Standard nearby point source model (Lambertian reflection)

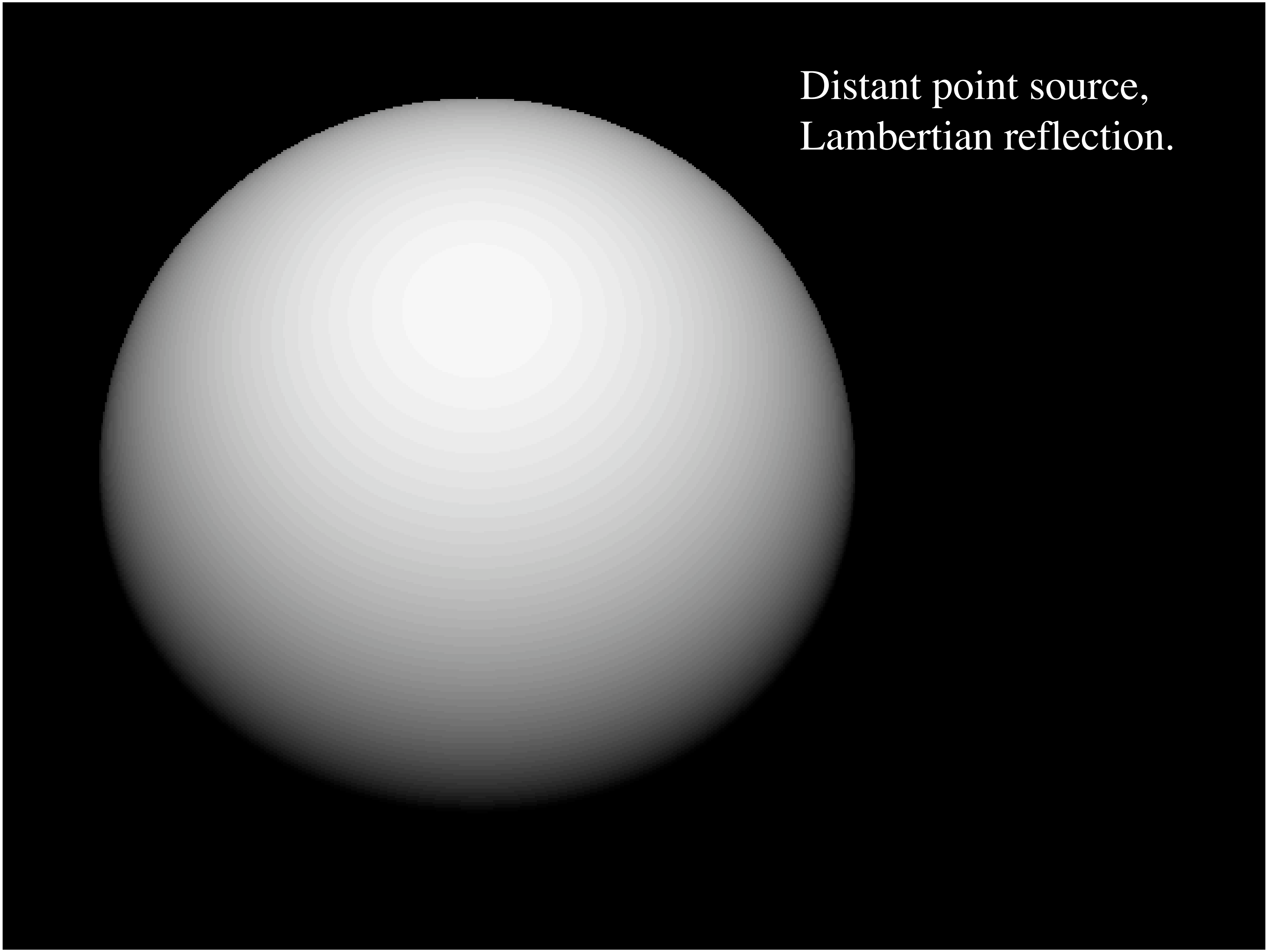
$$\rho_d(x)\left(\frac{N(x) \bullet S(x)}{r(x)^2}\right)$$

- N is the illuminated surface normal
- rho is diffuse albedo
- S is source vector - a vector from x to the source, whose length is the intensity term
  - works because a dot-product is basically a cosine
- r(x) is distance from surface point to source --- term occurs because source "looks smaller" as we move away--or, alternatively, its energy is spread out over a larger surface.

Standard distant point source model

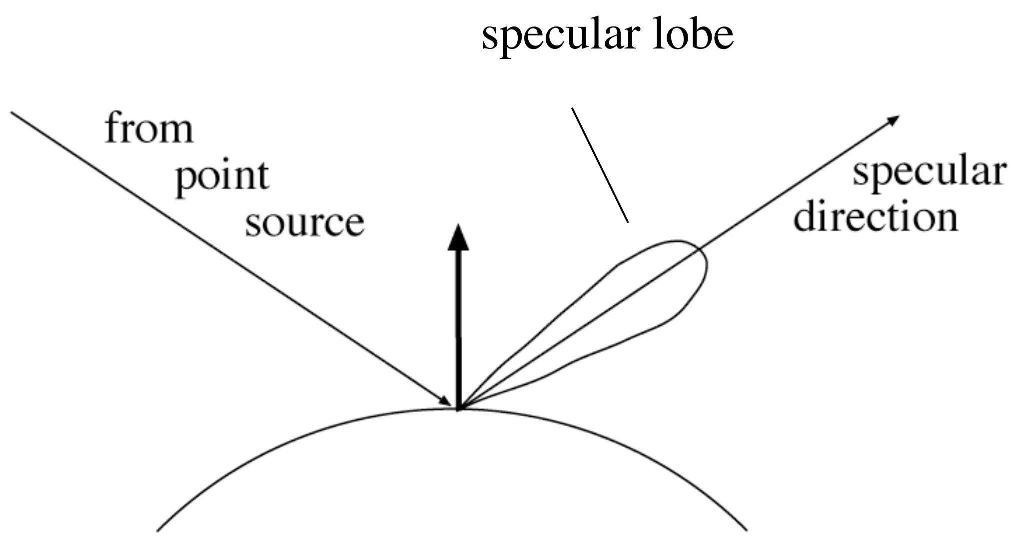
- Nearby point source gets bigger if one gets closer, but the effect for far away points is negligible (e.g. the sun).
- Assume that all points in the model are close to each other with respect to the distance to the source. Then the source vector doesn't vary much (and can be assumed to not vary with x---ignoring the possibility that it is ocluded), and the distance doesn't vary much either, and we can roll the constants together to get:

$$\rho_d(x)\left(N(x) \bullet S_d\right)$$

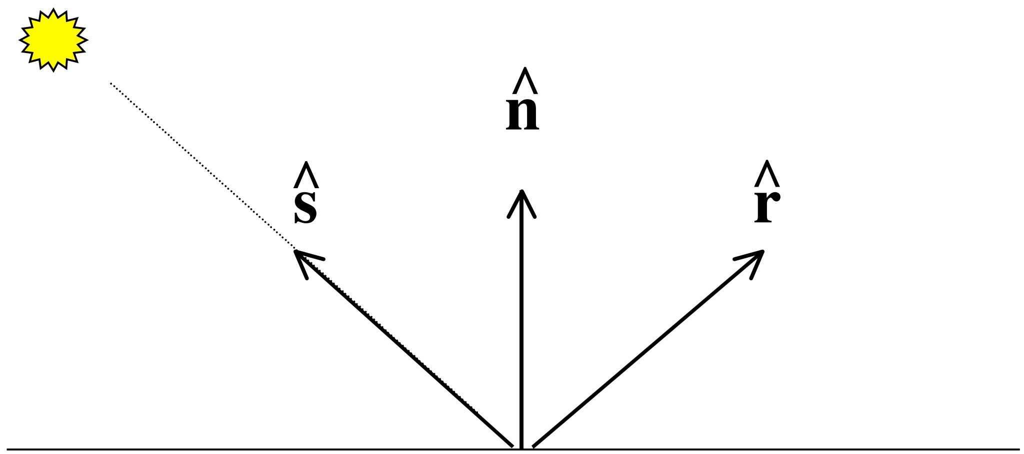

Distant point source,
Lambertian reflection.

Specular surfaces

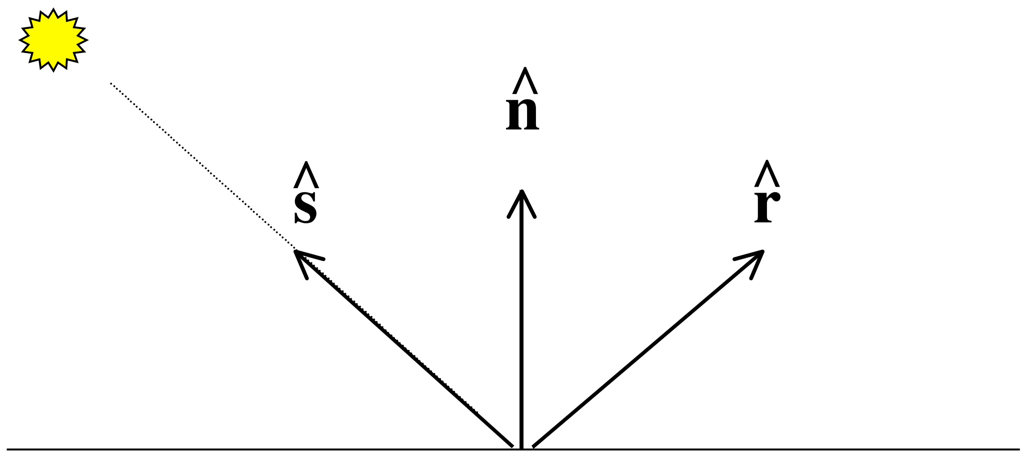
- Another important class of surfaces is specular (somewhat mirror-like).
  - specular surfaces reflect a significant amount of energy in the specular (mirror) direction
  - a significant amount may also be reflected in a direction roughly in the mirror direction (specular lob)
  - typically there is a diffuse component as well
  - writing a BRDF approximation is possible, but beyond the scope of this course



Computing reflection (specular) direction



Computing reflection (specular) direction



$\hat{\mathbf{s}} + \hat{\mathbf{r}} = k\hat{\mathbf{n}}$ and $\hat{\mathbf{n}} \bullet \hat{\mathbf{s}} = \hat{\mathbf{n}} \bullet \hat{\mathbf{r}}$

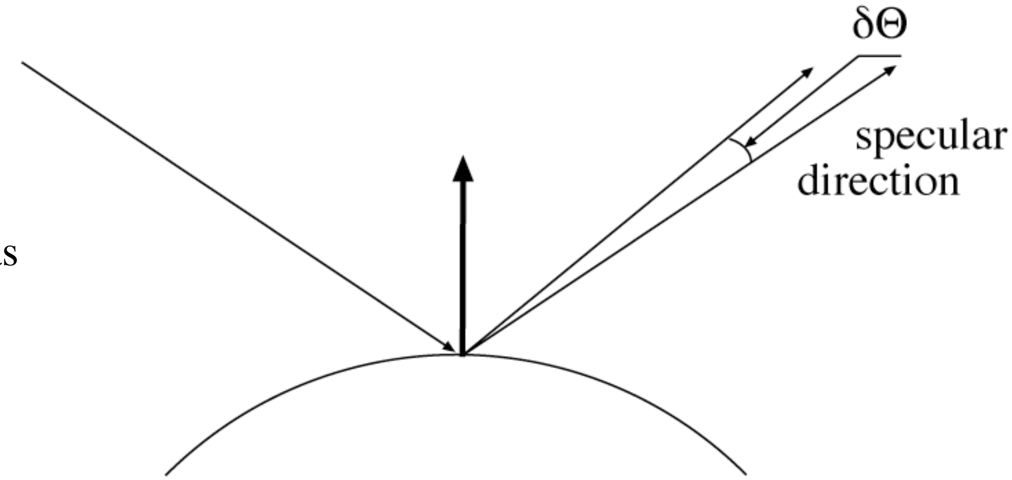
$\hat{\mathbf{n}} \bullet \hat{\mathbf{s}} + \hat{\mathbf{n}} \bullet \hat{\mathbf{r}} = k \;\Rightarrow\; k = \mathbf{2}\hat{\mathbf{n}} \bullet \hat{\mathbf{s}}$

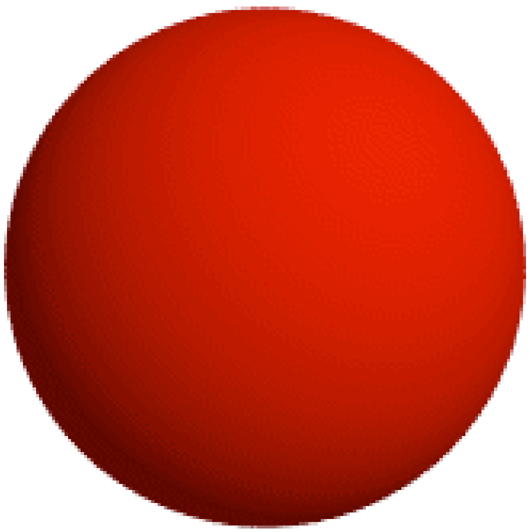
So $\hat{\mathbf{r}} = \mathbf{2}(\hat{\mathbf{n}} \bullet \hat{\mathbf{s}})\hat{\mathbf{n}} - \hat{\mathbf{s}}$

Phong's model of specularities

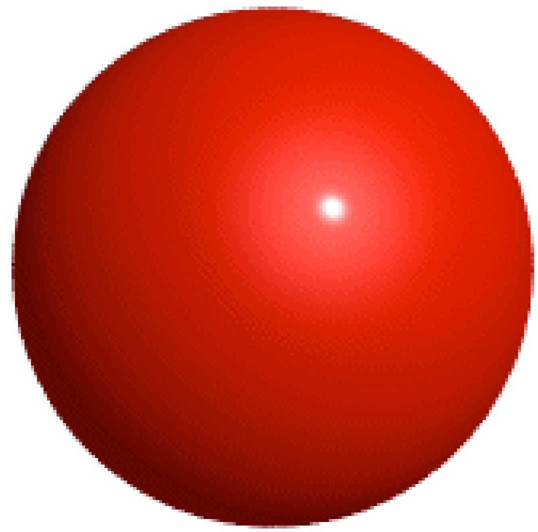
- There are very few cases where the exact shape of the specular lobe matters.
- Typically:
  - very, very small --- mirror
  - small -- blurry mirror
  - bigger -- see only light sources as "specularities"
  - very big -- faint specularities
- Phong's model
  - reflected energy falls off with

$$\cos^n(\delta\vartheta)$$





Diffuse Lighting



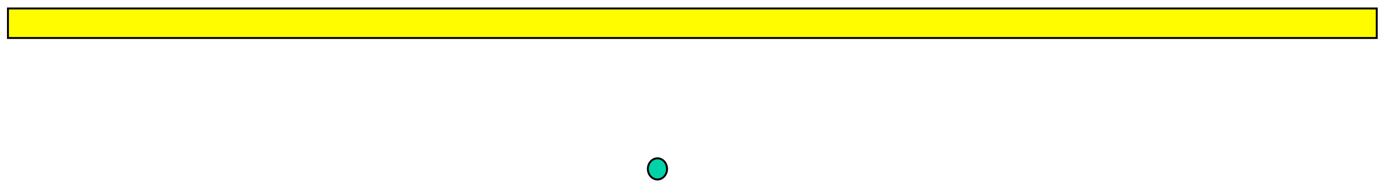
Plus Specular Highlight

from
http://www.geocities.com/SiliconValley/Horizon/6933/shading.html

Simple shading model

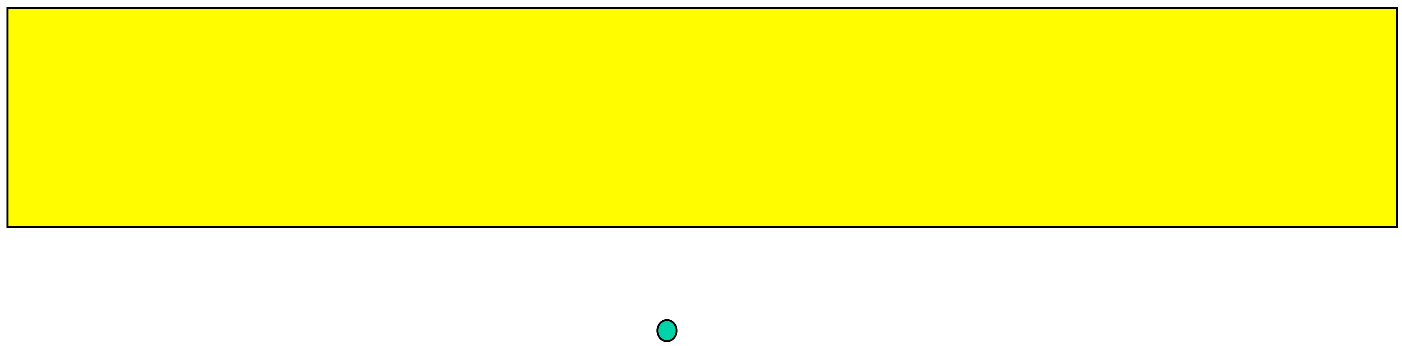
- Assume that all surface radiance is due to sources alone
  - i.e. both diffuse and specular, but no exitance.
- Can use standard point source model for diffuse term
  - either nearby or at infinity
- Common simplification:
  - drop 1/r^2 term from nearby point source (still have direction variation)
- Intensity = Diffuse intensity due to sources + specular term due to sources
- Multiple sources are added up (or integrated over)
- For some special cases, the integral can be estimated in advance

Line sources



Radiosity due to line source varies with inverse distance, if the source is long enough (derivation is through integration of the contributions along the line)

General extended sources



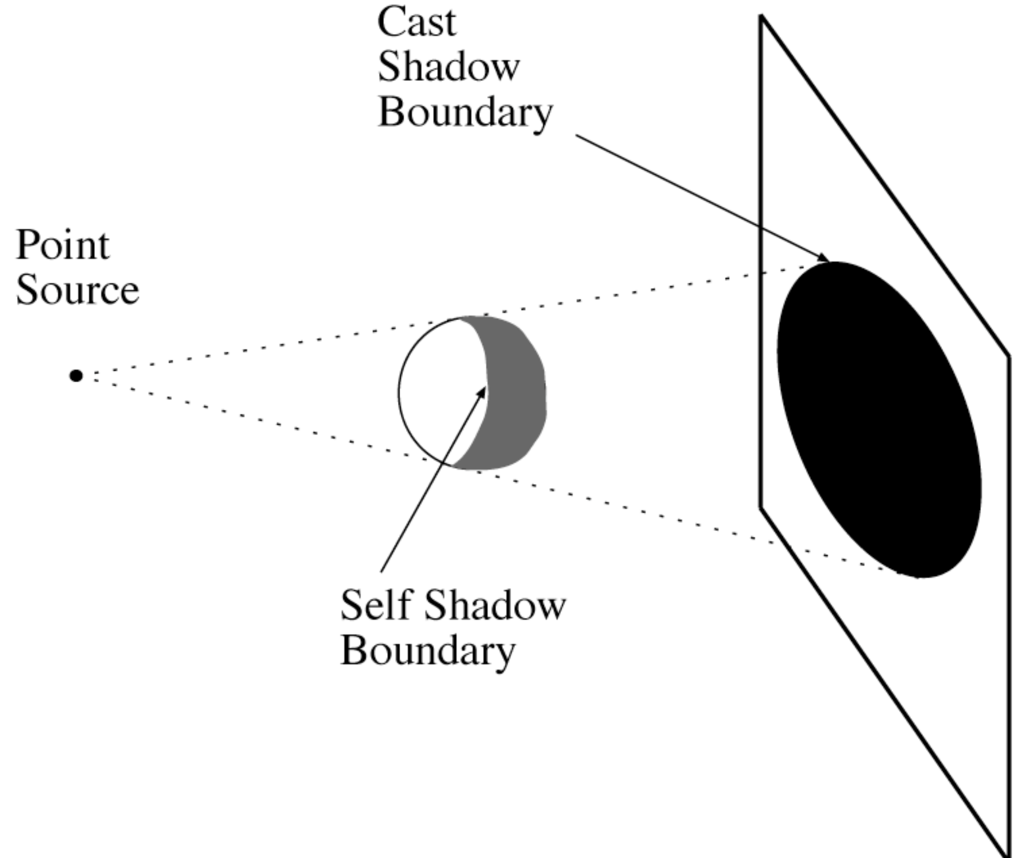
Can be handled by doing the integration (we won't)

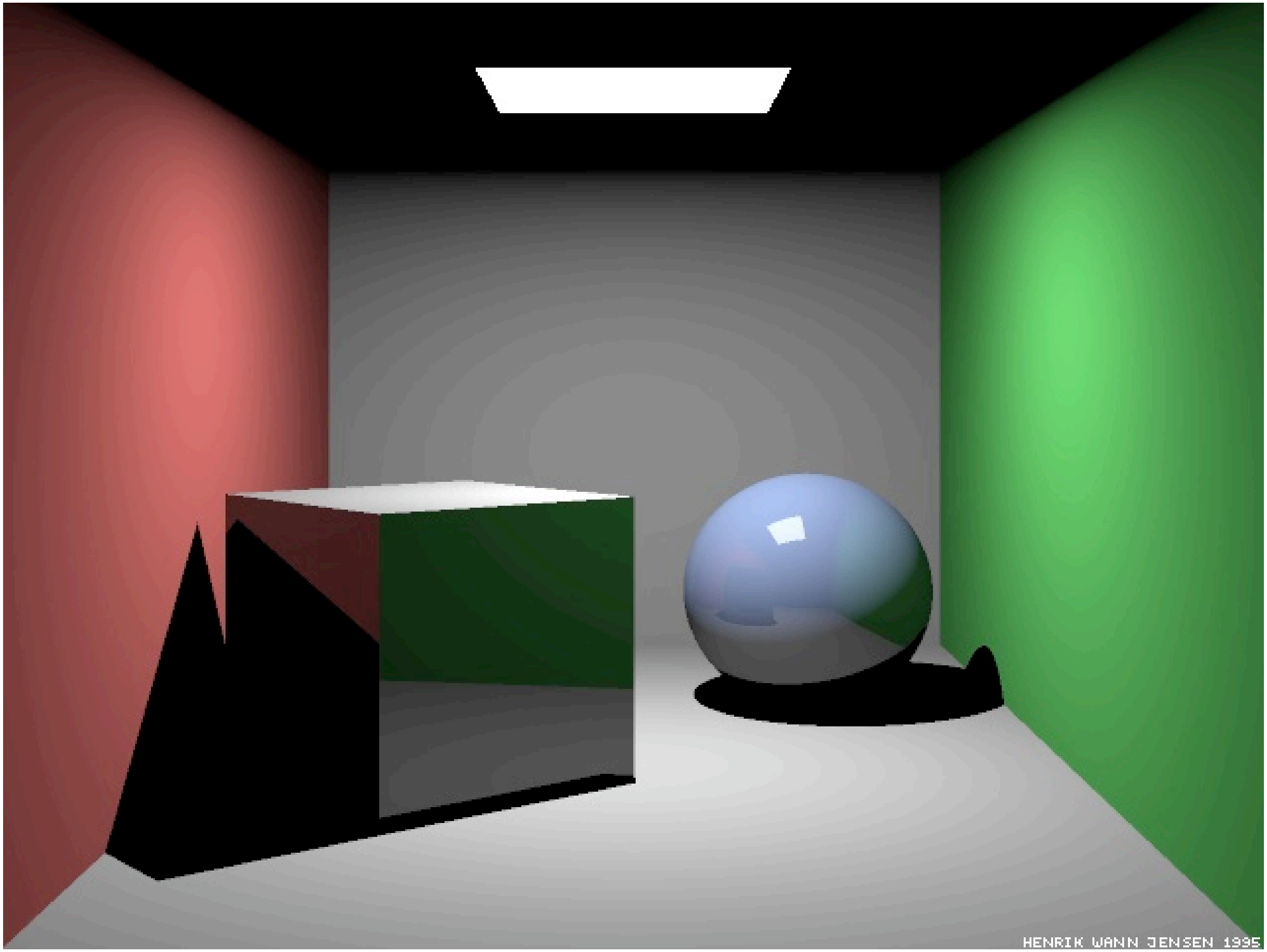
What if the source is large relative to the distance to it?

How about the hemisphere of the sky?

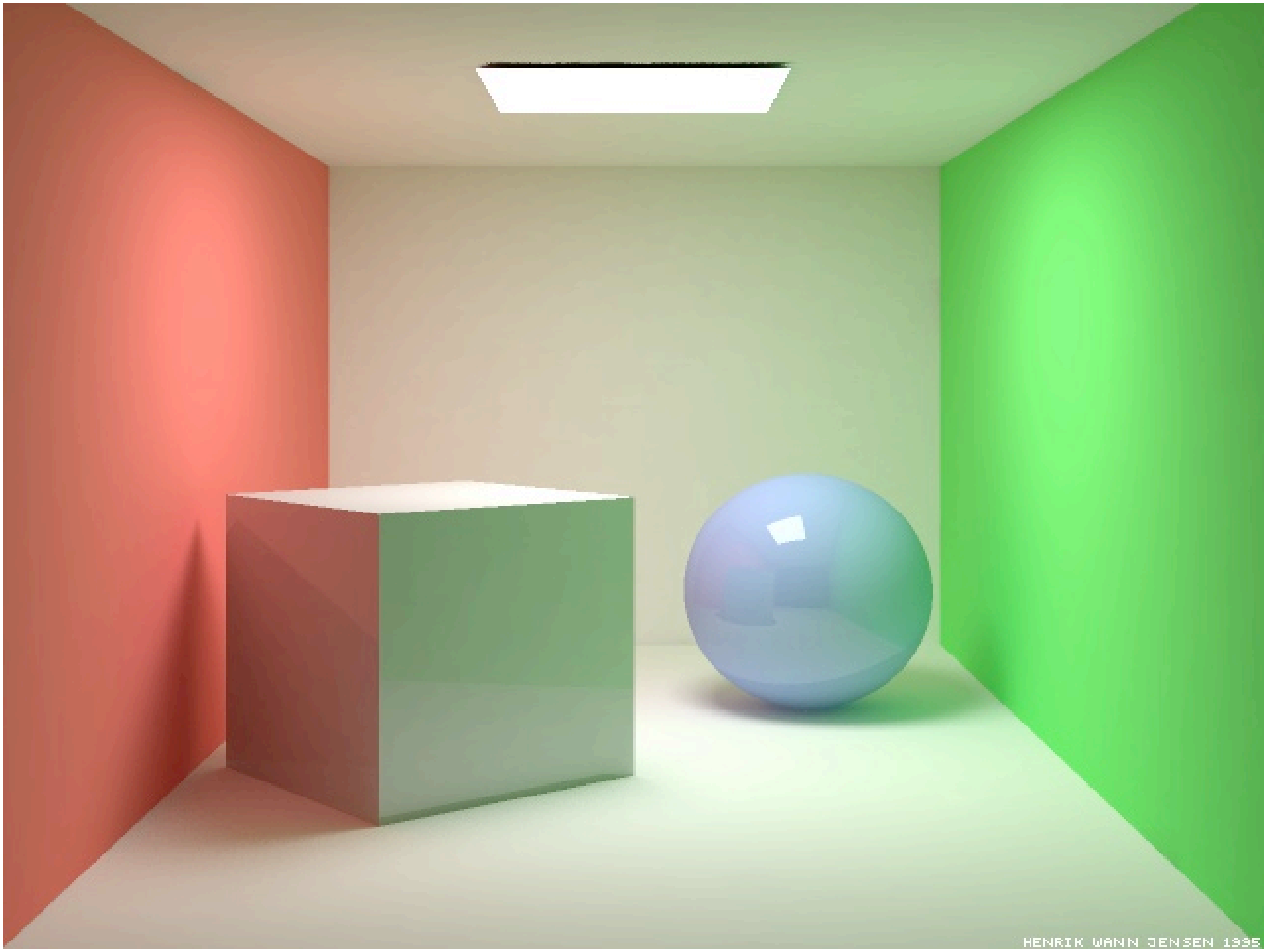
Shadows cast by a point source

- A point that can't see the source is in shadow
- For point sources, the geometry is simple





Ray-traced Cornell box, due to Henrik Jensen,
http://www.gk.dtu.dk/~hwj



Radiosity Cornell box, due to Henrik Jensen,
http://www.gk.dtu.dk/~hwj, rendered with ray tracer