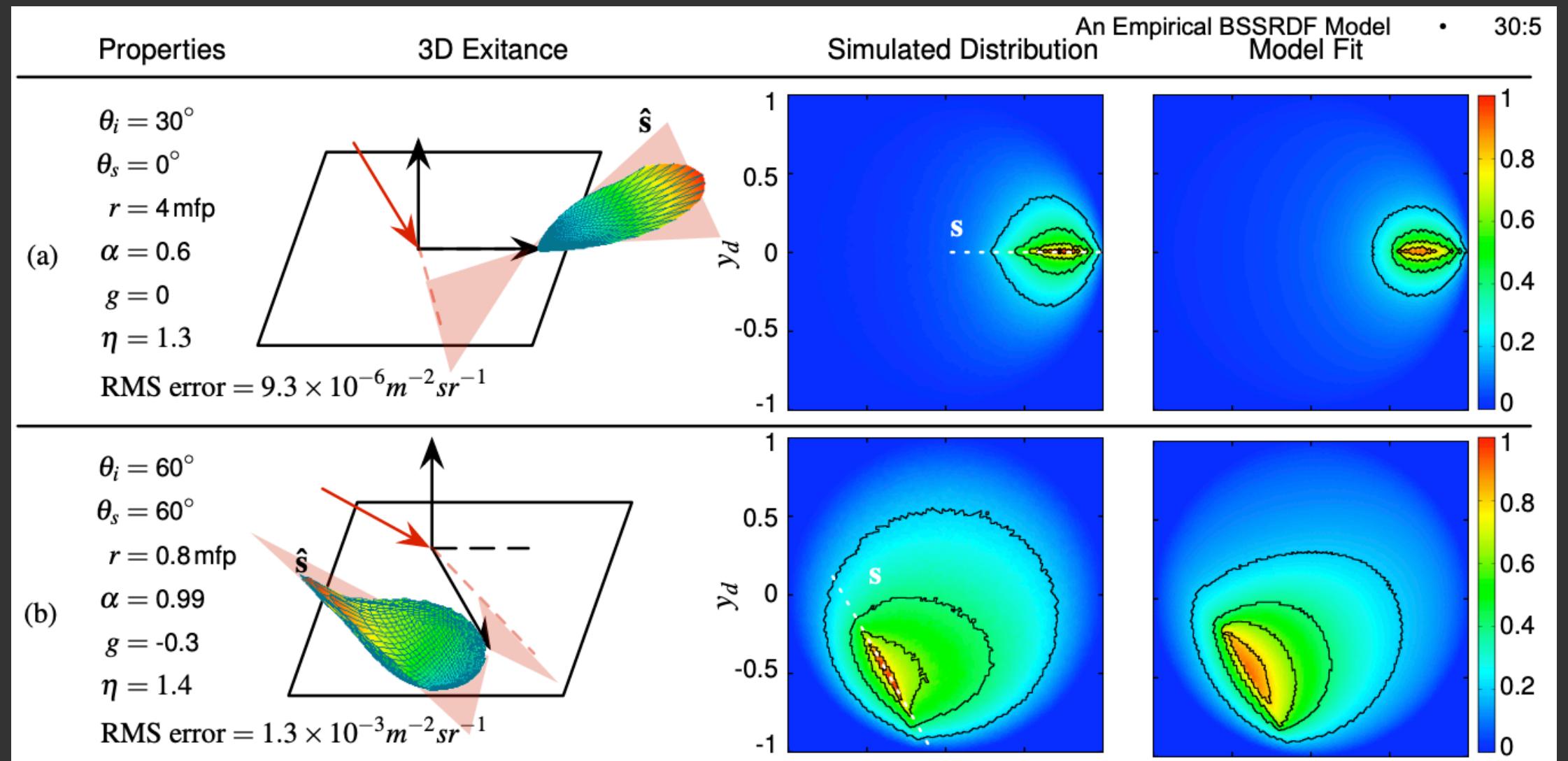


sum-of-Gaussian filtering in texture space [D'Eon et al. 2007]

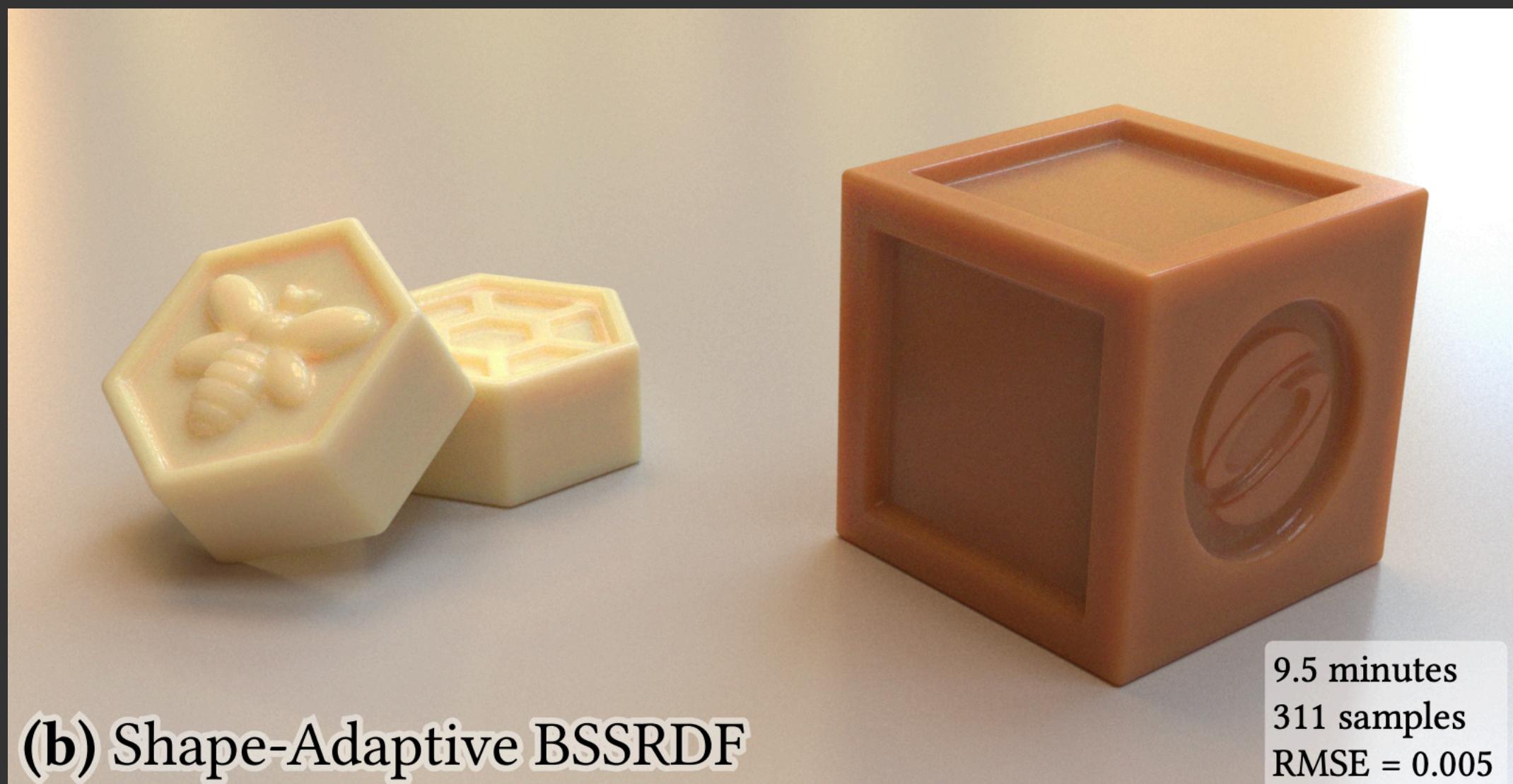


screen space filtering [Jimenez et al. 2009]

Less analytical models



Empirical BSRDF model [Donner et al. 2009]



(b) Shape-Adaptive BSSRDF

Learned shape-adaptive model [Vicini et al. 2019]

Path traced subsurface =
current production s.o.a.



Disney Hyperion Renderer
[Burley et al. SIGGRAPH Courses 2017]