Environment Matting and BRDF's

Topics in Image-Based Modeling and Rendering

CSE291 J00

Lecture 11

Environment Matting & Compositing

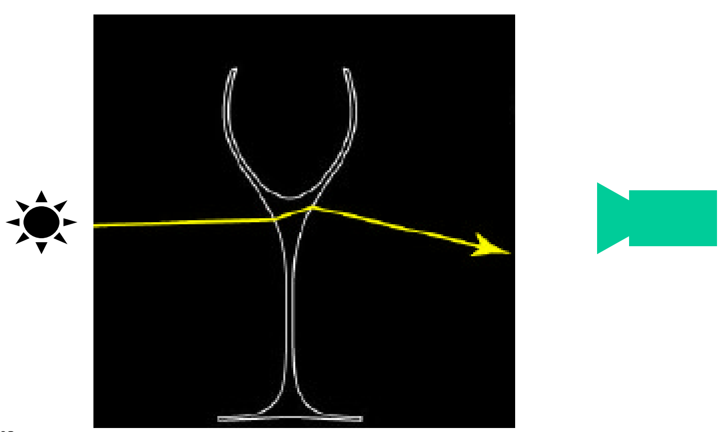
- D. Zonker, D.M. Werner, B. Curles and D.H. Salesin Environment Matting and Compositing , SIGGRAPH 1999, pp. 205-214
- Yung-Yu Chuang, Douglas E. Zongker, Joel Hindorff, Brian Curless, David H. Salesin, Richard Szeliski, Environment matting extensions: towards higher accuracy and real-time capture, SIGGRPAPH 2000, pp. 121 - 130

Environment Matting

- Capture way light rays from background interact with foreground object – e.g. trasparent/specular object
- Imagine if foreground object is a magnifying glass.

Environment Matte

Basic Assumption: Single ray into object, single ray out.

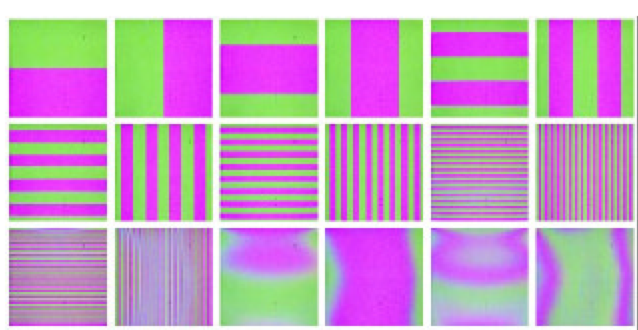


Environment Matting Equation

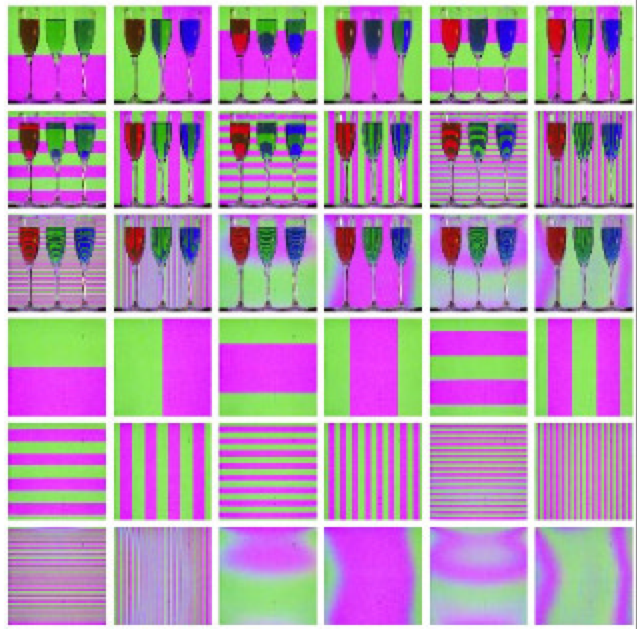
$$\boldsymbol{C = F + (1-\alpha)B} + F$$

- *C*: Rendered color
- *F*: Foreground color
- *B*: Background color
- α: Only masking: {0,1}
- *F* : Contribution of light from nvironment that reflects from or refracts through the object.

Background Textures



Background textures w/ foreground object



Background Textures

Note: Complex O(log k)

Explanation of Φ

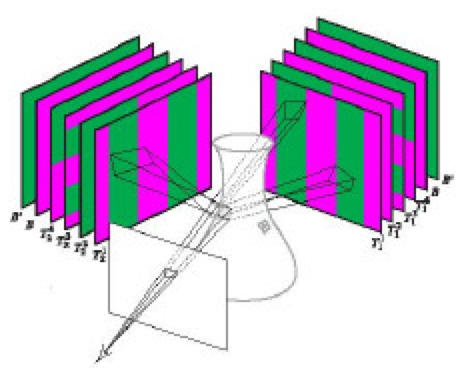
$$F = \sum_{i=1}^{m} R_i M(T_i, A_i)$$

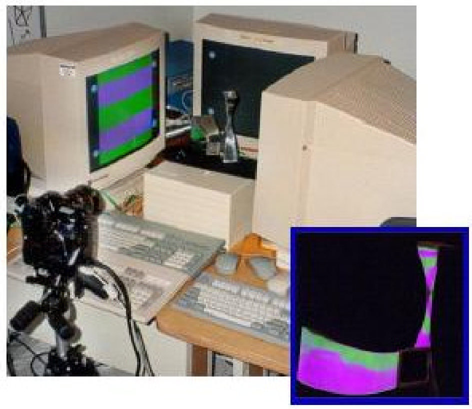
R_i: Reflectance coefficient

M: Texture mapping operator

for axis-aligned rectangle (A_i)

of texture (T_i)





Sunflower/Huricane Movie

Environment Matte Example

Alpha Matte **Environment Matte** **Photograph**

Environment Matte Example

Alpha Matte **Environment Matte** **Photograph**

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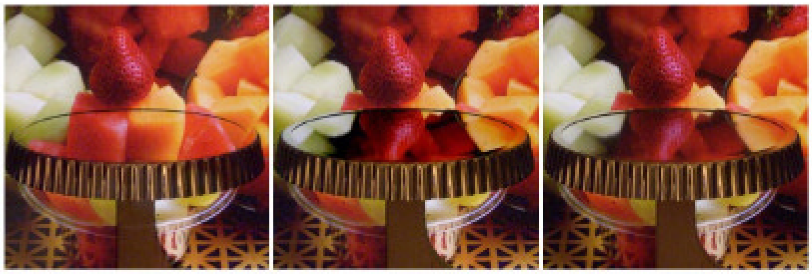
Environment Matte Example



Alpha Matte **Environment Matte** **Photograph**

Environment Matte Example

Alpha Matte **Environment Matte** **Photograph**

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Movies

Glass block movie

Goblet movie

Morphing

Extensions

1. How might you do this right?

2. Higher accuracy – O(k) backgrounds

3. Real time

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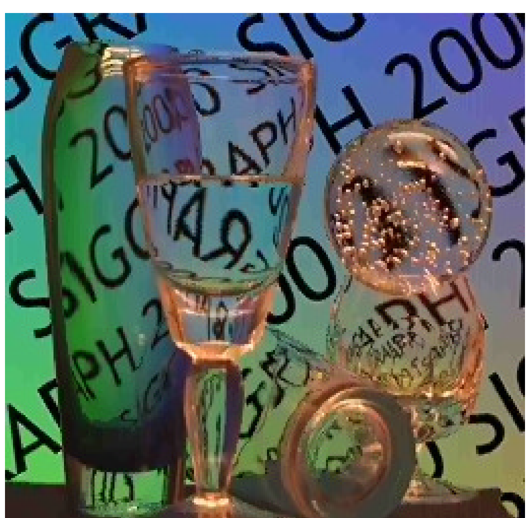

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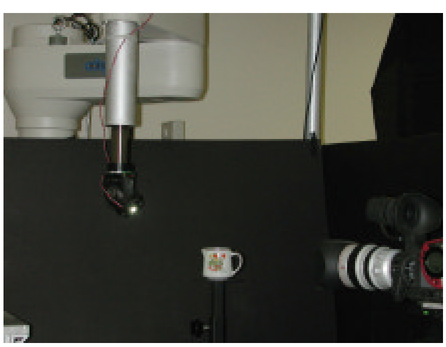
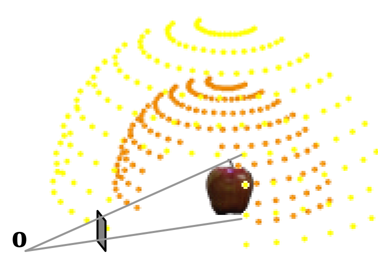
Compositing to match lighting

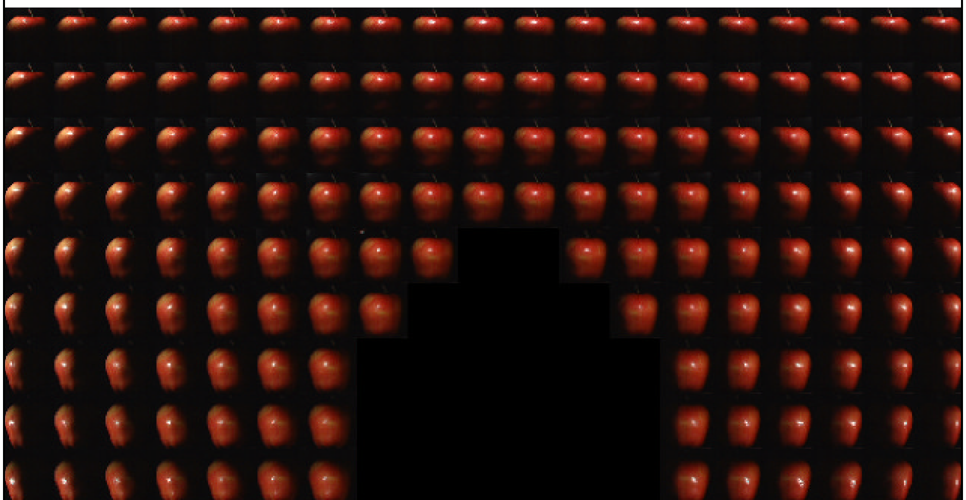
M. Koudelka, S. Magda, P. Belhumeur, D. Kriegman, “Image-based Modeling and Rendering of Surfaces with Arbitrary BRDFs,” IEEE CVPR, 2001, pp.568-575.

Image Acquisition





A Dataset from onesphere



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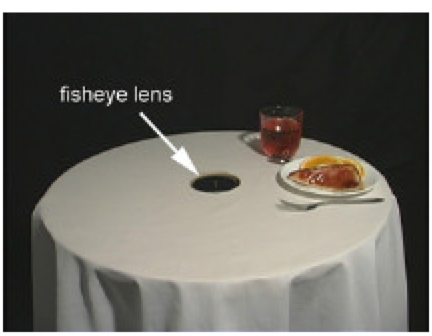
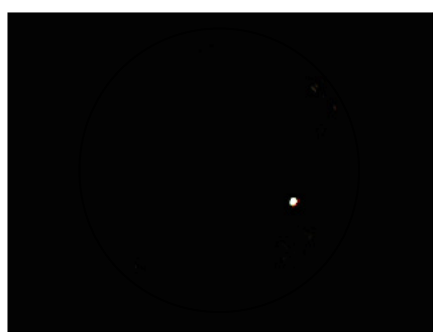
Video Compositing of Real Objects



Video Footage



Radiance Map

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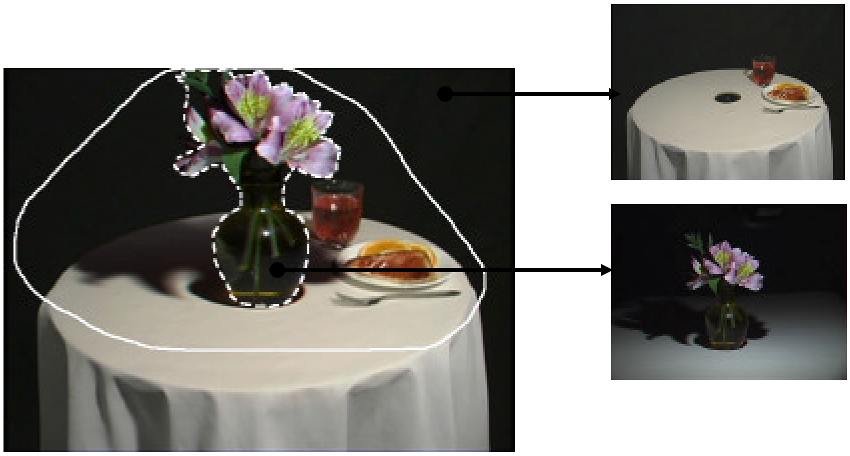
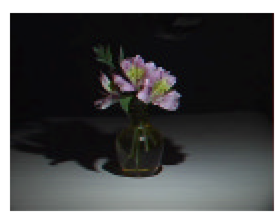
Compositing: Computing Pixel Values



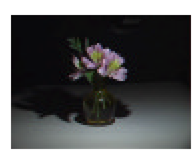
Compositing

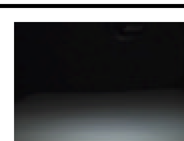
→ (θ, φ) →



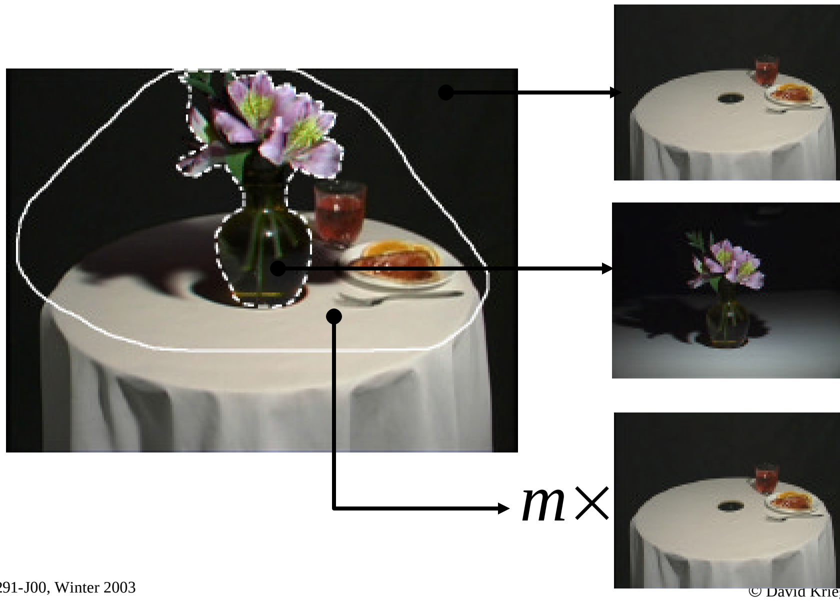
Shadows and Interreflections

Radiance Scale Factor, m =





Compositing: Computing Pixel Values



A composited object

Compositing Real Objects in Video

BRDF

Reflectance vs. Texture

- *Reflectance:* How light is scattered at a single point on the surface
- *Texture:* Characteristic variation in reflectance and visible geometry across the surface.
- Distinction depends on scale

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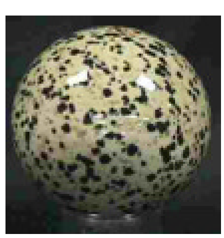
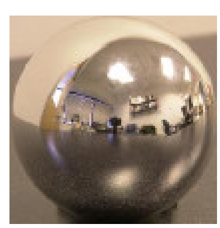
From Ron Dror's slides

How to characterize *reflectance* properties?

- Reflectance is defined for a small surface patch.
- Reflectance is an intrinsic surface property, independent of illumination.



Varying reflectance



Constant reflectance

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BRDF

- Bi-directional Reflectance Distribution Function

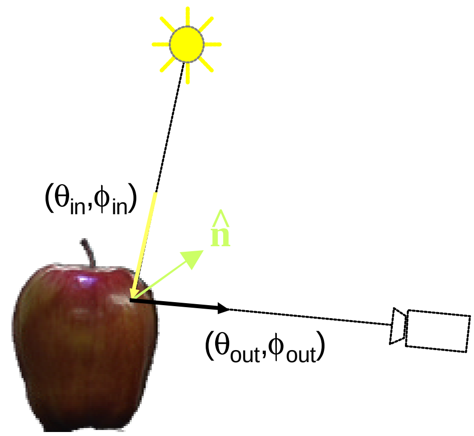
  $\rho(\theta_{in}, \phi_{in} ; \theta_{out}, \phi_{out})$

- Function of
  - Incoming light direction:

    θ_{in} , ϕ_{in}
  - Outgoing light direction:

    $\theta_{out} , \phi_{out}$

- Ratio of incident irradiance to emitted radiance



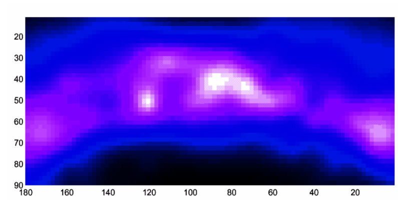
Surface Reflectance Models

Common Models

- Lambertian
- Phong
- Physics-based
  - Specular
    [Blinn 1977], [Cook-Torrance 1982], [Ward 1992]
  - Diffuse
    [Hanrahan, Kreuger 1993]
  - Generalized Lambertian
    [Oren, Nayar 1995]
  - Thoroughly Pitted Surfaces
    [Koenderink et al 1999]
- Phenomenological

  [Koenderink, Van Doorn 1996]

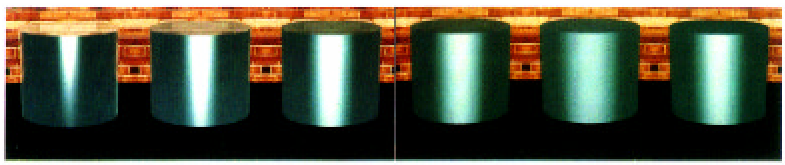
Arbitrary Reflectance



- Non-parametric model
- Anisotropic
- Non-uniform over surface
- BRDF Measurement *[Dana et al, 1999]*

Physically-based models

- Example: He-Torrance-Sillion-Greenberg model



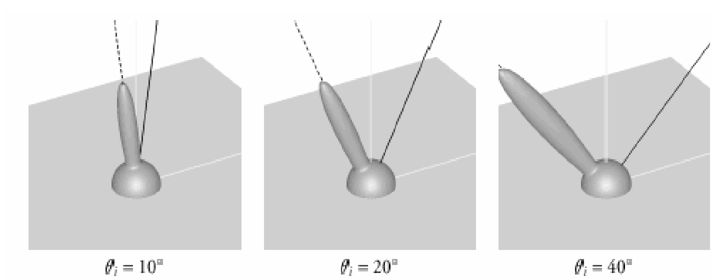
Aluminum cylinders with different surface roughness

Model Parameters: spectral sensitivity function; complex index of refraction; surface height RMS deviation and autocorrelation length.

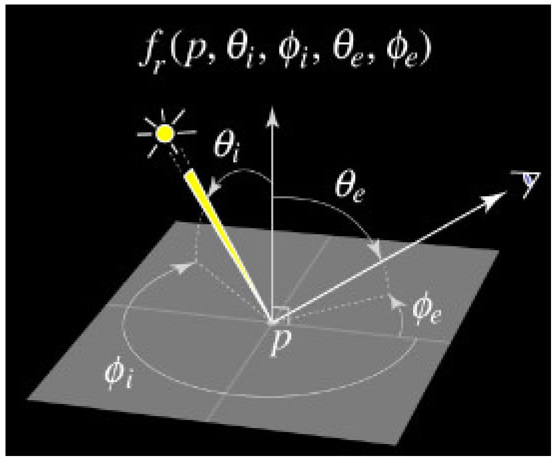
From Ron Dror's slides

A couple 2-D slices of the 4-D BRDF

Cook-Torrance-Sparrow BRDF



BRDF



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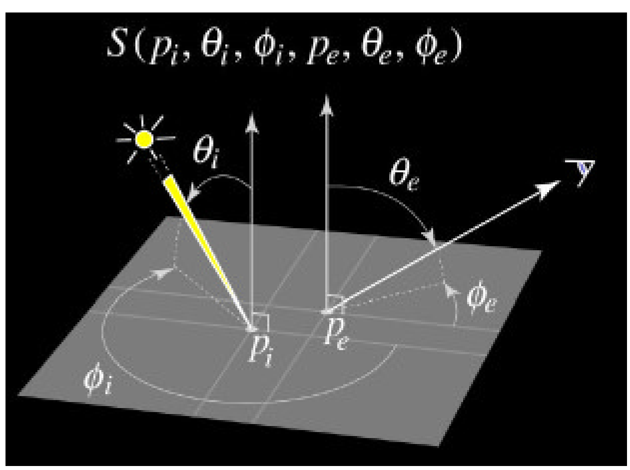
Adapted from Steve Marschner

BSSRDF



Bidirectional Subsurface Scattering Reflectance Distribution Function

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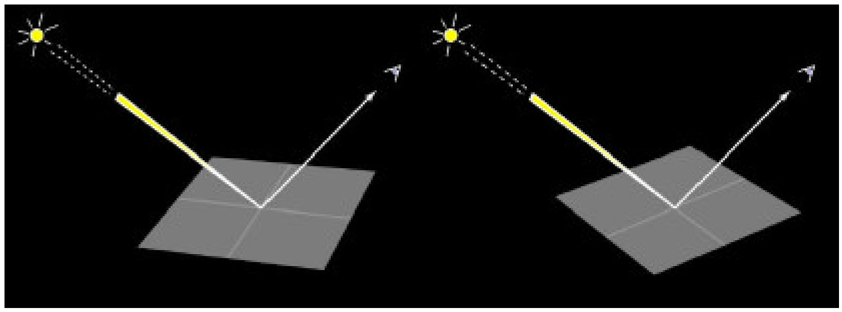
Isotropic BRDF

BRDF is constant over rotation about surface normal

Isotropic BRDF has 3-DOF



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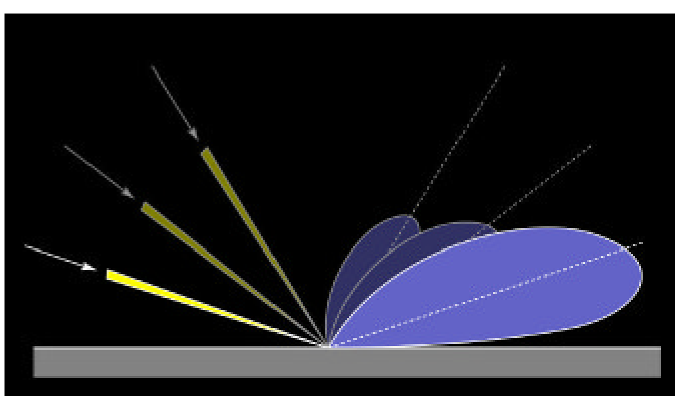
Off Specular Reflection



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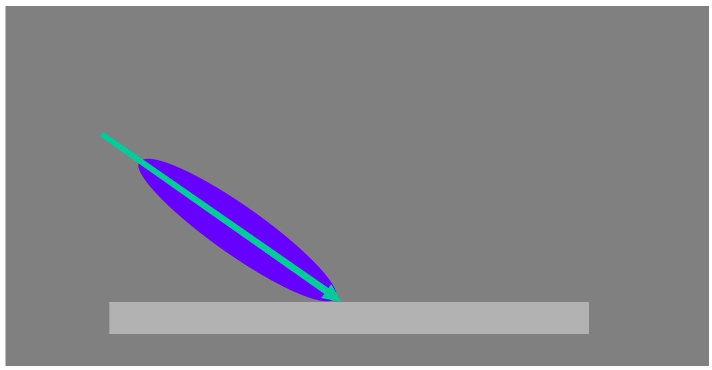
Backscatter



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