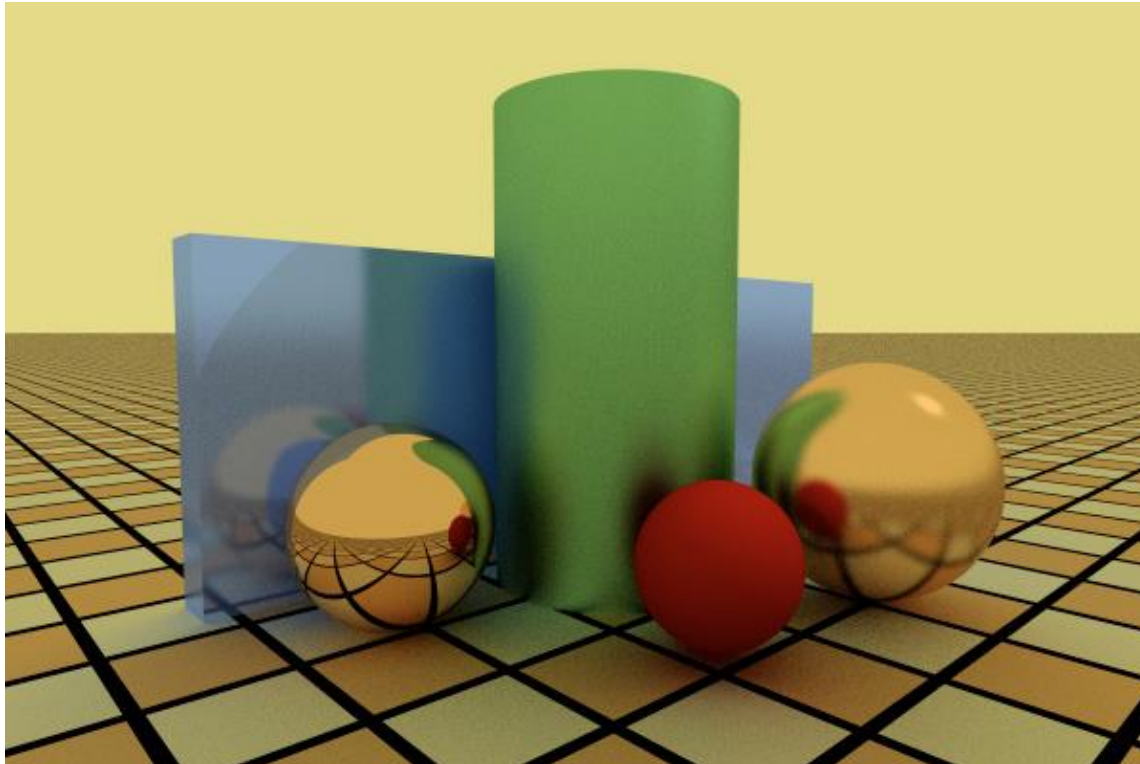# Glossy Reflection

## Production Computer Graphics
Eric Shaffer

Objectives

- Remove inconsistent specular reflection effects
- Learn how to model imperfect reflectors
- Be able to implement a glossy reflection with varying roughness

Glossy Reflection

- Blurry reflection rather than perfect (mirror reflection)
- We'll shoot reflection rays in more than one direction
- Be consistent with our specular highlight model
  - Use the same cosine power formula to generate the ray directions
- Density of ray distribution is given by angle around mirror direction

surface
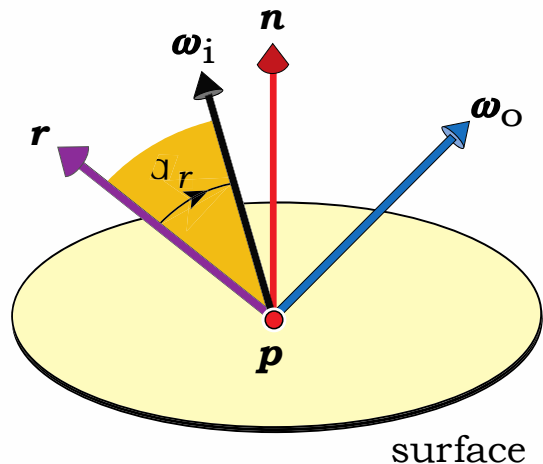
$$d = \left(\cos q_r\right)^e$$

What is *e*?

Glossy BRDF Model

- Our BRDF could be

$$f_{r,s}(p, W_i, W_o) = ck_r \mathbf{c}_r \cos(q_r)^e = ck_r \mathbf{c}_r (r \times W_i)^e$$

- r is the mirror reflection direction

- c is a normalization constant proportional to e+1

- As e → ∞ the BRDF becomes a delta function
  - Only reflects in the mirror direction

Monte Carlo Estimator

Our approximation of reflected indirect light is now an integral
- Because we're using more than one direction

$$L_{indirect}(p, W_o) = ck_r \mathbf{c_r} \int_{2p+} (W_{i,j} \times r)^e L_o(r_c(p, W_i), -W_i) \cos q_i \, dW_i$$

$$\langle L_r(p, W_o) \rangle = \frac{ck_r \mathbf{c_r}}{n} \sum_{j=1}^{n} \frac{(W_{i,j} \times r)^e L_o(r_c(p, W_{i,j}), -W_{i,j}) \cos q_{i,j}}{p(W_{i,j})}$$

The pdf

The pdf should be proportional to the BRDF

$$p(W_{i,j}) \mu (r \times W_i)^e$$

But we need the cos to go away

- So it matches perfect mirror reflection when e → ∞

$$p(W_{i,j}) \mu (r \times W_i)^e (n \times W_i)$$

- So then the estimator simplifies to

$$\langle L_r(p, W_o) \rangle = \frac{k_r \mathbf{c_r}}{n} \mathring{a}_{j=1}^n L_o(r_c(p, W_{i,j}), -W_{i,j})$$

Generating Reflection Rays
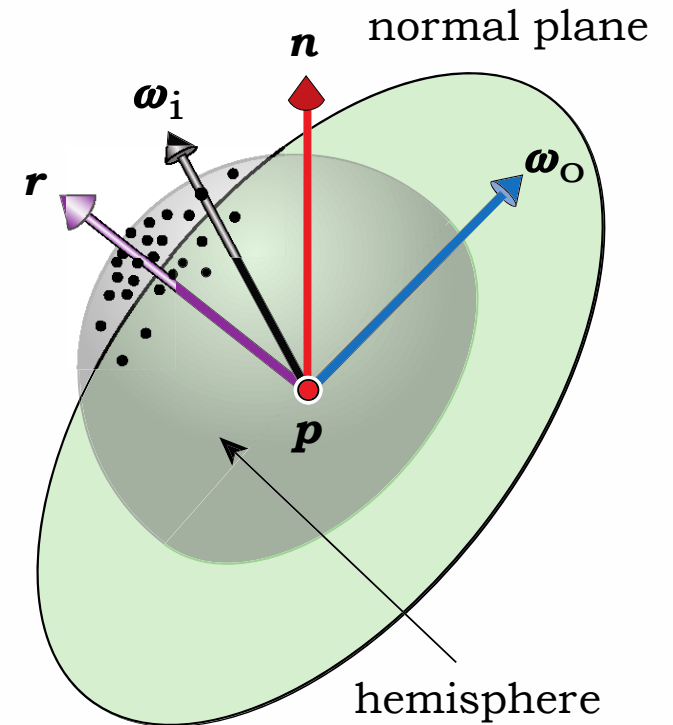
The parameter e controls the blur
- Higher e makes the material shinier

To construct the ray we
- need to generate samples on a hemisphere
  - (s_x, s_y, s_z)
- map those samples to the hemisphere around r
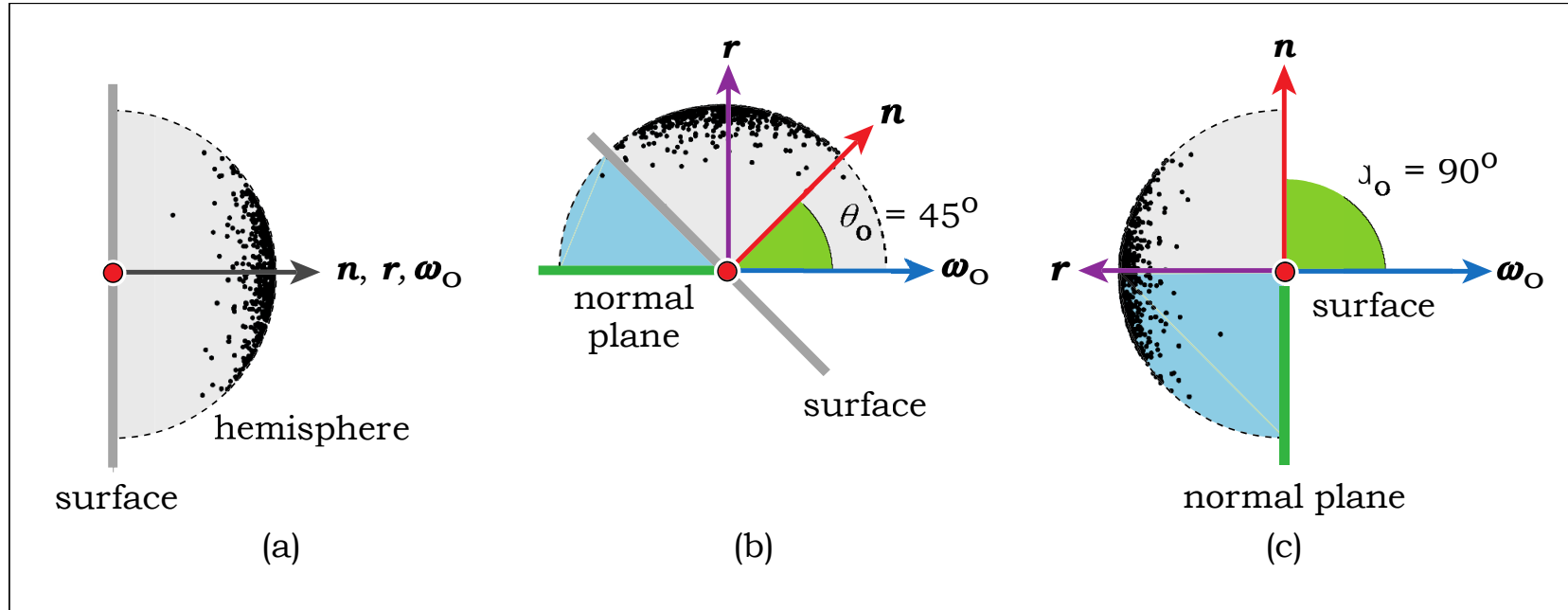
Construct an orthonormal basis (u,v,w)
- w is parallel to r and v,w are in plane normal to r
- map origin to p
- ray direction is $s_x u + s_y v + s_z w$

normal plane

hemisphere

Sampling Issues

Rays can be generated that are below the object surface
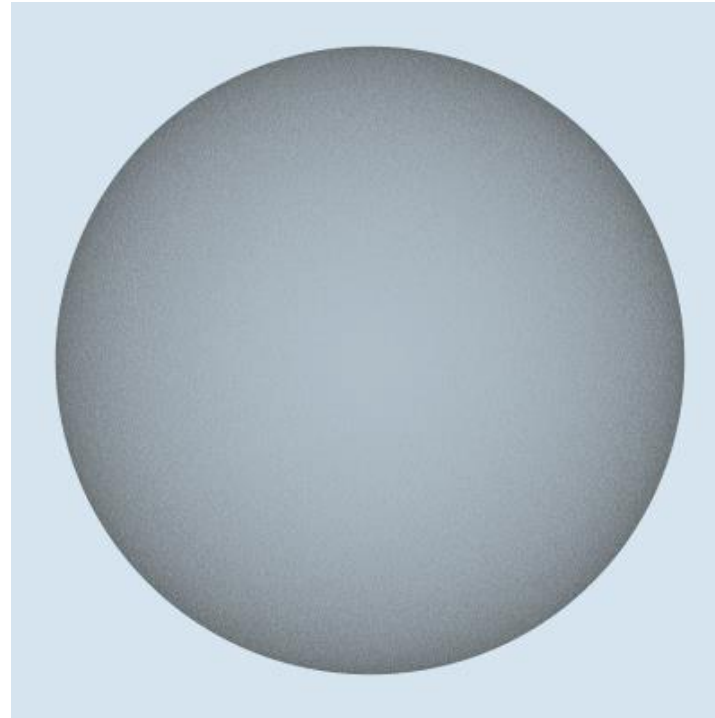- Why?

Sampling Issues

Test image e=1, k_r=0.8, c_r=white, 100 rays per pixel

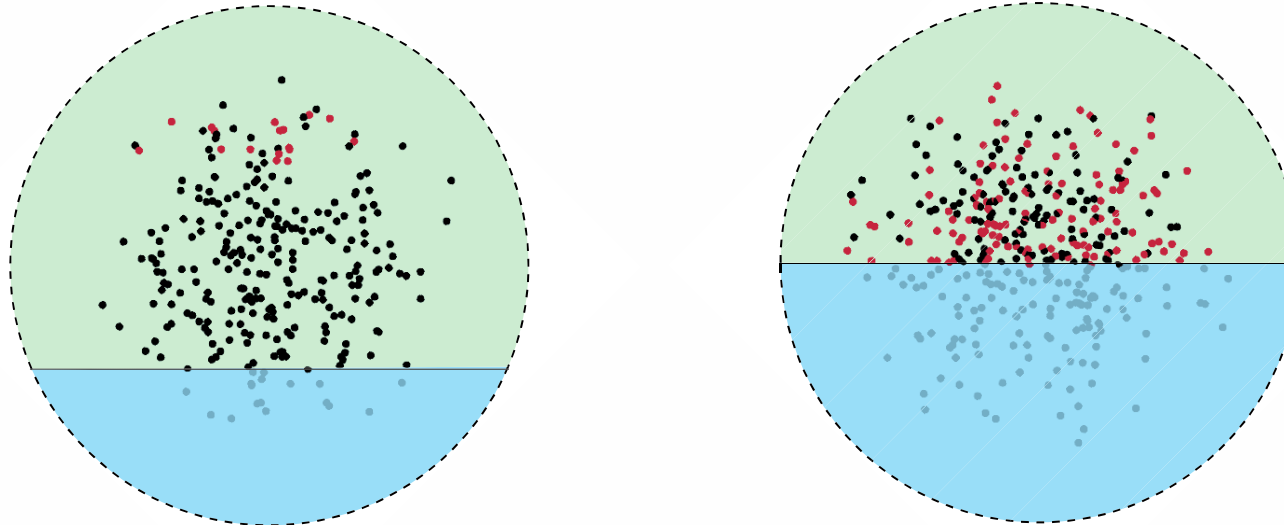Color of sphere should be constant
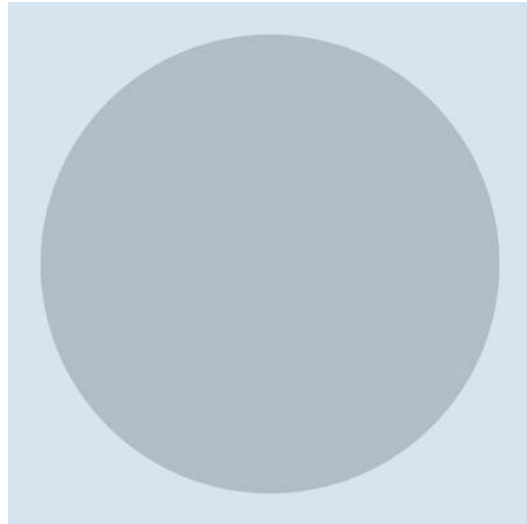
- Why?

It's not

- Why?

ILLINOIS

Fixing the Sampling Issues

- Reflect rays below surface through r
  - Moves them above surface
  - Biases distribution but it's still better

Fixing the Sampling Issues

- Test for ray below surface $n \times W_i < 0$

- Reflected ray $\qquad W_i = -s_x u - s_y v + s_z w$

Examples: Varying e