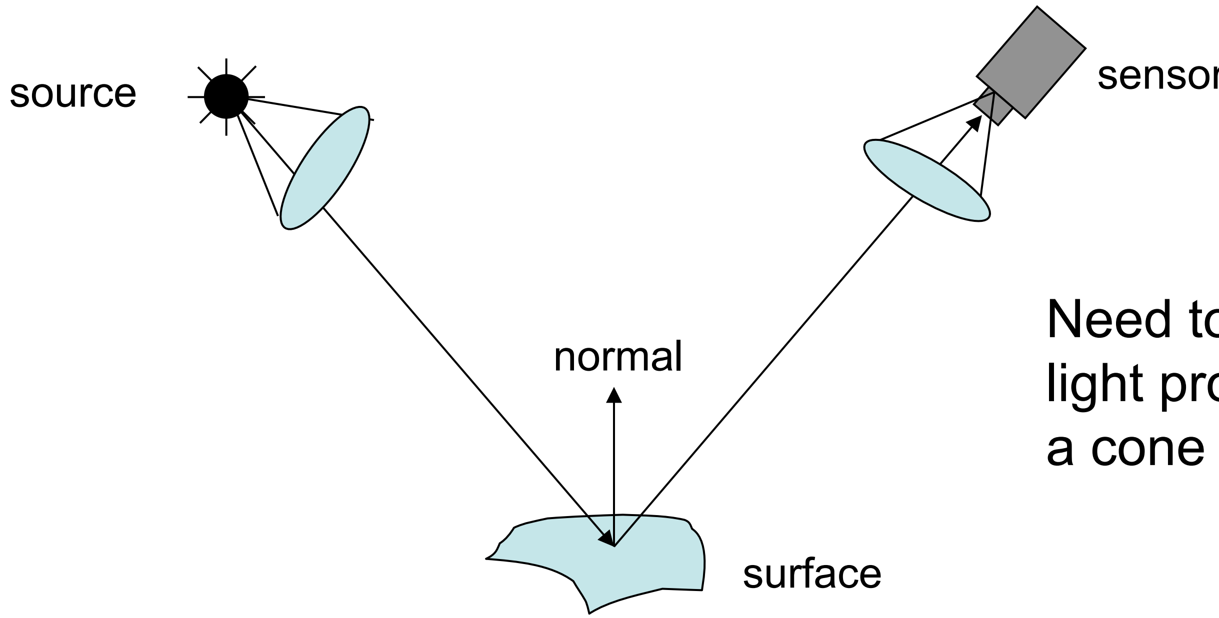
Light

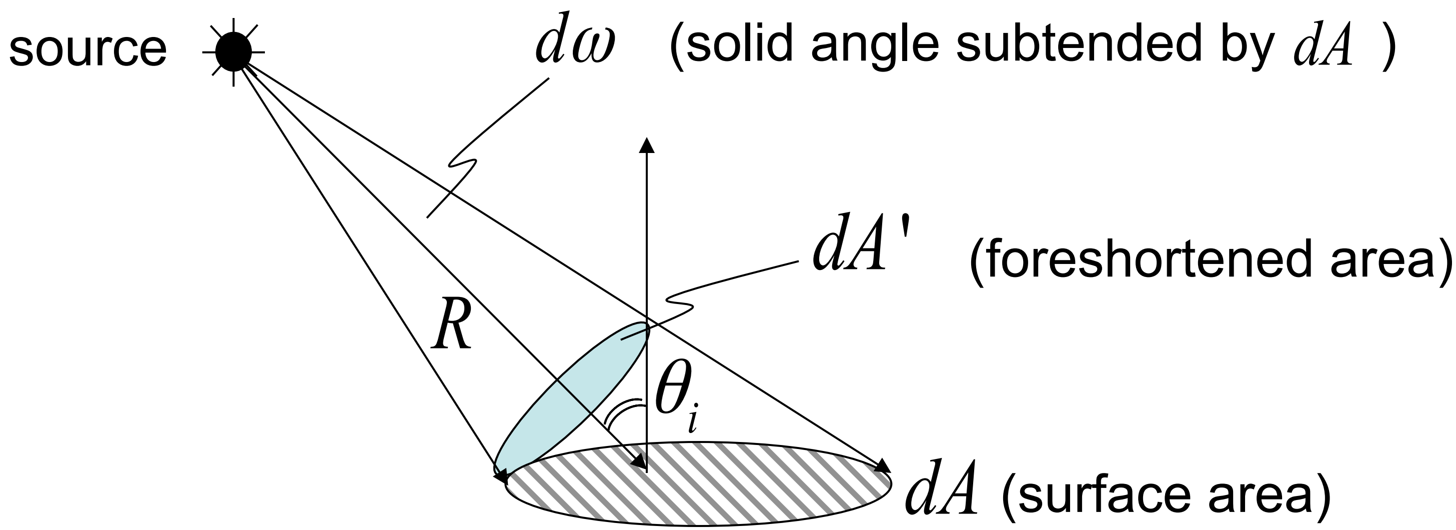
Thanks to Langer-Zucker, Henrik Wann Jensen, Ravi Ramamoorthi, Hanrahan, Preetham

How to quantify light?



Need to consider light propagation in a cone

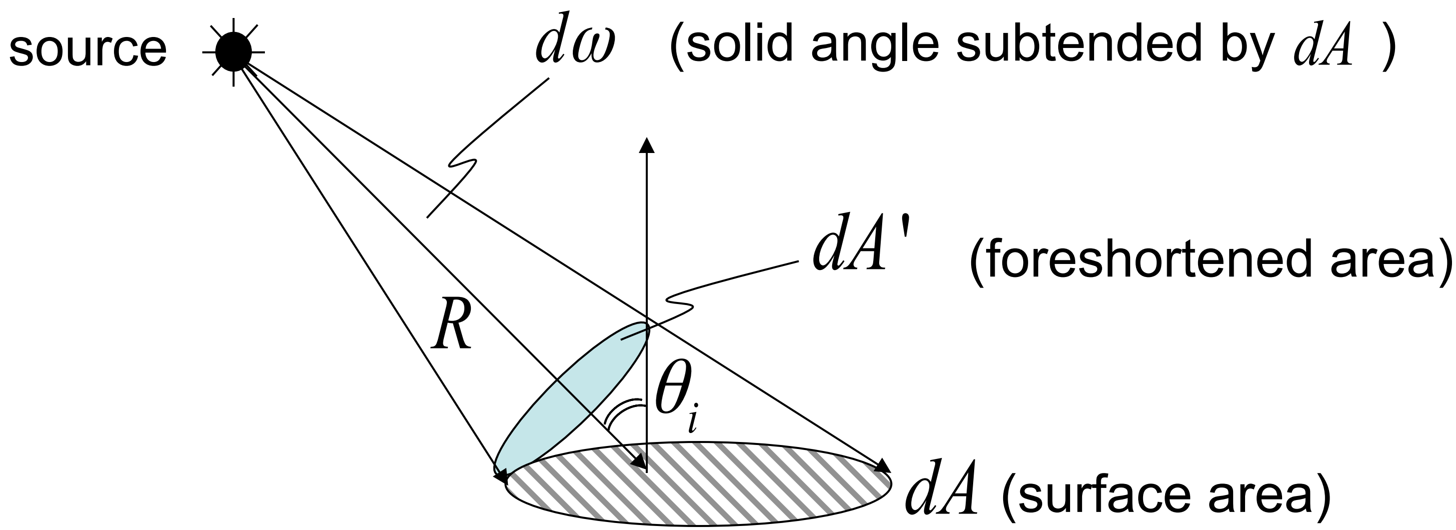
Solid Angle



Solid Angle : $$d\omega = \frac{dA'}{R^2} = \frac{dA\cos\theta_i}{R^2}$$ (steradian)

What is the solid angle subtended by a hemisphere?

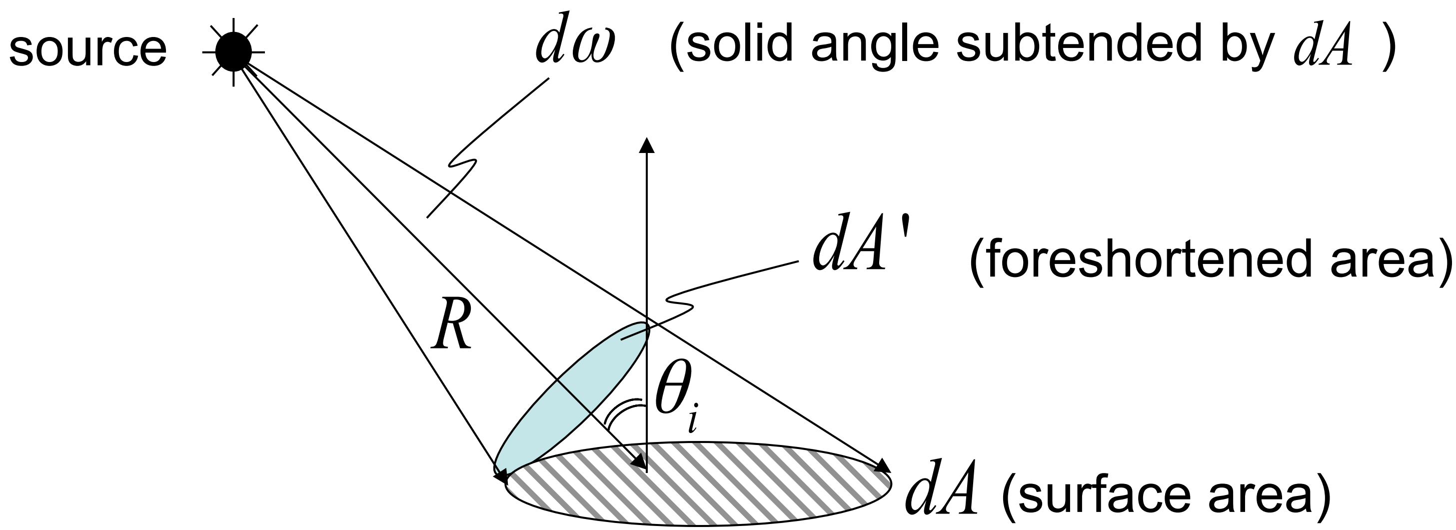
Radiant Intensity of Source



Radiant Intensity of Source : $$I = \frac{d\Phi}{d\omega}$$ (watts / steradian)

Light Flux (power) emitted per unit solid angle

Surface Irradiance

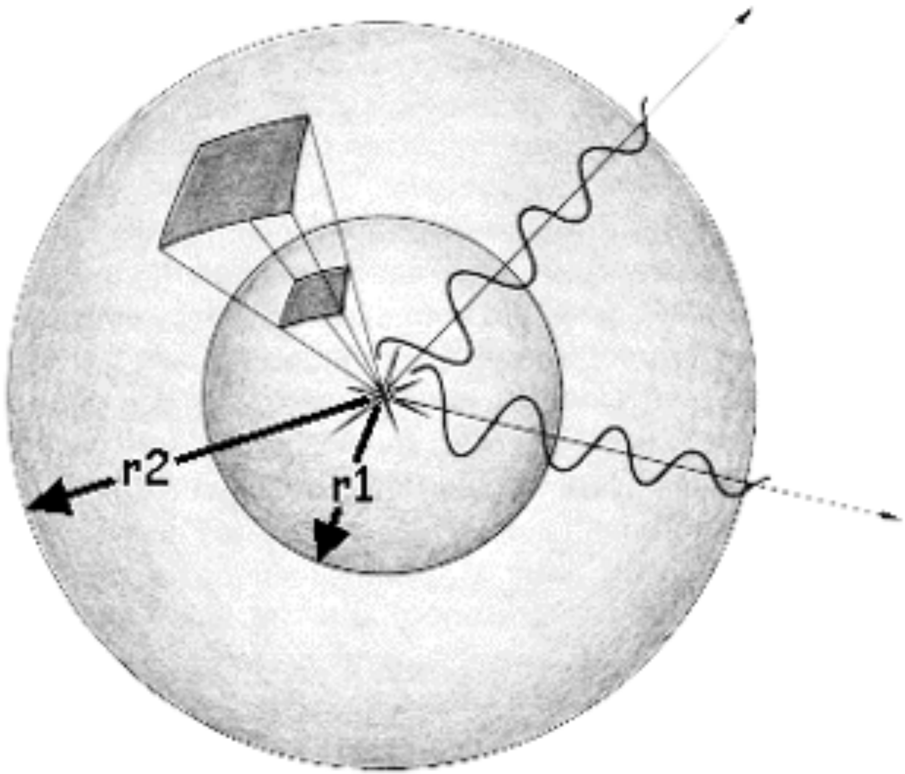


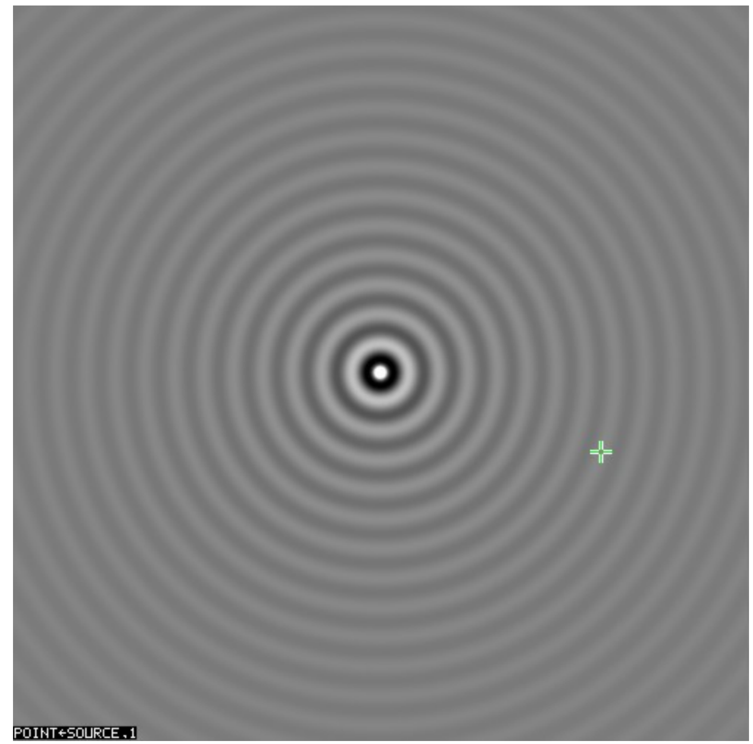
Surface Irradiance : $$E = \frac{d\Phi}{dA}$$ (watts / m^2)

Light Flux (power) incident per unit surface area.

Does not depend on where the light is coming from!

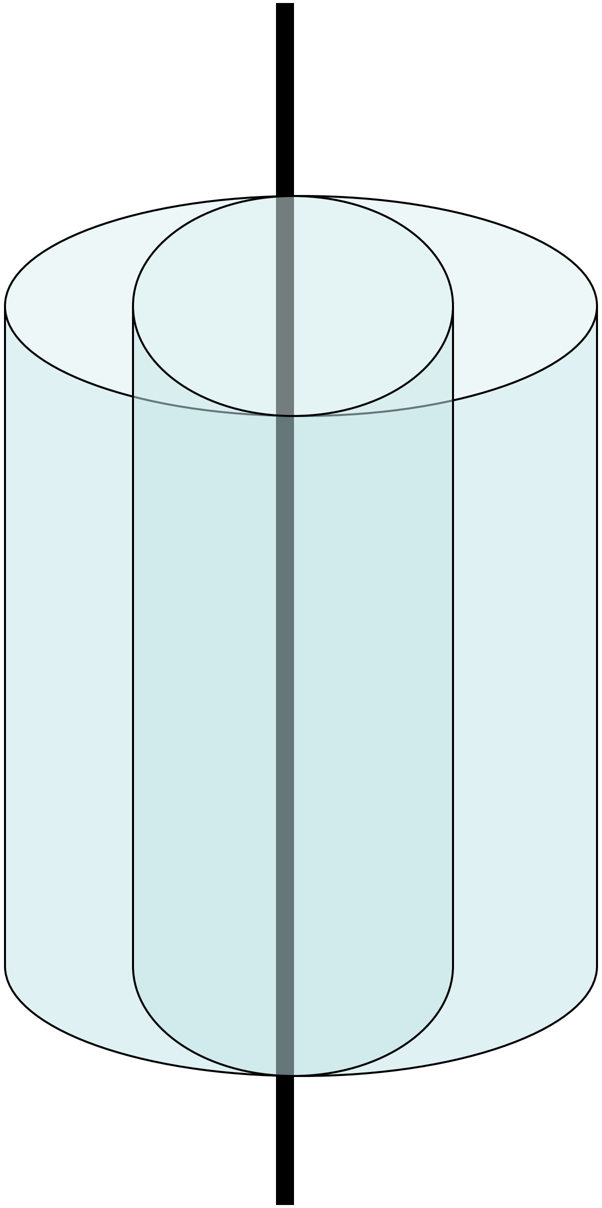
Isotropic Point Light Source





We see an inverse distance squared fall off in intensity.
Here light does not weaken, but only spreads in a sphere.

Infinite Line Source



Line source shows cylindrical symmetry.

The intensity fall-off is inversely proportional to distance from the line source. Why?

Infinite Planar Area Source

- Assume every point on the plane is an isotropic point light source.
- We saw inverse squared fall off, inverse fall off…so, this must be…
- Intensity CONSTANT with respect to distance! WHY?

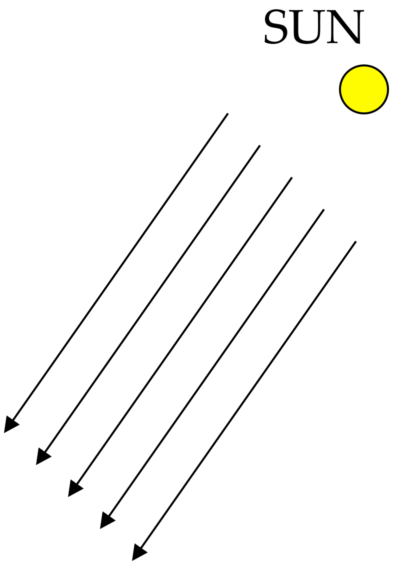
As distance increases,

Intensity from one point source decreases

But we add intensities from all point sources on the plane.

Distant and Collimated Lighting

Distant Lighting:



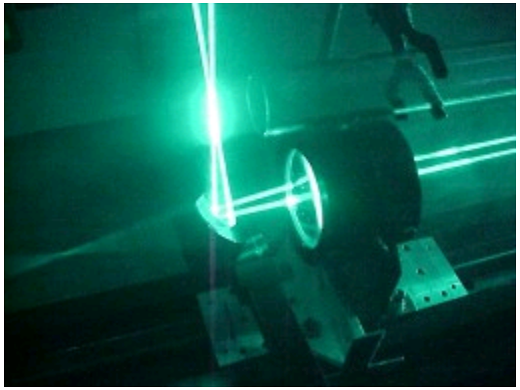
Essentially source at infinity

All surface points receive light from the same direction

Intensity fall must not be ignored!

Most vision and graphics algorithms assume this.

Collimated:

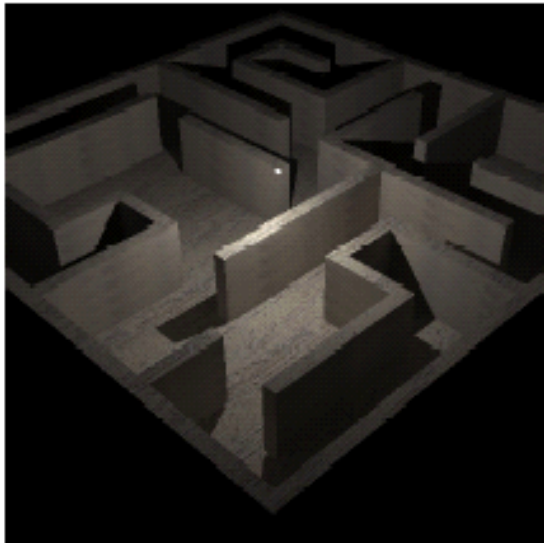


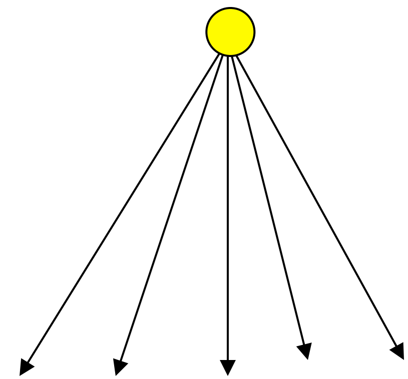
Parallel rays of light on the surface

Lasers (no fall off) - need not be at infinity

Lighting at infinity - (inverse squared fall off)

Divergent and Near-field Lighting





- Every scene point can receive light from a different direction.
- Much harder to model.
- Examples: near by point sources, spot lights
- Assume distant lighting when size of scene is 10% of the distance to the source.

Fluorescent versus Incandescent Lighting

Fluorescent:

Less heat generated.

More efficient lighting for the same brightness.

Flickers continuously.

Shows sparse, spikes in spectrum.

Incandescent:

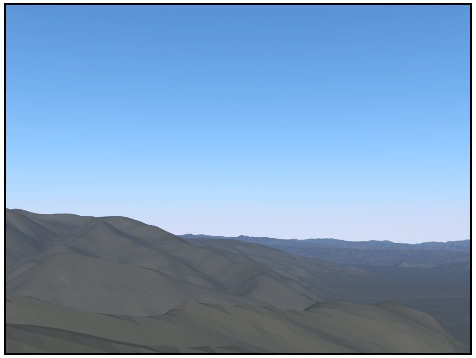
Lots of heat generated.

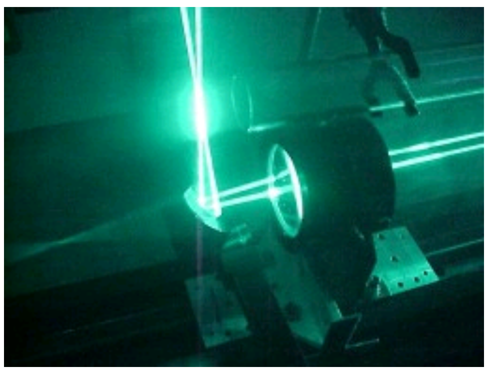
Less efficient lighting for the same brightness.

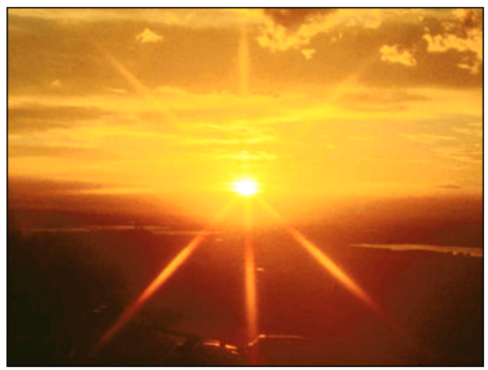
No flickers.

Shows continuous spectrum.

Is there a unified representation for light sources?





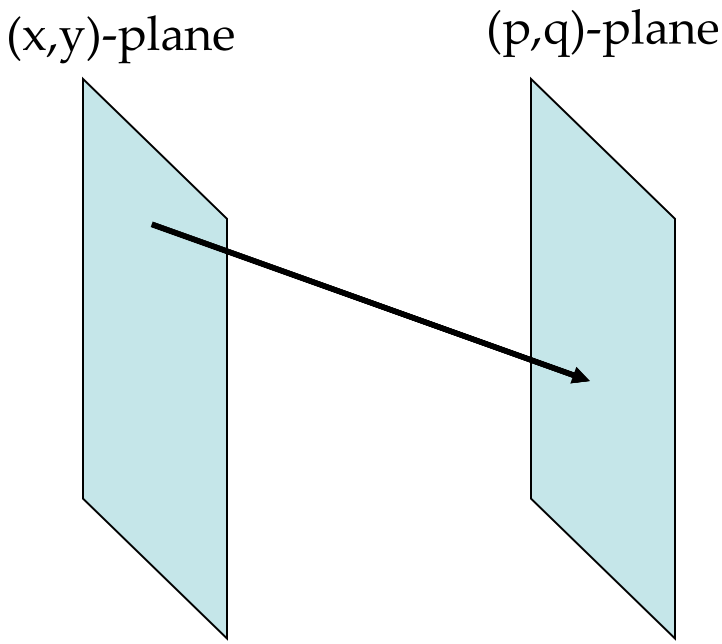


How do we compare the light from a street lamp to that from an overcast sky?

It is important to unify source representation so that algorithms may be developed for all sources instead of one per type of source.

Consider the SPACE of LIGHT RAYS!

4D Hypercube of Rays



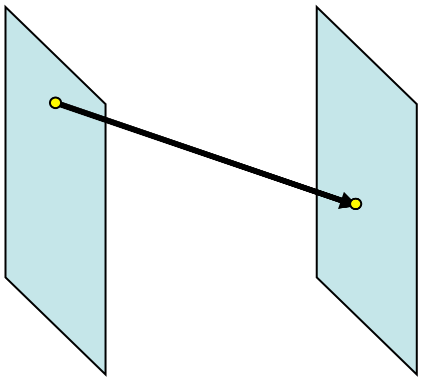
- Assumes vacuum (no absorption or scattering)
- No fluorescence, phosphorescence

Langer and Zucker, CVPR 97

Representation of Sources

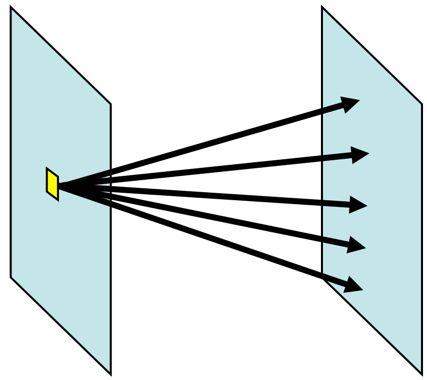
Langer and Zucker, CVPR 97

(x,y)-plane (p,q)-plane



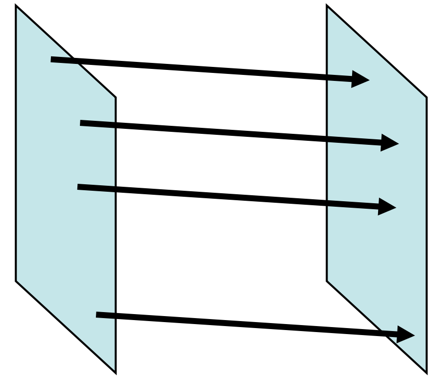
Laser beam – 0D

(x,y)-plane (p,q)-plane

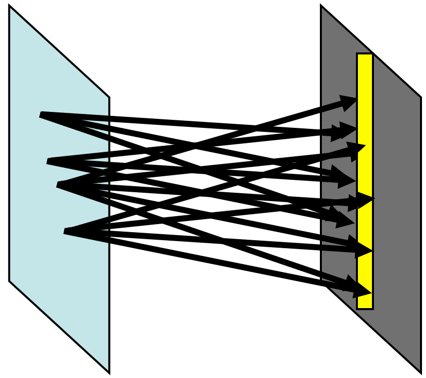


Point source – 2D

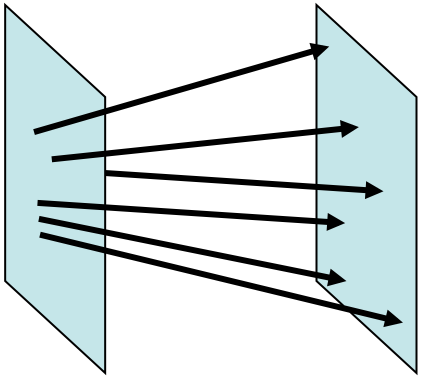
(x,y)-plane (p,q)-plane



Distant Source (Sun) – 2D



Area source (Sky) with
a crack in the door – 3D



Area source (Sky) with
door completely open – 4D

The Rendering Equation

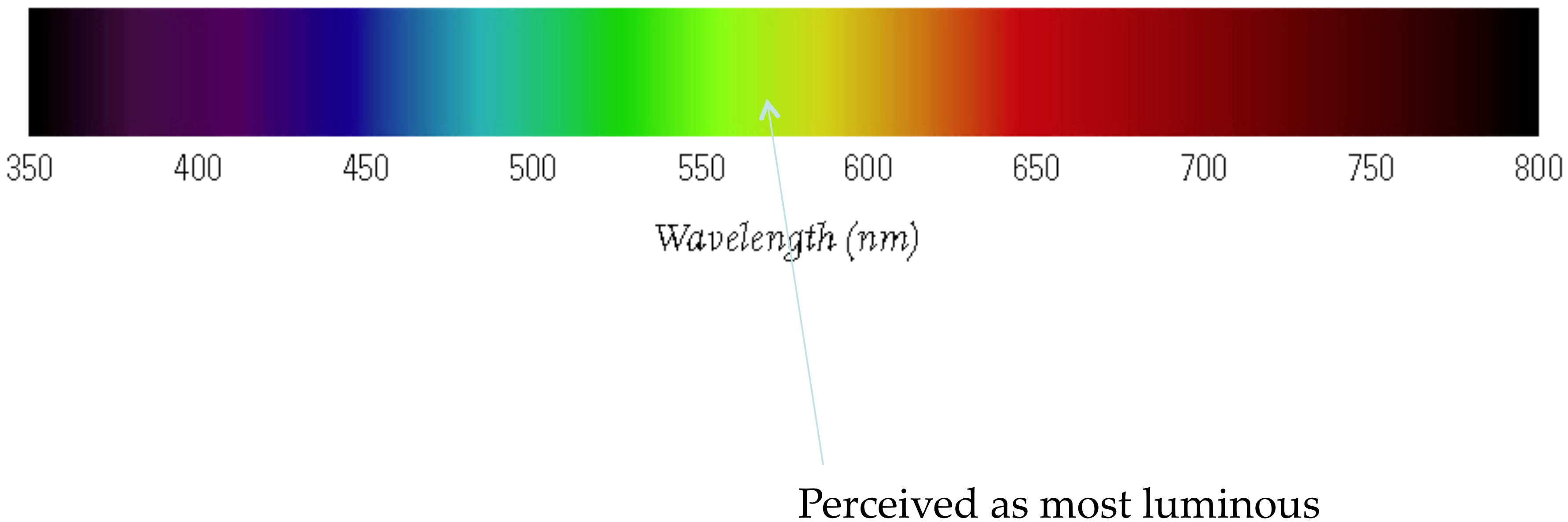
$$L_o(\mathbf{x}, \omega, \lambda, t) = L_e(\mathbf{x}, \omega, \lambda, t) + \int_\Omega f_r(\mathbf{x}, \omega', \omega, \lambda, t) L_i(\mathbf{x}, \omega', \lambda, t)(-\omega' \cdot \mathbf{n}) d\omega'$$

Kajiya, James T. "The rendering equation." In ACM Siggraph Computer Graphics, vol. 20, no. 4, pp. 143-150. ACM, 1986. http://dl.acm.org/citation.cfm?id=15902

http://en.wikipedia.org/wiki/Rendering_equation

Color

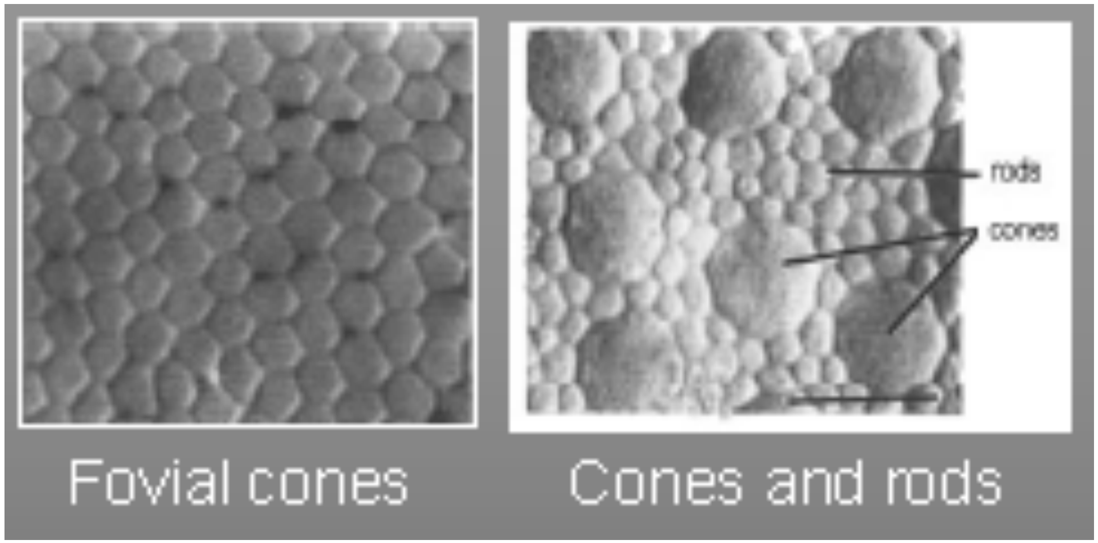
Visible Light Spectrum



Visible Light Spectrum

Spectroradiometers accurately measure the visible light spectrum

Human Vision



Human vision is three-dimensional
Our display systems are also three-dimensional

How do we find a display color that matches a person's perception of a real-world object?

Notes on Color

Brown University Color Exploratory (including metamers app)
http://cs.brown.edu/exploratories/freeSoftware/catalogs/color_theory.html

Maureen Stone has a number of links, talks, etc. related to color, especially for information visualization http://www.stonesc.com/

We followed her SIGGRAPH 2001 course notes, which can be downloaded from the course web page.

Her SIGGRAPH 2004 course notes are here:
http://www.stonesc.com/signotes/

Also of possible interest:
Cinematic Color: From Your Monitor to the Big Screen (SIGGRAPH 2012)
http://s2012.siggraph.org/attendees/sessions/cinematic-color-your-monitor-big-screen