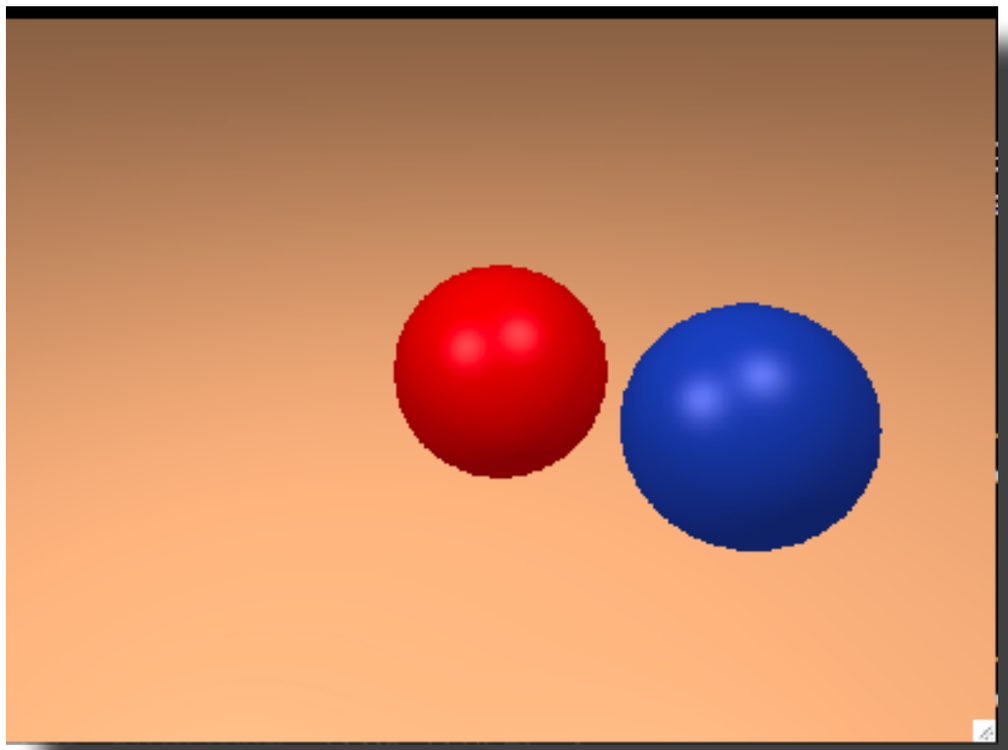
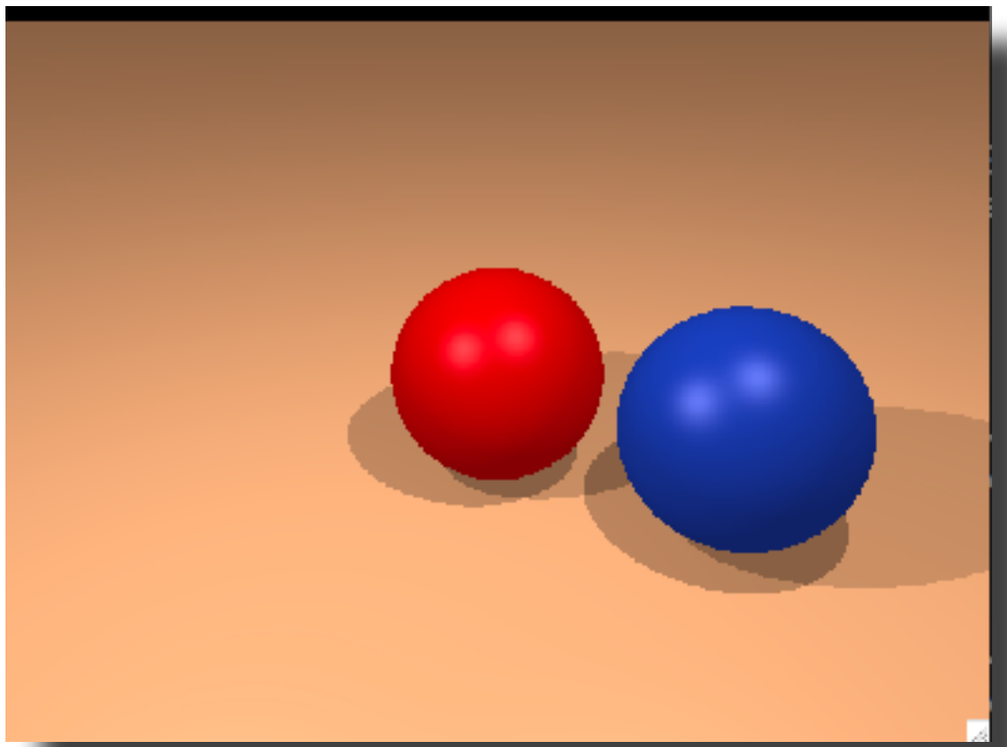
CS130 : Computer Graphics

Ray Tracing (cont.)

Tamar Shinar
Computer Science & Engineering
UC Riverside

Shadows





Shadows

```
for each pixel do
    compute viewing ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        evaluate shading model and set pixel to that color
else
    set pixel color to the background color
```

Shadows

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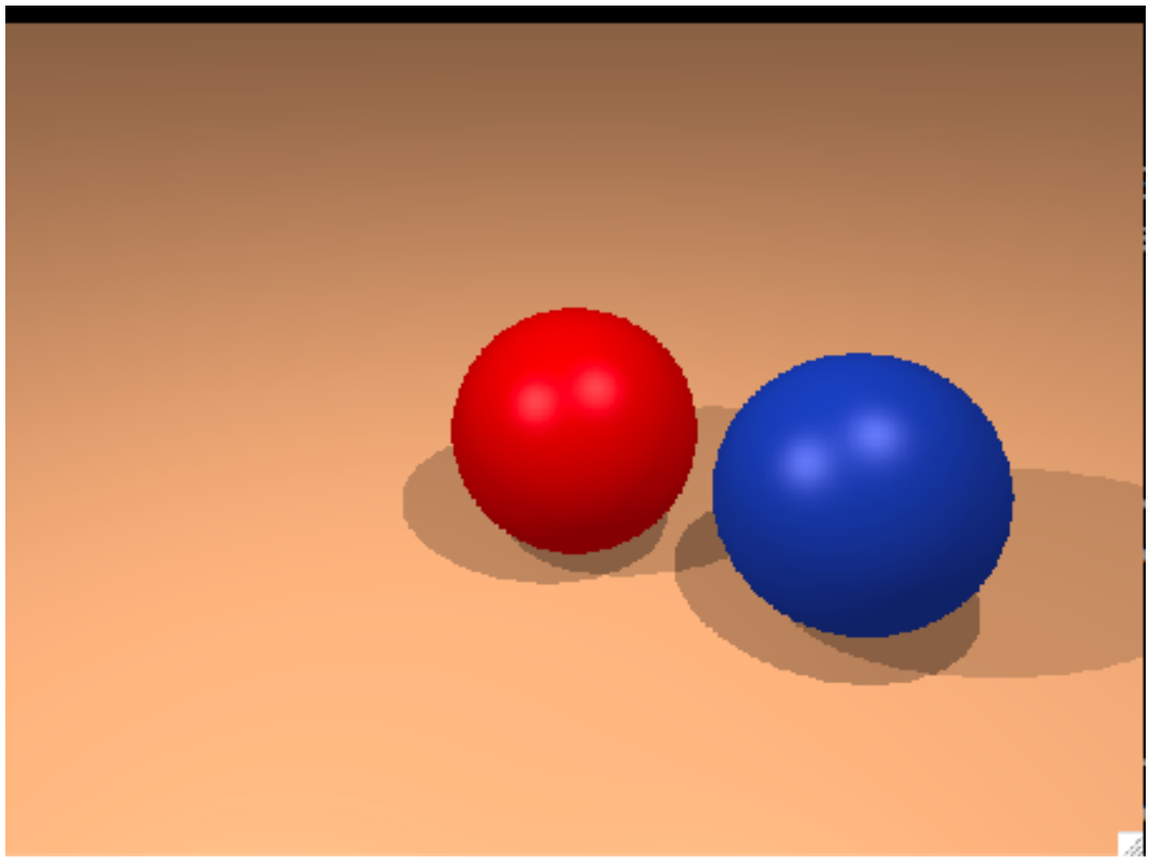
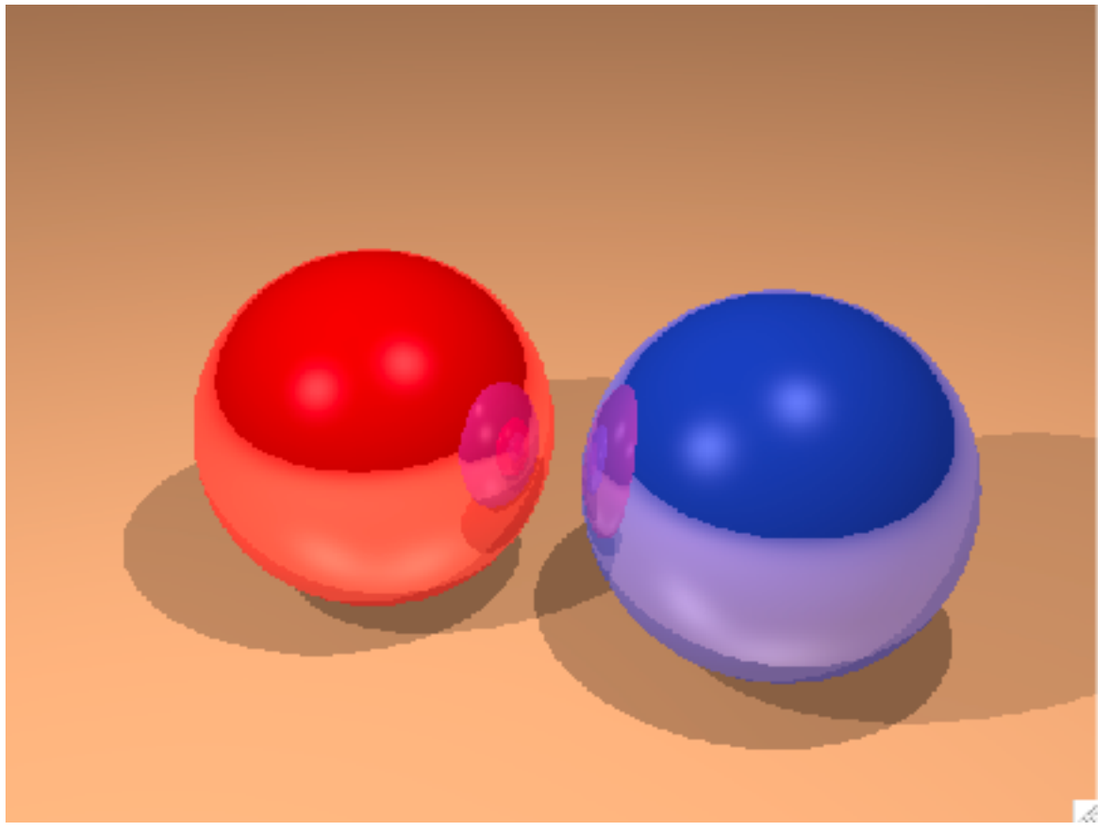
Shadows

```
for each pixel do
    compute viewing ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        // e.g., phong shading
        for each light
          add light's ambient component
          compute shadow ray
          if ( ! shadow ray hits an object )
            add light's diffuse and specular components
else
    set pixel color to the background color
```

Reflections





Reflections

```
for each pixel do
    compute viewing ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        evaluate shading model and set pixel to that color
    else
        set pixel color to the background color
```

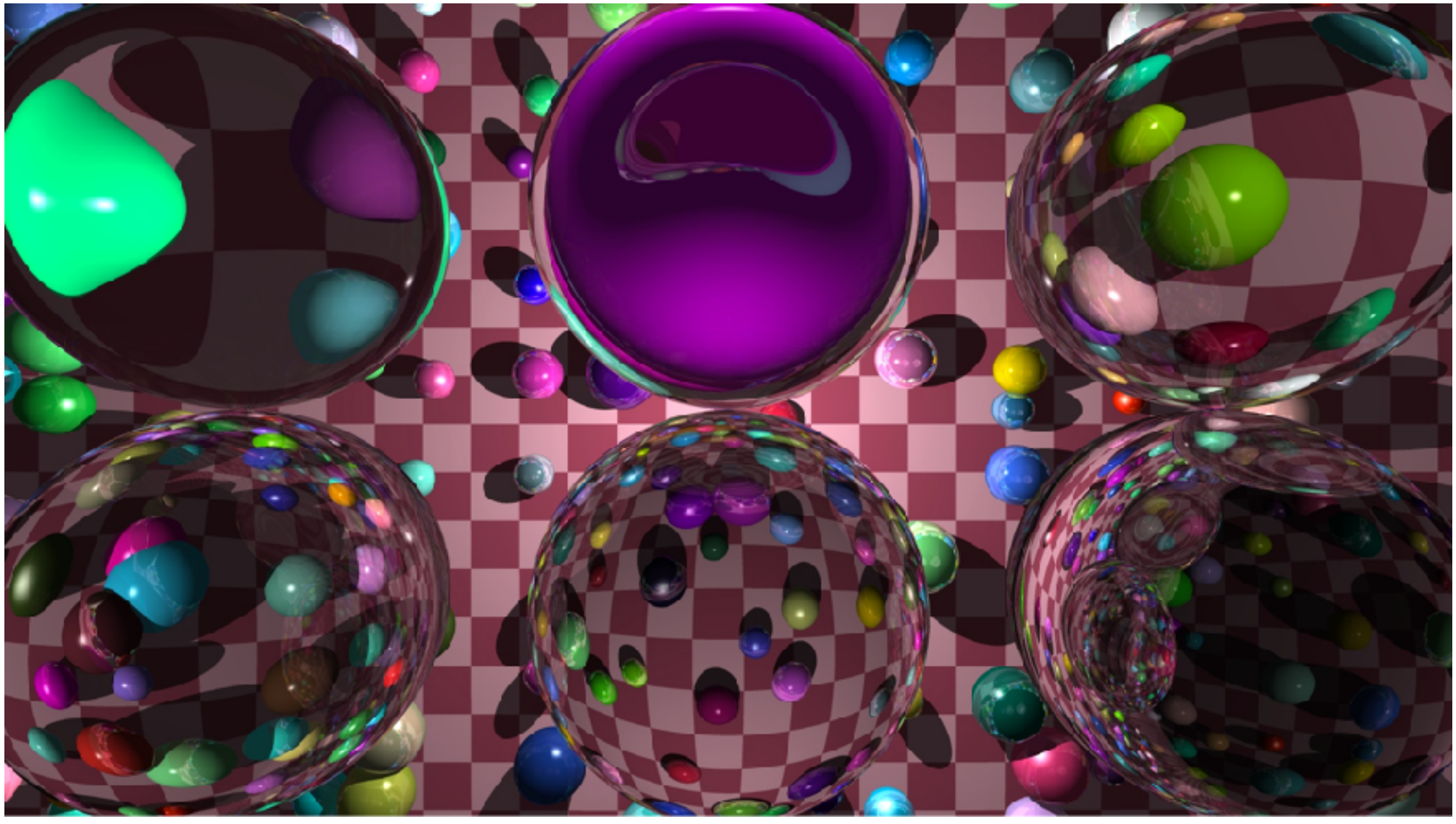
Reflections

```
for each pixel do
    compute viewing ray
    pixel color = cast_ray(viewing ray)

cast_ray:
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        return color = shade_surface
    else
        return color = to the background color

shade_surface:
    color = ...
    compute reflected ray
    return color = color + k * cast_ray(reflected ray)
```

ray tracer extensions

- refraction
- more complex geometry
  - instancing
  - CSG
- distribution ray tracing (Cook et al., 1984)
  - antialiasing
  - soft shadows
  - depth of field
  - fuzzy reflections
  - motion blur

Transparency and Refraction



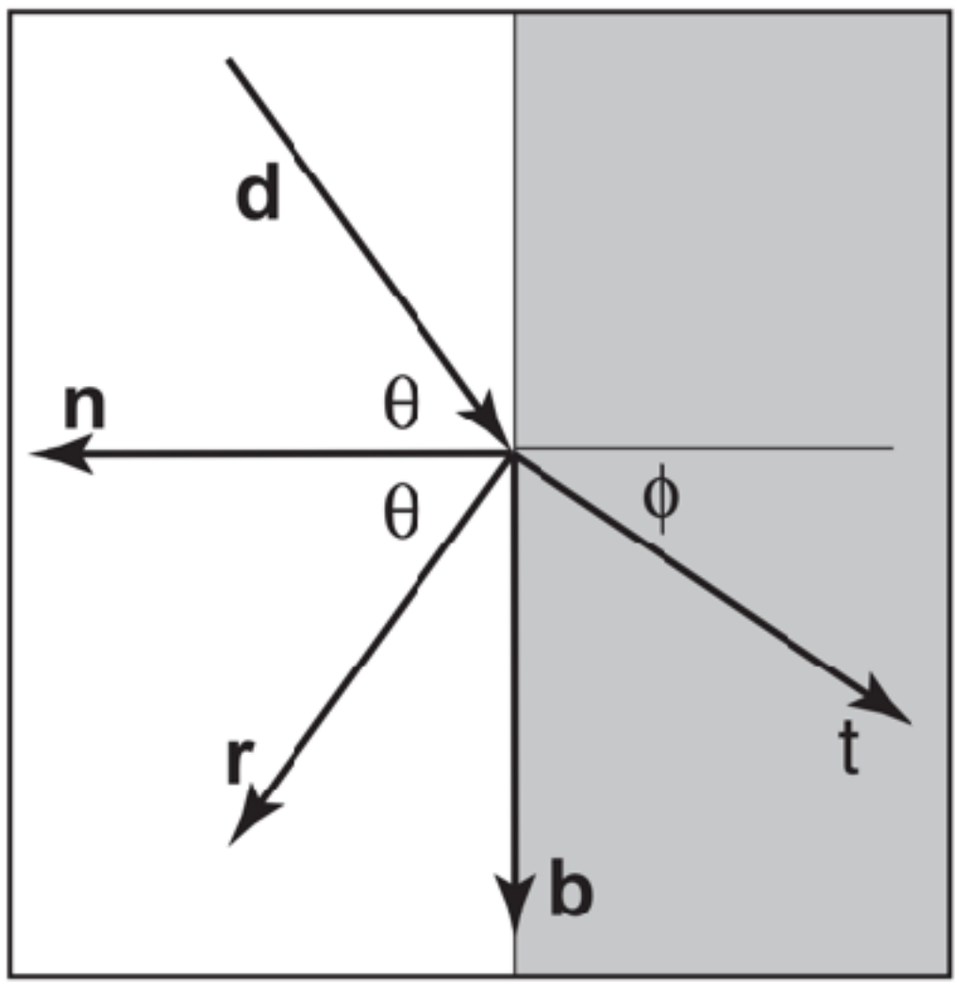
[marczych/github]

Transparency and Refraction

Snell's Law

n1 sinθ= n2 sinϕ

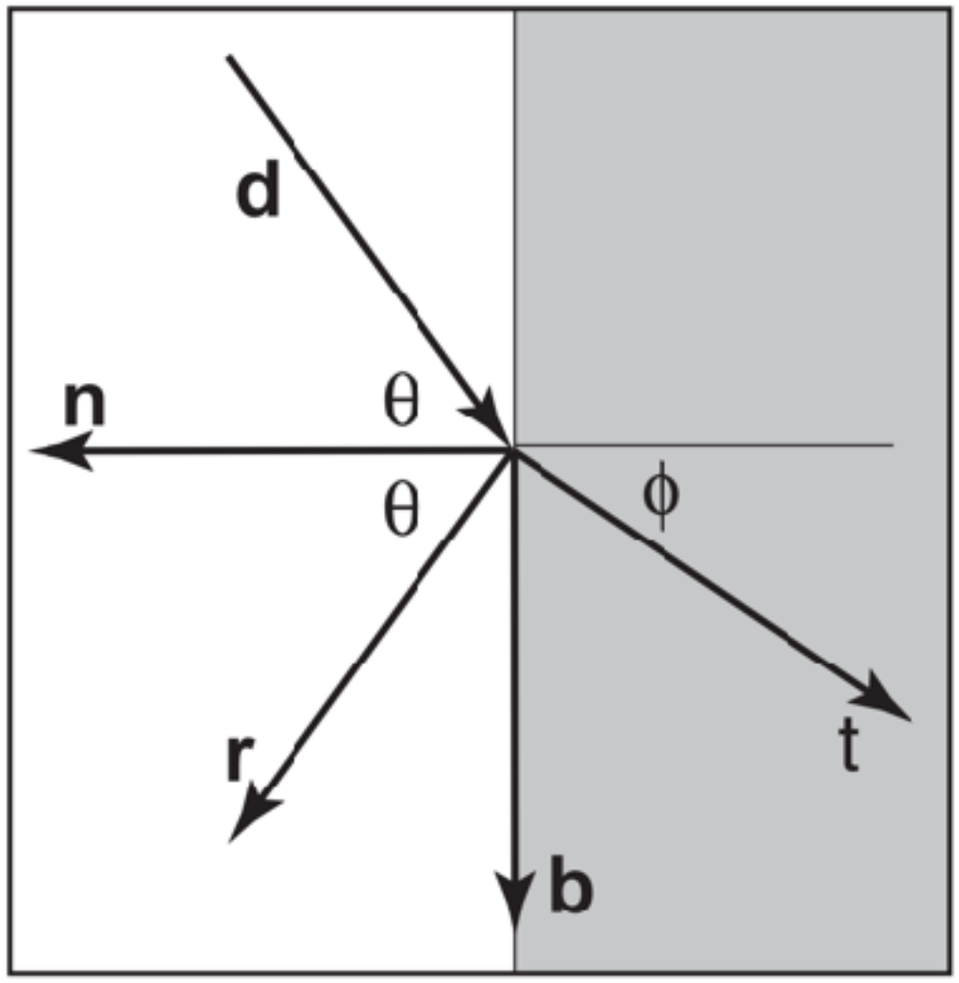
Example values of *n*:
air: 1.00;
water: 1.33–1.34;
window glass: 1.51;
optical glass: 1.49–1.92;
diamond: 2.42.



<whiteboard>

Transparency and Refraction

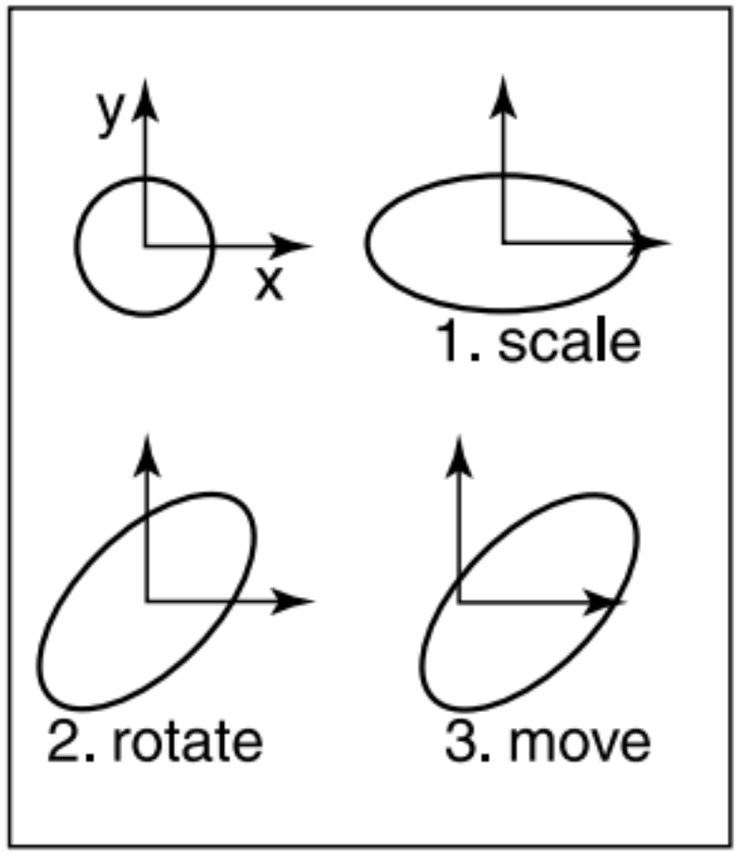
Snell's Law



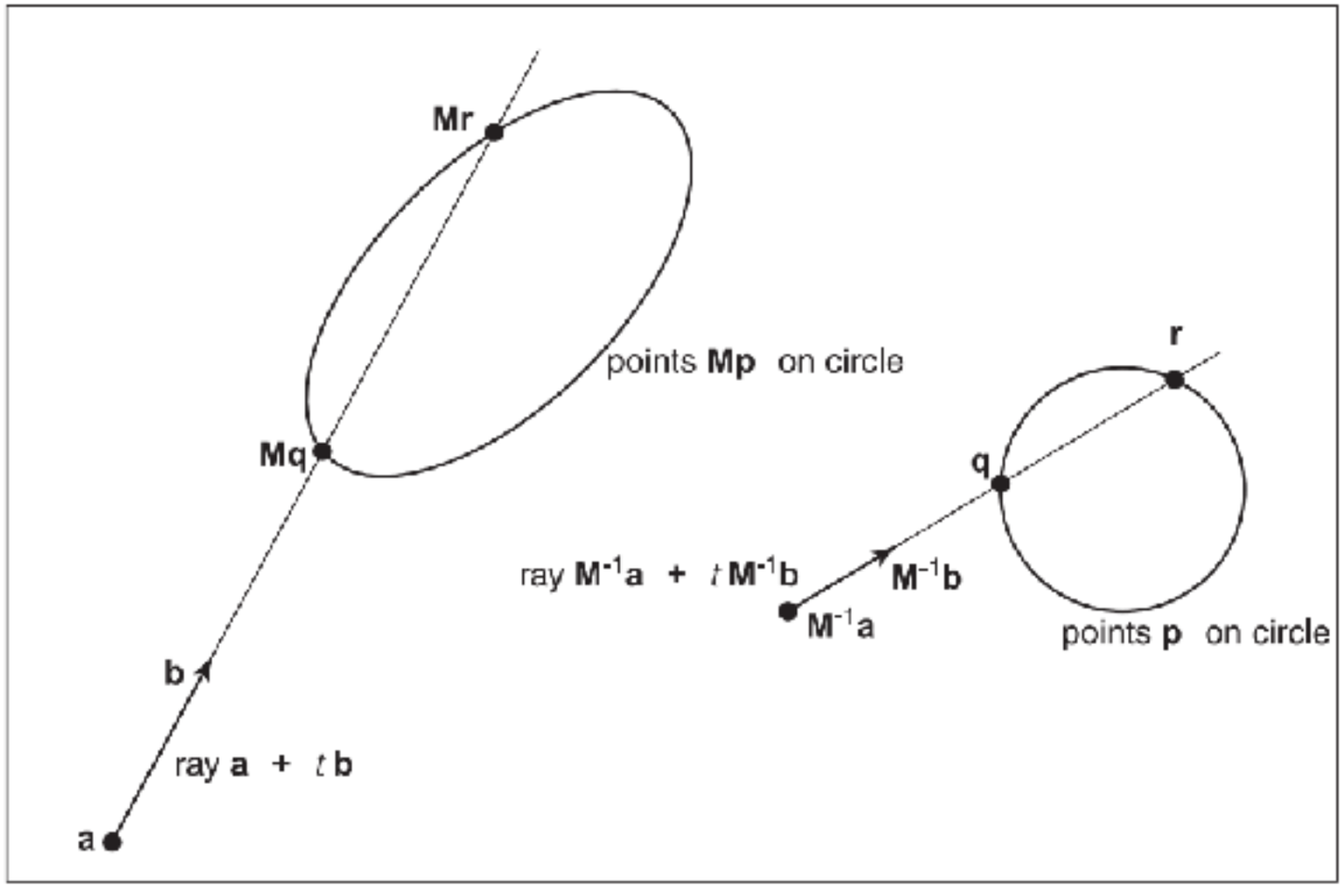
<u>Additional effects</u>

- varying reflectivity
  Fresnel equations
- attenuation of light intensity
  Beer's Law

Object Instancing

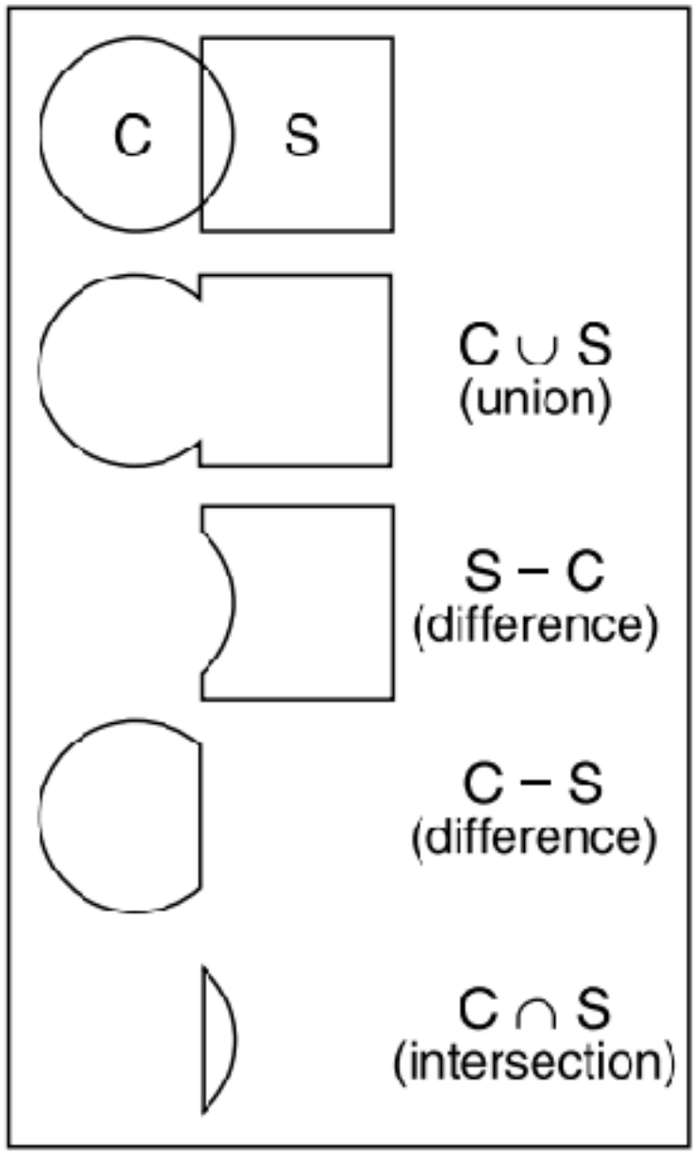


instance of circle with 3 transformations applied

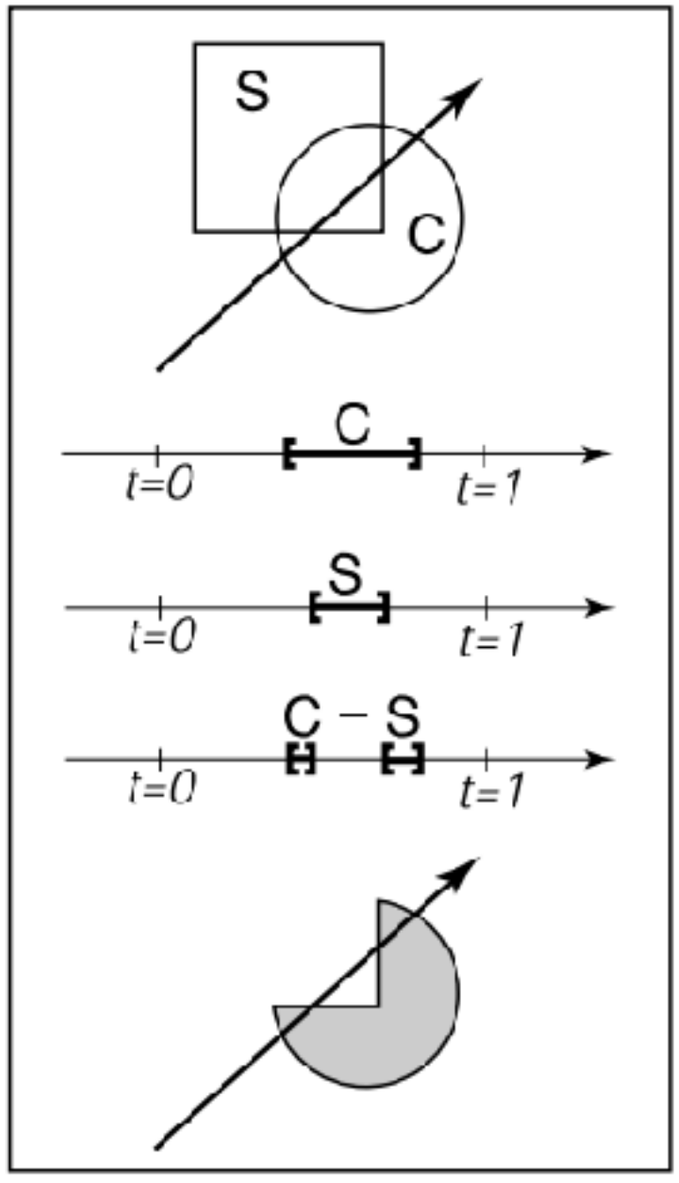


ray intersection problem in the two spaces are simple transforms of each other

Constructive Solid Geometry (CSG)



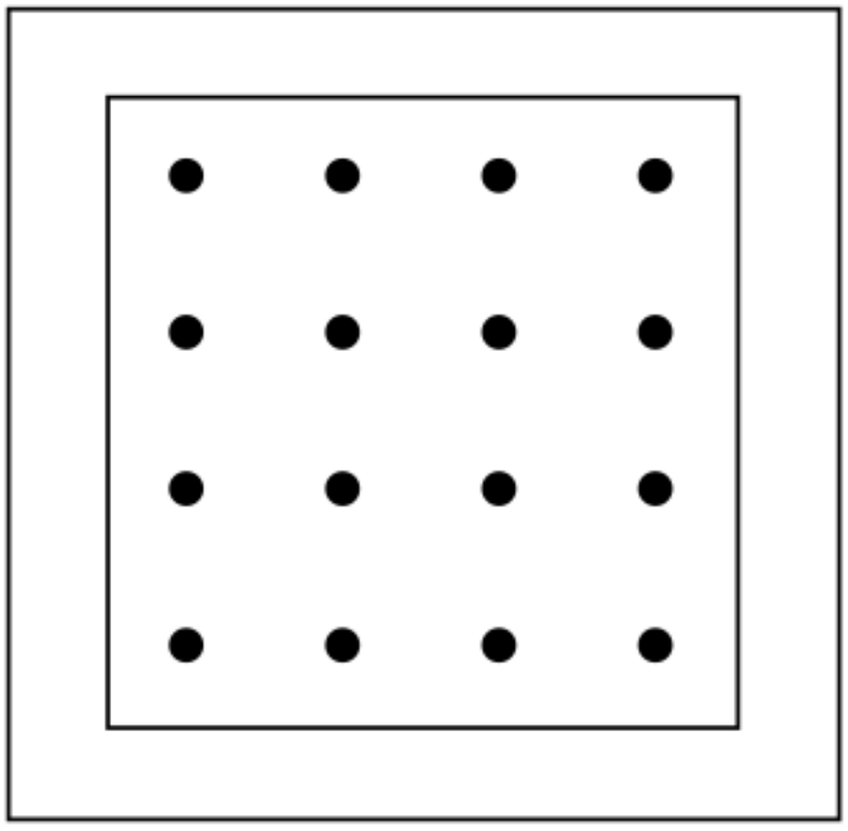
use set operations to combine solid shapes



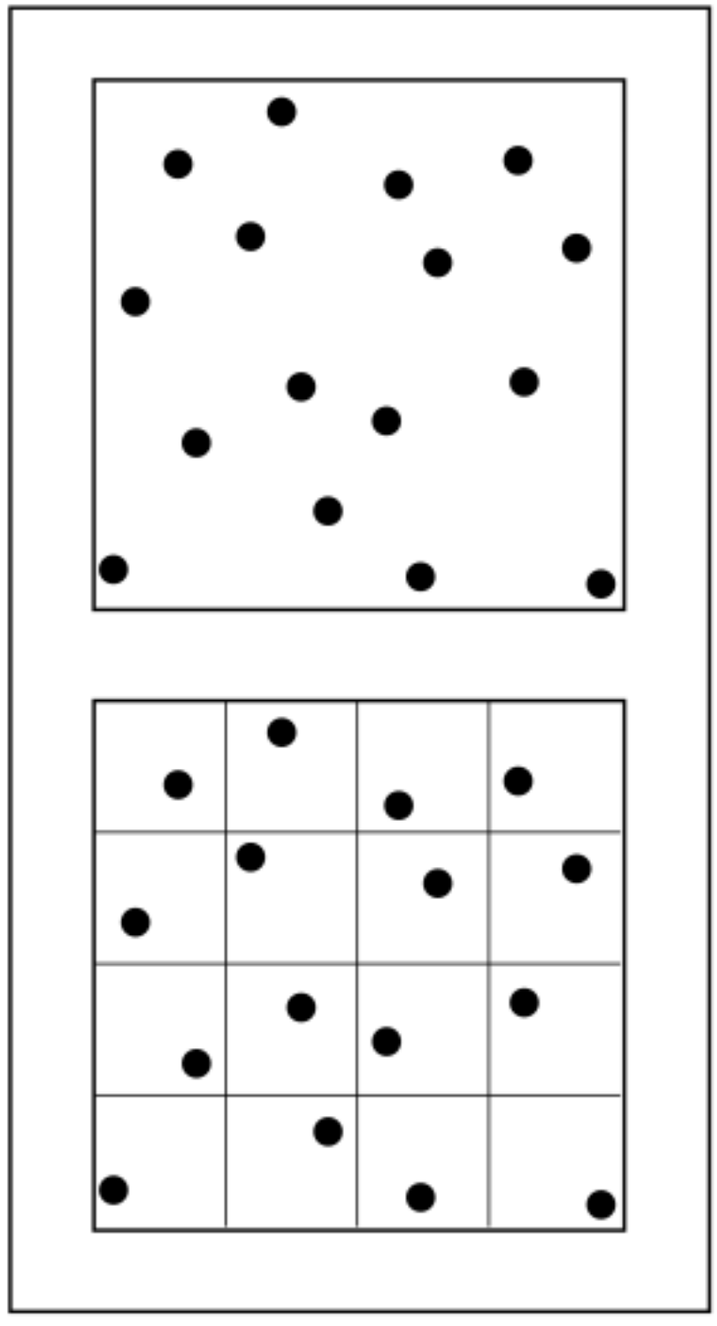
intersection with composite object

Distribution Ray Tracing

Anti-aliasing



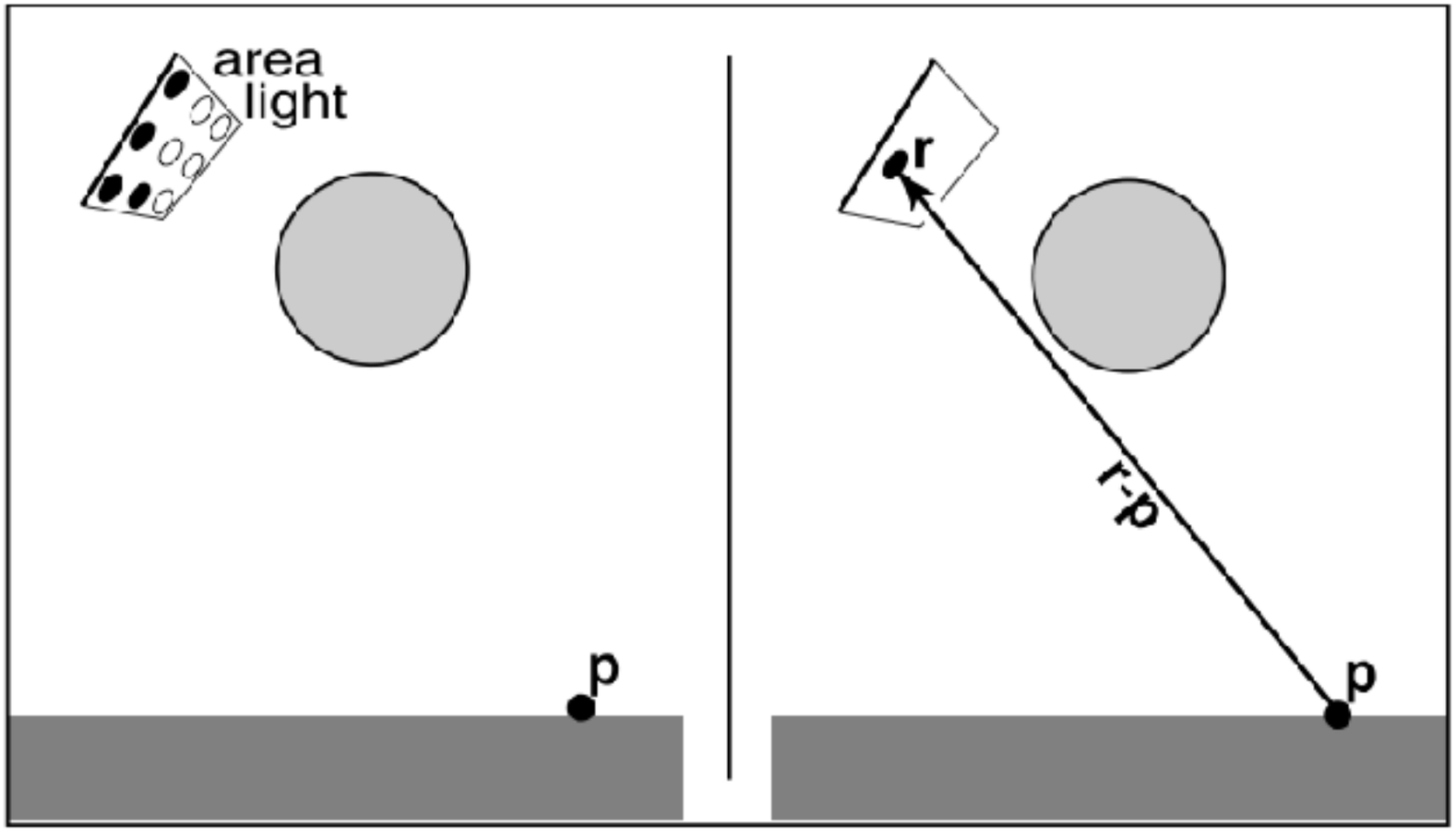
16 regular samples / pixel

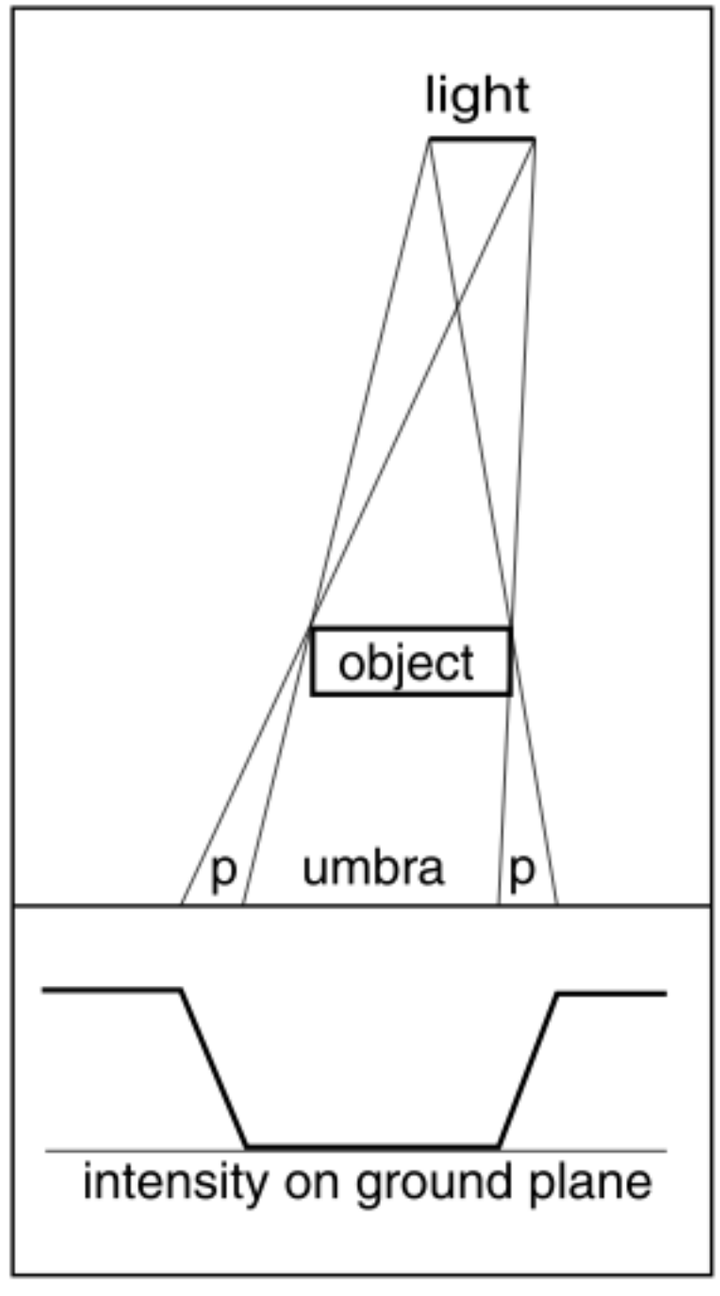


jittered samples

[Shirley and Marschner]

Soft Shadows

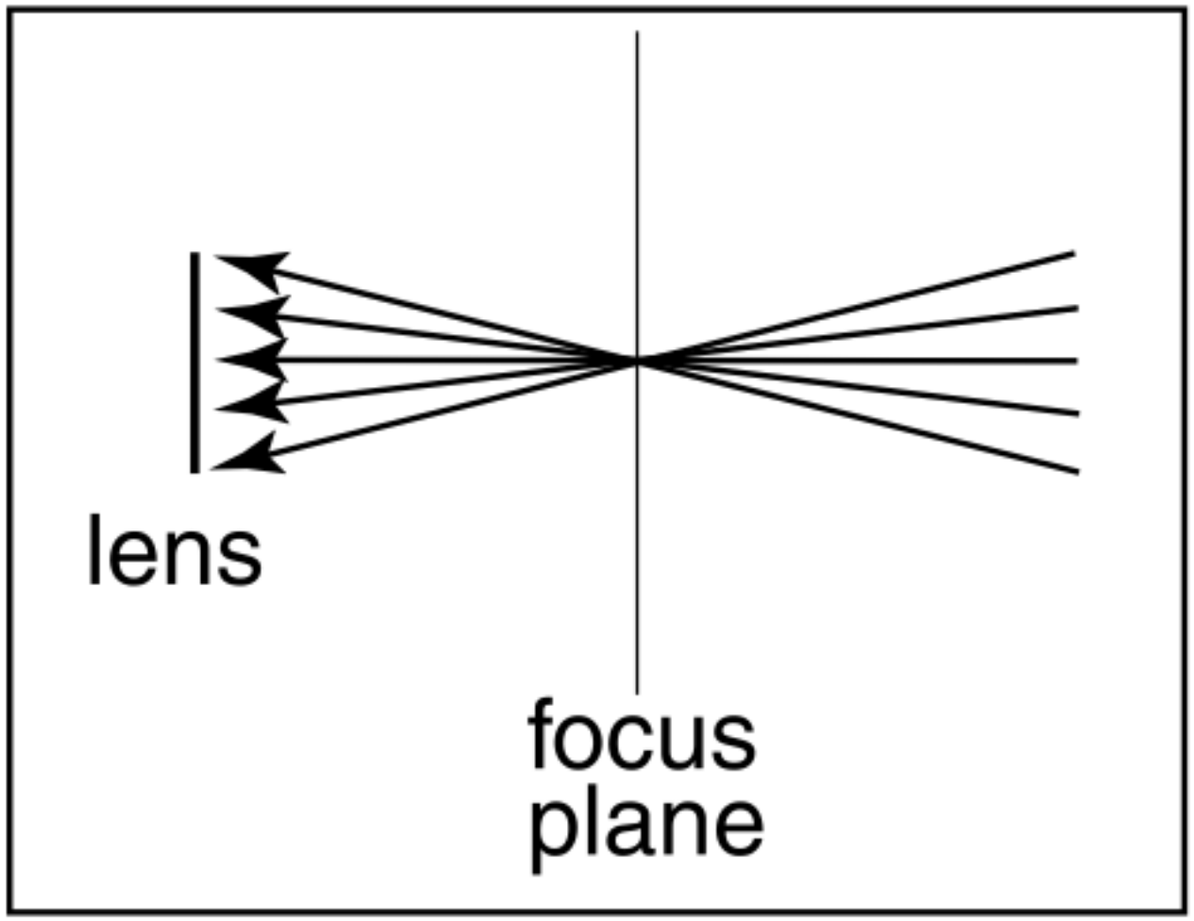




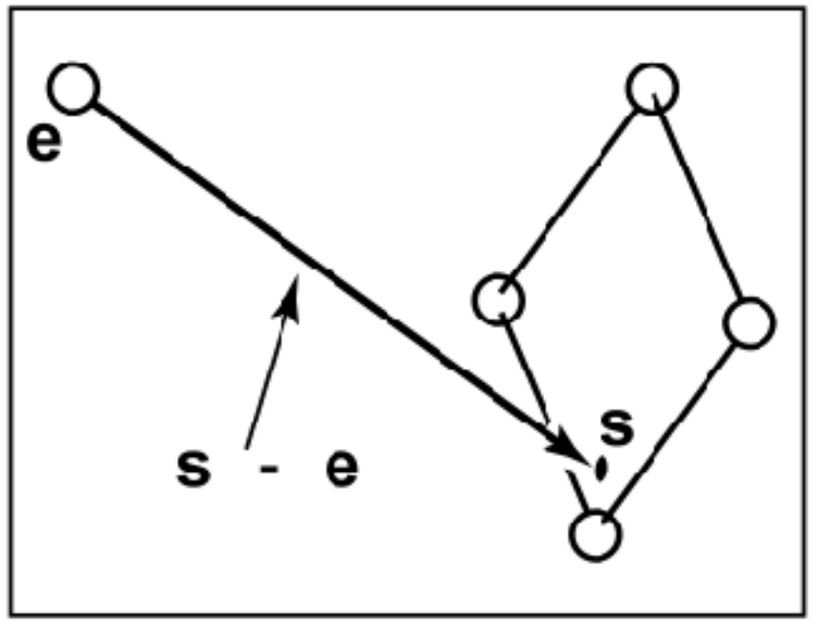
[Shirley and Marschner]

$$\mathbf{r} = \mathbf{c} + \xi_1 \mathbf{a} + \xi_2 \mathbf{b}$$

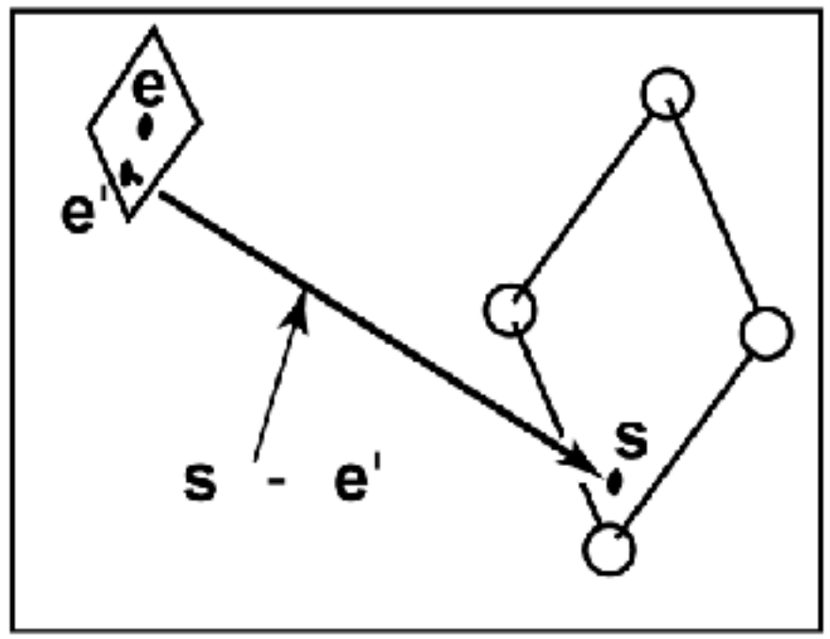
Soft Focus (depth of field)



lens (eye location) averages over a cone of directions



without depth of field



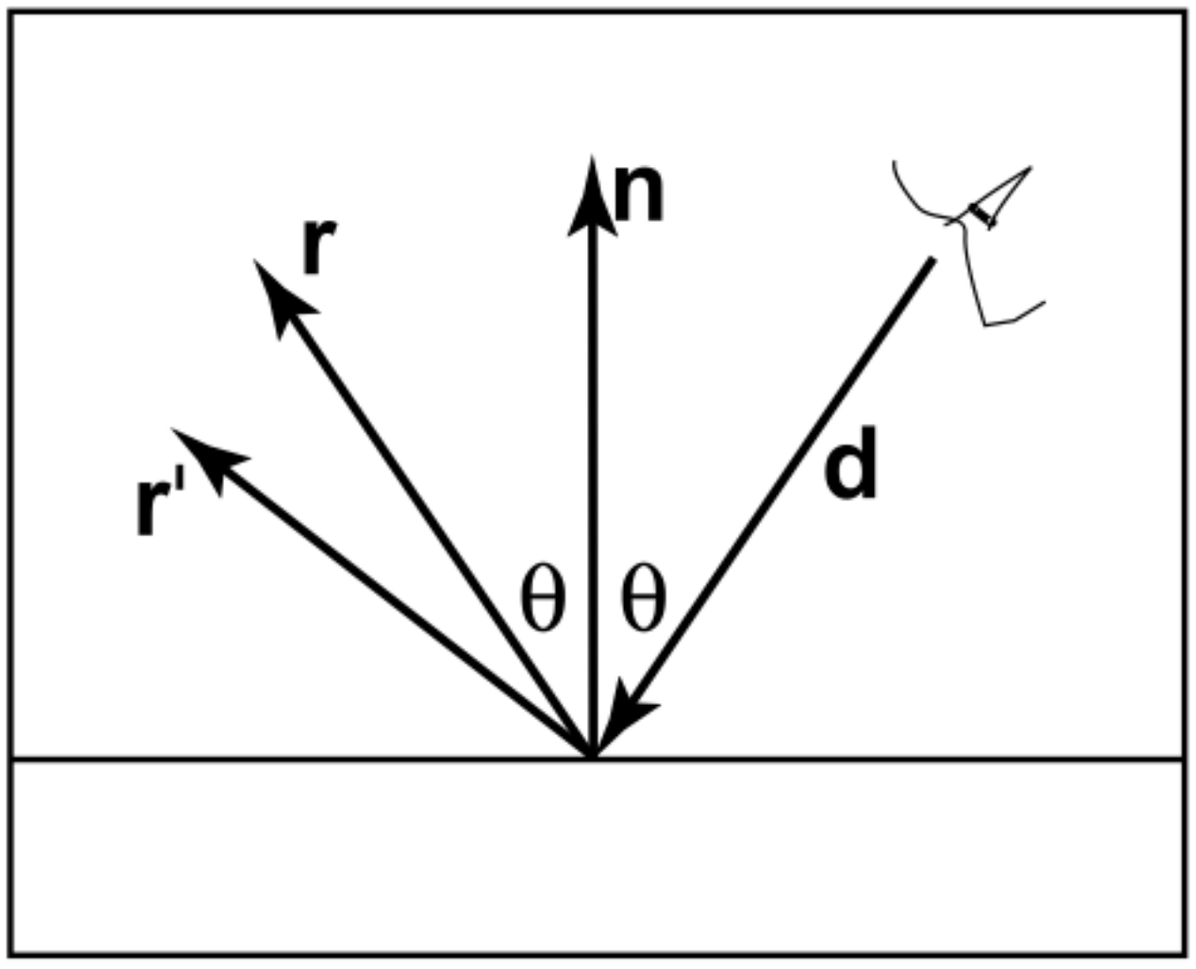
with depth of field

[Shirley and Marschner]

[Shirley and Marschner]

image using 25 samples per pixel

Fuzzy Reflections

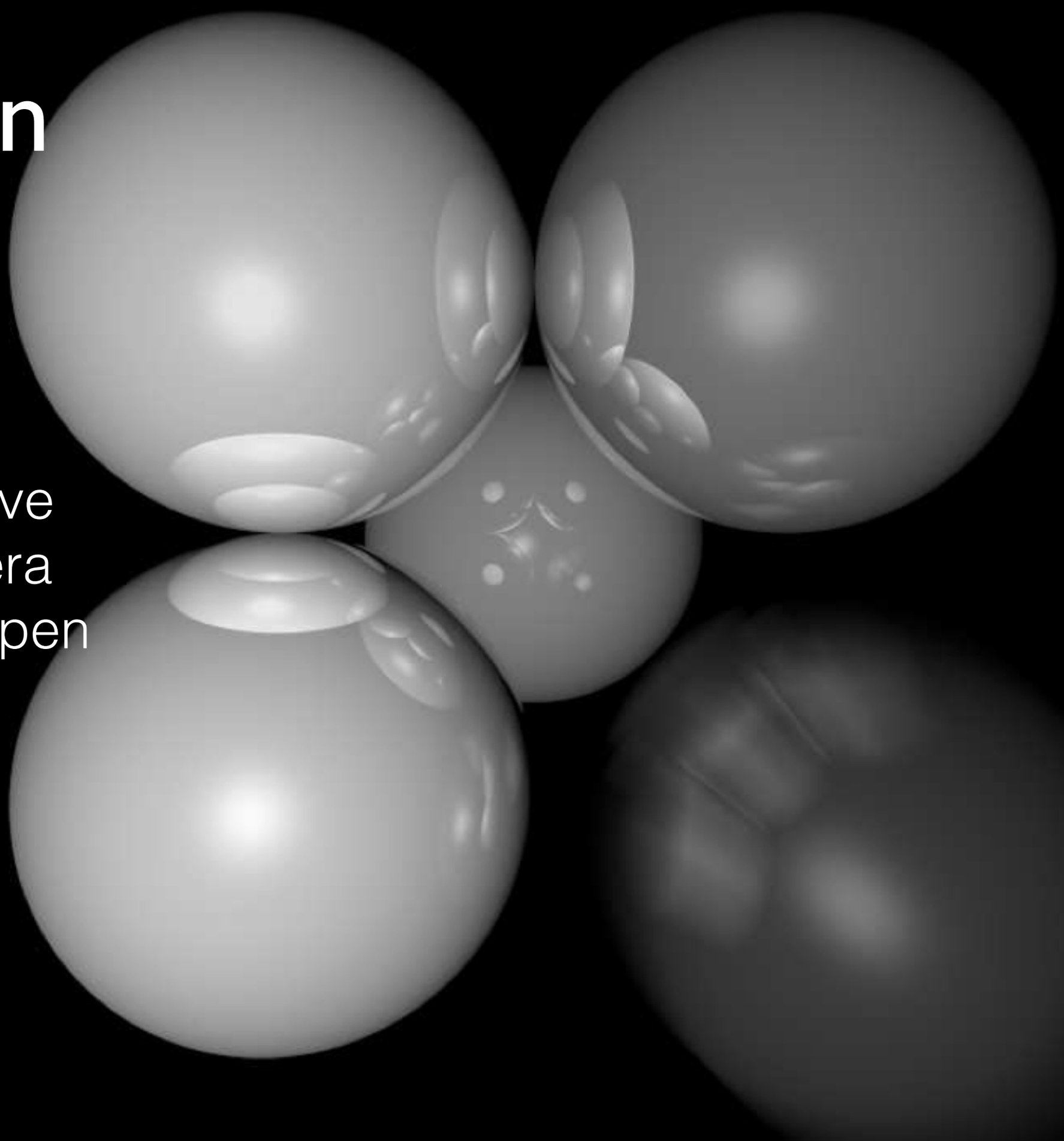


randomly perturb ideal specular reflection rays

[Shirley and Marschner]

Motion Blur

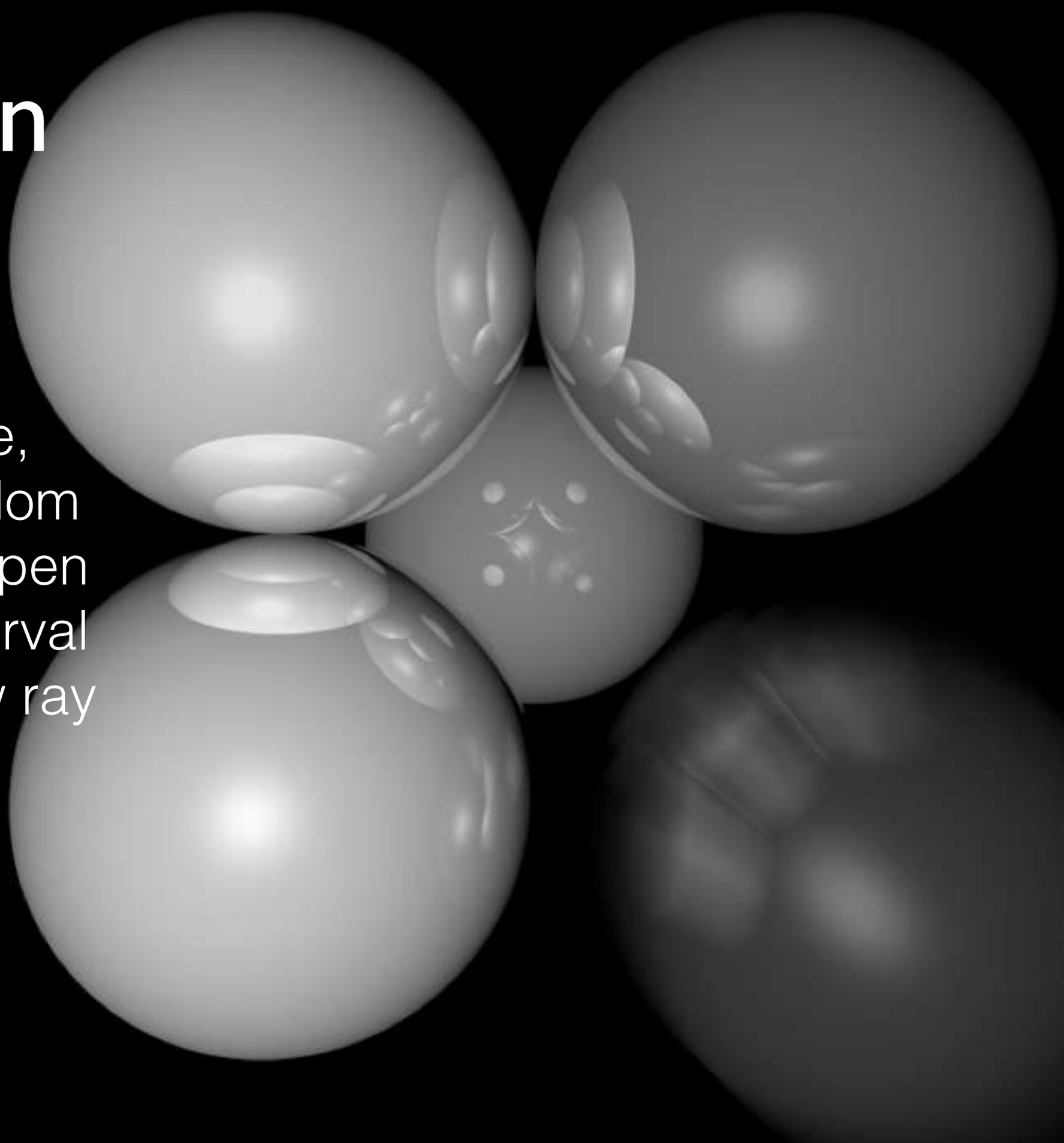
objects move while camera aperture is open



[Shirley and Marschner]

Motion Blur

to simulate,
choose random
time within open
aperture interval
for each view ray



[Shirley and Marschner]