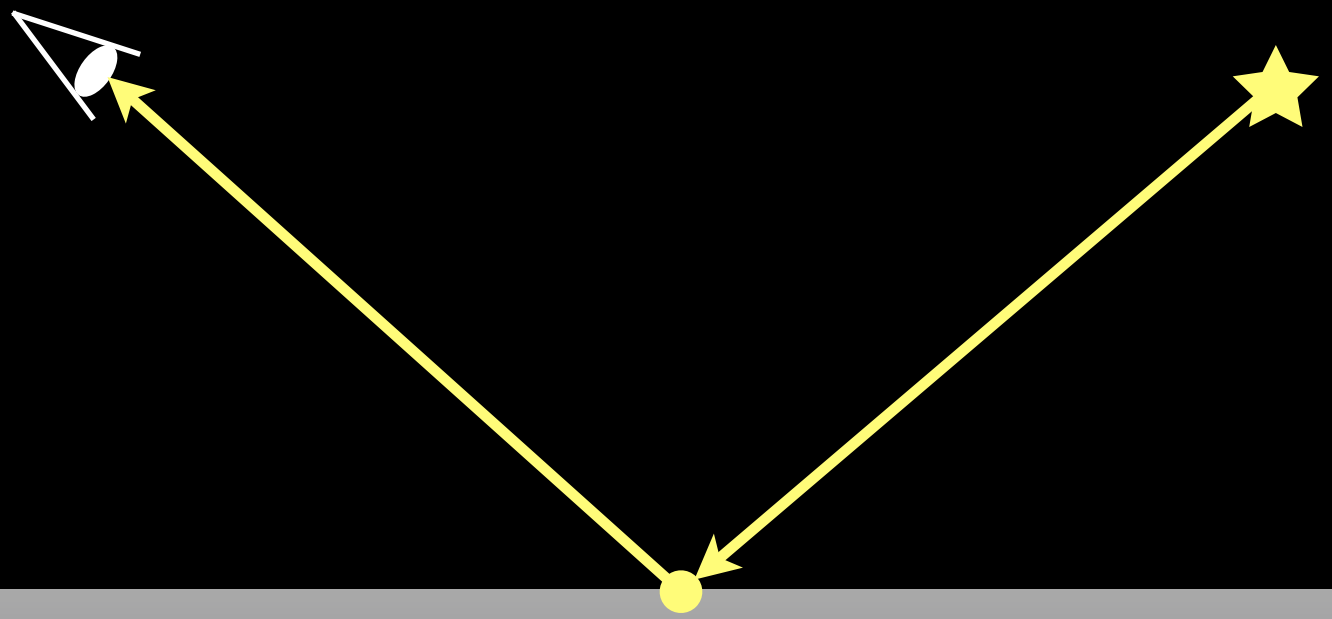
Directional Dipole Model for Subsurface Scattering

Toshiya Hachisuka

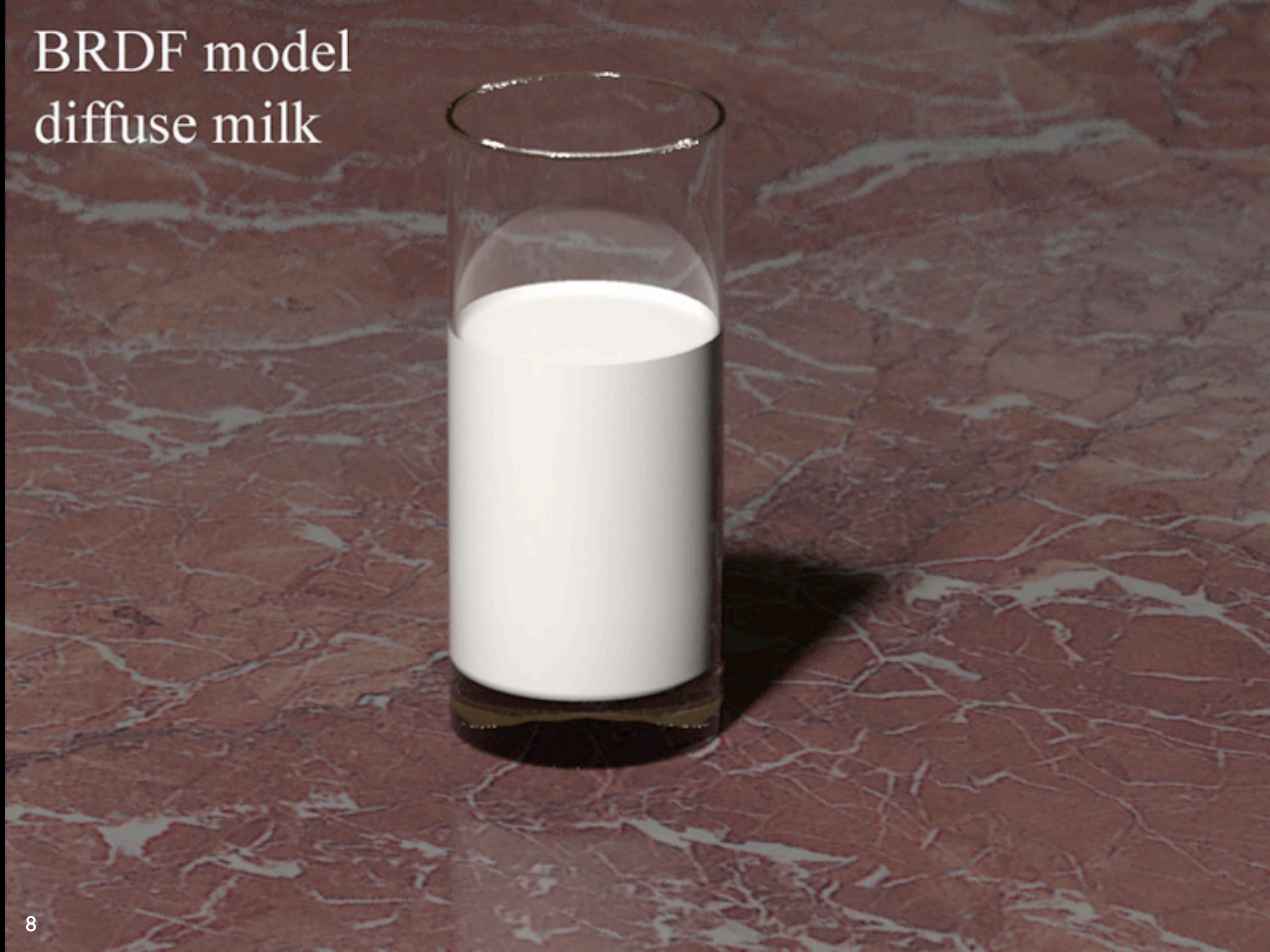
Collaboration with Jeppe Frisvad and Thomas Kjeldsen

The slides are based on the tech. report published in August 2013
For the latest results, please refer to the corresponding paper at TOG

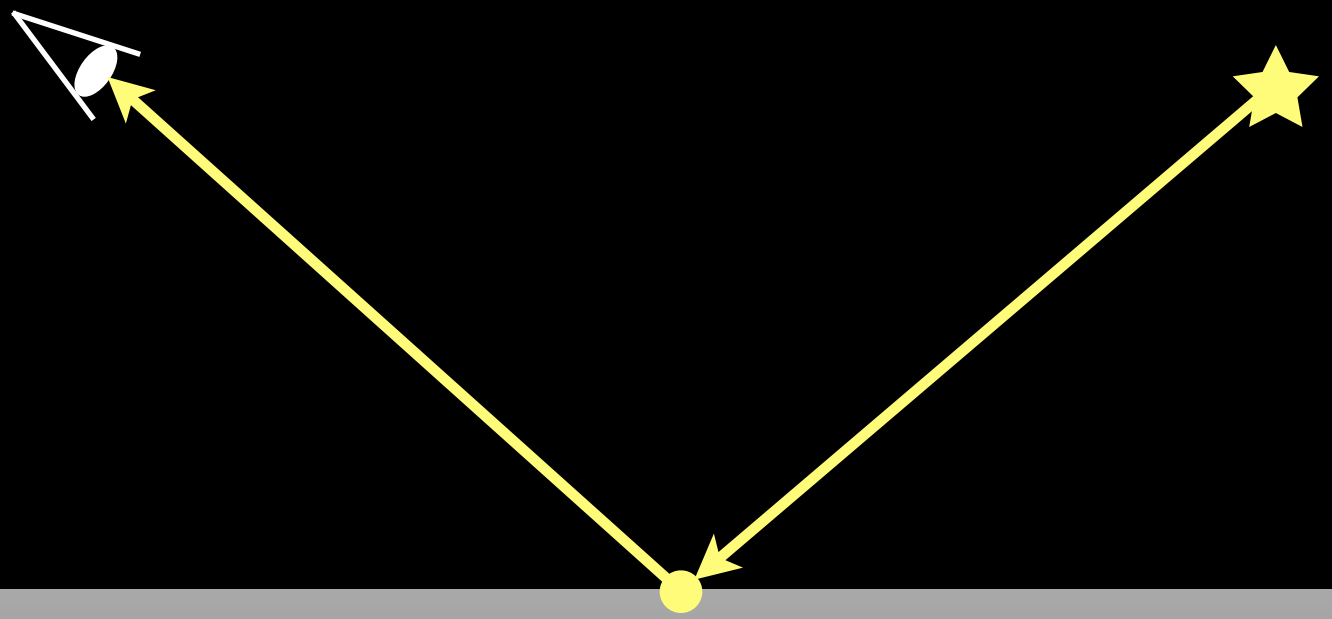
Bidirectional Reflectance Distribution Function



BRDF model
diffuse milk



Bidirectional Surface Scattering Reflectance Distribution Function



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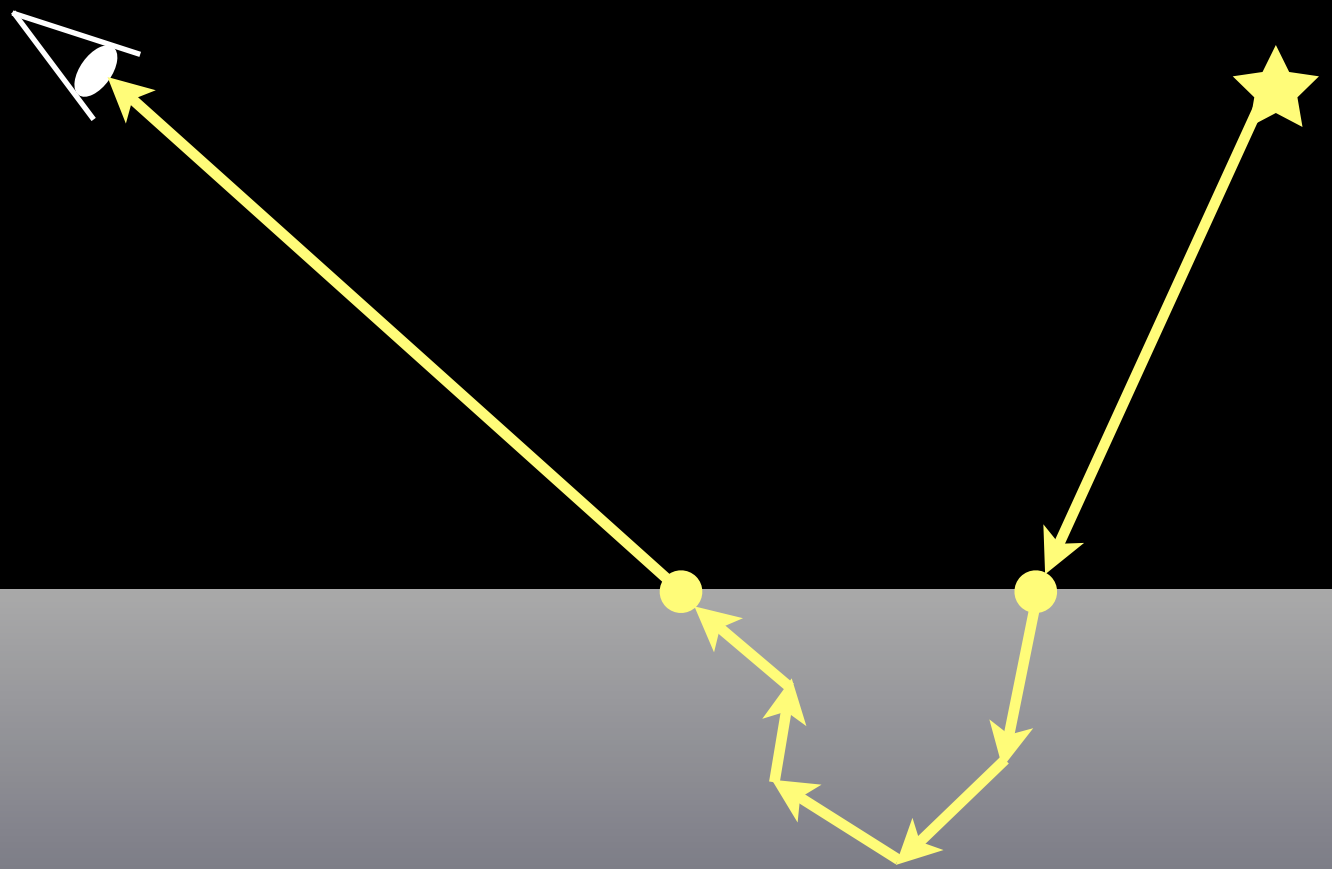
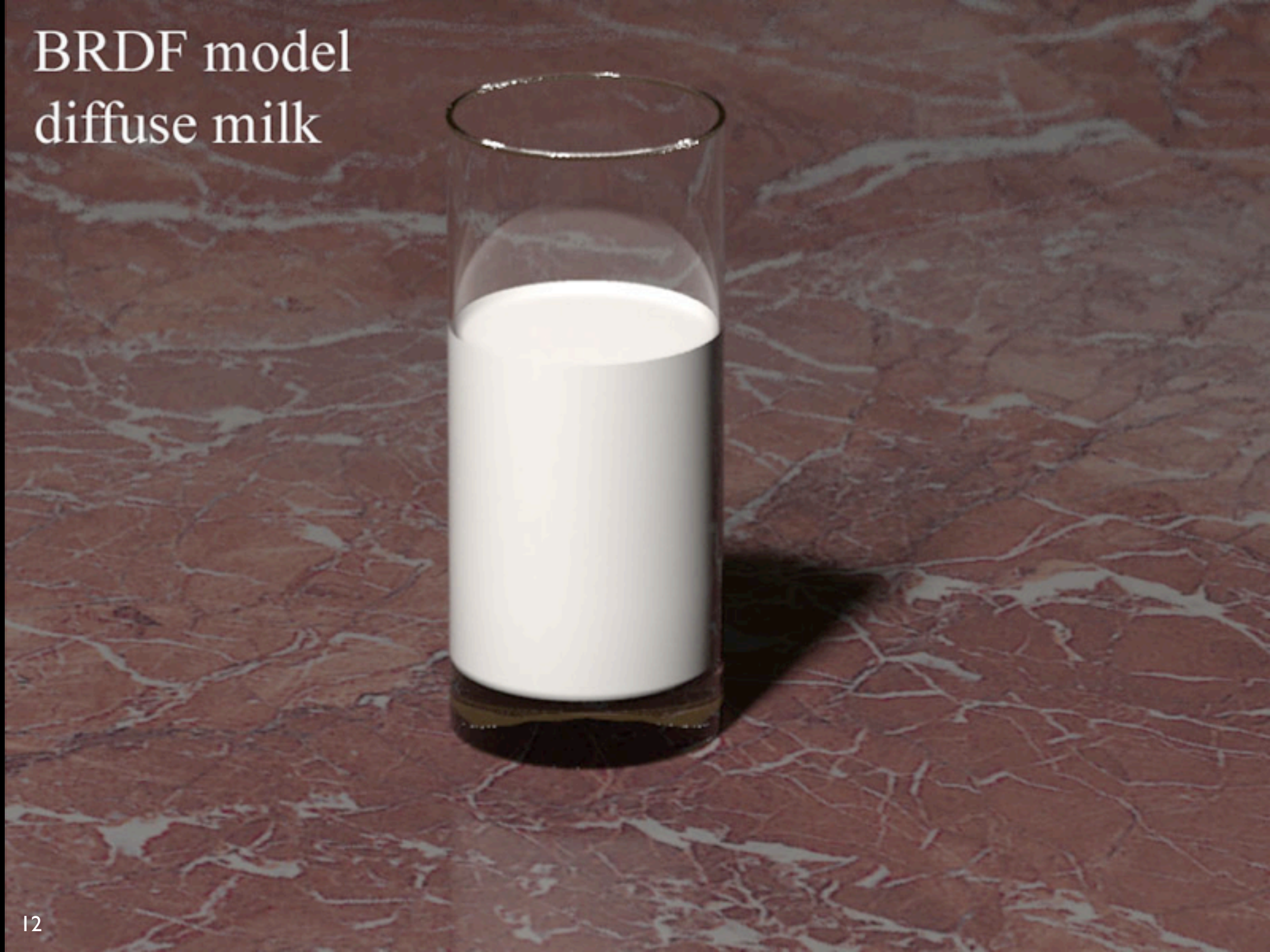


BSSRDF model
skim milk

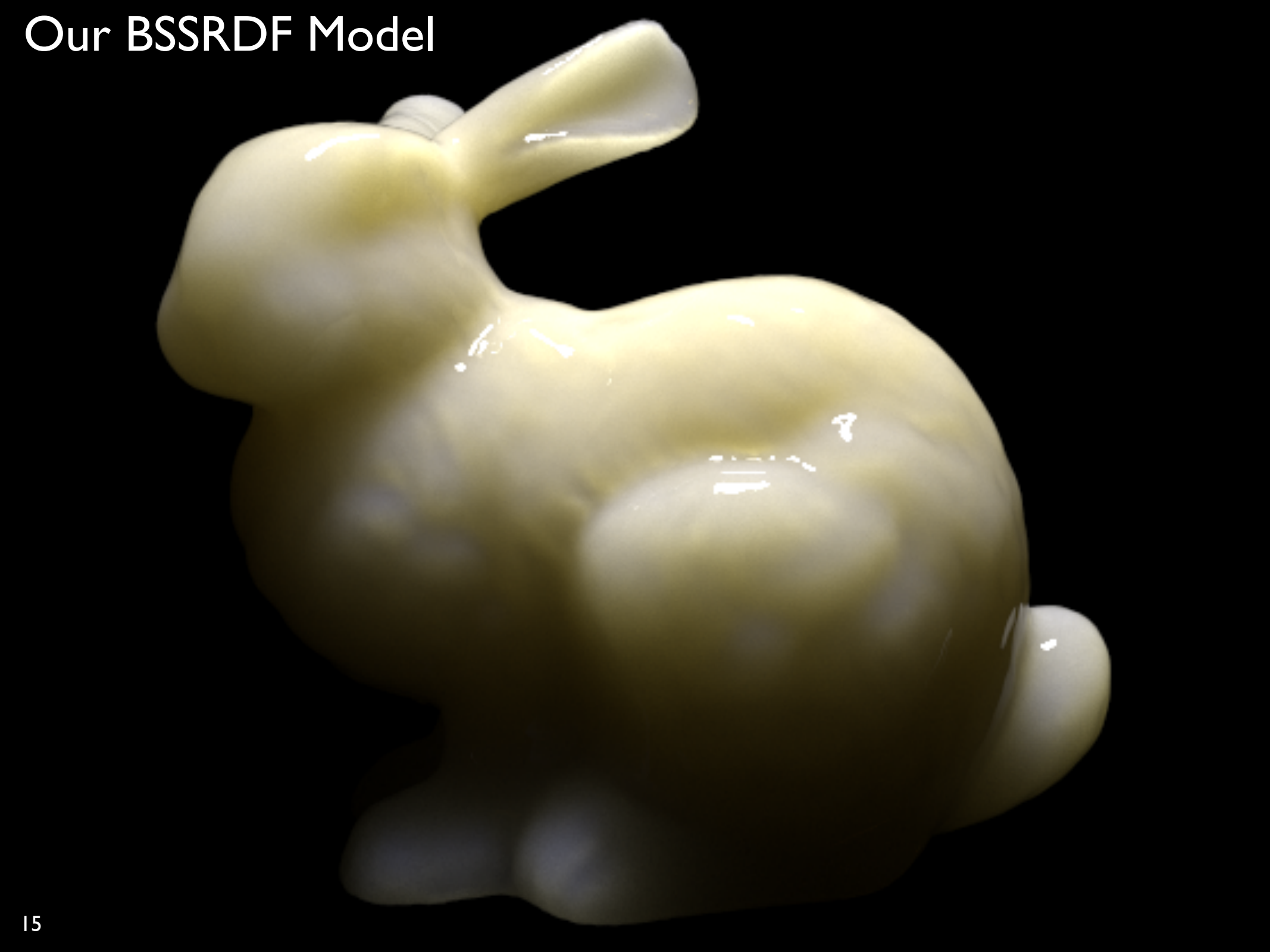
BRDF model
diffuse milk



Reference Solution

Existing BSSRDF Model

Our BSSRDF Model



Previous Model A
Previous Model B
Our Model
Reference

Previous Models

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- Dipole [Jensen et al. 2001]
- Multipole [Donner & Jensen 2005]
- Quantized diffusion [d'Eon & Irving 2011]
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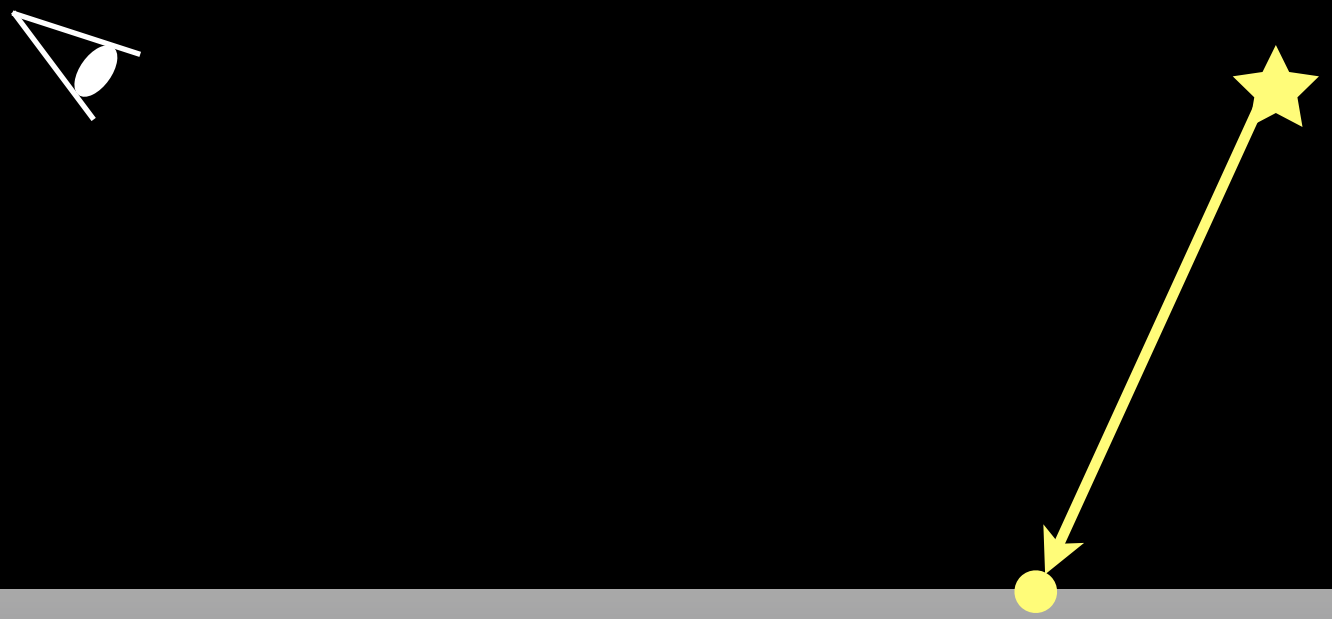
Dipole



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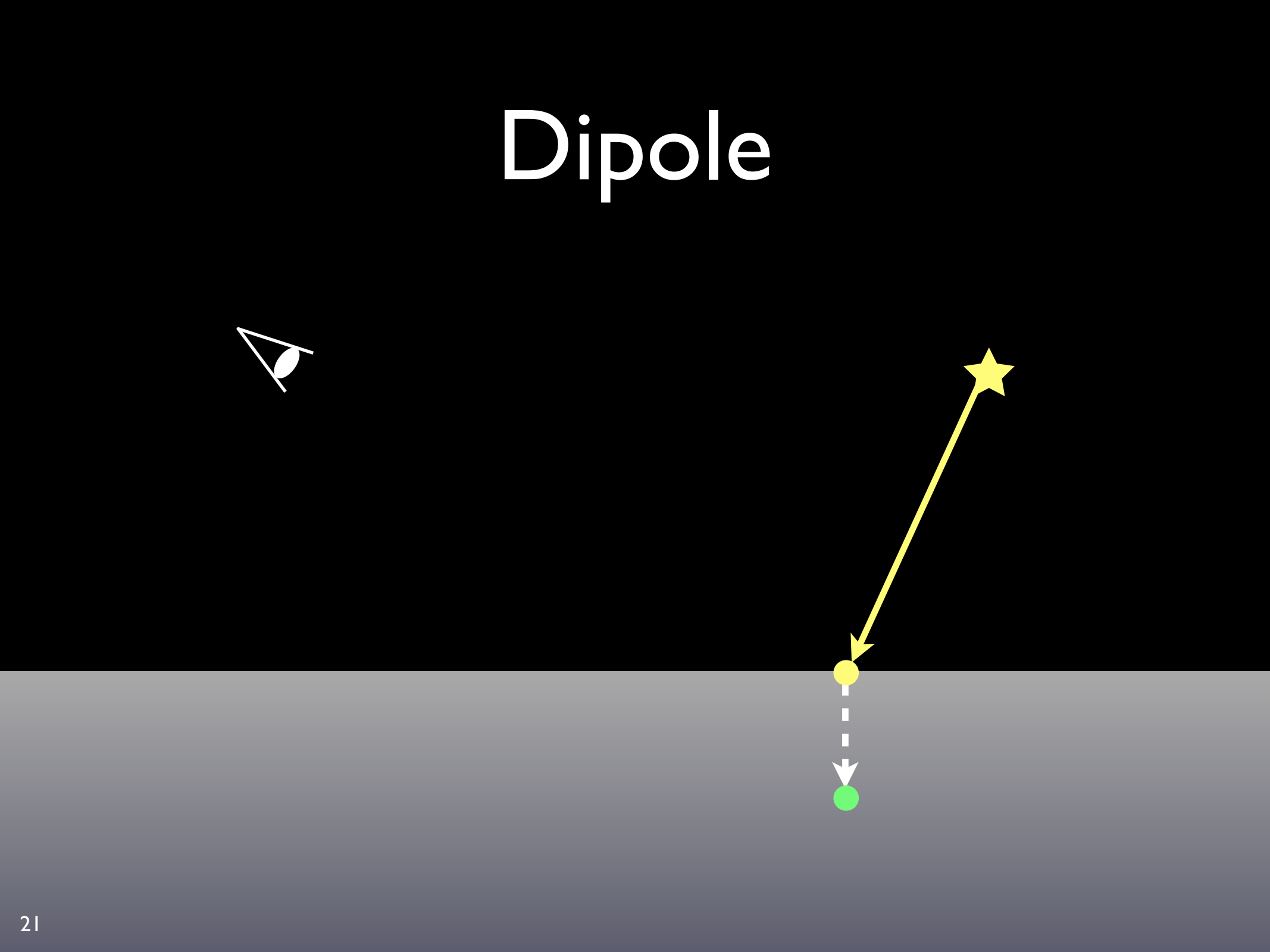

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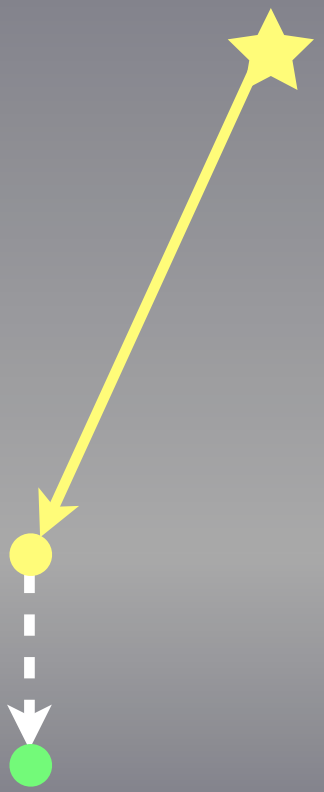
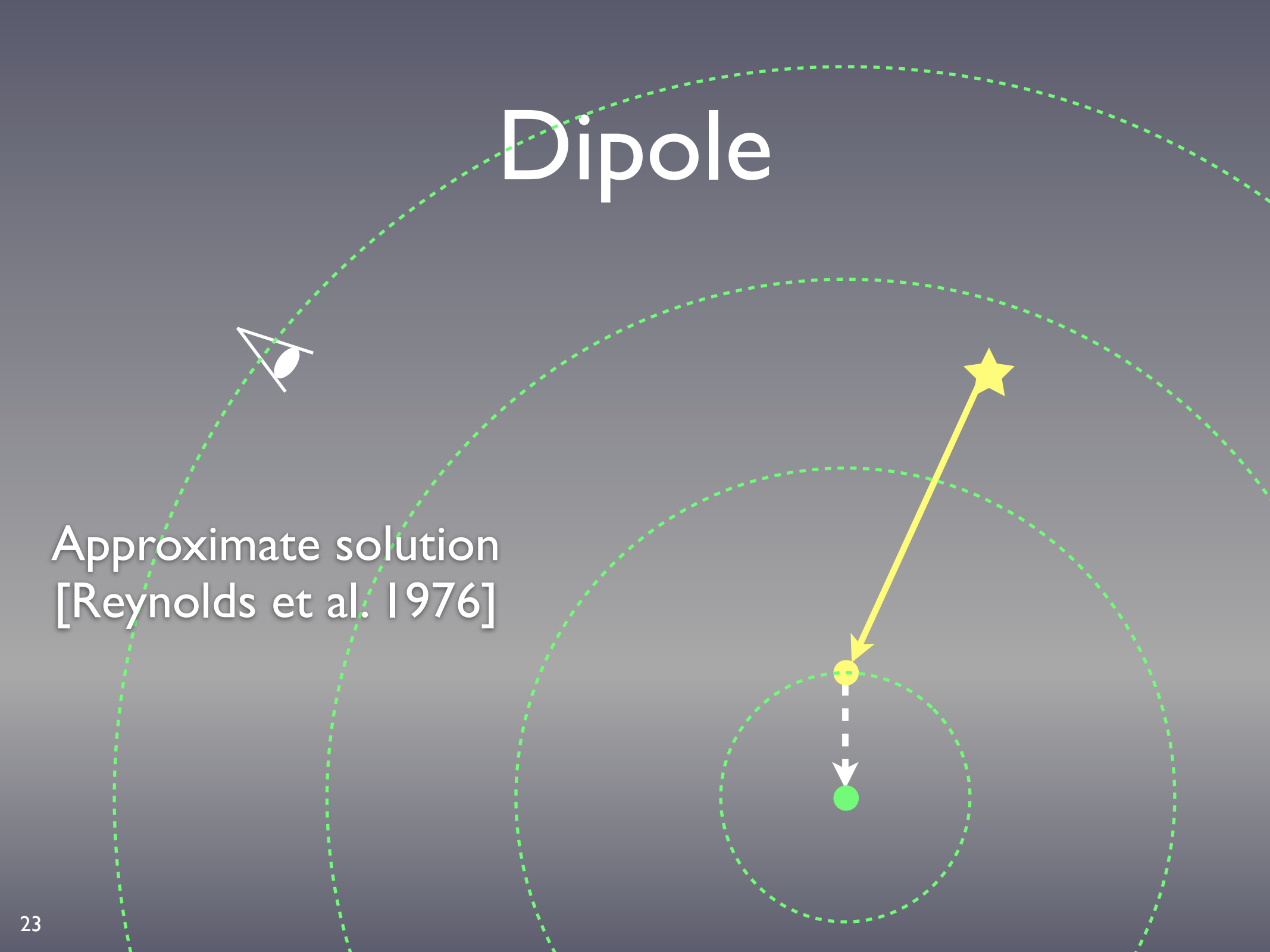
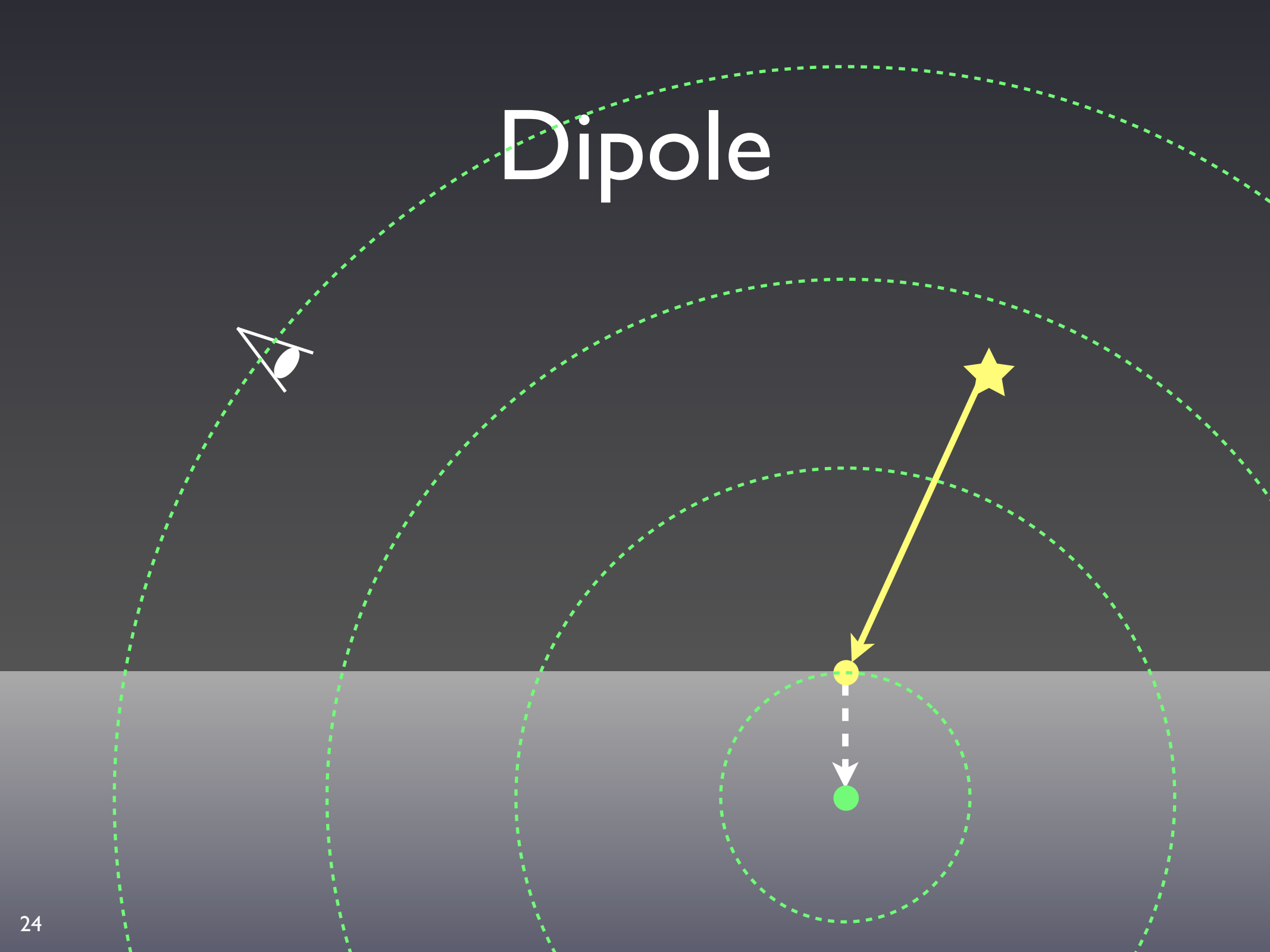


Dipole

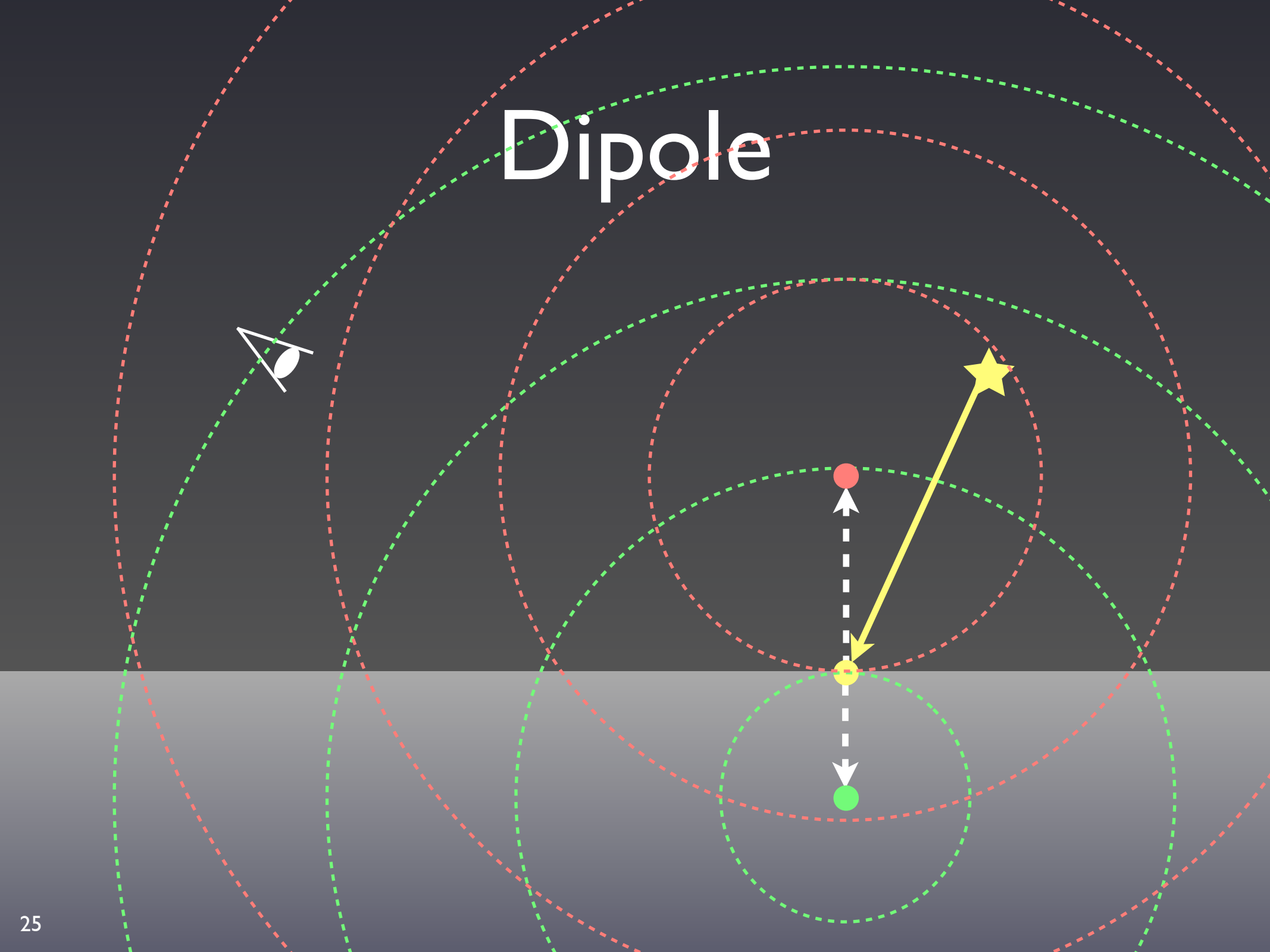


Approximate solution
[Reynolds et al. 1976]

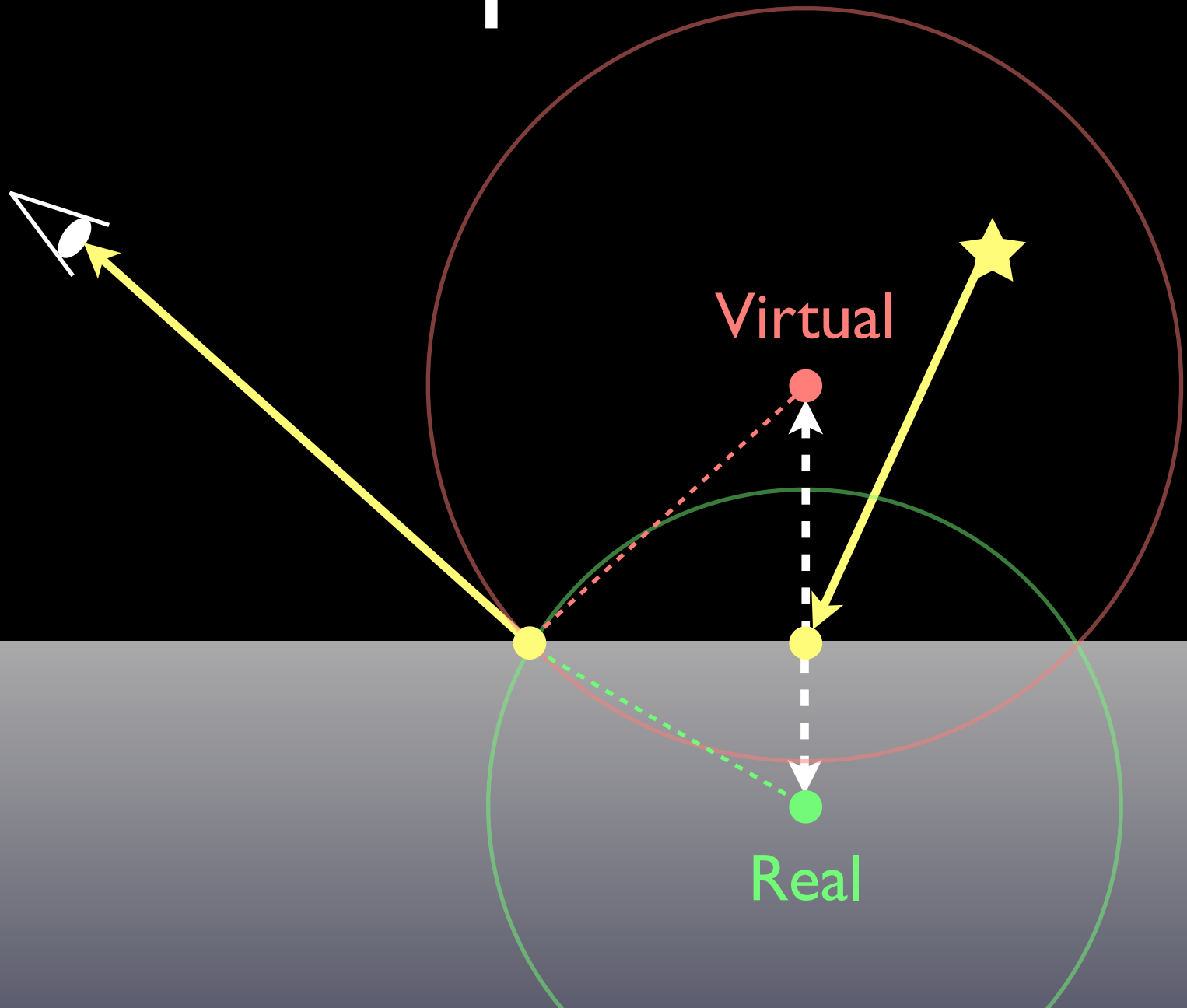
Dipole



Dipole



Dipole



Dipole

Diffuse BRDF

Dipole BSSRDF

[Jensen et al. 2001]

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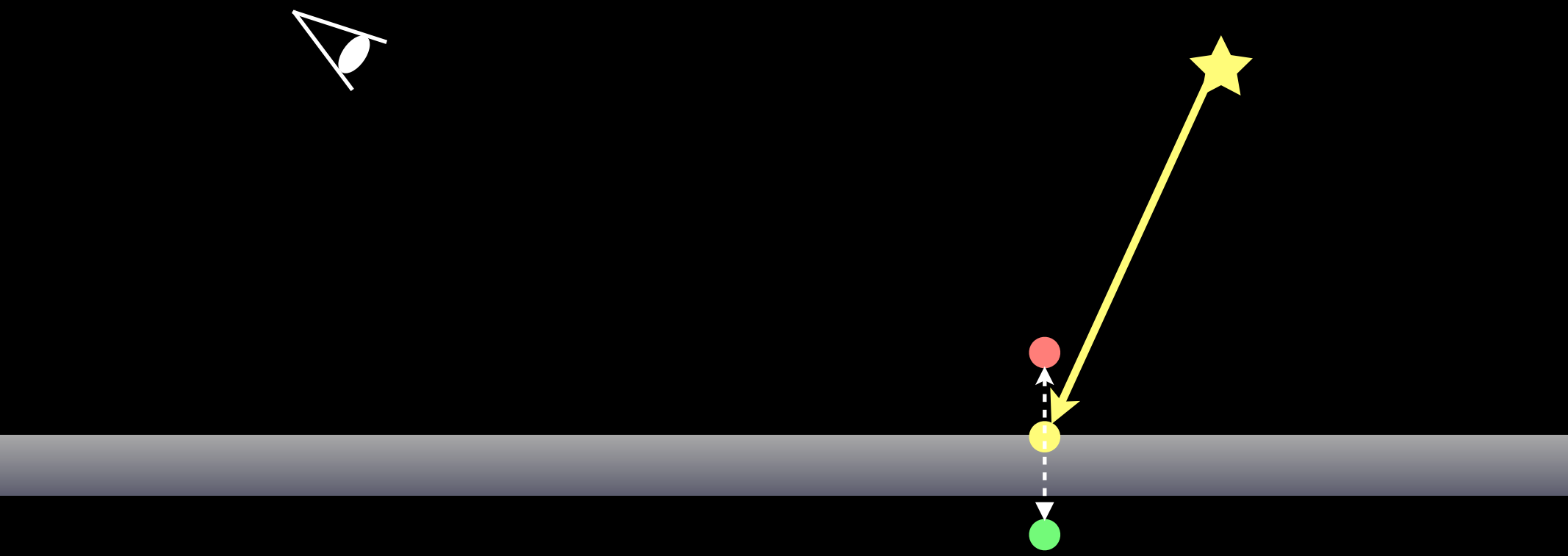
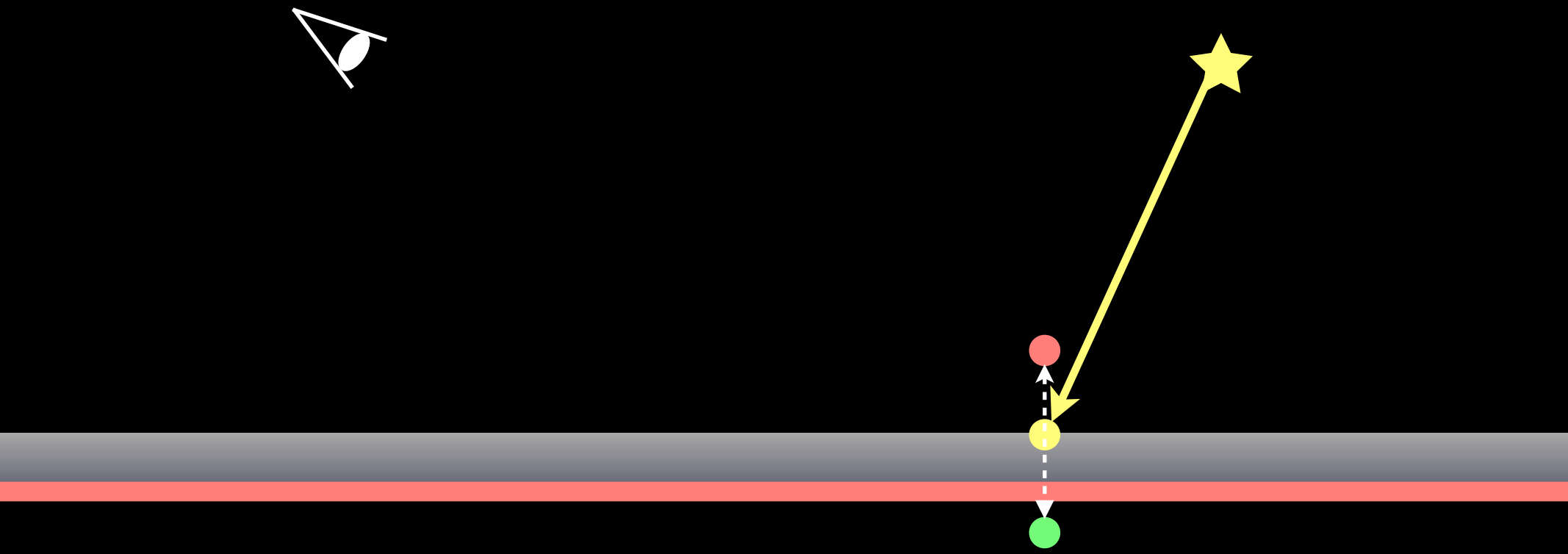
Multipole



Multipole



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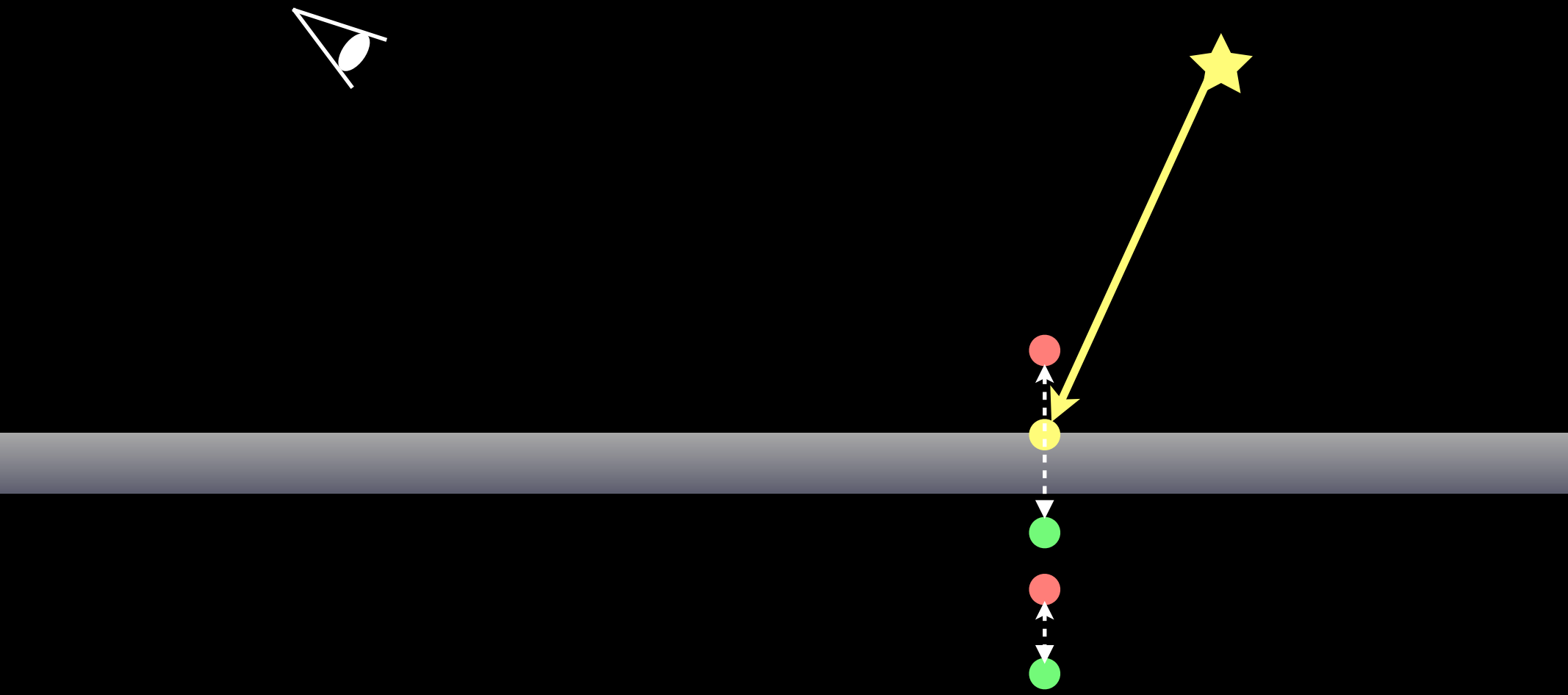
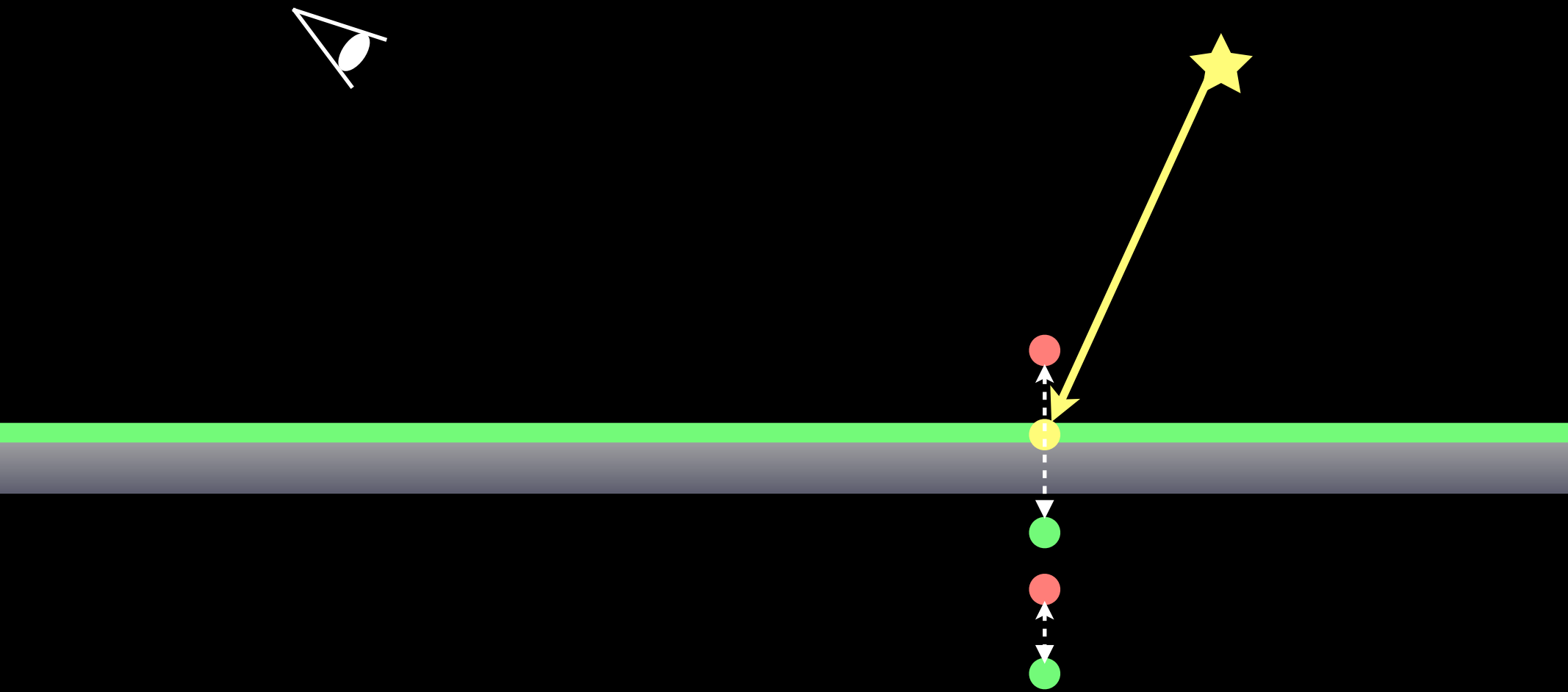
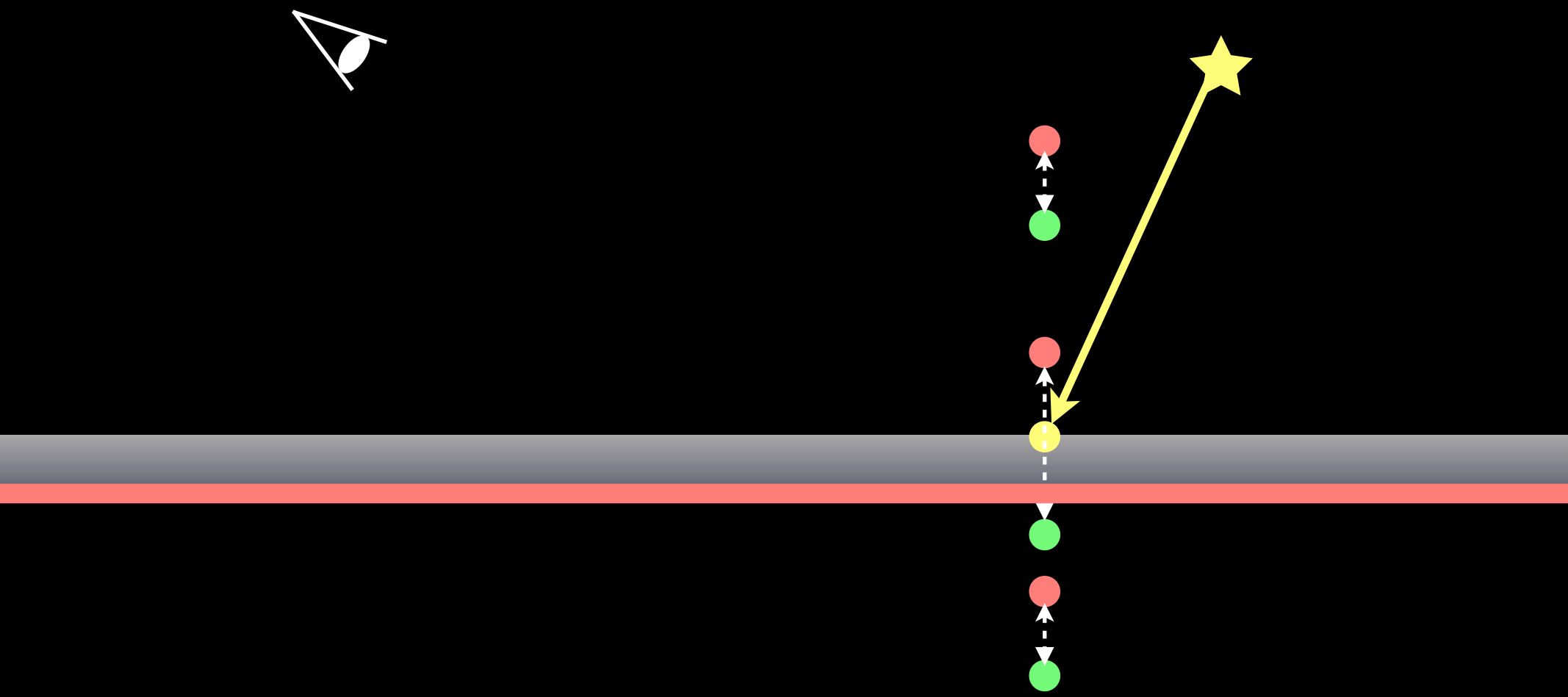


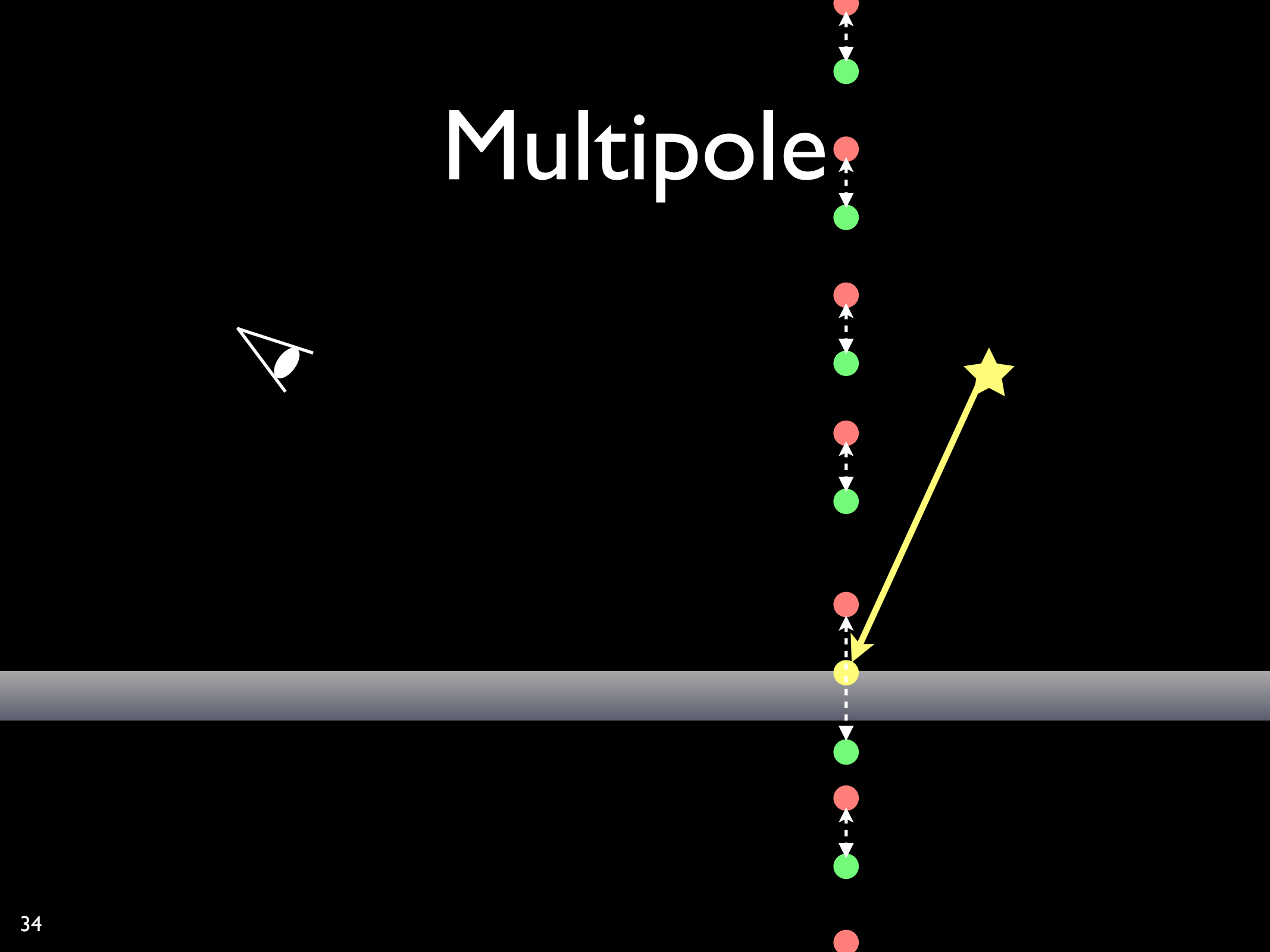
Multipole



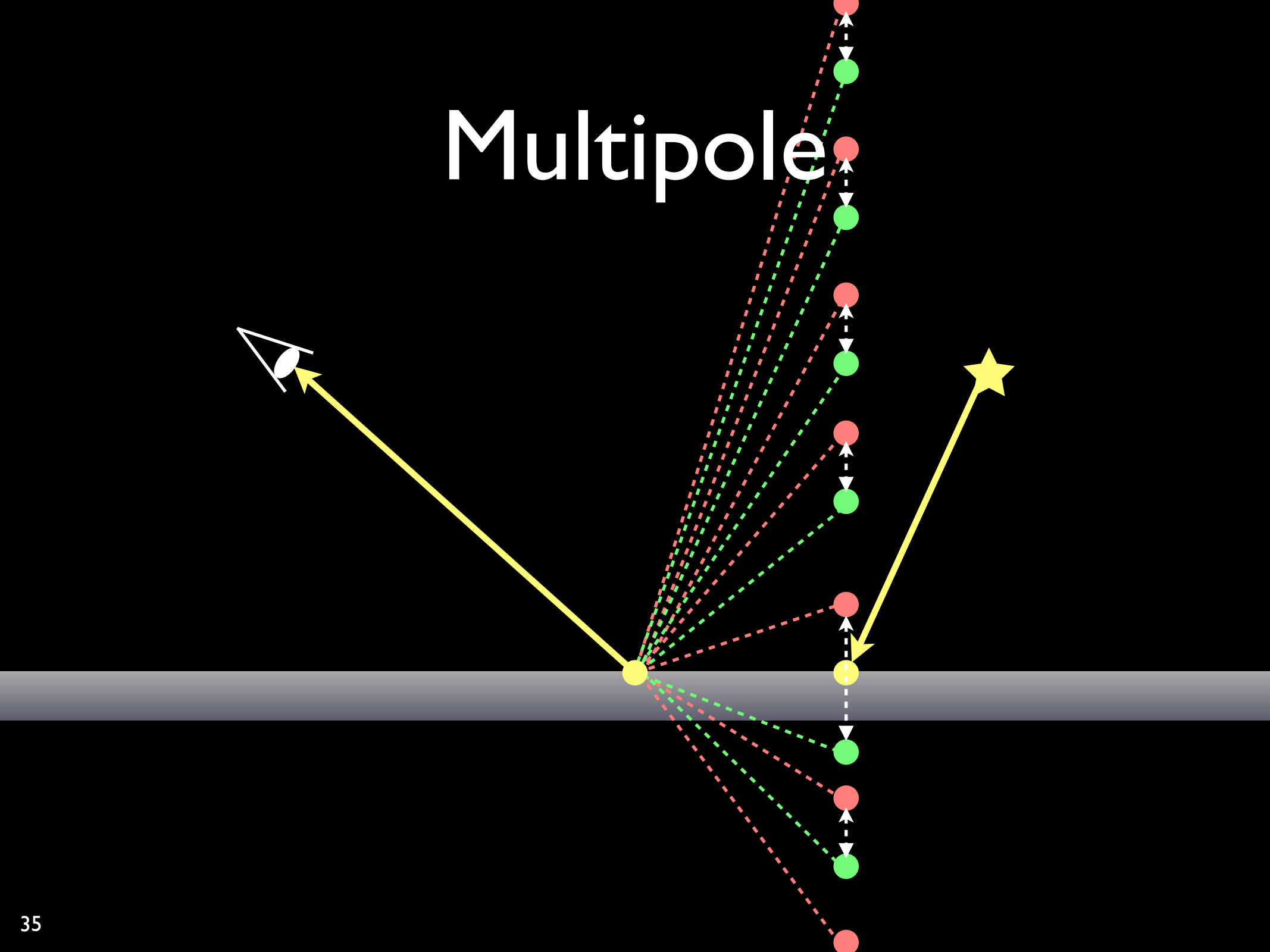
Multipole



Multipole



Multipole



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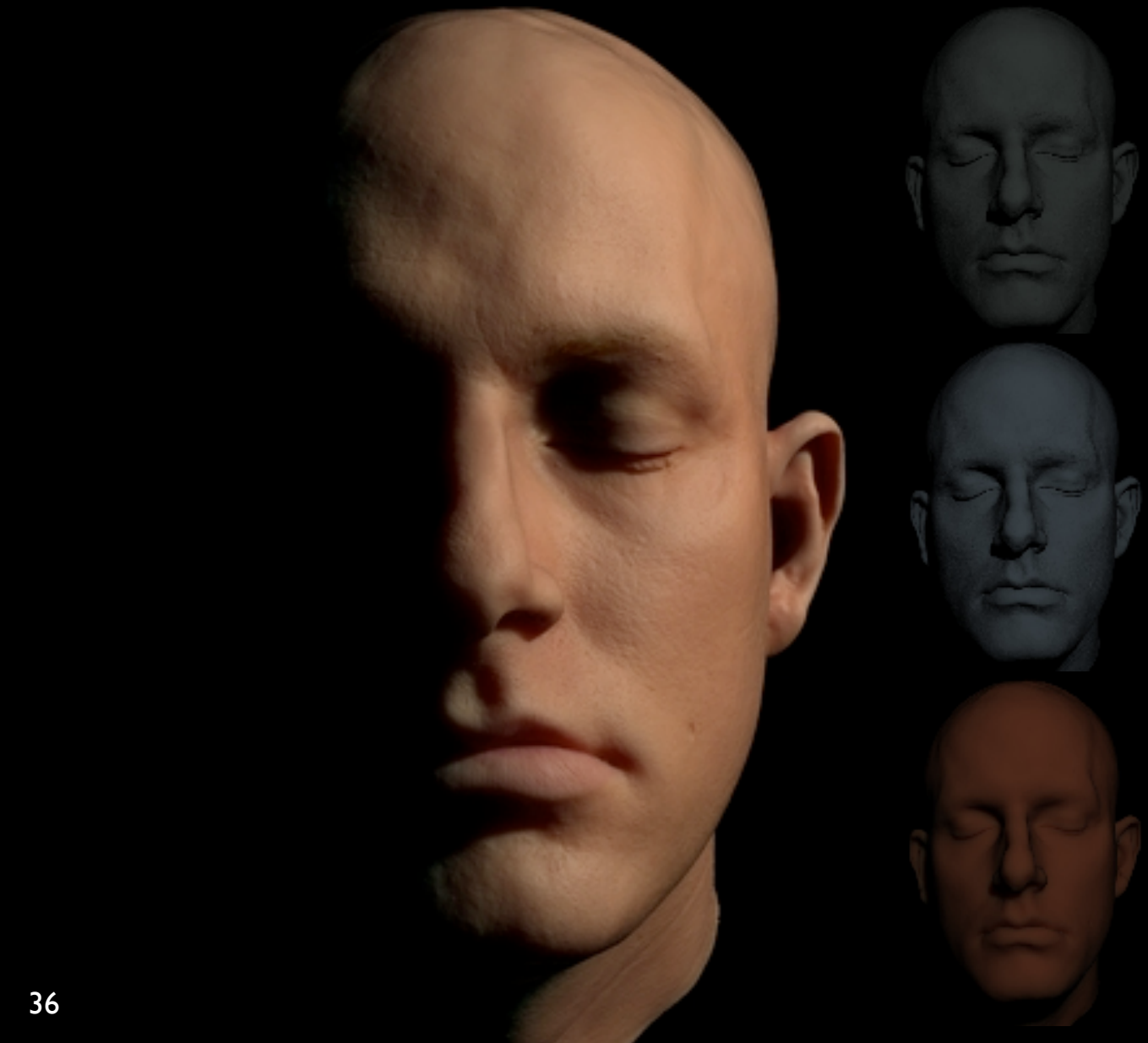

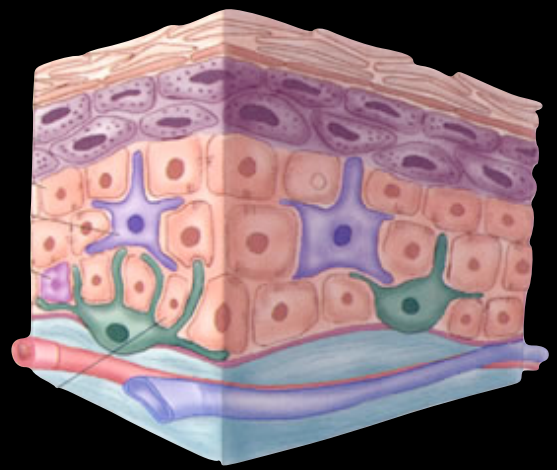

[Donner & Jensen 2005]

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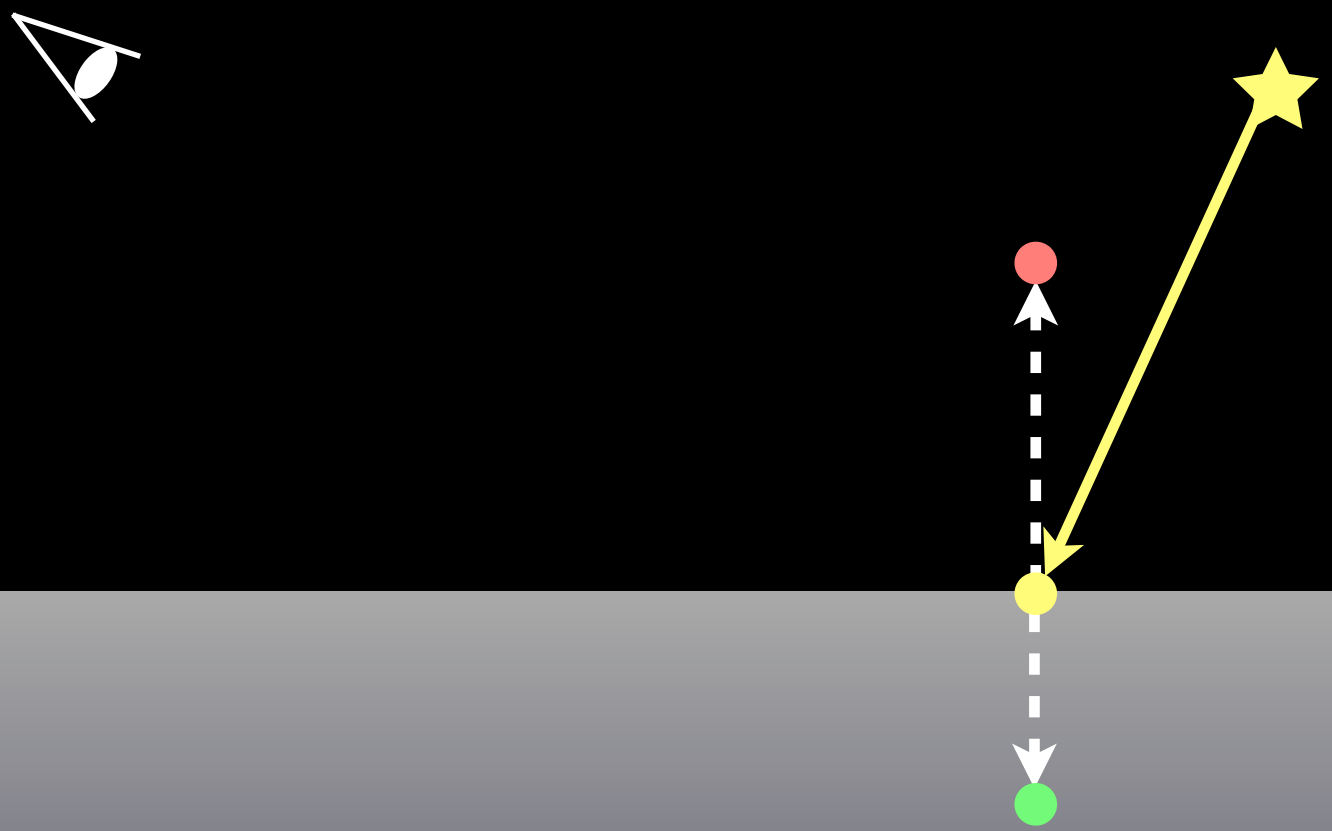
Quantized Diffusion



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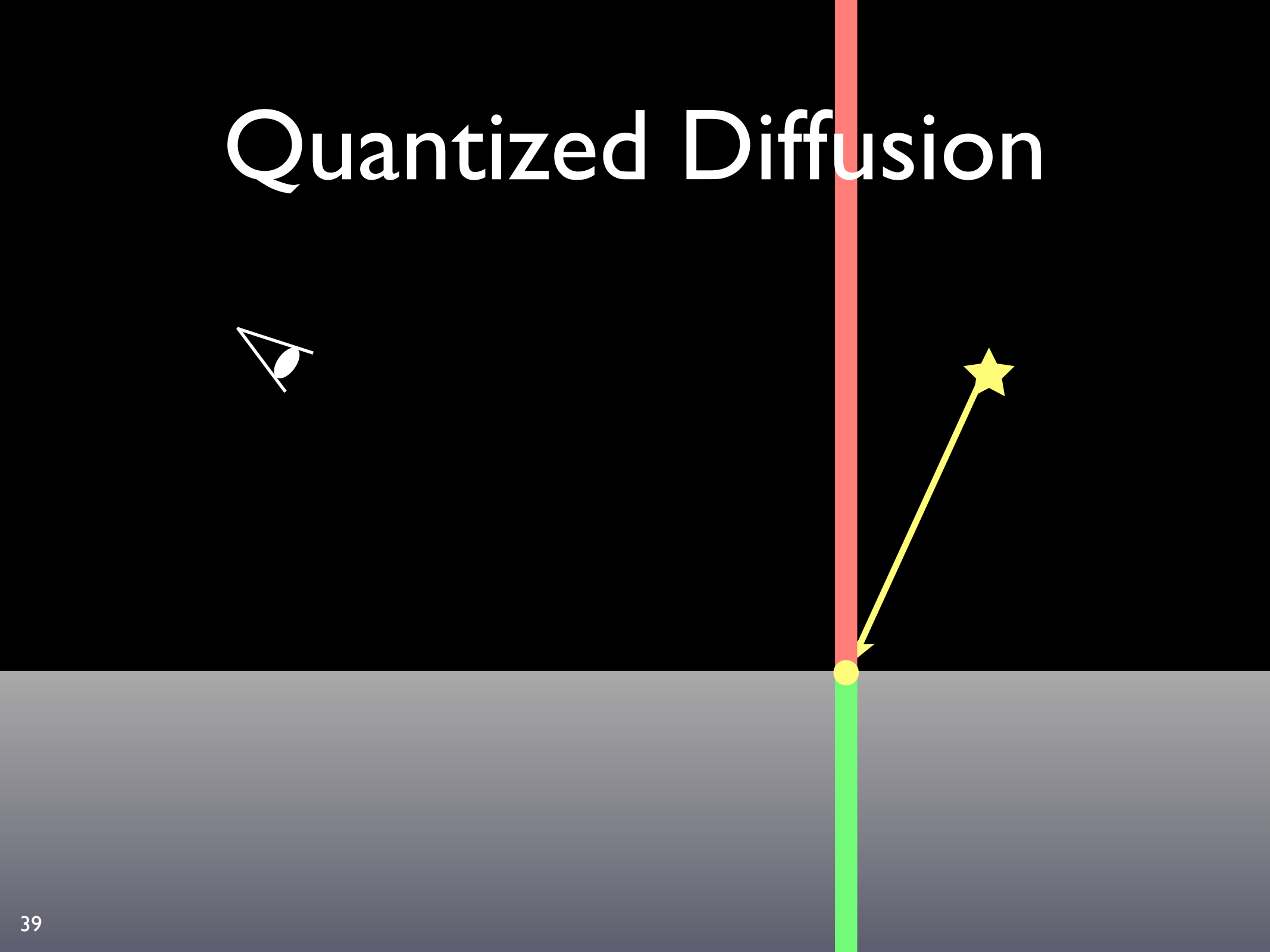

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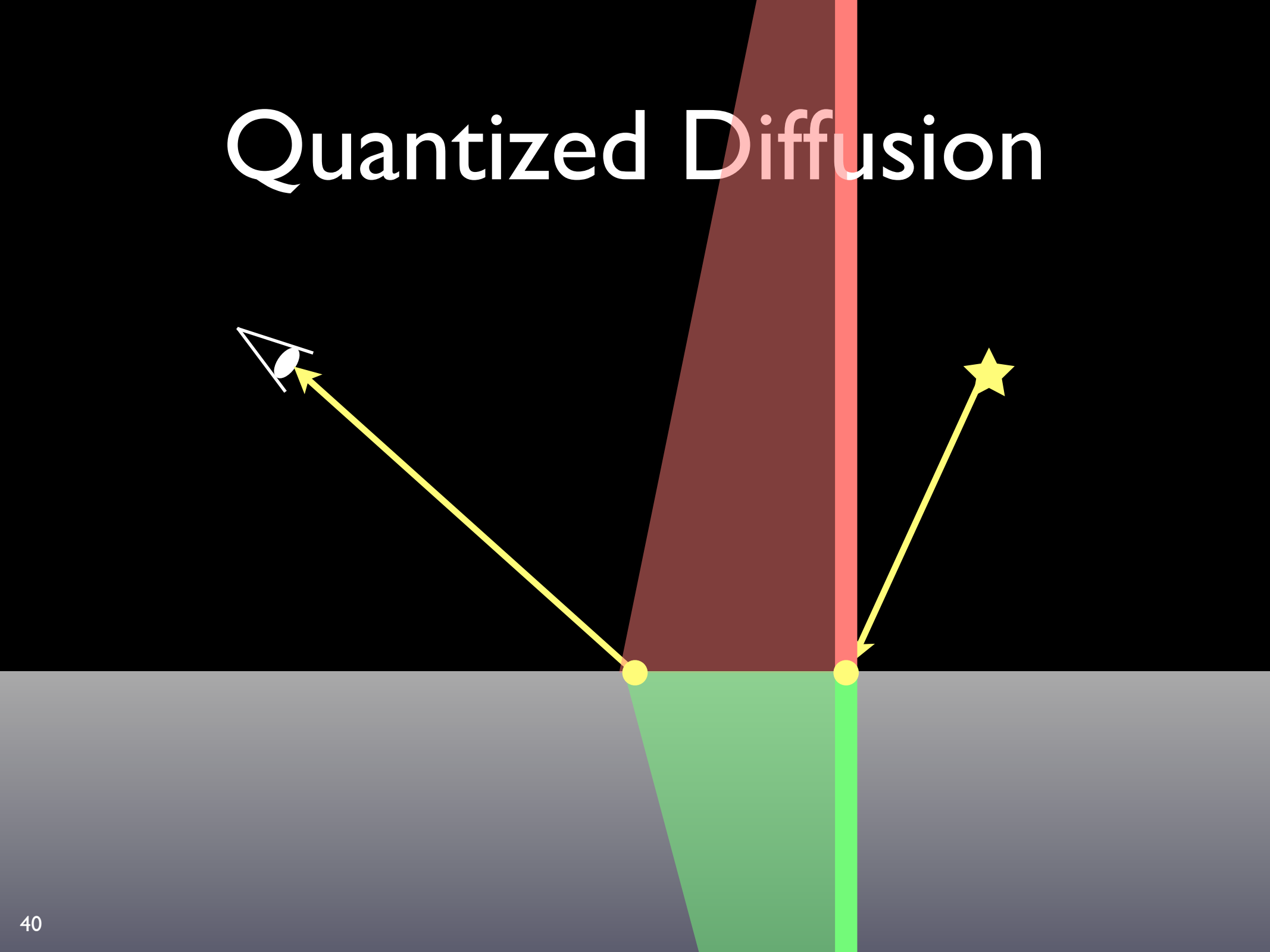

Quantized Diffusion

Dipole

Quantized Diffusion

[d'Eon & Irving 2011]

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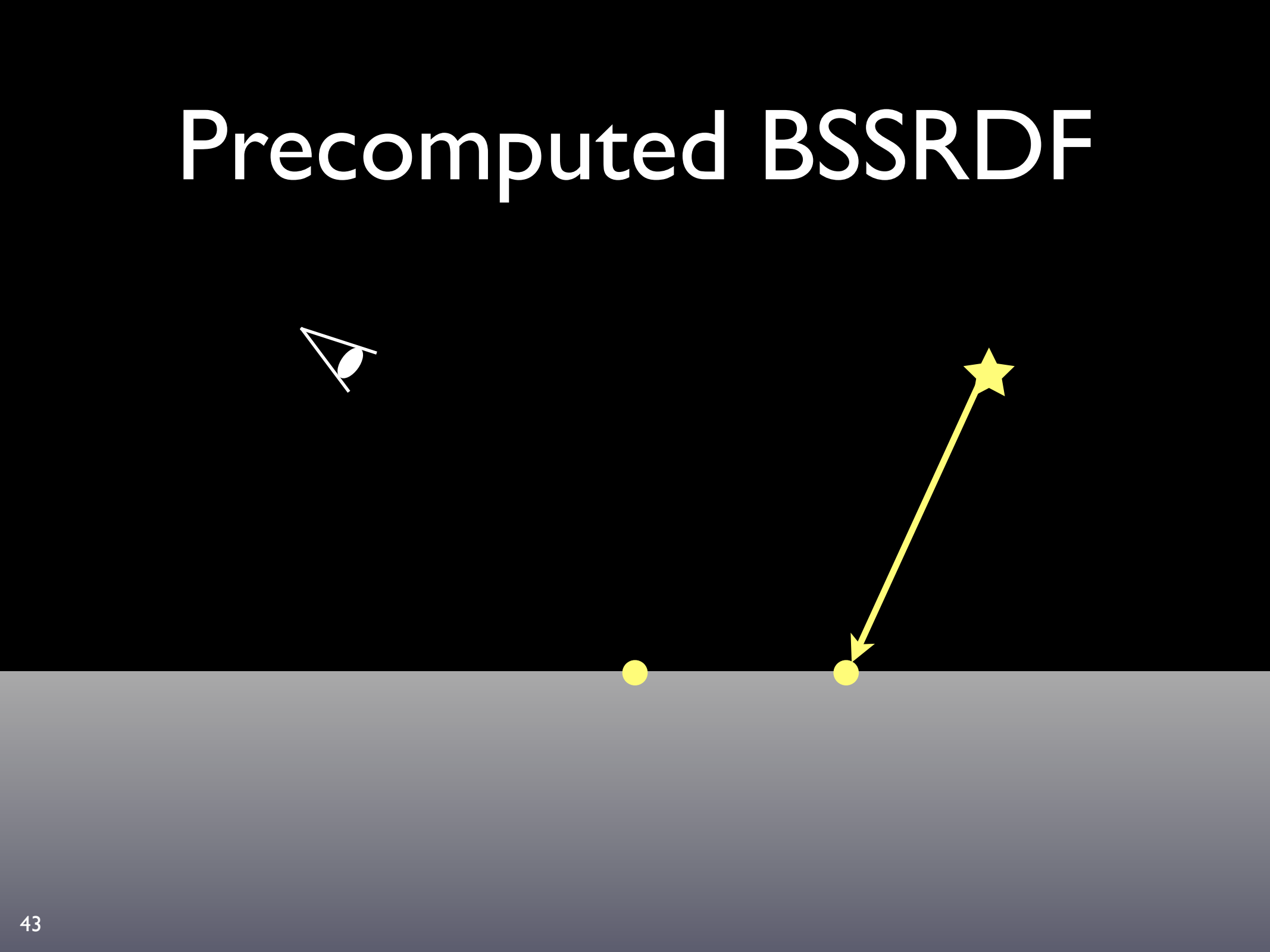
Precomputed BSSRDF



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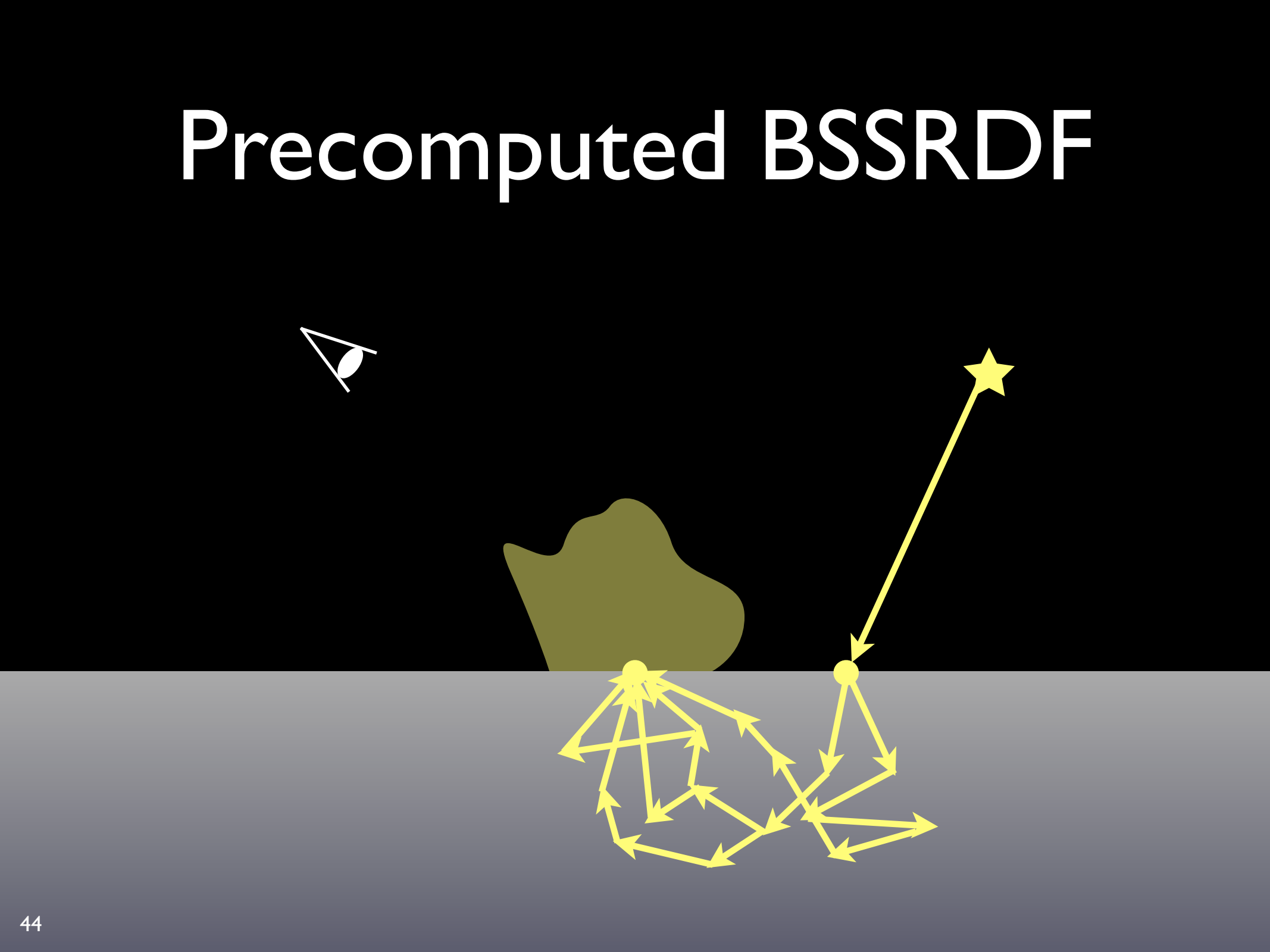

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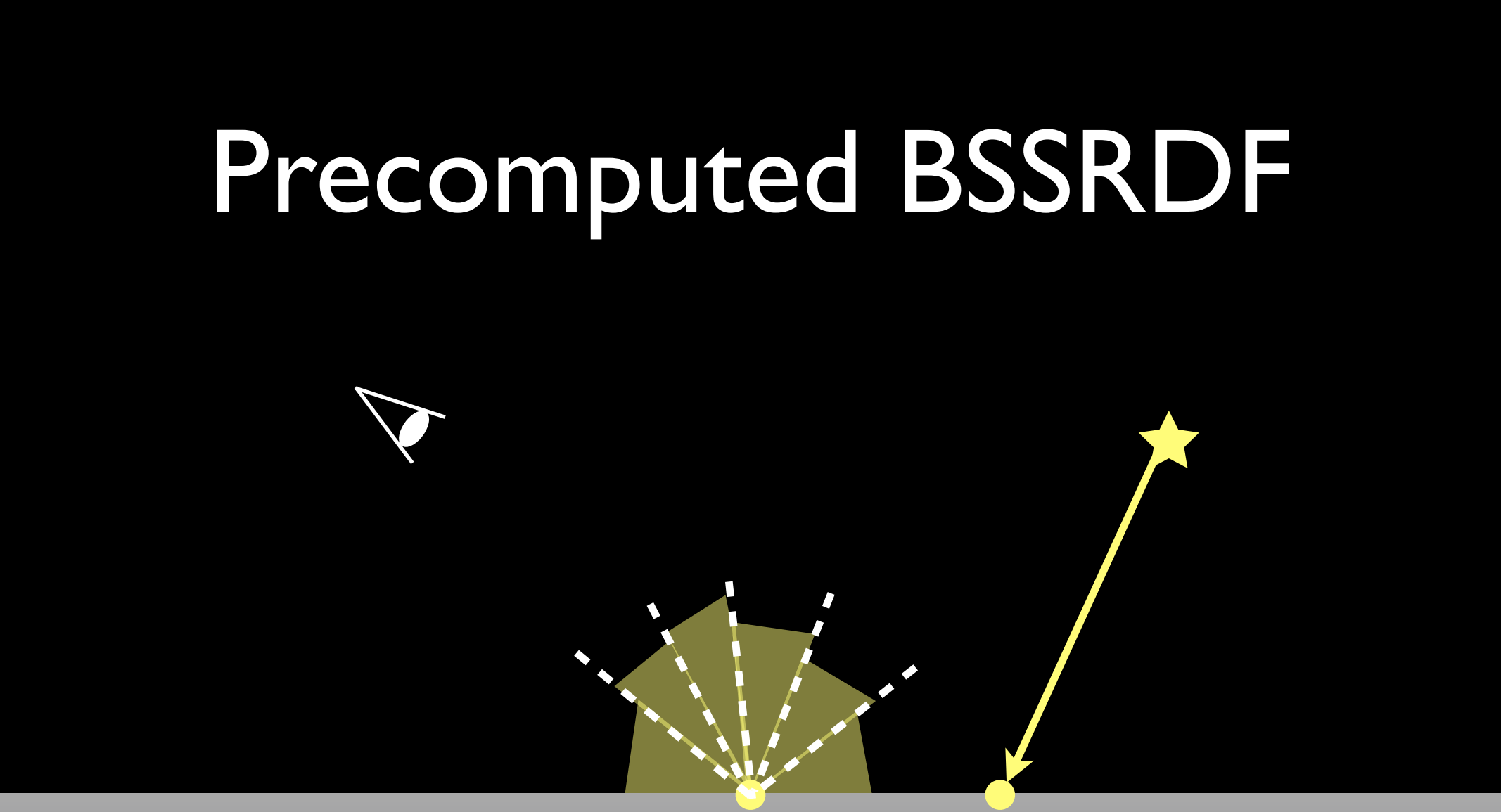

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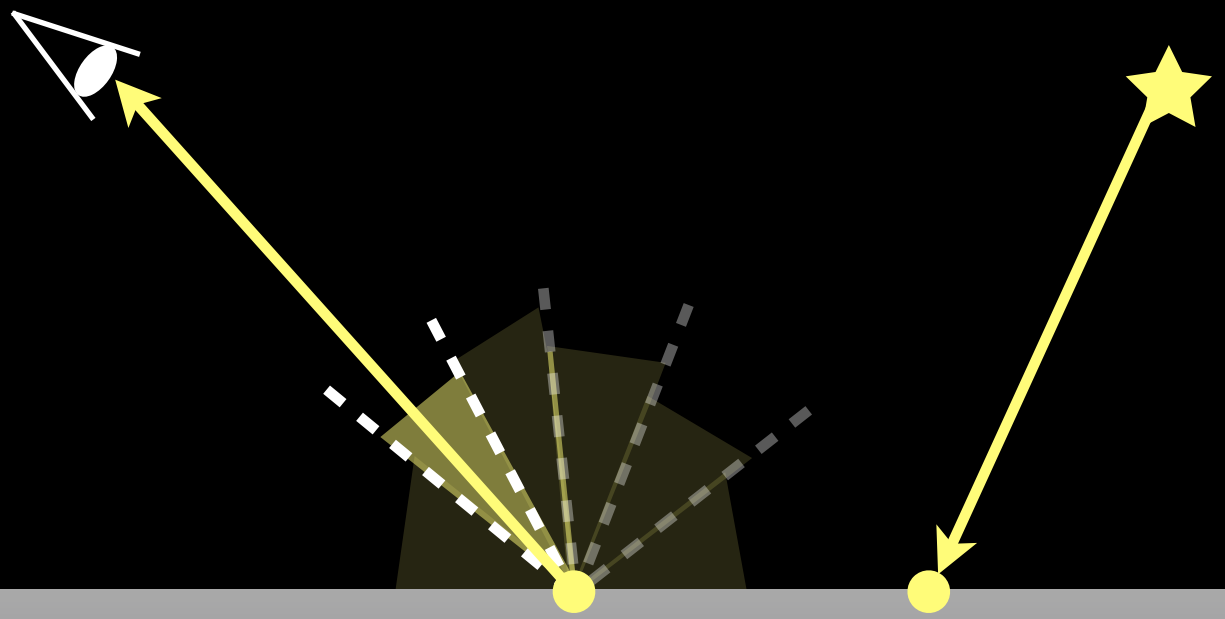

Precomputed BSSRDF

Reference
(30 hours)

Dipole
(10 min)

Precomputed
(30 min)

[Donner et al. 2009]

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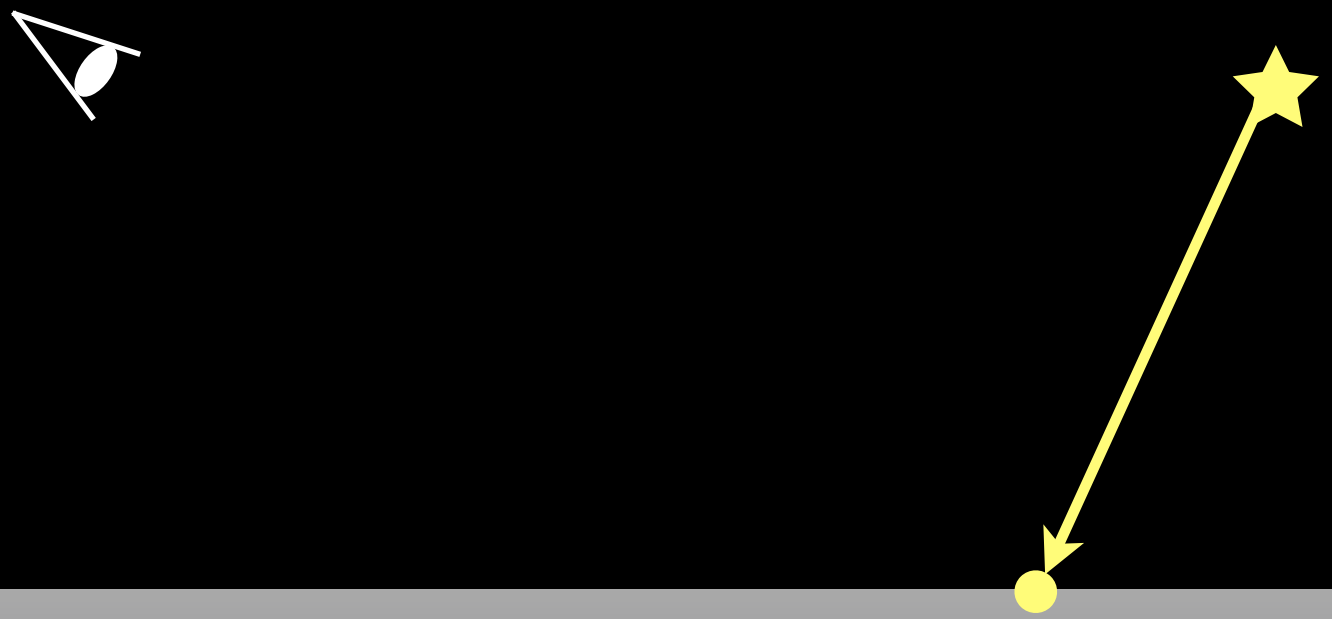
Photon Diffusion



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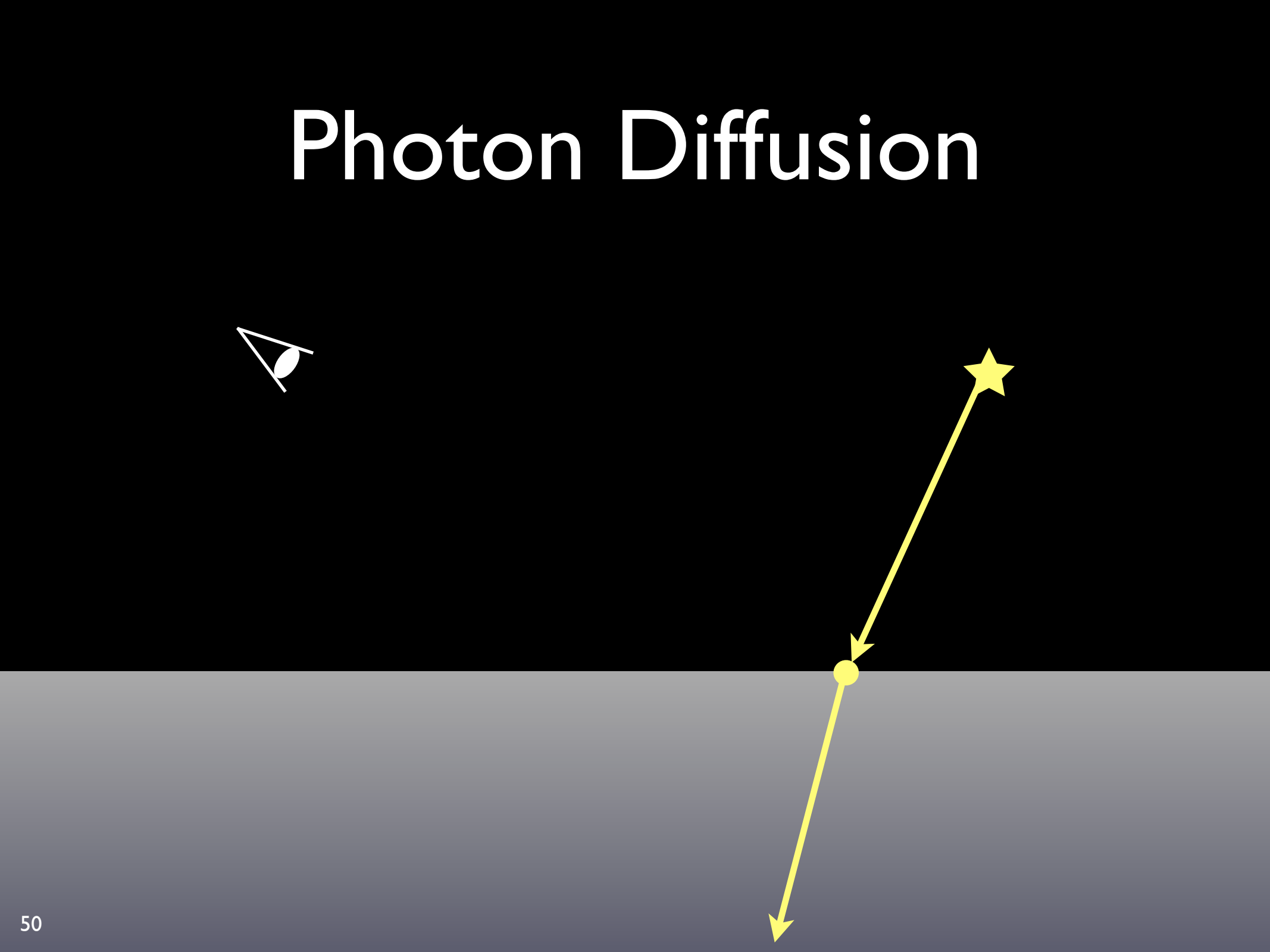

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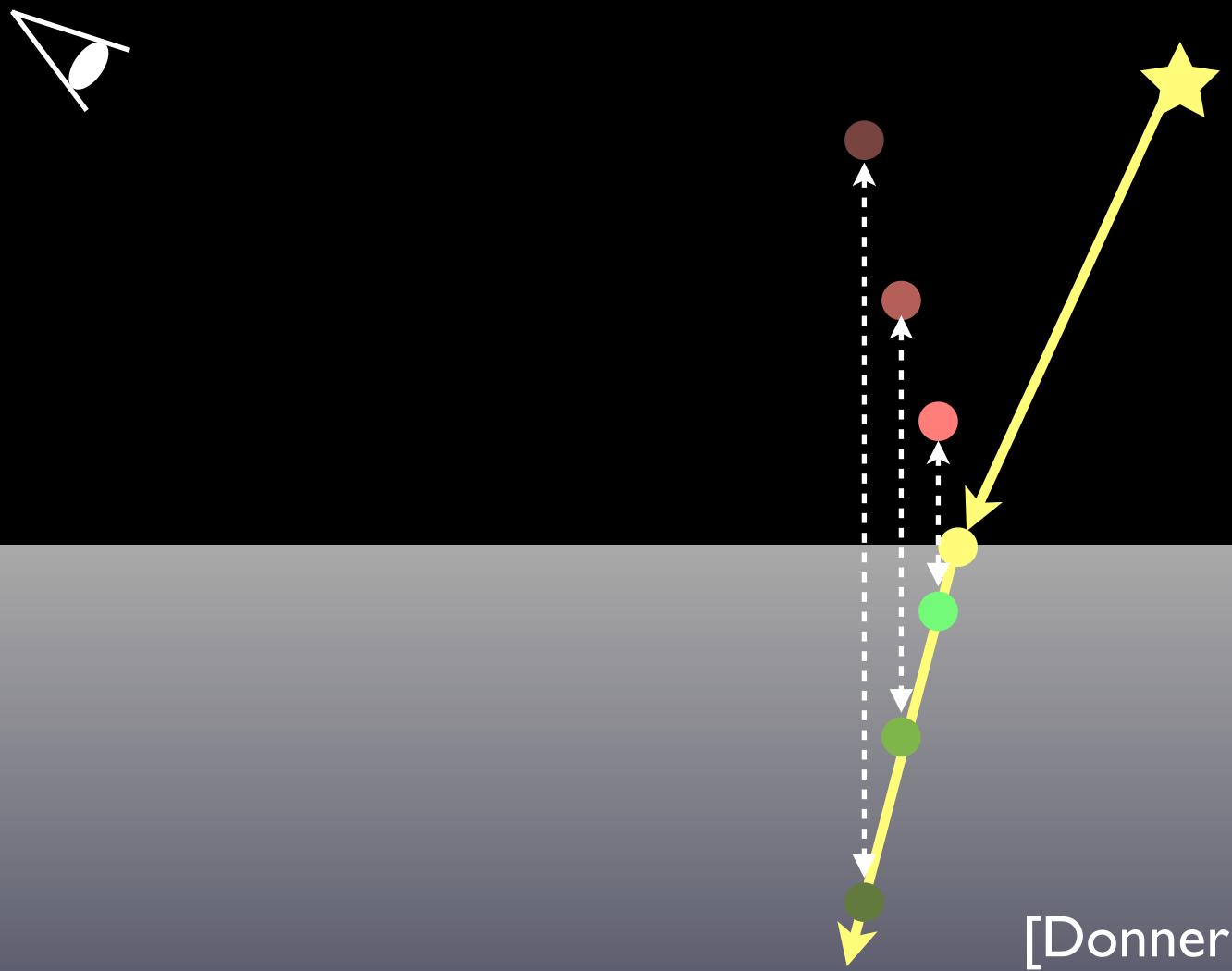
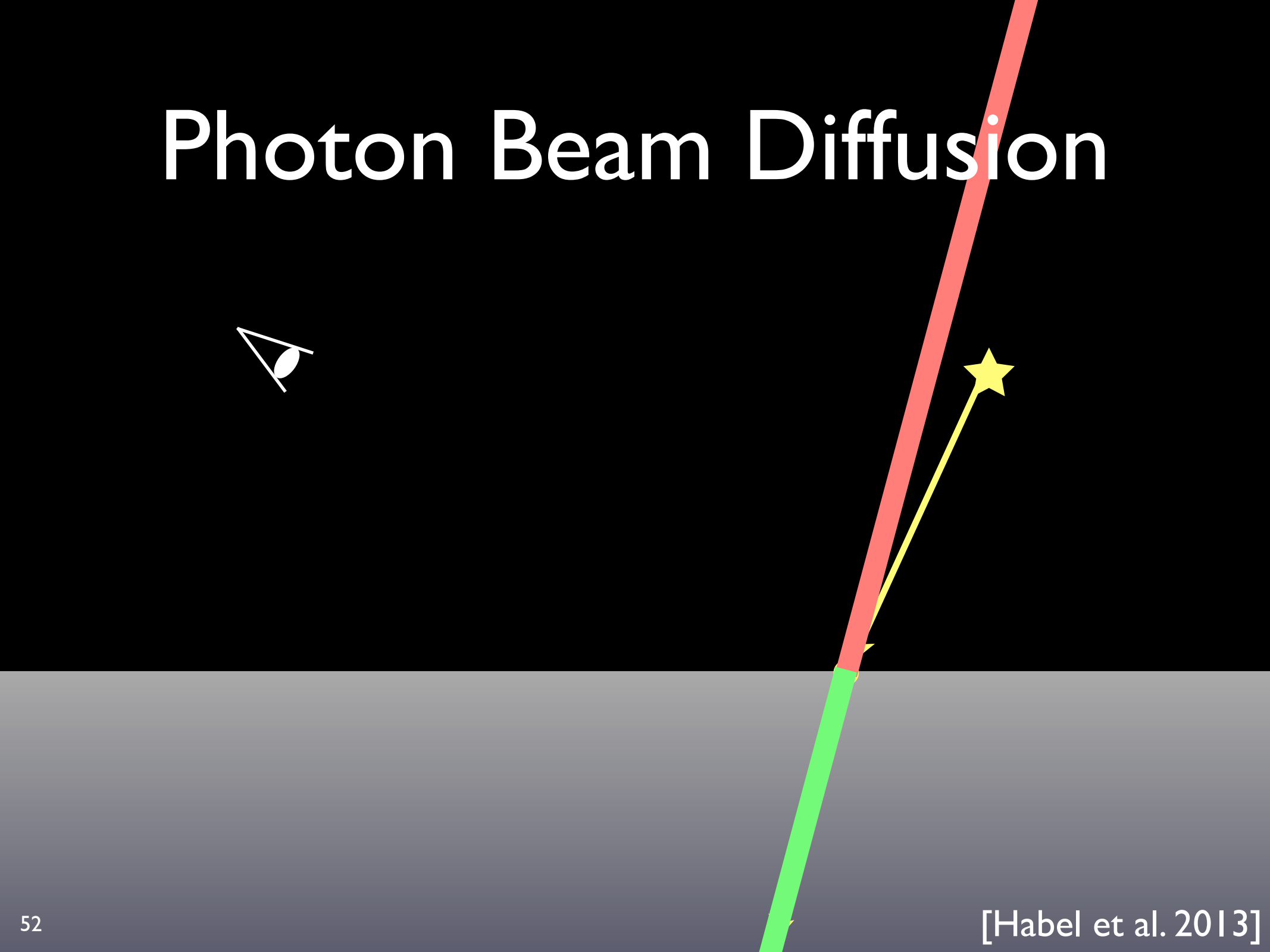


[Donner & Jensen 2007]

Photon Beam Diffusion



[Habel et al. 2013]

Photon Diffusion

Dipole

Photon Diffusion

[Donner & Jensen 2007]

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- Ignores incoming light direction
- Requires no precomputation
- Provides fully analytical function

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  - Considers incoming light direction
  - Requires precomputation
  - Provides fully analytical function

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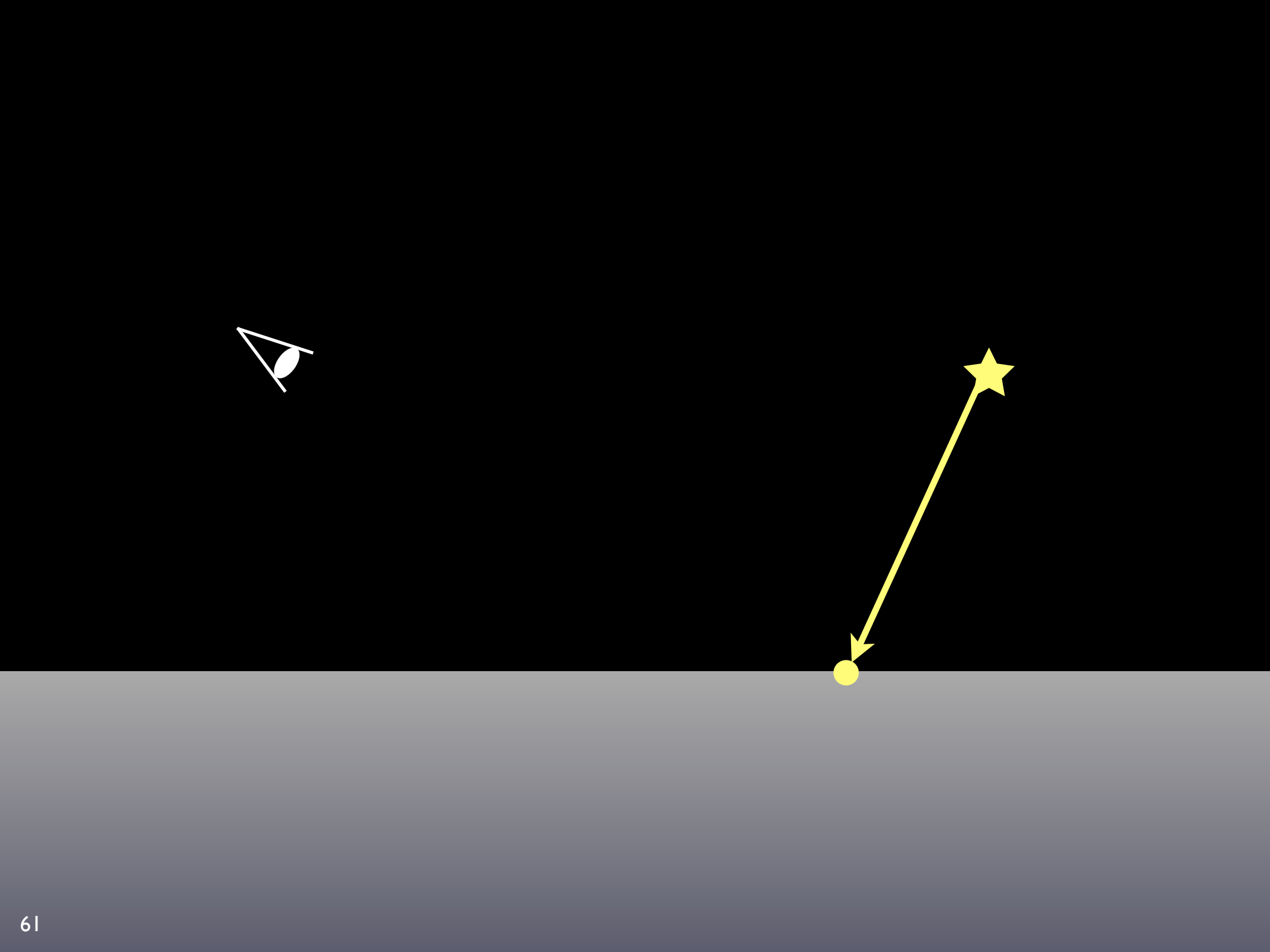
  - Considers incoming light direction
  - Requires no precomputation
  - Relies on numerical integration

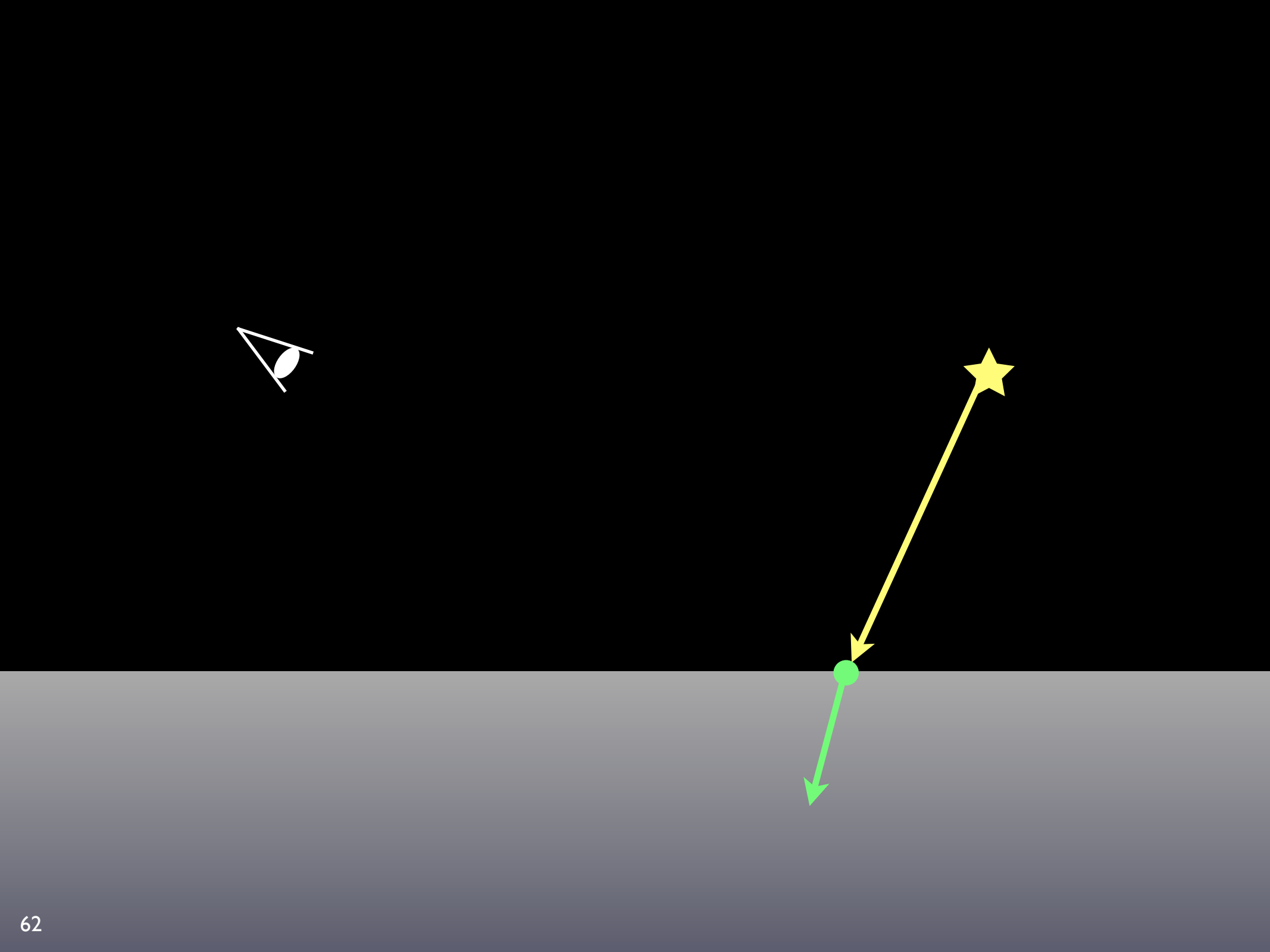
Contributions

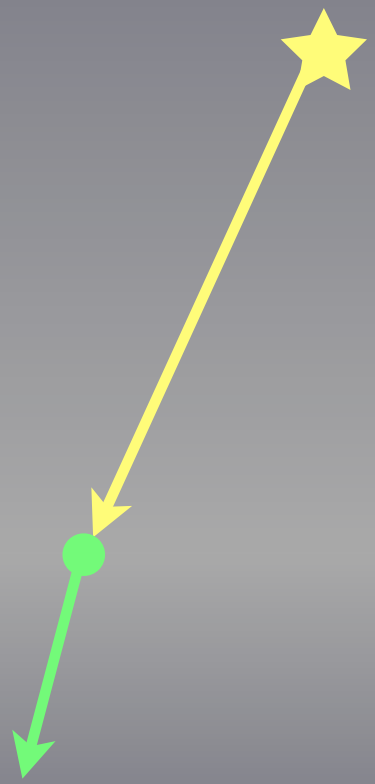
- First BSSRDF which...
  - Considers incoming light direction
  - Requires no precomputation
  - Provides fully analytical function

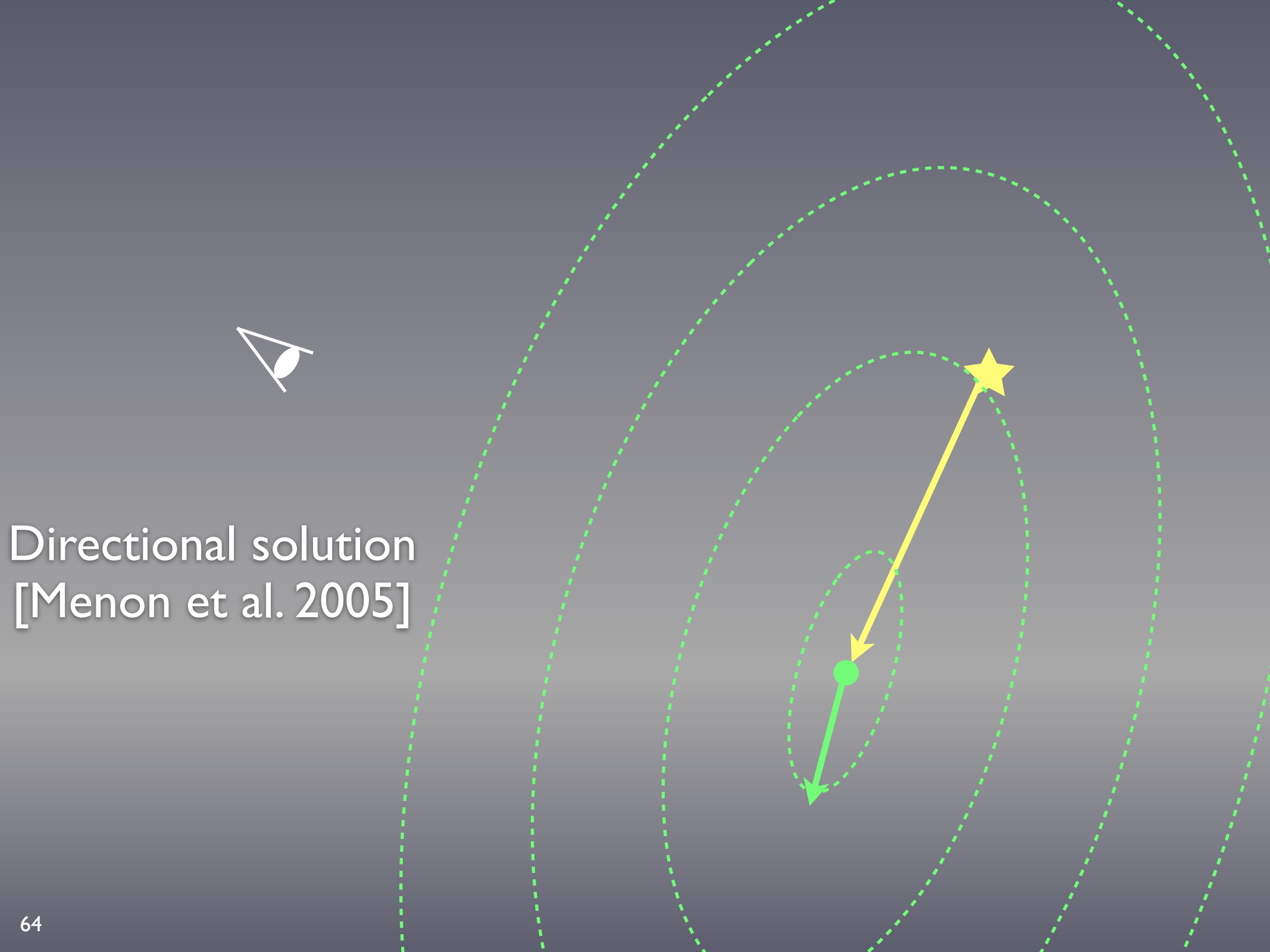
Dipole
Quantized
Our Model
Reference

Idea

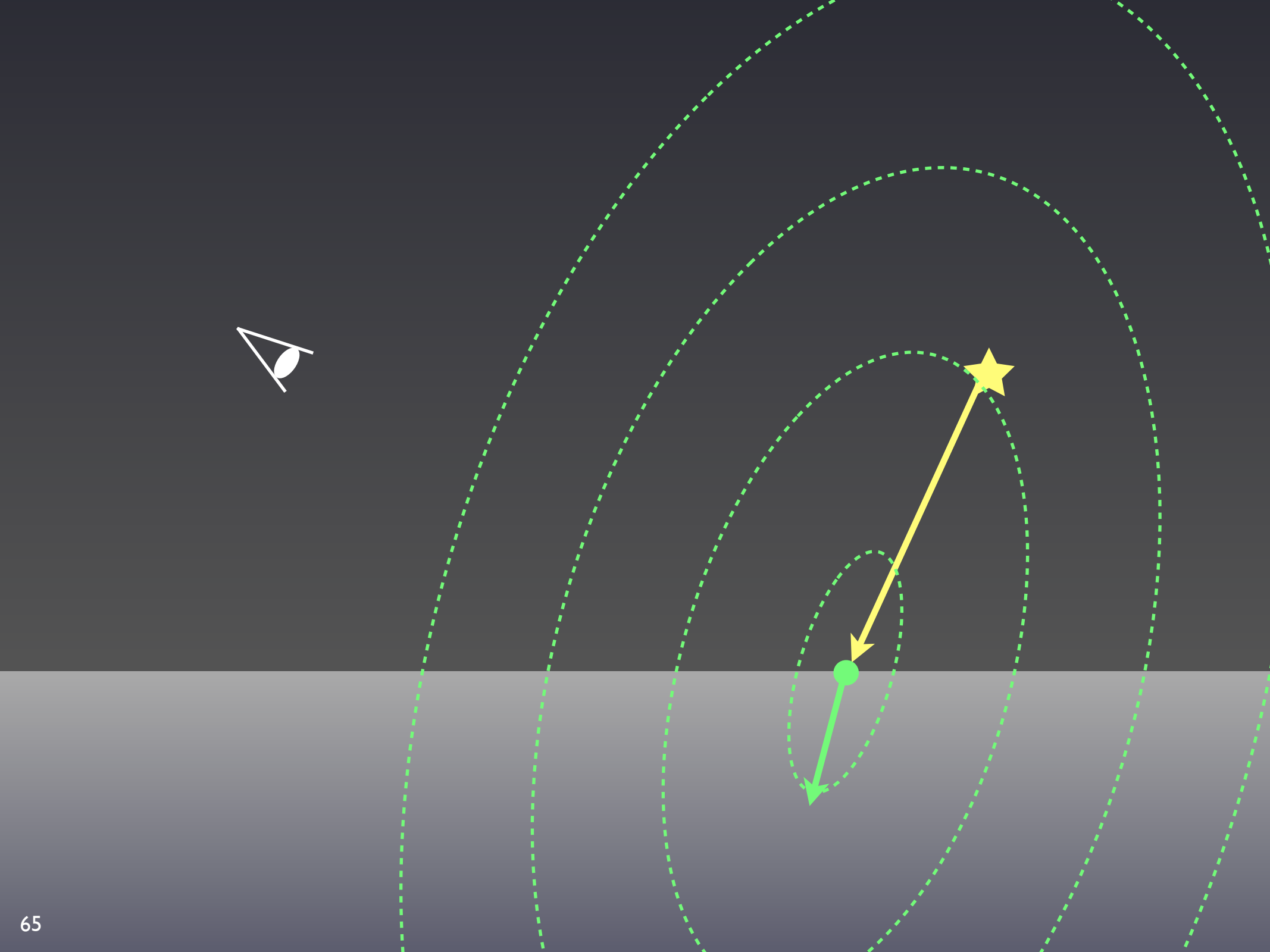


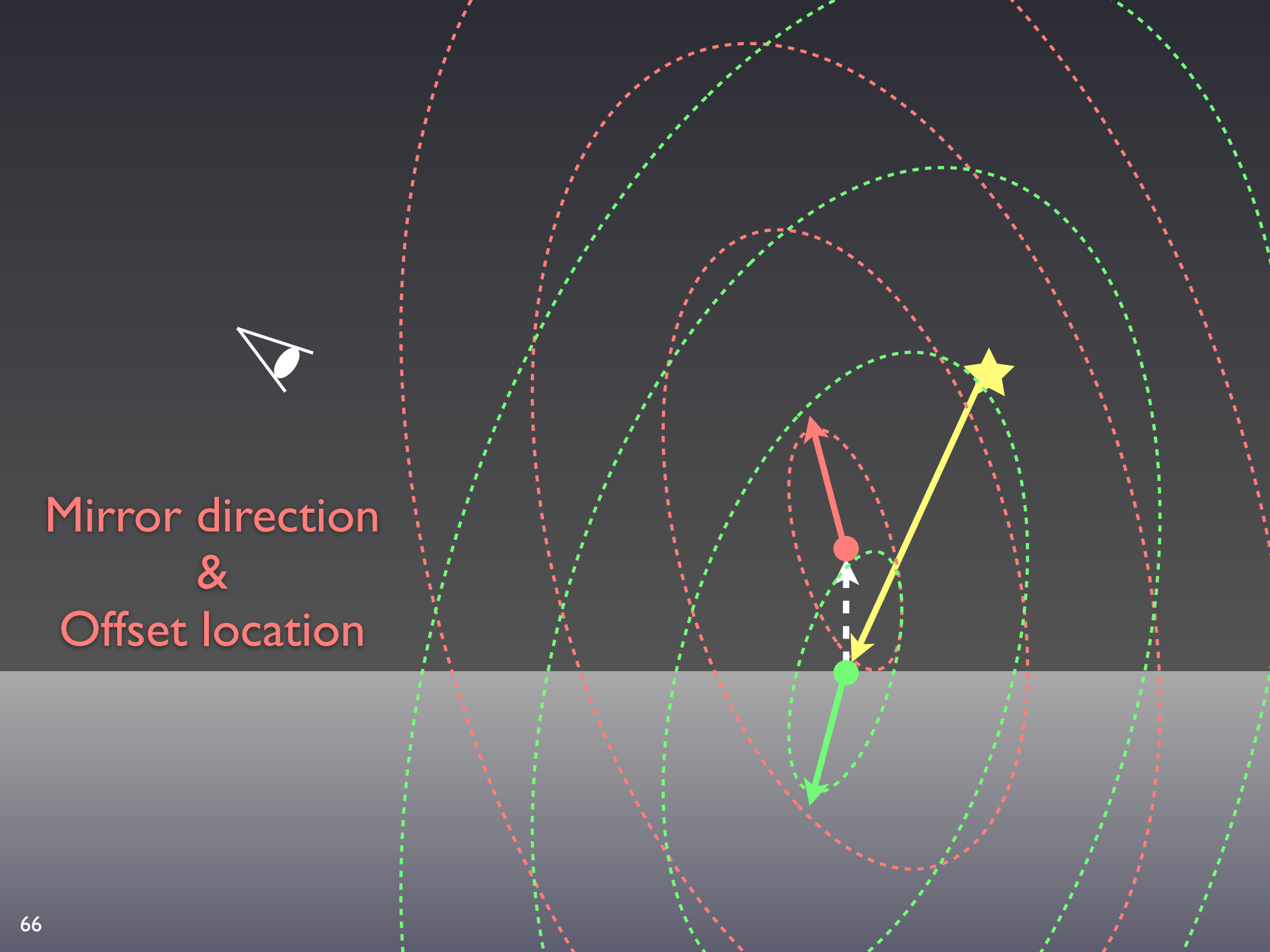


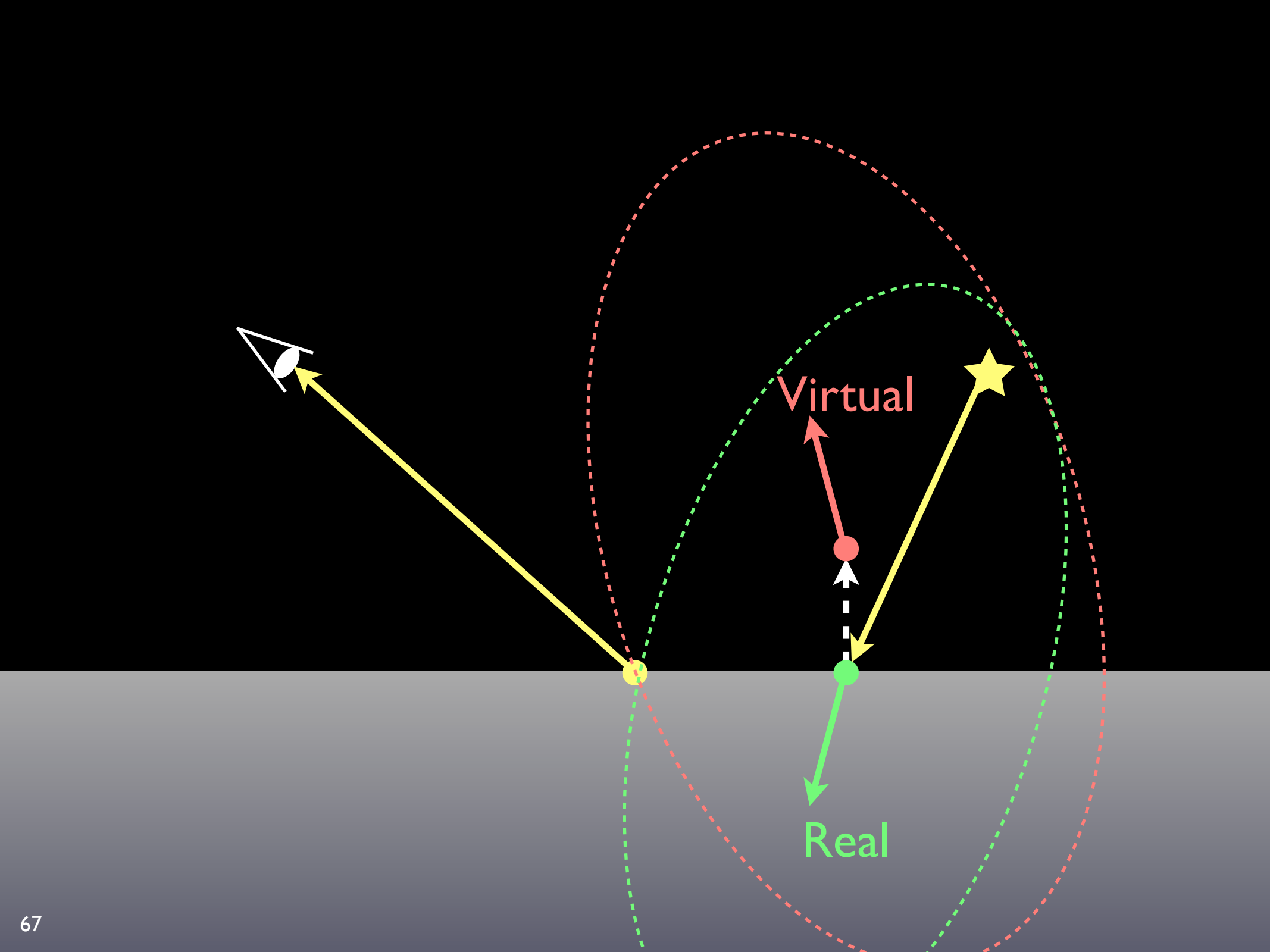




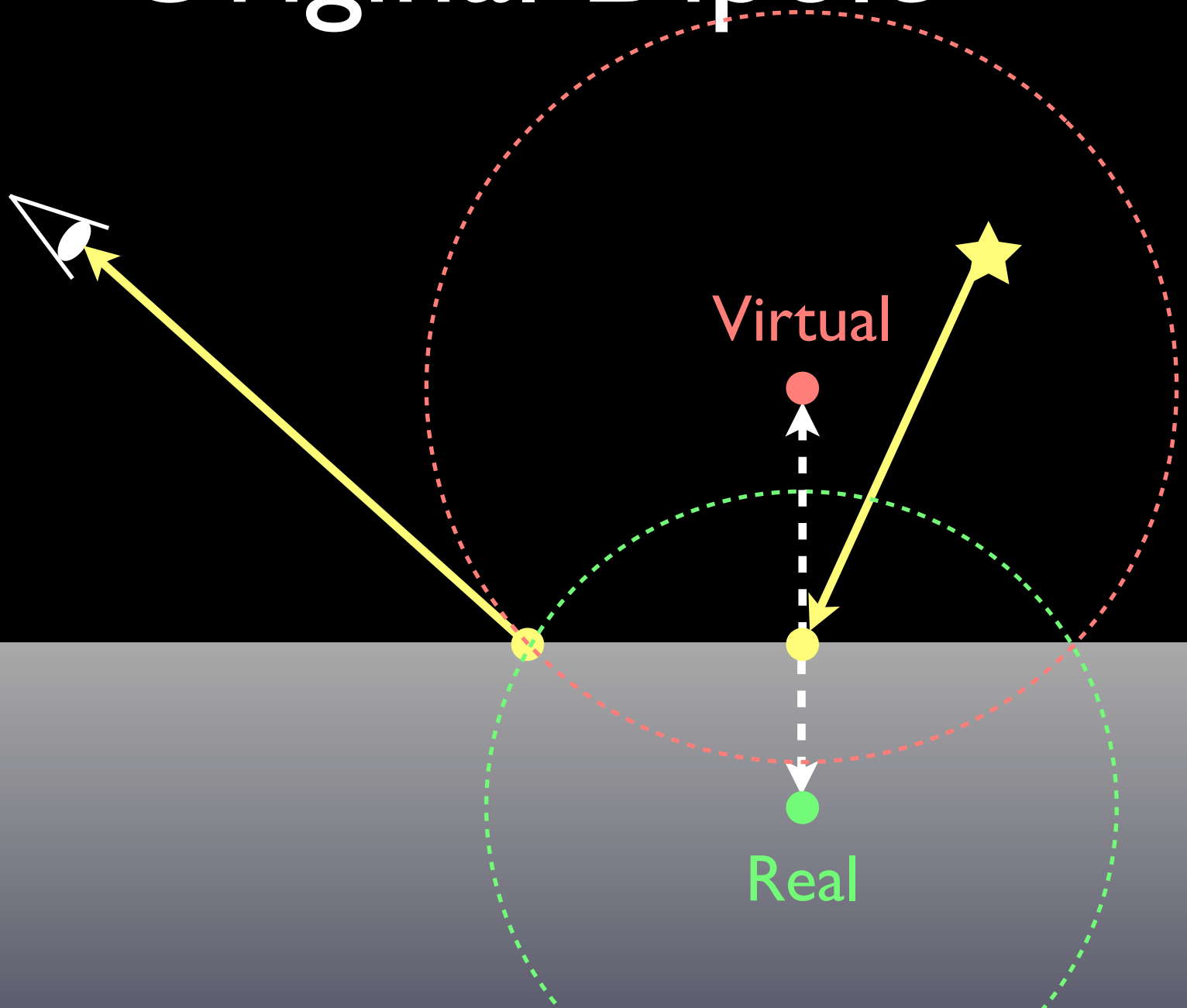
Directional solution
[Menon et al. 2005]



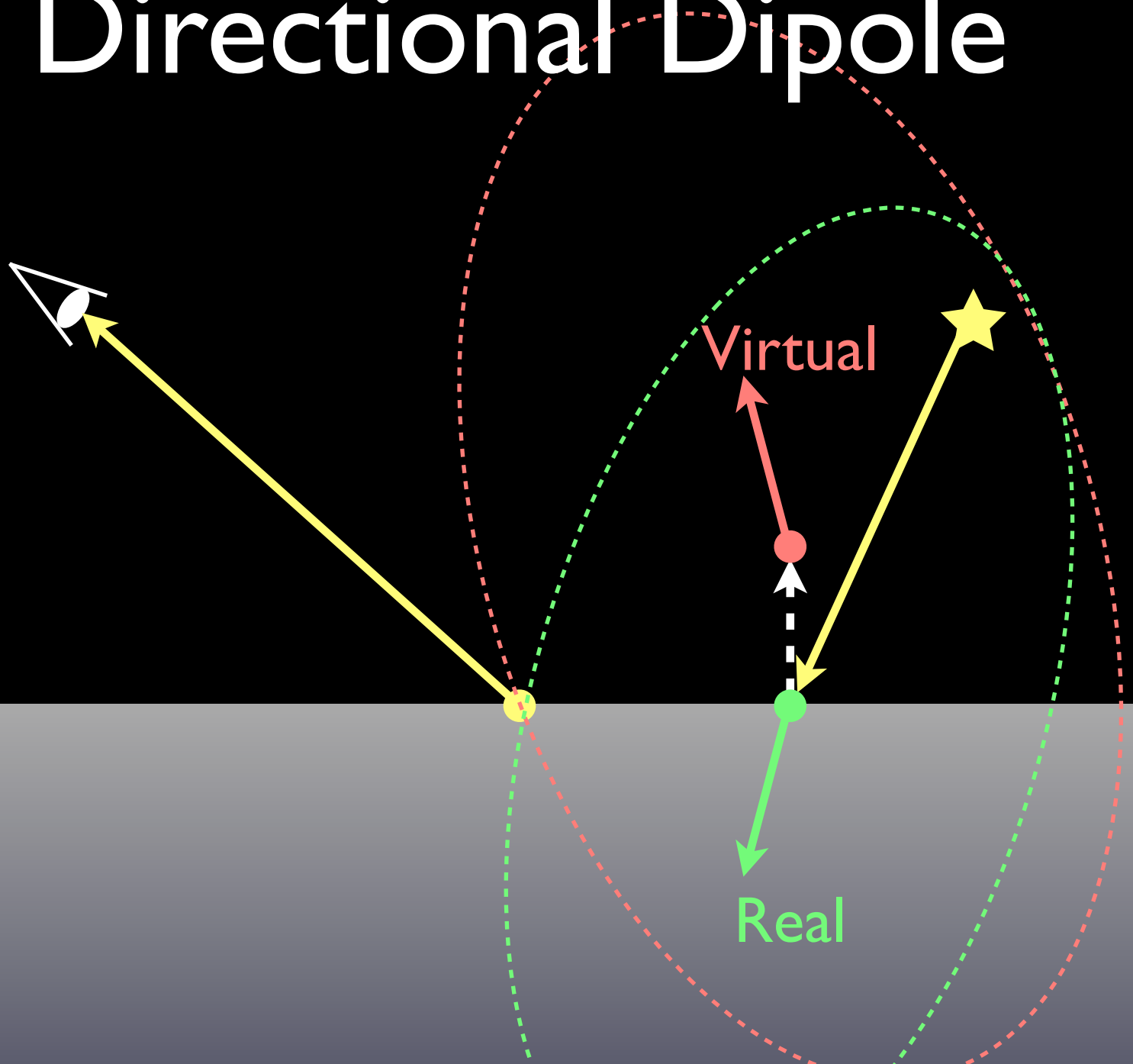

Mirror direction
&
Offset location


Virtual
Real

Original Dipole



Directional Dipole



Two Challenges

- Mirroring sources is unstable
- Singularity at the real source

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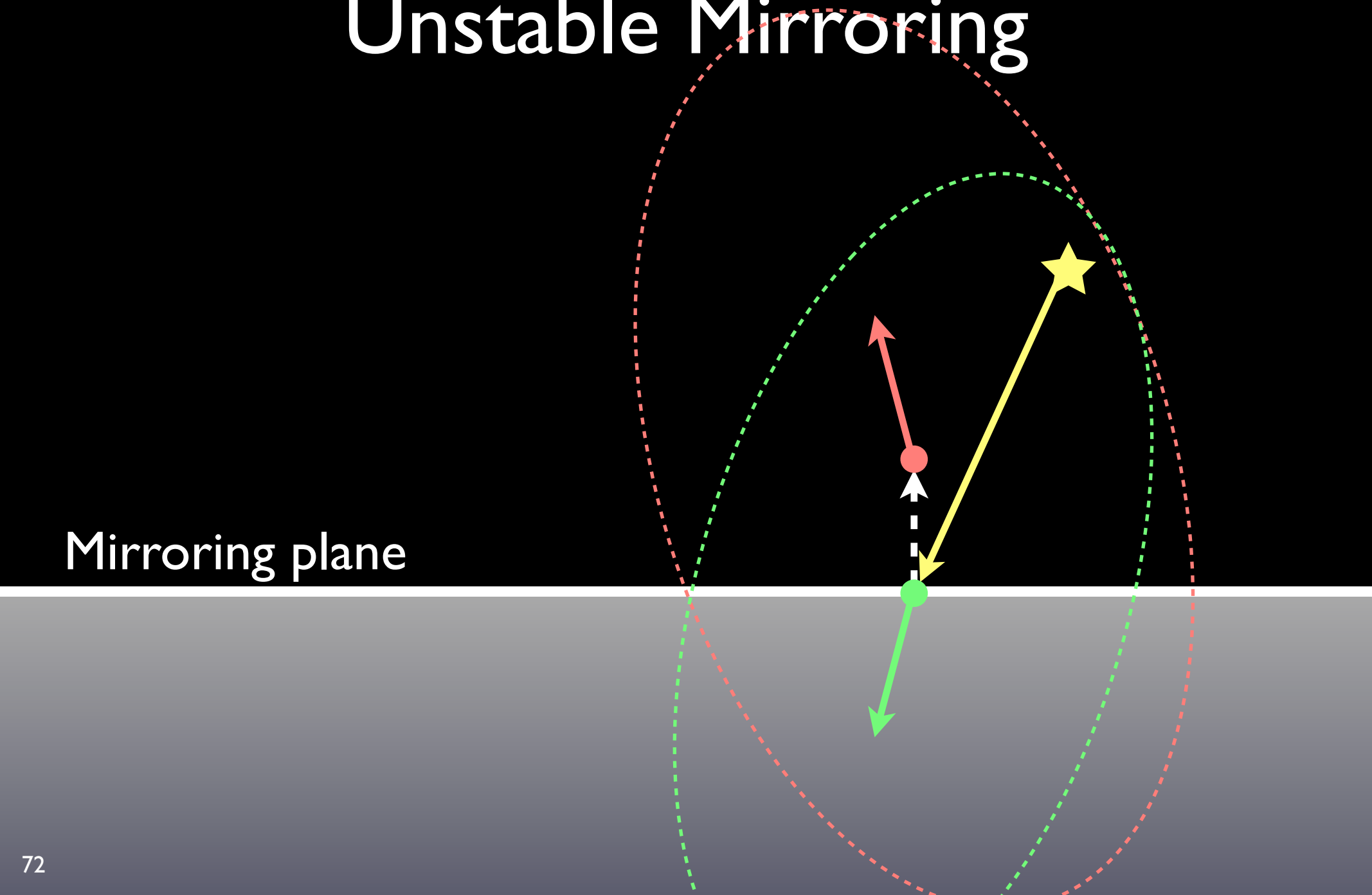
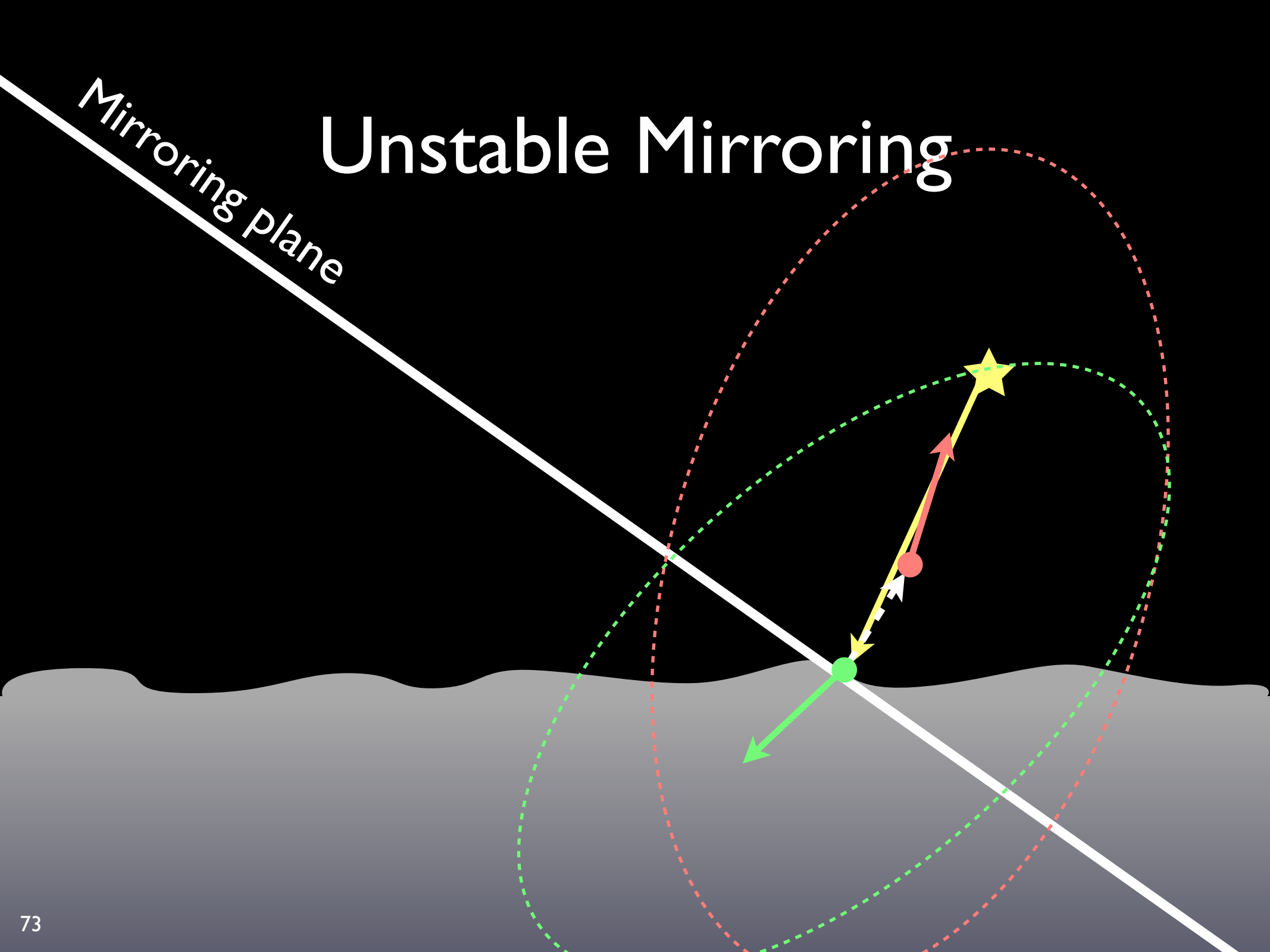
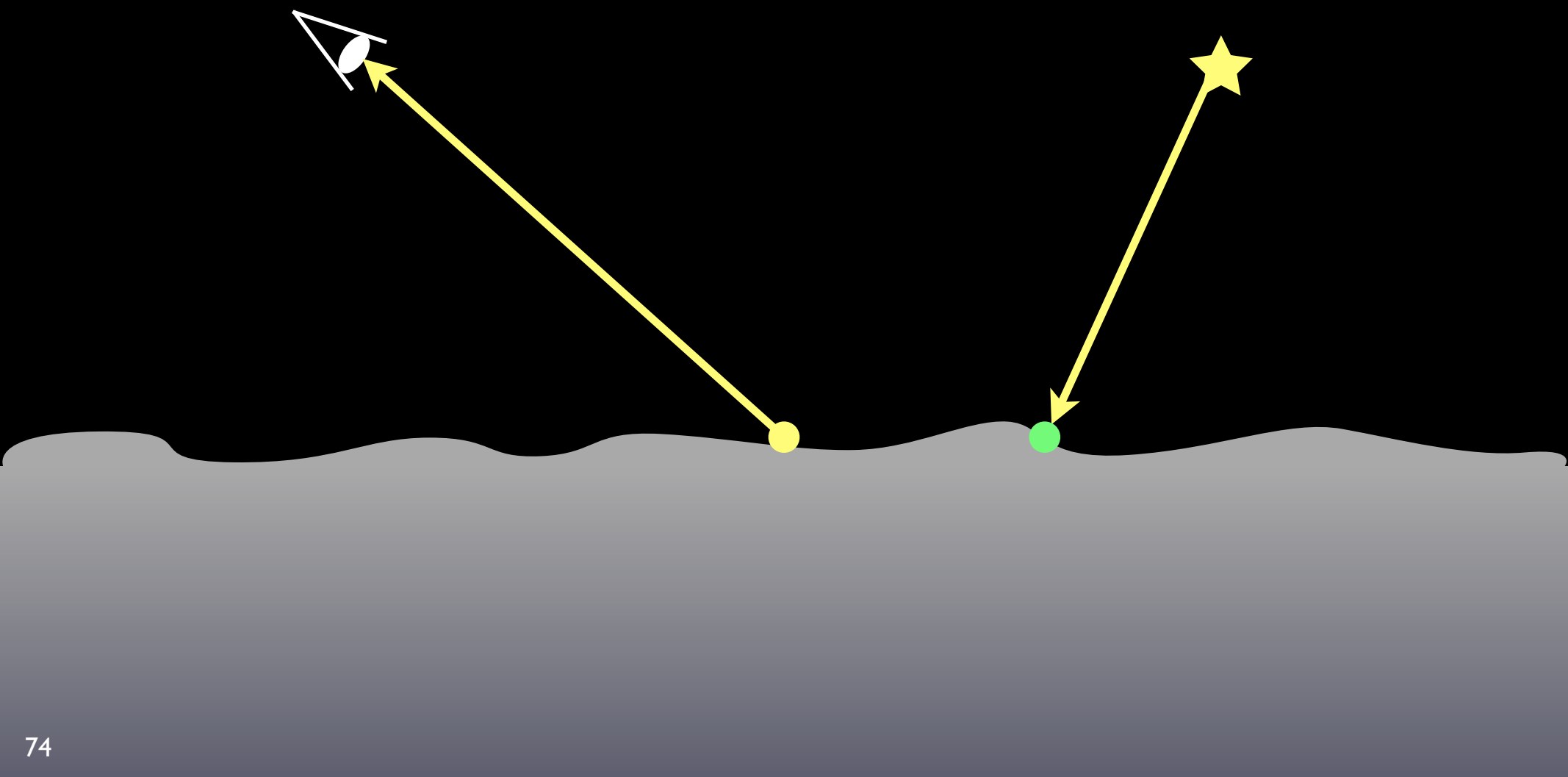
Unstable Mirroring



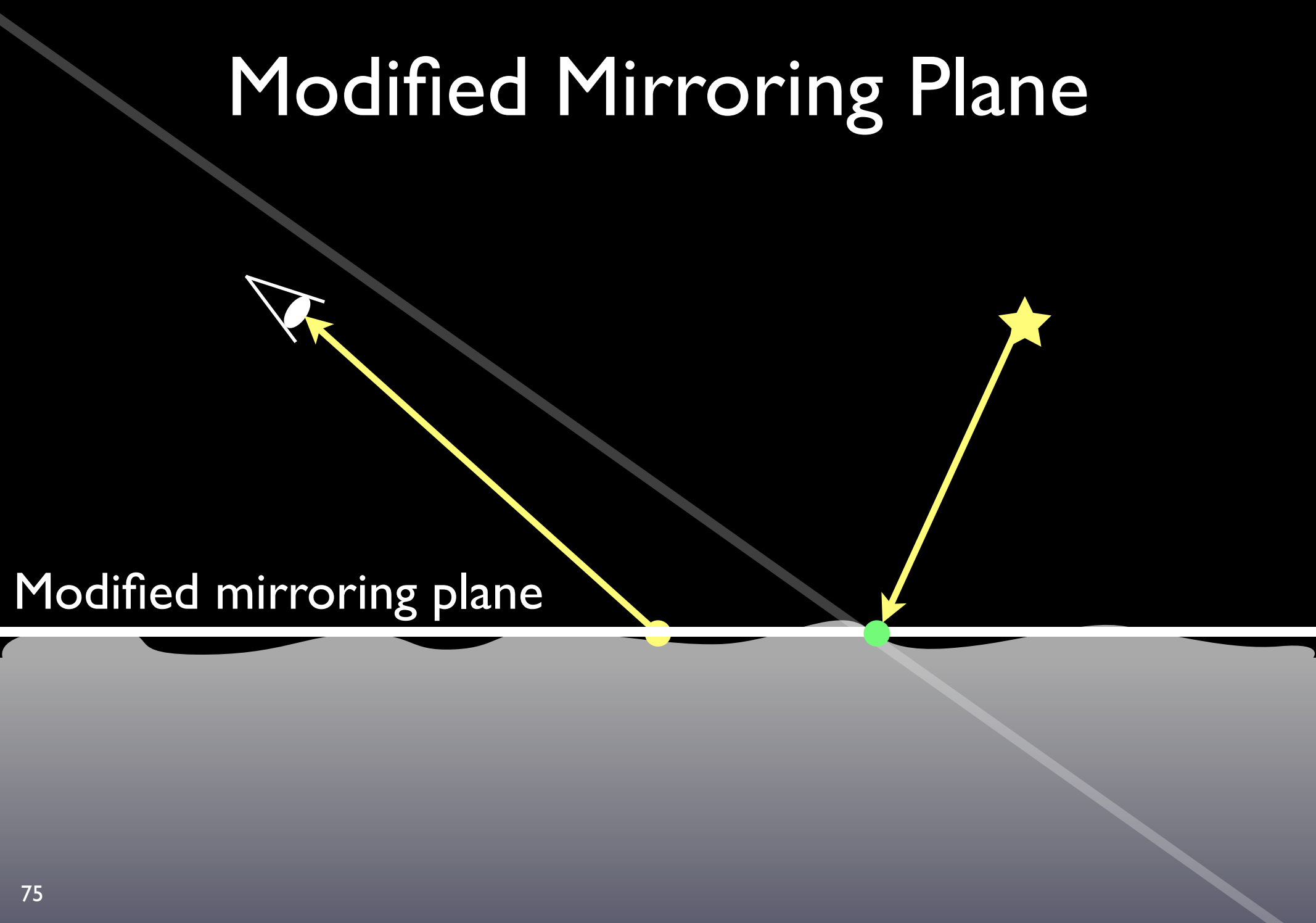
Unstable Mirroring



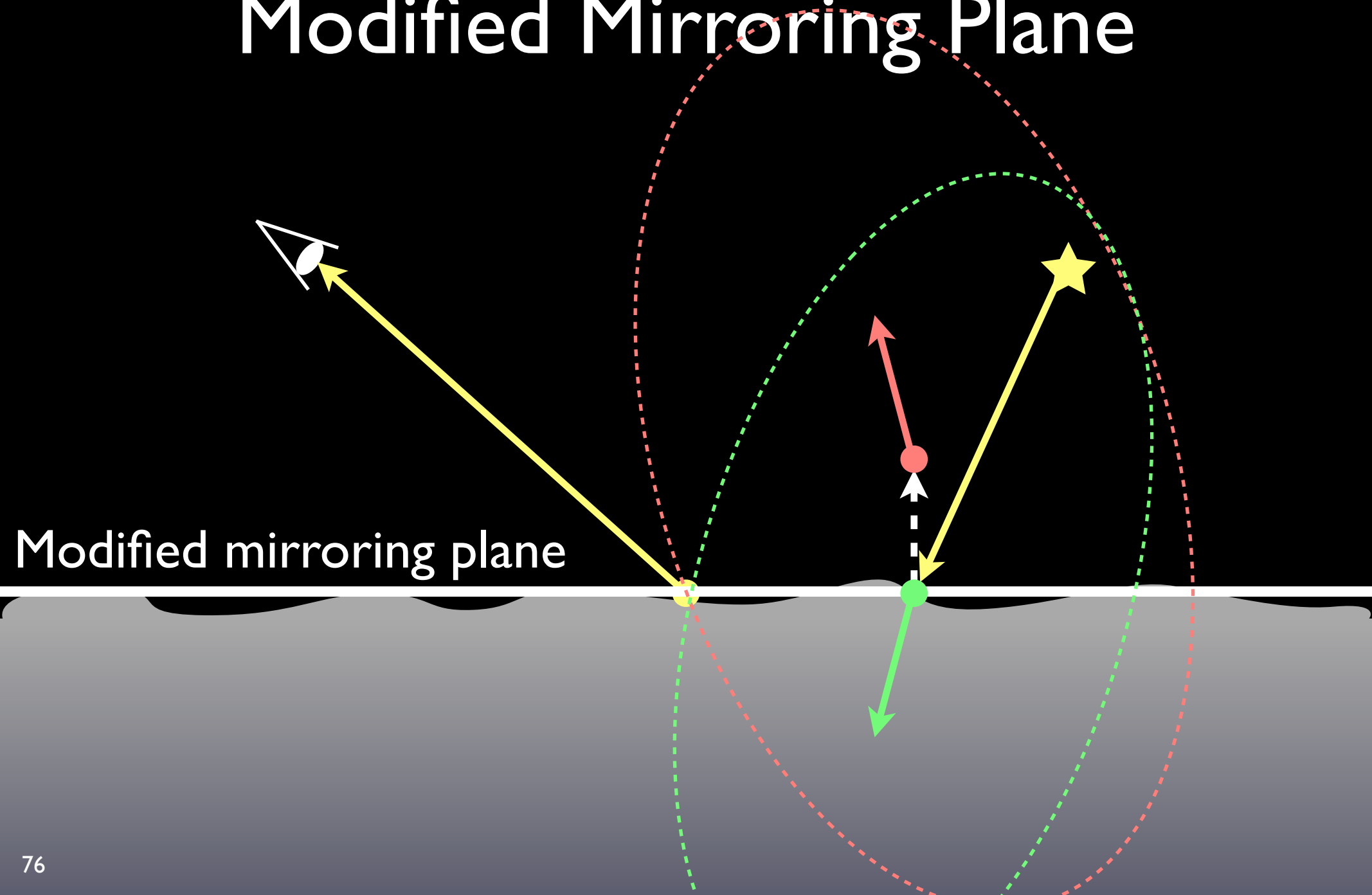
Modified Mirroring Plane



Modified Mirroring Plane



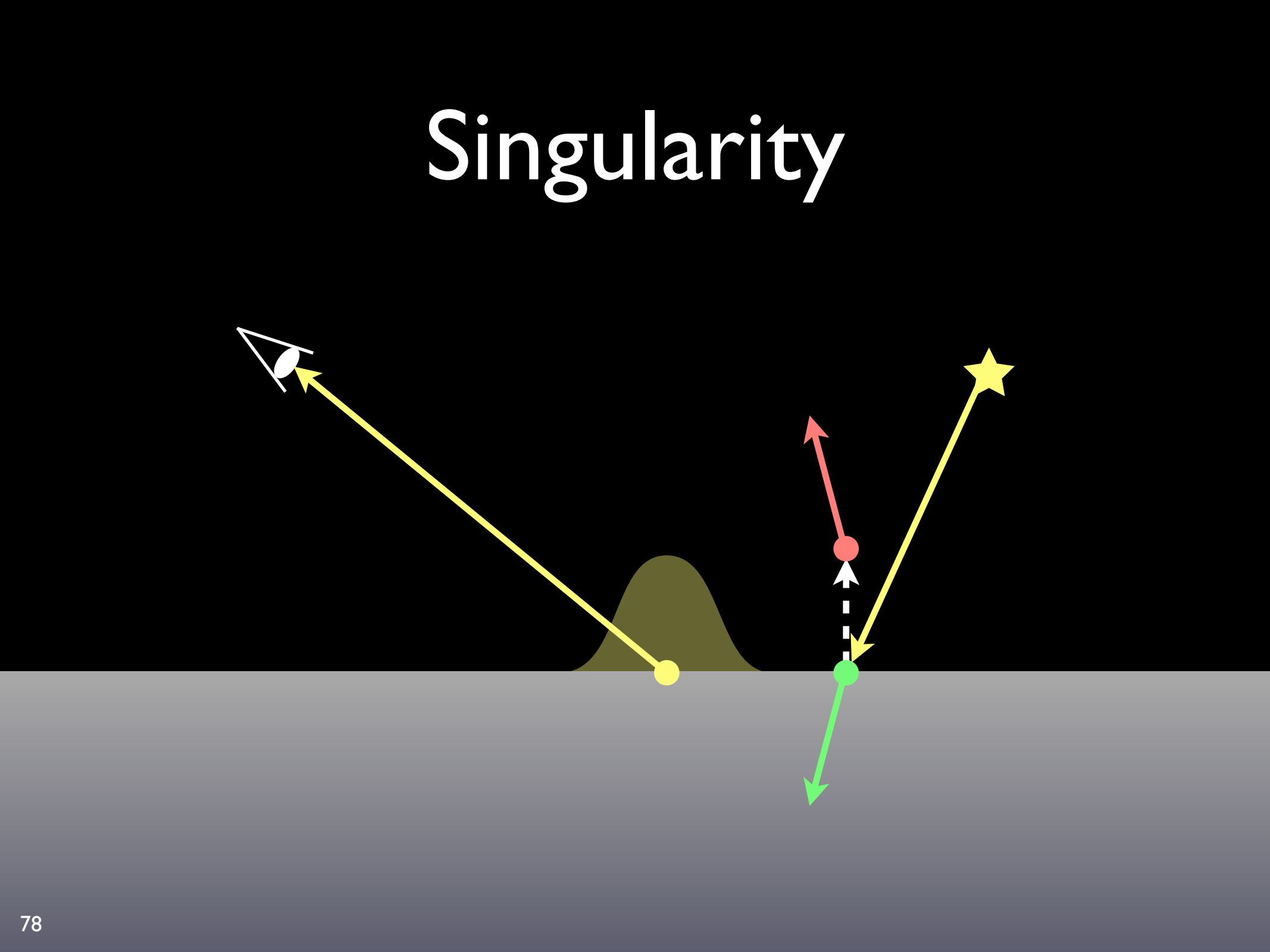
Modified Mirroring Plane



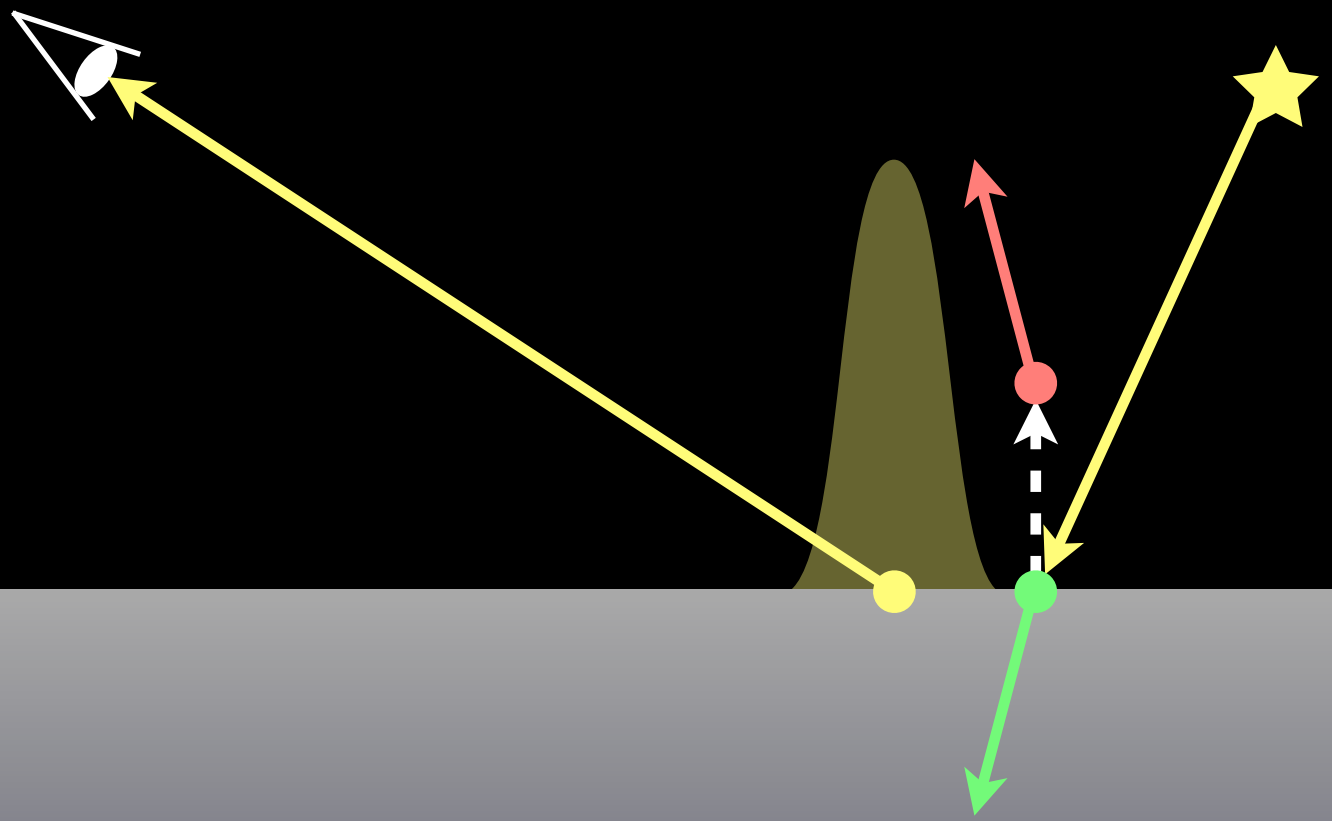
Two Challenges

- Mirroring sources is unstable
- Singularity at the real source

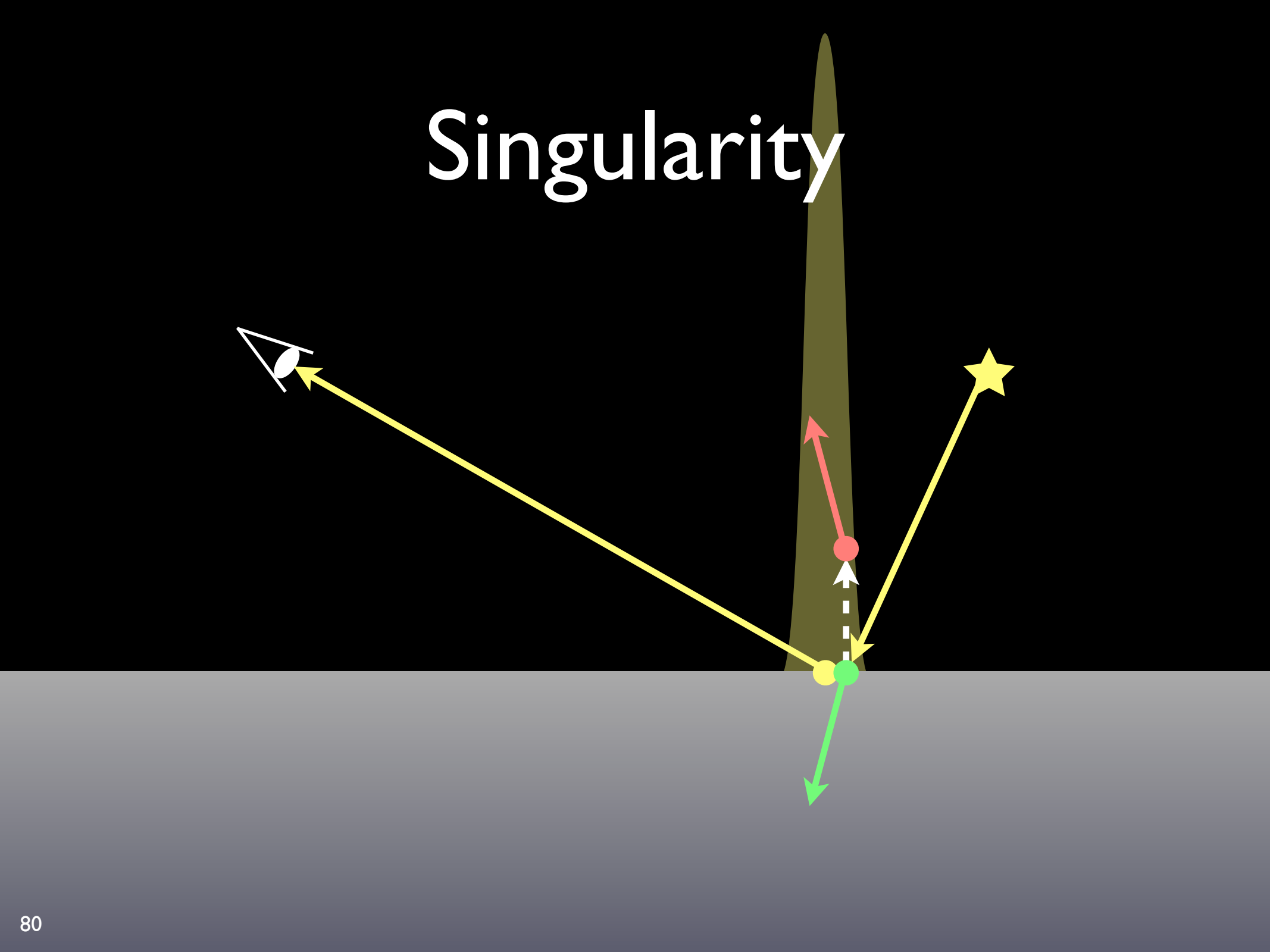
Singularity



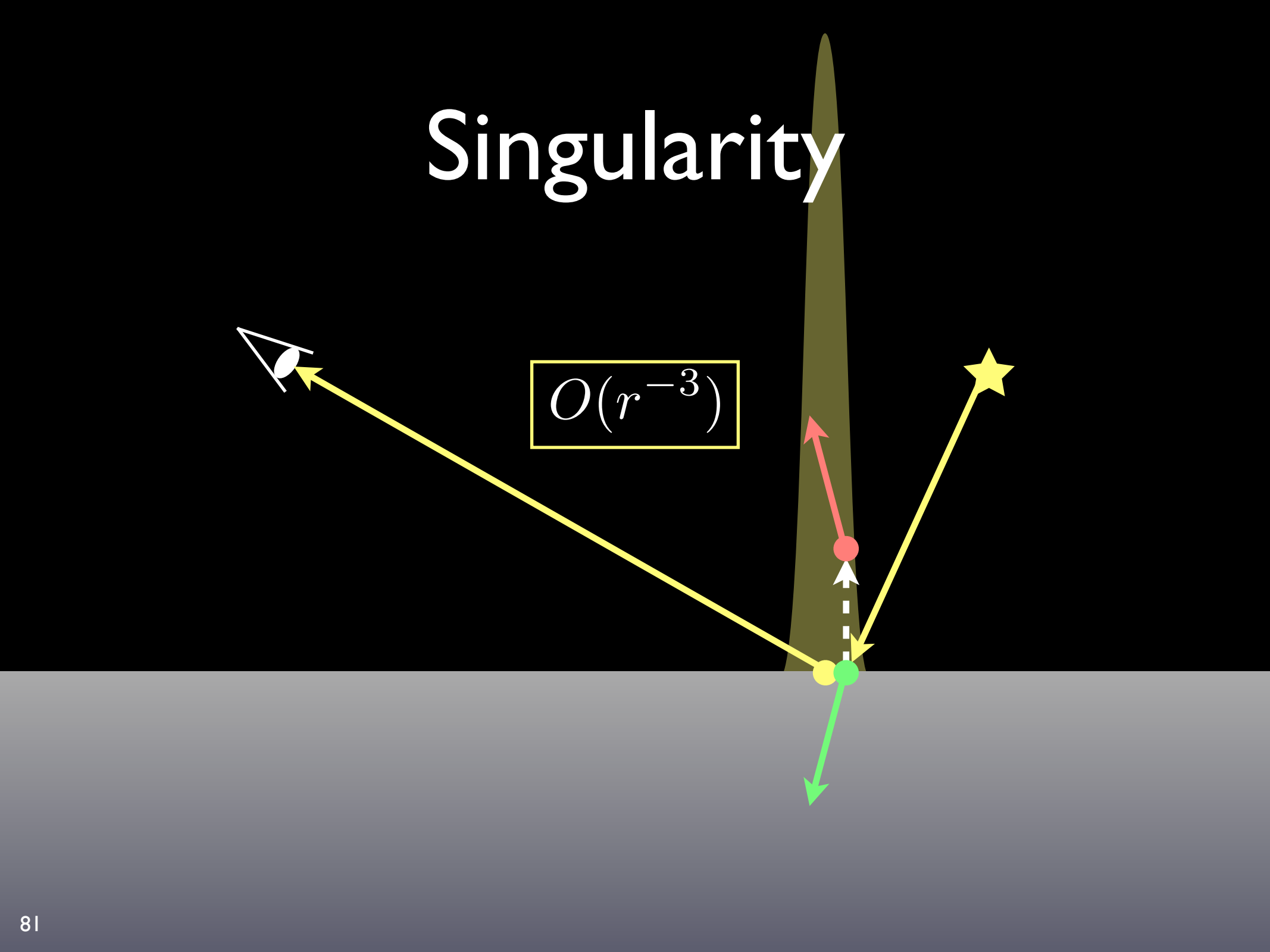
Singularity



Singularity

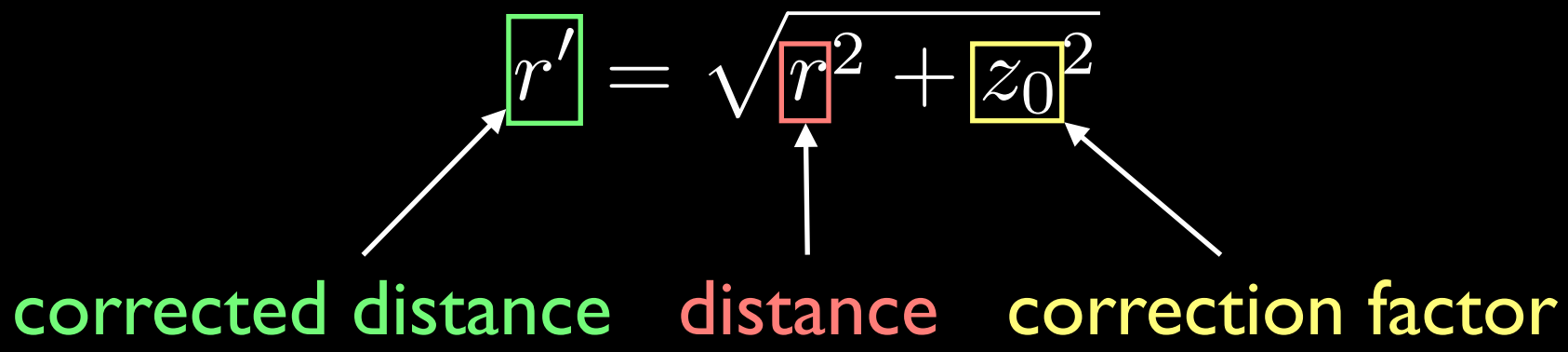


Singularity



Distance Correction

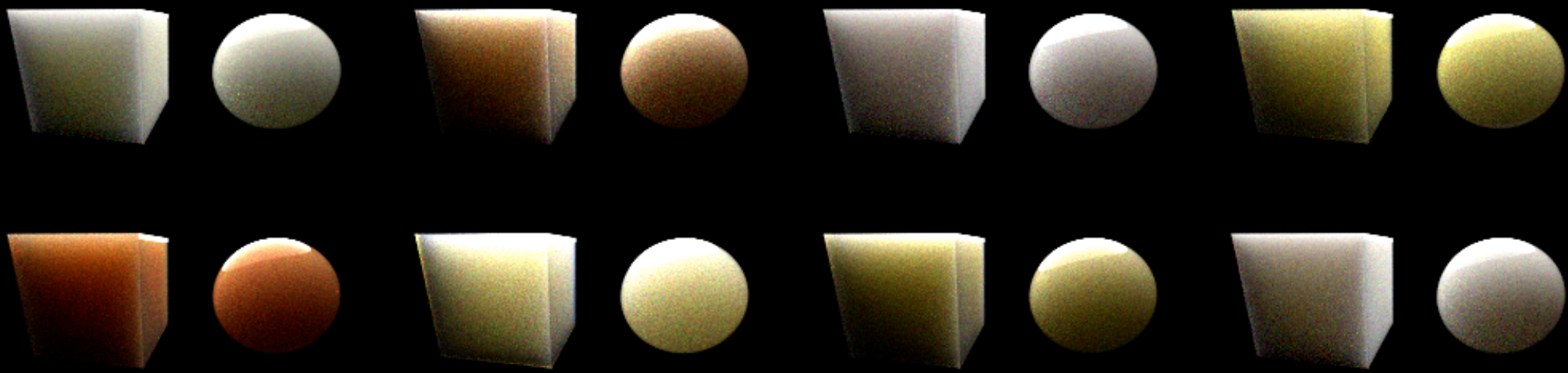
- Inspired by the correction technique in computational physics [Elliot 86]



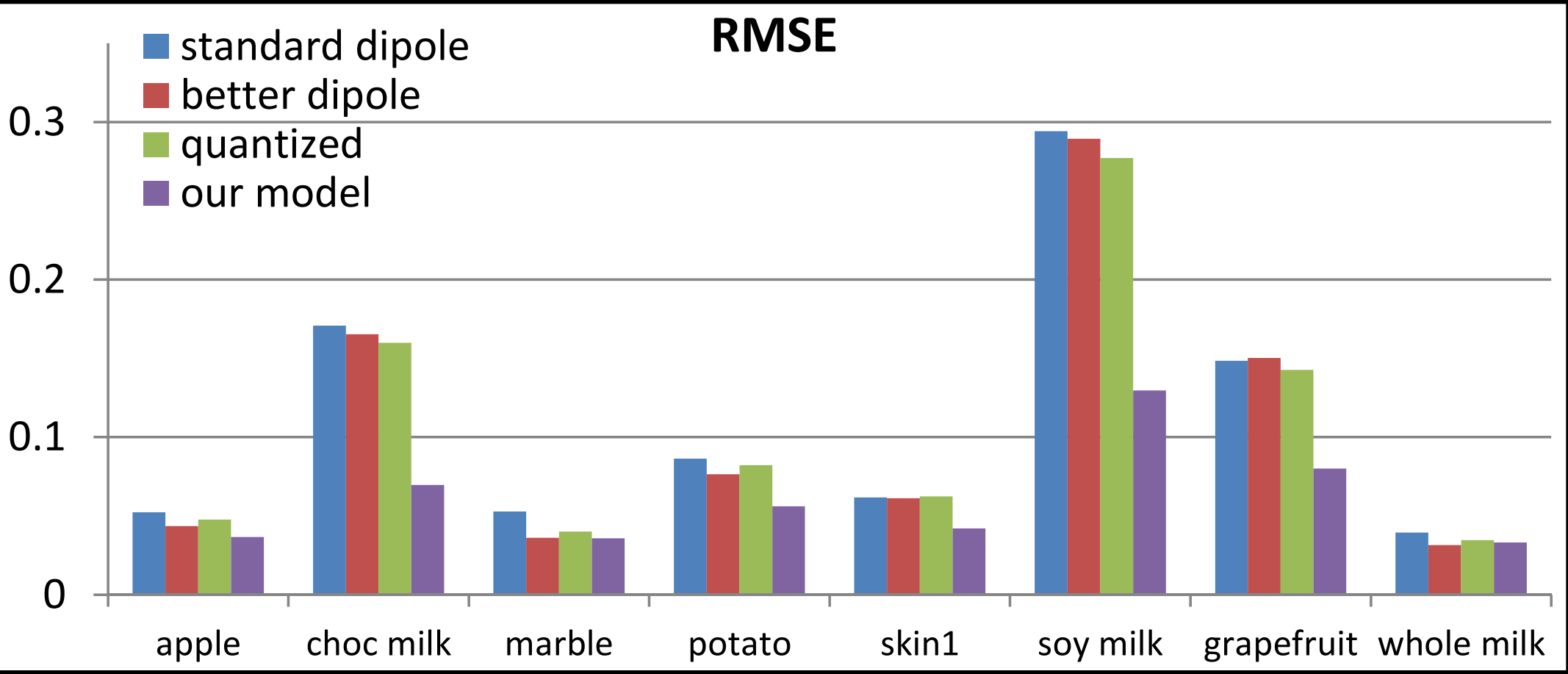
Results

Simple Test Cases

- Various measured materials
- Comparisons with Monte Carlo simulation
- Highly directional lighting

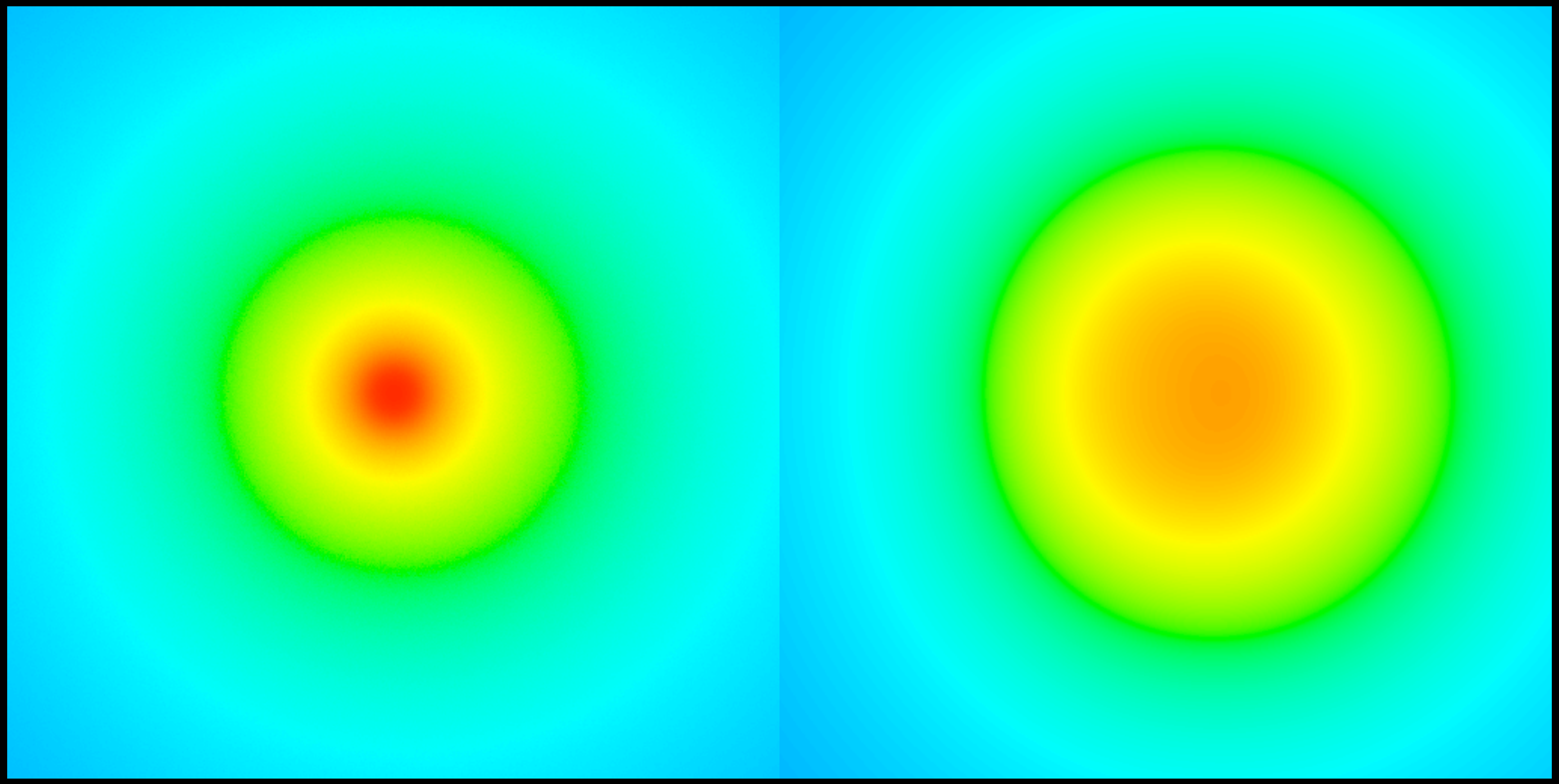


Simple Test Cases



Directional Effect

- Incident angle: 30°

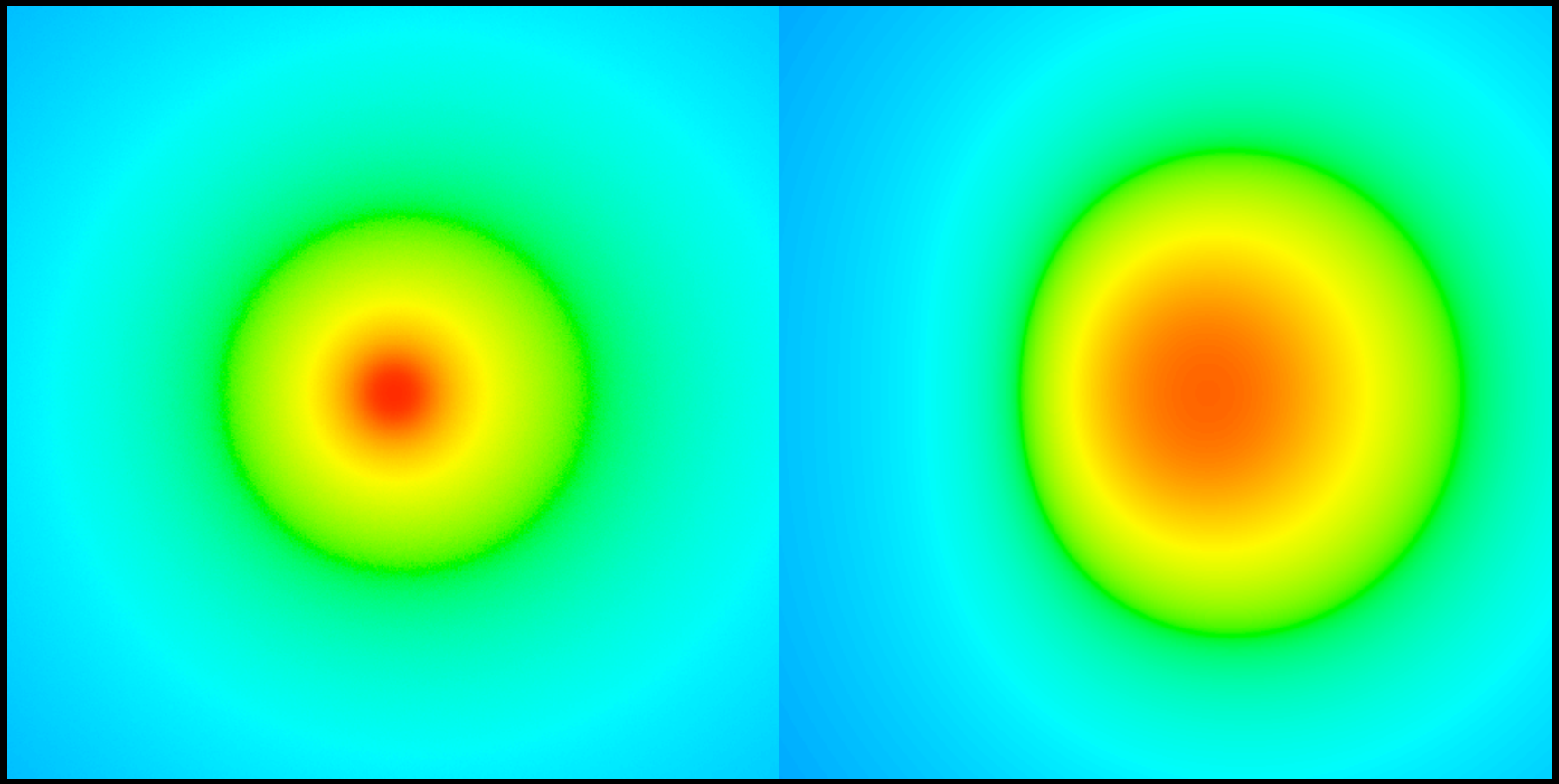


Quantized

Ours

Directional Effect

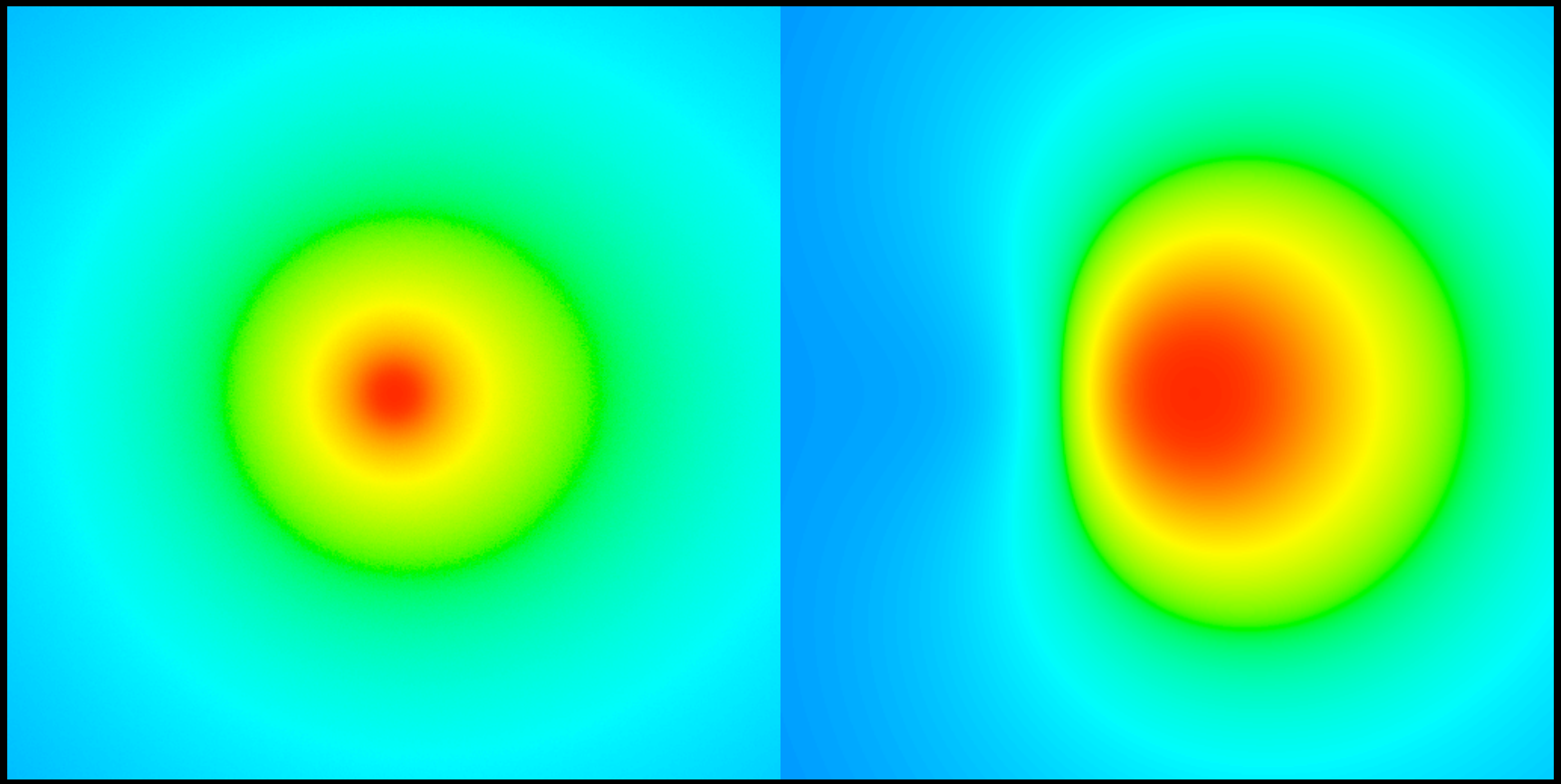
- Incident angle: 45°



Quantized Ours

Directional Effect

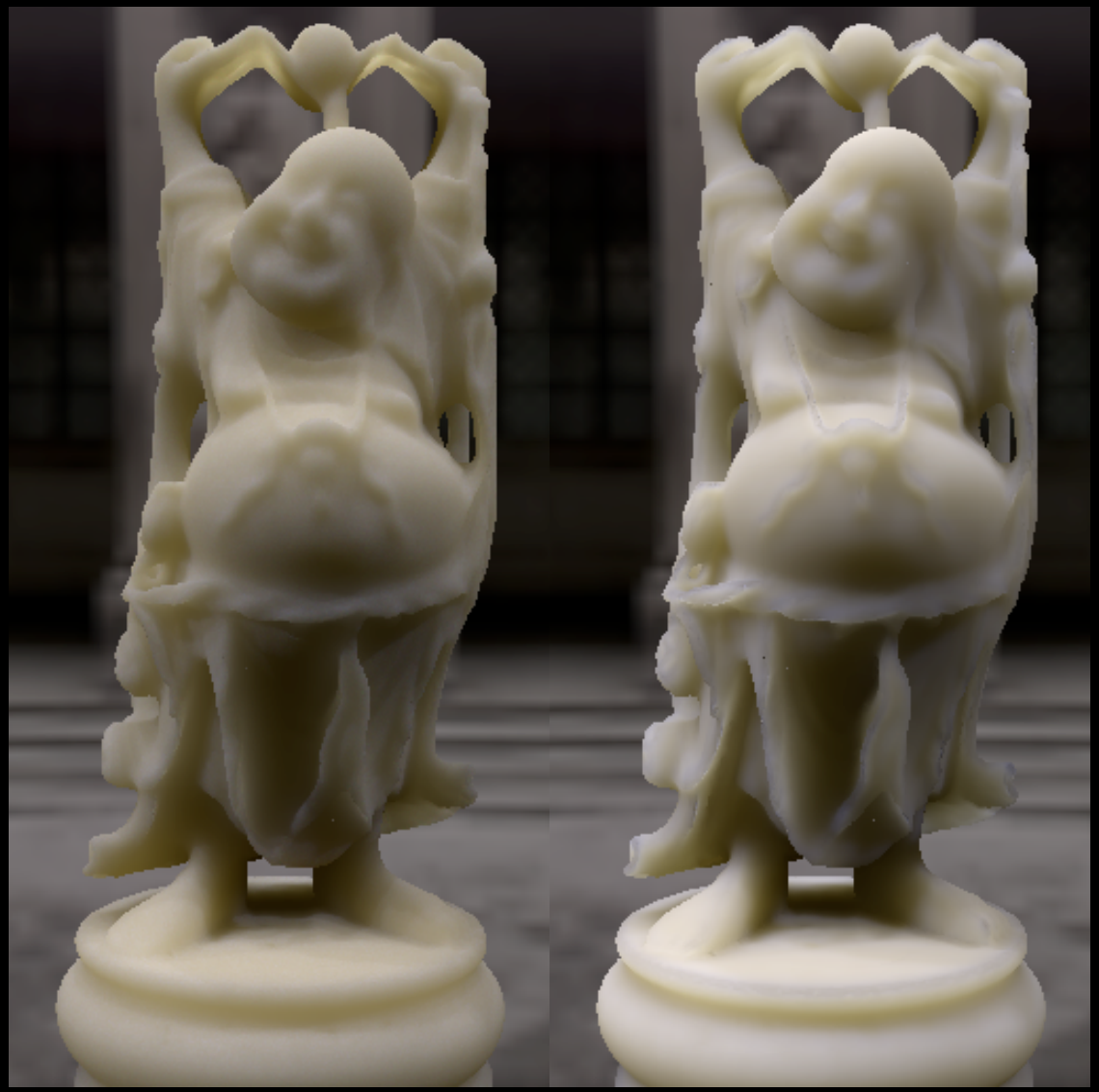
- Incident angle: 60°



Quantized Ours

Grapefruits Bunny

Image Based Lighting

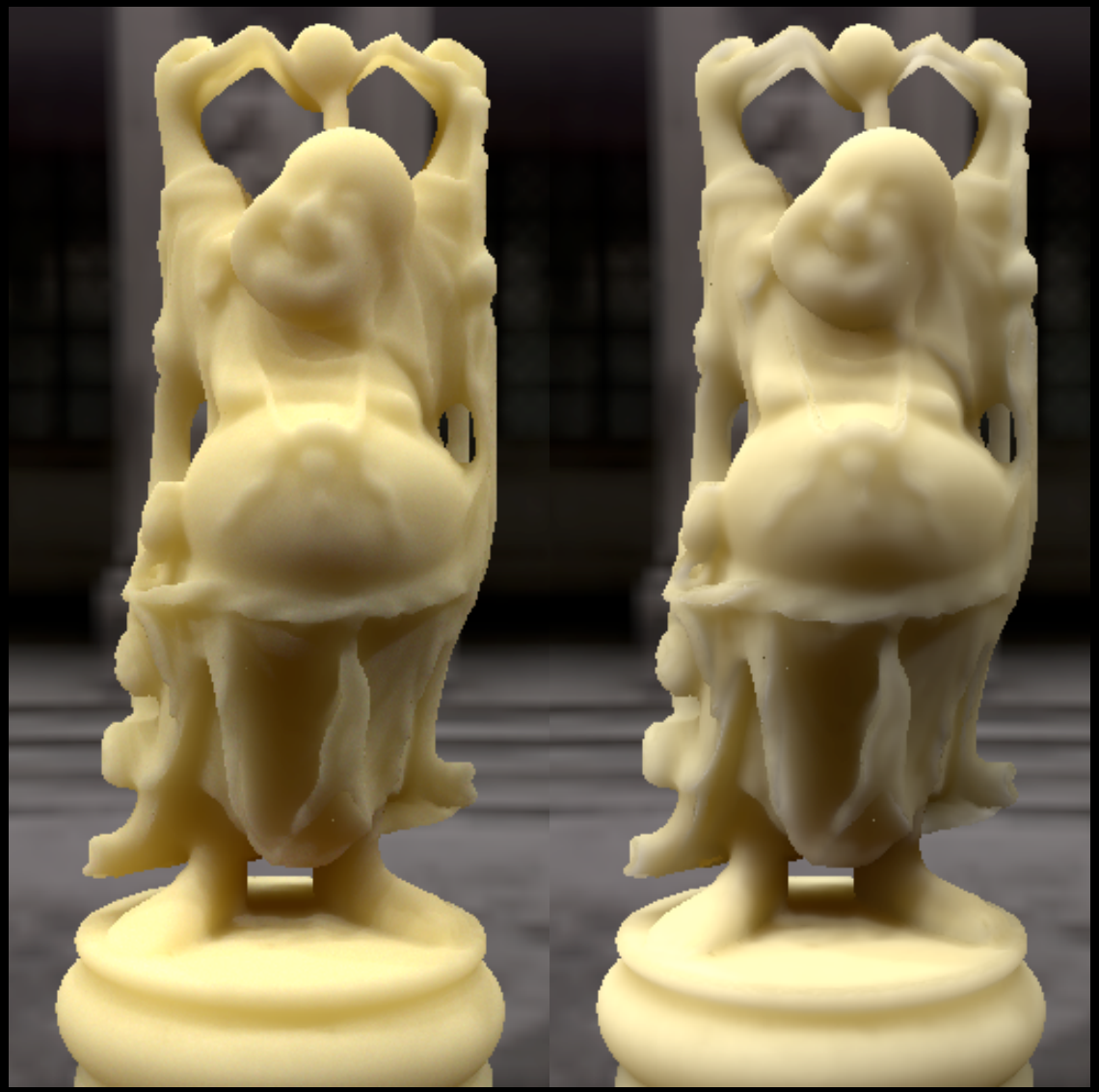


Quantized Ours

Image Based Lighting

Quantized Ours

Image Based Lighting



Quantized Ours

Failure Case

- Low albedo materials (e.g., Cranberry juice)

Dipole

Ours

Conclusions

- First BSSRDF which...
  - Considers incoming light direction
  - Requires no precomputation
  - Provides fully analytical solution

- Far more accurate than previous models

Thank You

- First BSSRDF which...
  - Considers incoming light direction
  - Requires no precomputation
  - Provides fully analytical solution

http://cs.au.dk/~toshiya/dirpole_tr.pdf