Course Updates

- Alex will have office hour today
- Assignment 3 Programming is due Friday
- If you are still unsure about ray tracing, there is an excellent demo on the web:

http://www.siggraph.org/education/materials/HyperGraph/raytrace/rt_java/raytrace.html

Distribution Ray Tracing: Continuation

Computer Graphics, CSCD18

Fall 2007

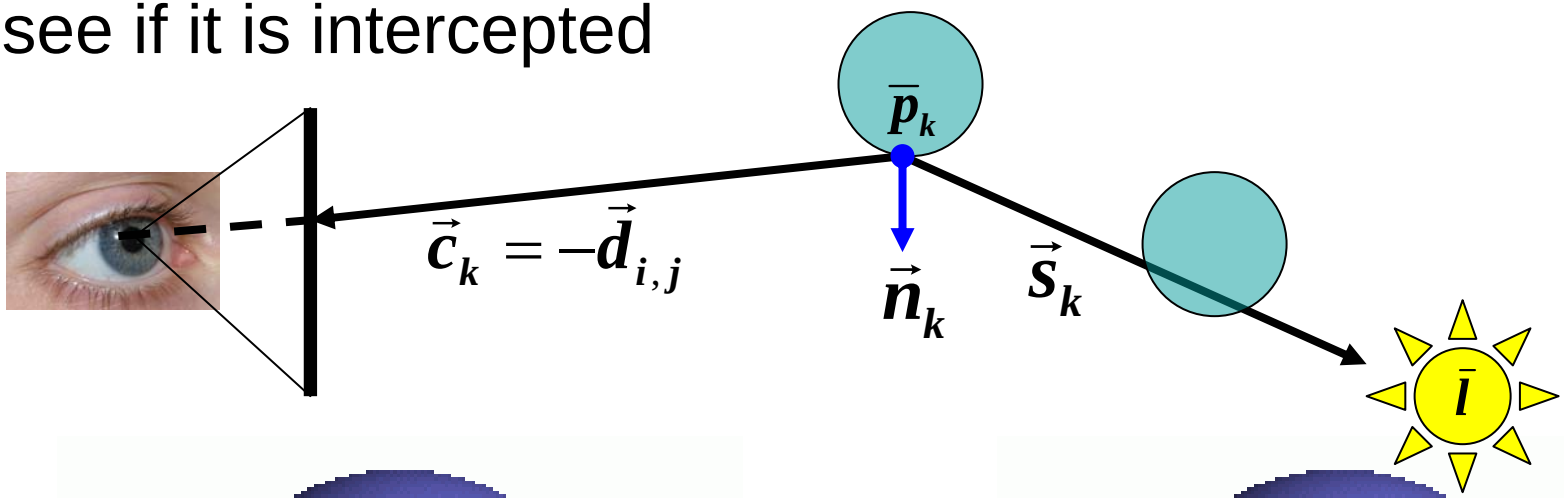
Instructor: Leonid Sigal

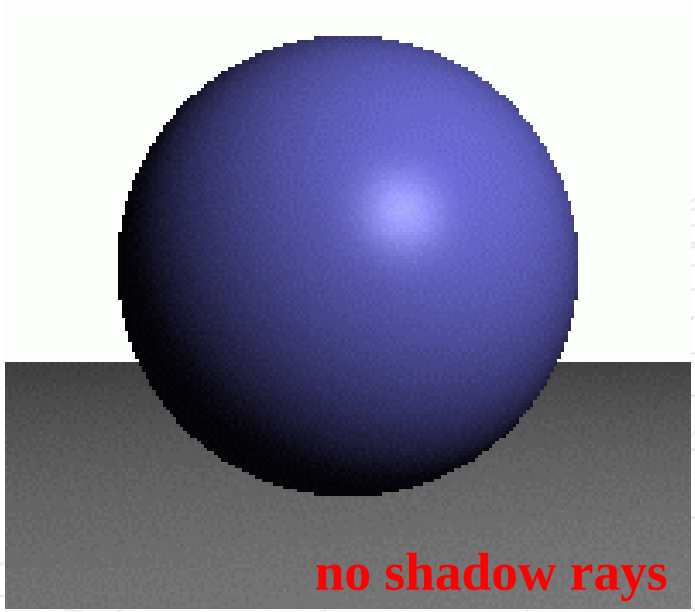
Benefits of Distribution Ray Tracing

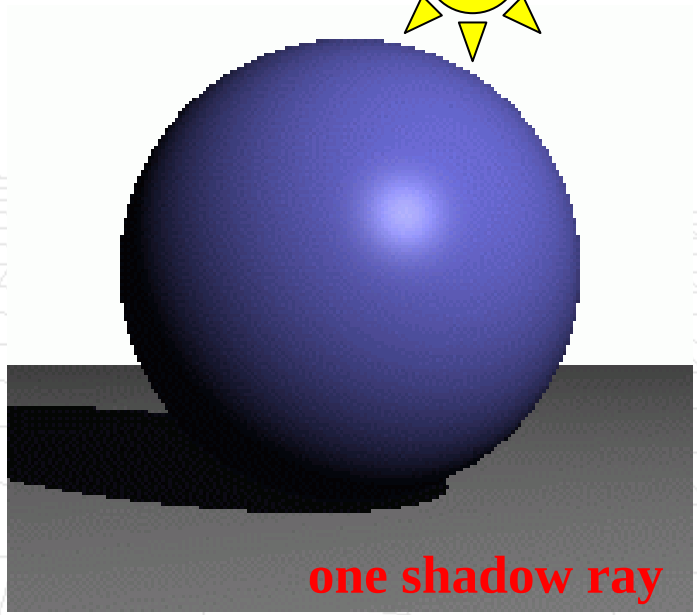
- Better global diffuse lighting
  - Color bleeding
  - Bouncing highlights
- Extended light sources
- Anti-aliasing
- Motion blur
- Depth of field
- Subsurface scattering

Shadows in Ray Tracing

- Recall, we shoot a ray towards a light source and see if it is intercepted



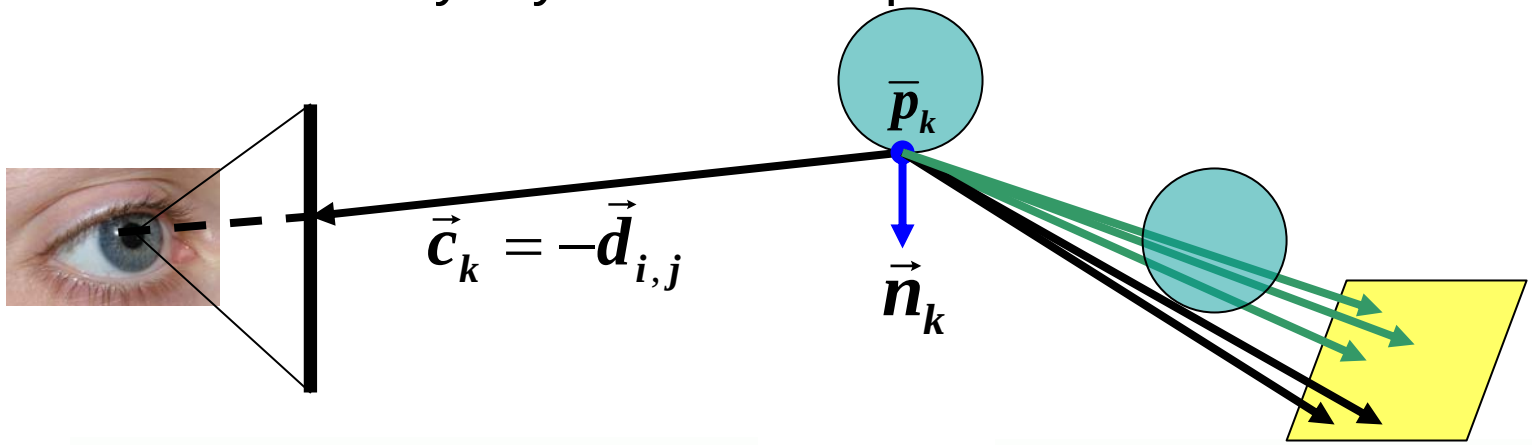


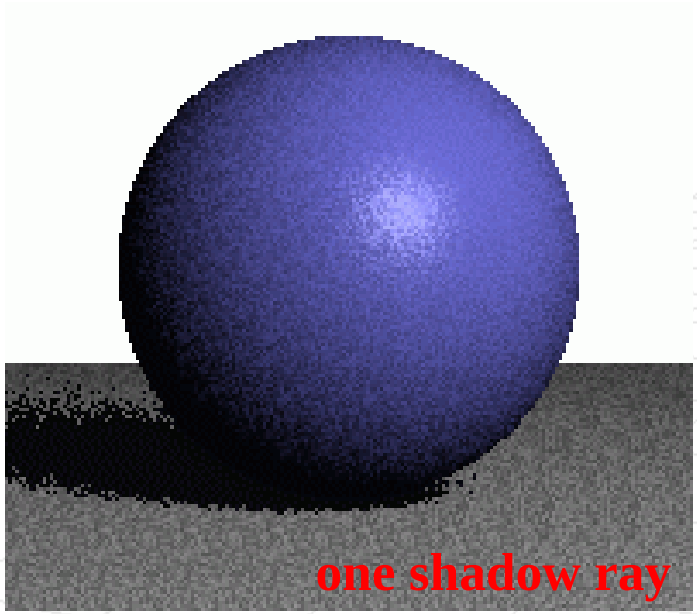


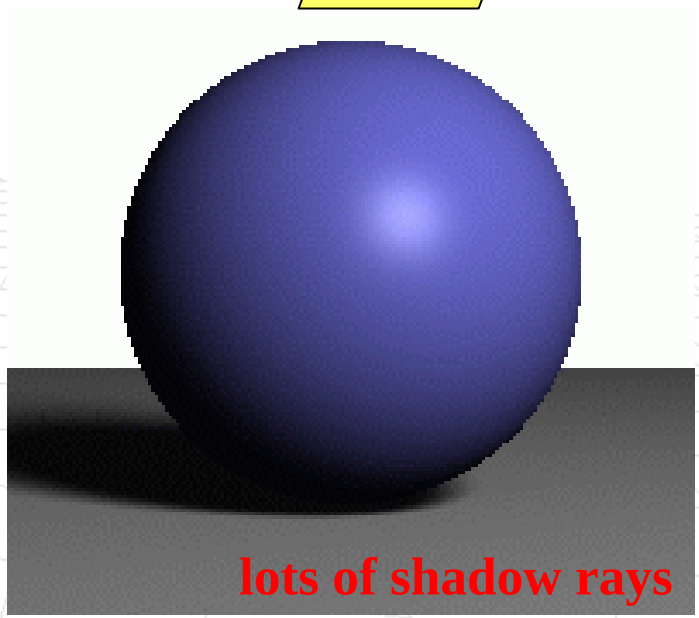
Images from the slides by Durand and Cutler

Soft Shadows with Distribution Ray Tracing

- Lets shoot multiple rays from the same point and attenuate the color based on how many rays are intercepted







Images from the slides by Durand and Cutler

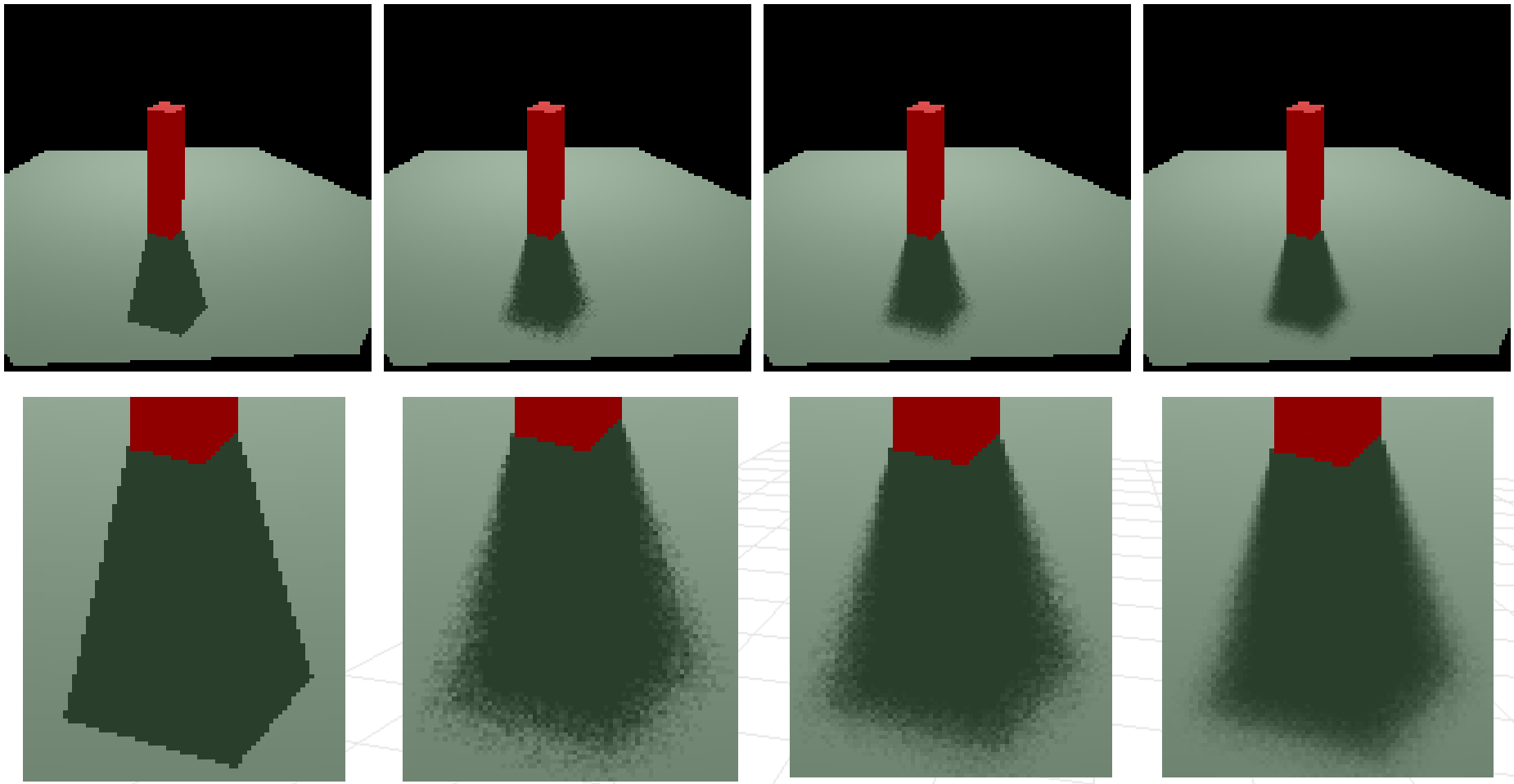
How many rays do you need?

1 ray/light

10 ray/light

20 ray/light

50 ray/light



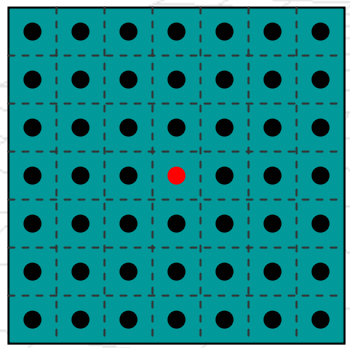
Images taken from http://web.cs.wpi.edu/~matt/courses/cs563/talks/dist_ray/dist.html

Antialising by Deterministic Integration

- **Idea:** Use multiple rays for every pixel

- **Algorithm**
  - Subdivide pixel ***(i,j)*** into squares
  - Cast ray through square centers
  - Average the obtained light

- Susceptible to structured noise, repeating textures

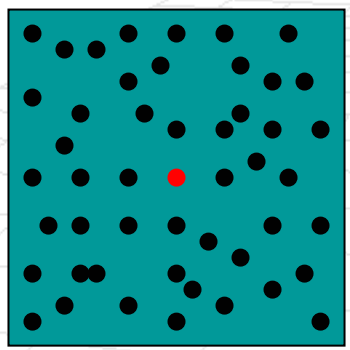


Antialising by Monte Carlo Integration

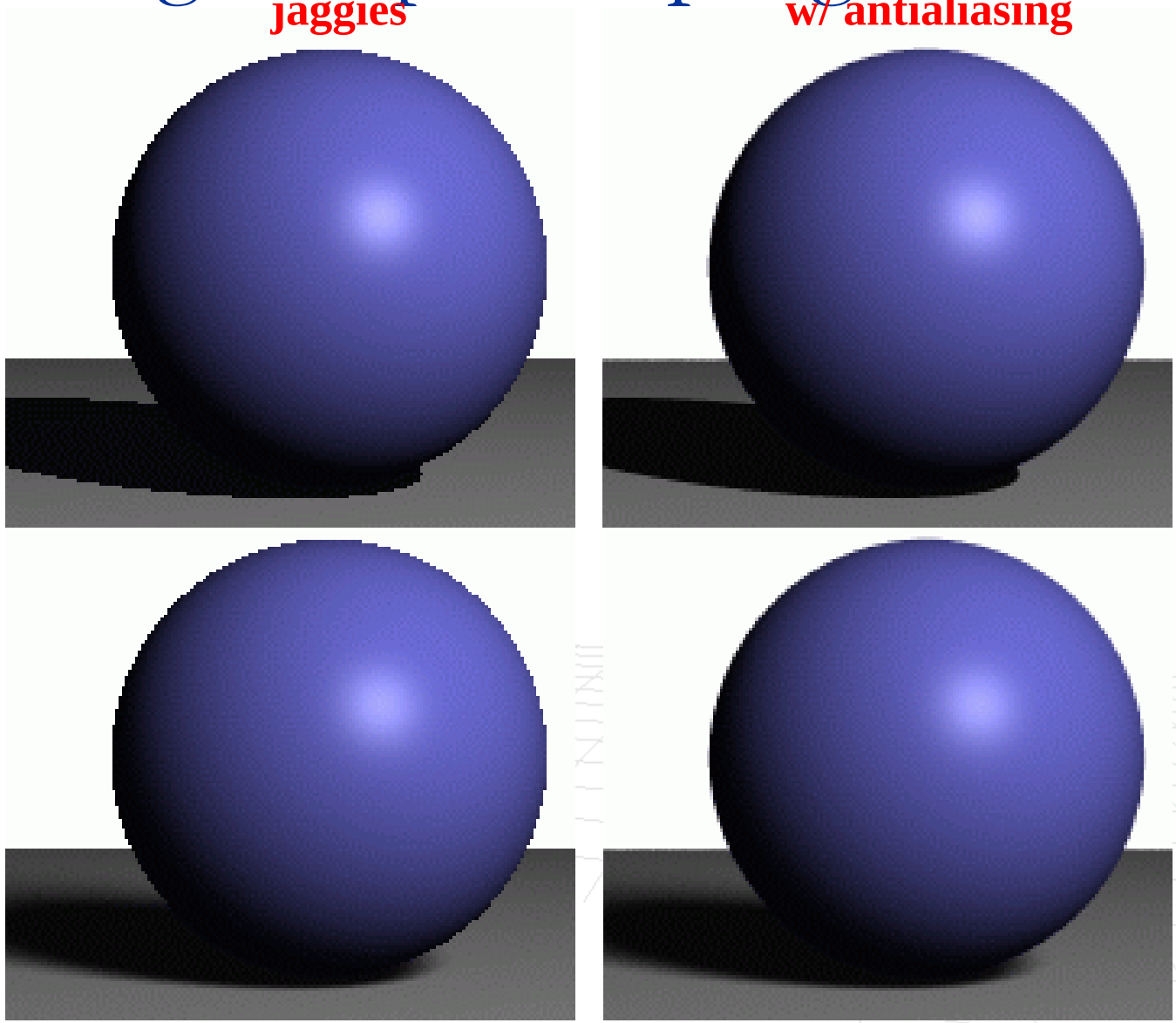
- **Idea:** Use multiple rays for every pixel

- **Algorithm**
  - Randomly sample point inside the pixel ***(i,j)***
  - Cast ray through square centers
  - Average the obtained light

- Susceptible to structured noise, repeating textures



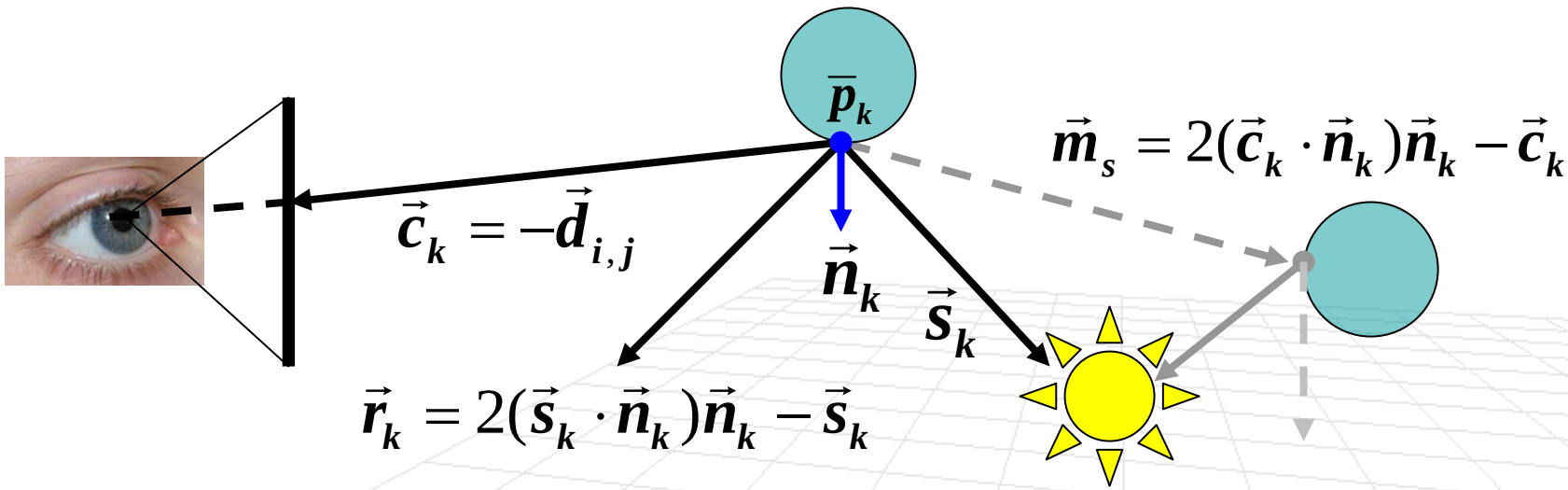
Antialiasing – Supersampling



Images from the slides by Durand and Cutler

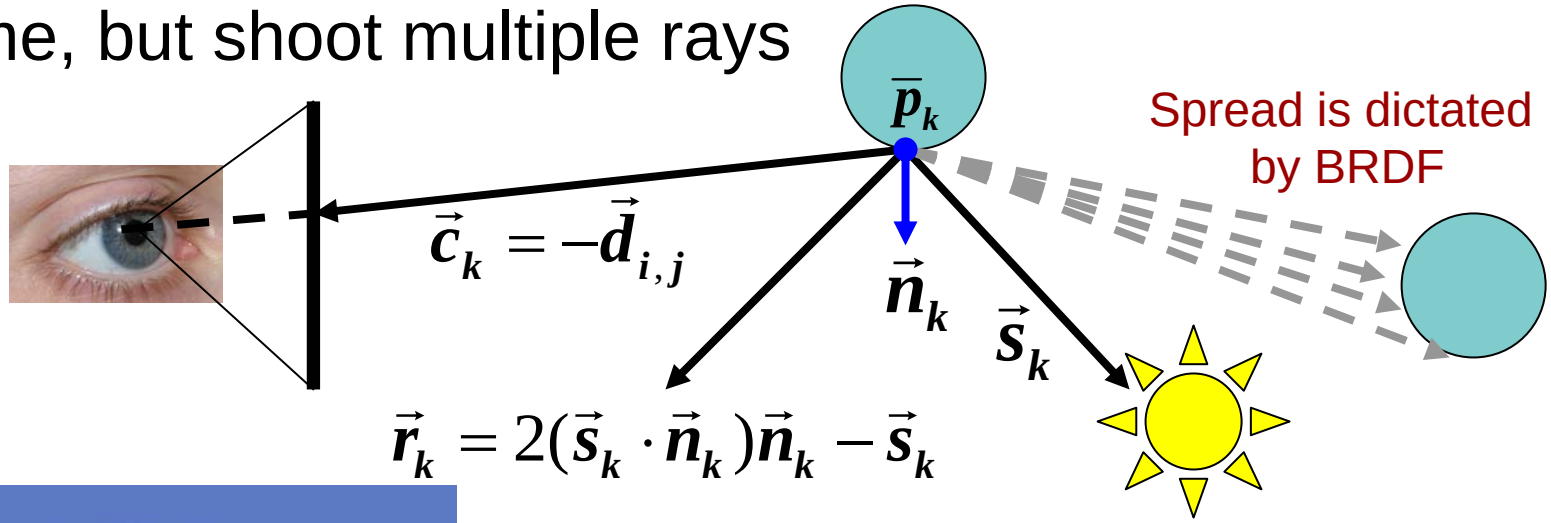
Specular Reflections

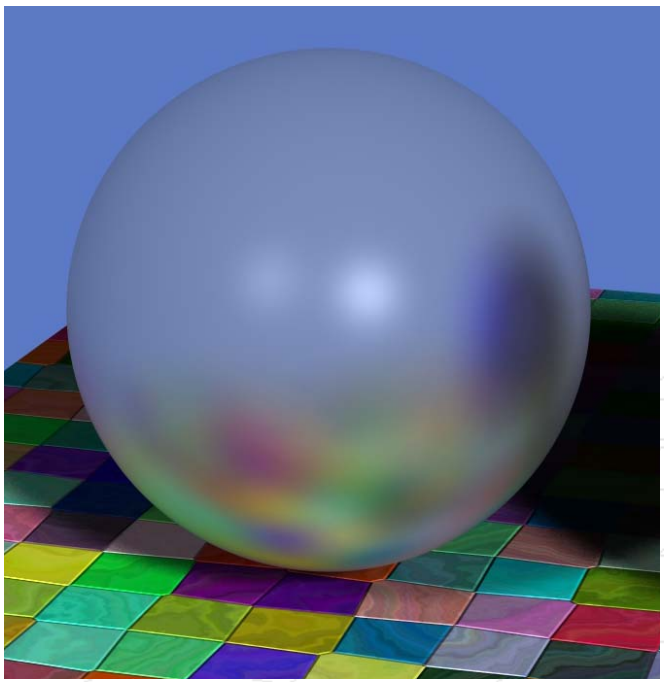
- Recall, we had to shoot a ray in a perfect specular reflection direction (with respect to the camera) and get the radiance at the resulting hit point



Specular Reflections with DRT

- Same, but shoot multiple rays



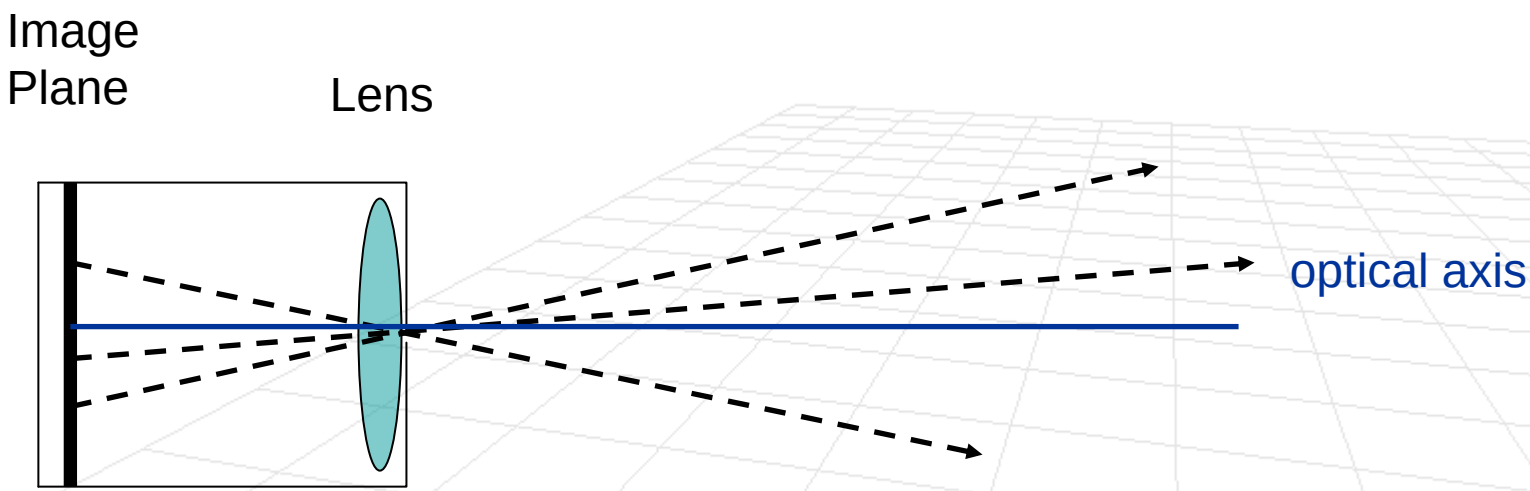


Justin Legakis

[Jensen]

Depth of Field

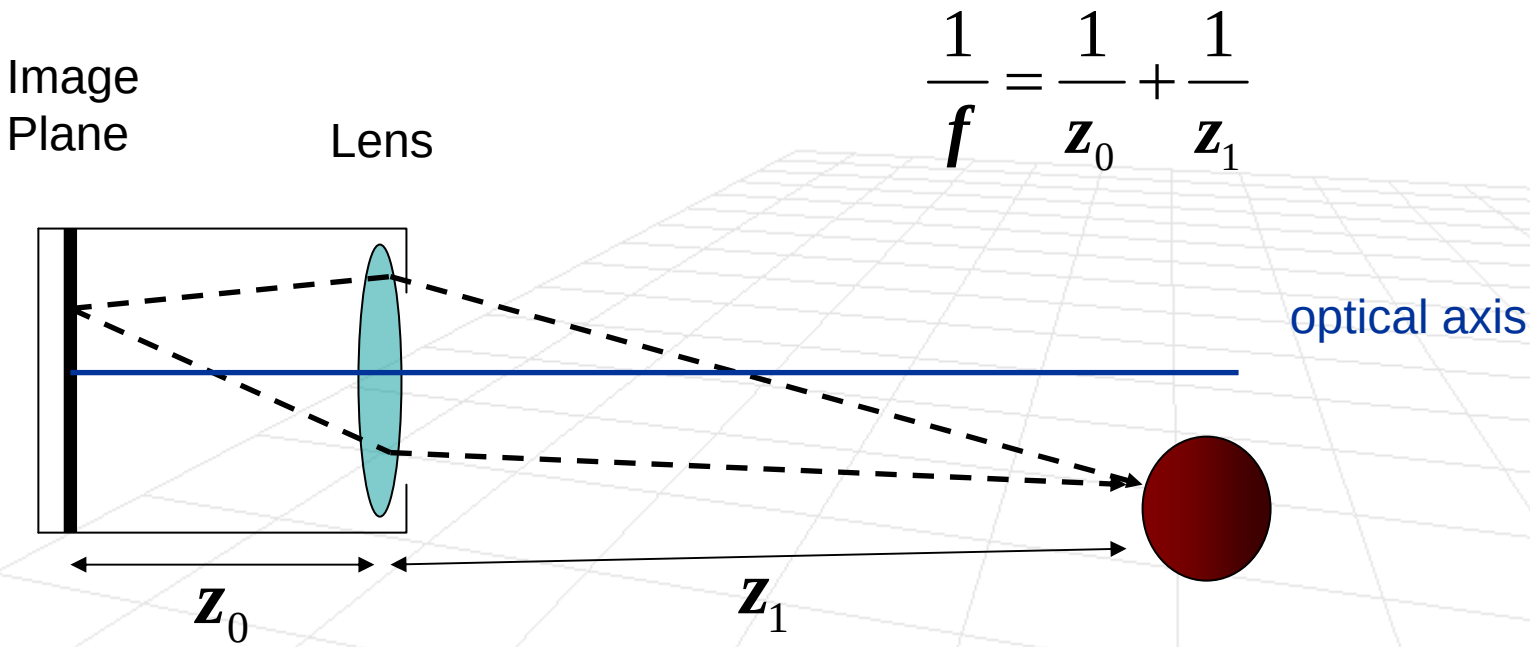
- So far with our Ray Tracers we only considered pinhole camera model (no lens)
  - or alternatively, lens, but tiny aperture



Depth of Field

- So far with our Ray Tracers we only considered pinhole camera model (no lens)
  - or alternatively, lens, but tiny aperture
- What happens if we put a lens into our “camera”
  - or increase the aperture
- Remember the thin lens equation?

$$\frac{1}{f} = \frac{1}{z_0} + \frac{1}{z_1}$$



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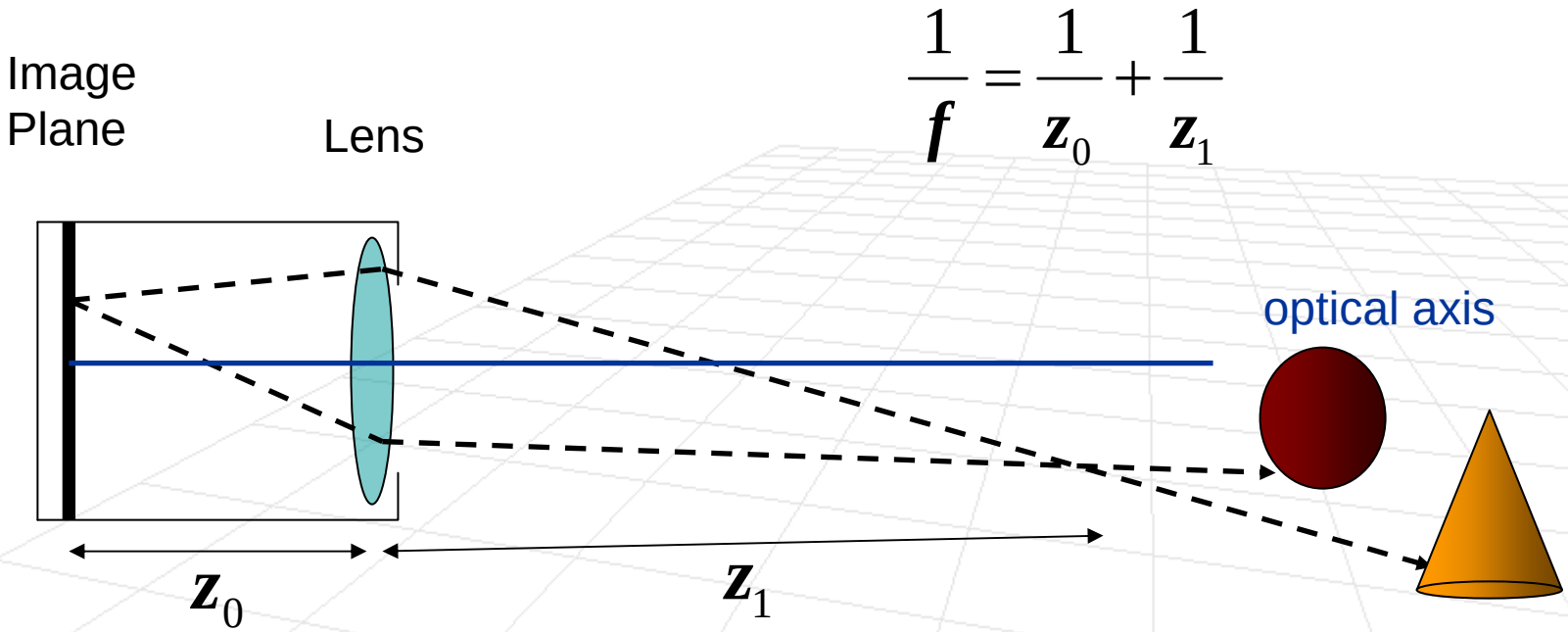


Depth of Field

P. Haeberli

Depth of Field

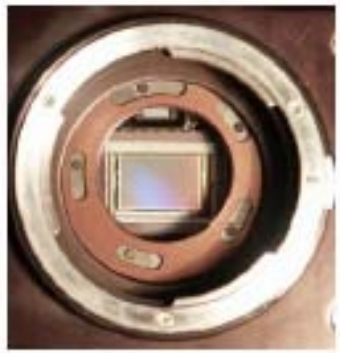
Depth of Field

Depth of Field

Depth of Field

Camera Shutter

Closed



Open

- We ignored the fact that it takes time to form the image
  - We ignored this for radiometry
- During that time the shutter is open and light is collected
  - We need to integrate temporally, not only spatially and account for speed of light transmission

$$\int_t \int_\alpha \int_\beta \boldsymbol{H}(\alpha, \beta, t)\, d\alpha\, d\beta\, dt$$

Motion Blur

Cook, Porter & Carpenter

Motion Blur

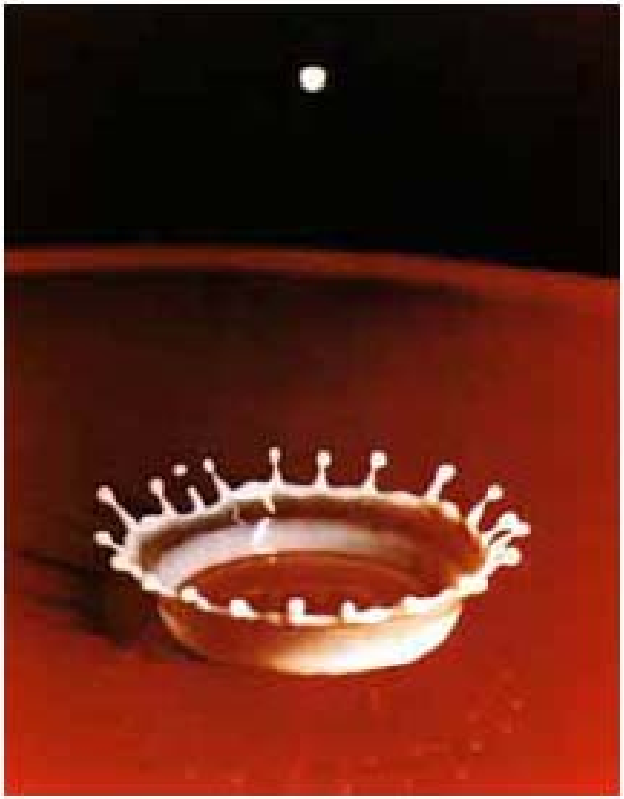
Long Exposure Photography

Motion Blur (long exposures)

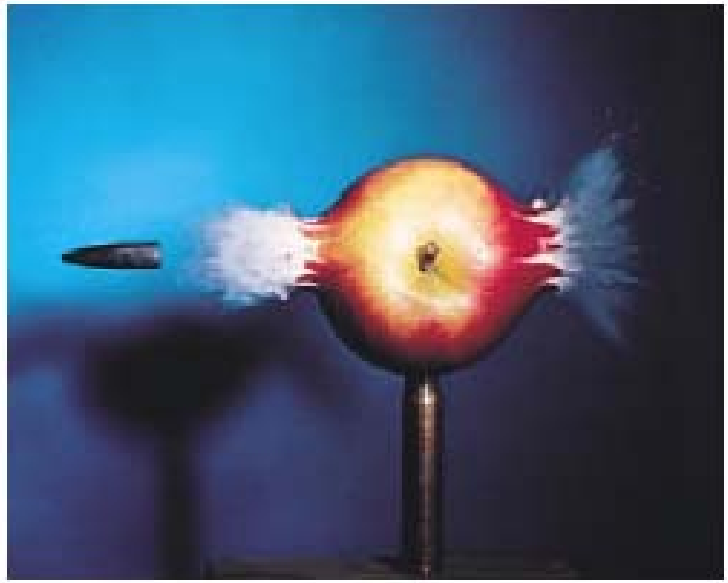
Golden Gate Bridge
30 sec. exposure @ f4

Bodie State Park
30 min. exposure @ f4

Motion Blur (short exposures)



Doc Edgerton, 1936



Sub-surface Scattering

H. W. Jensen

Sub-surface Scattering

Bidirectional Surface Scattering Distribution Function)

Rendering with BRDF

Rendering with BSSRDF

H. W. Jensen

Semi-Transparencies

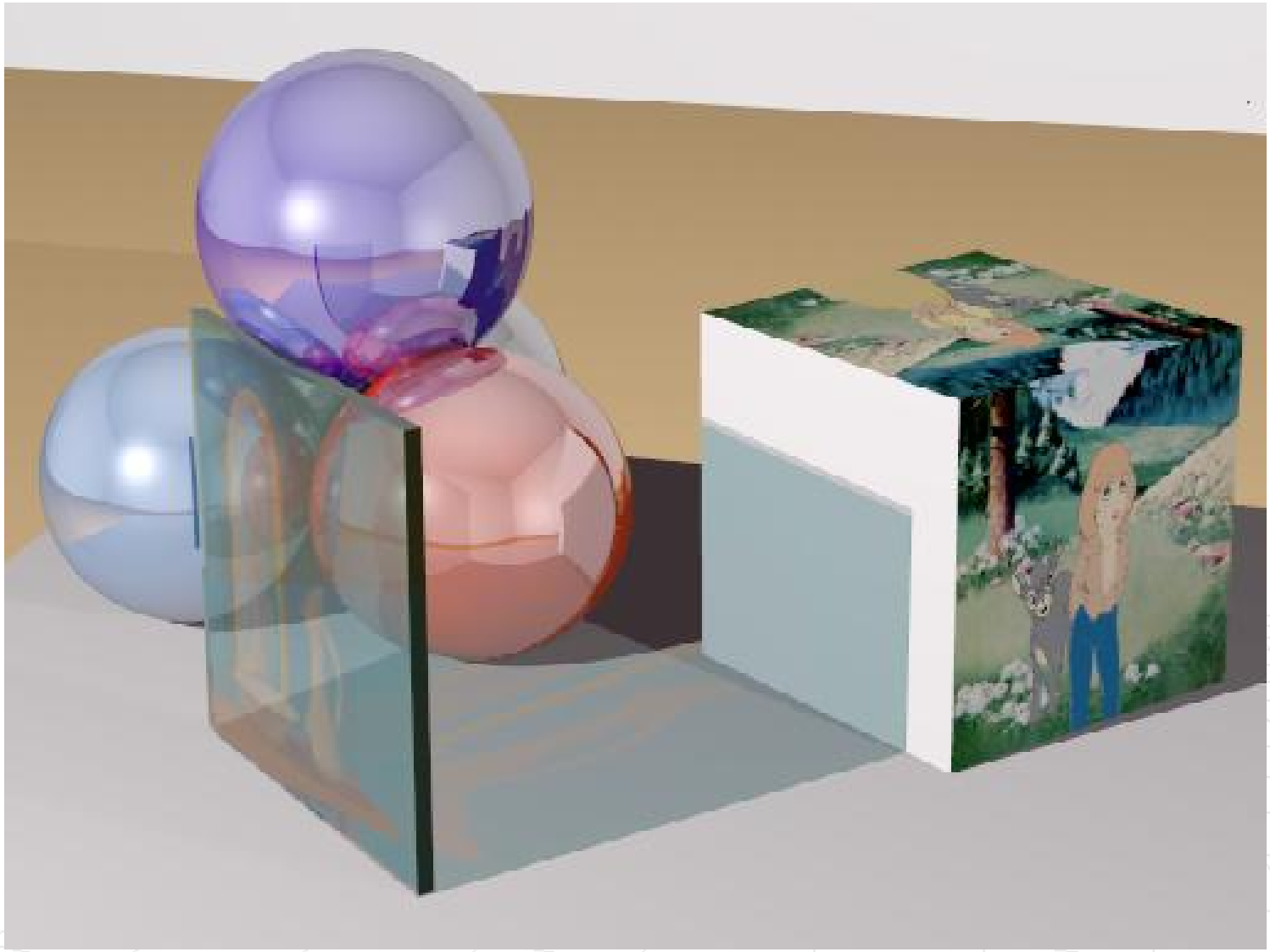


Image form http://www.graphics.cornell.edu/online/tutorial/raytrace/

Texture-mapping and Bump-mapping in Ray Tracer

Image form http://www.graphics.cornell.edu/online/tutorial/raytrace/

Caustics

- Often done using bi-directional ray tracing (a.k.a. photon mapping)
  - Shoot light rays from light sources
  - Accumulate the amount of light (radiance) at each surface
  - Shoot rays through image plane pixels to “look-up” the radiance (and integrate irradiance over the area of the pixel)