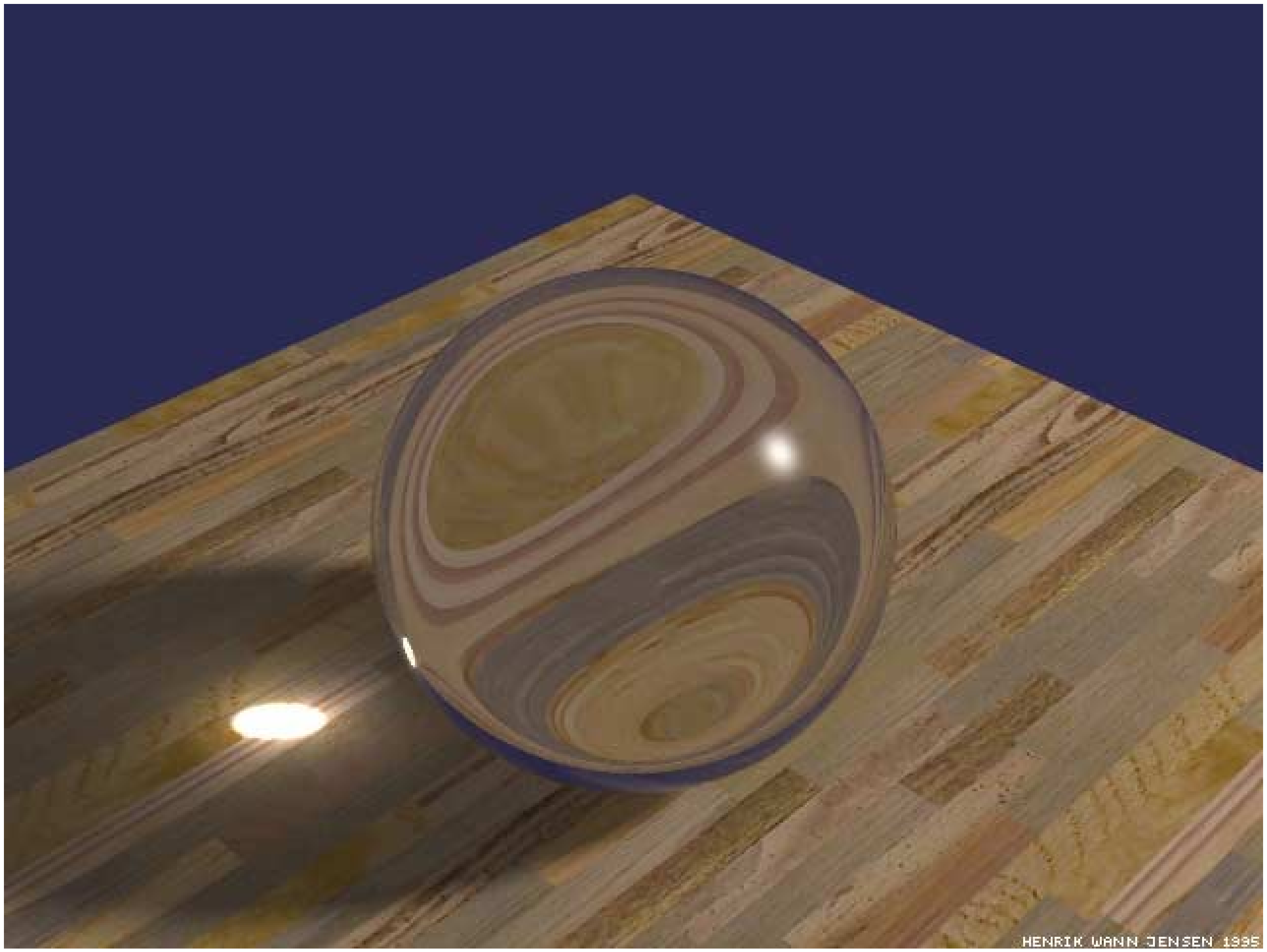
Illumination effects

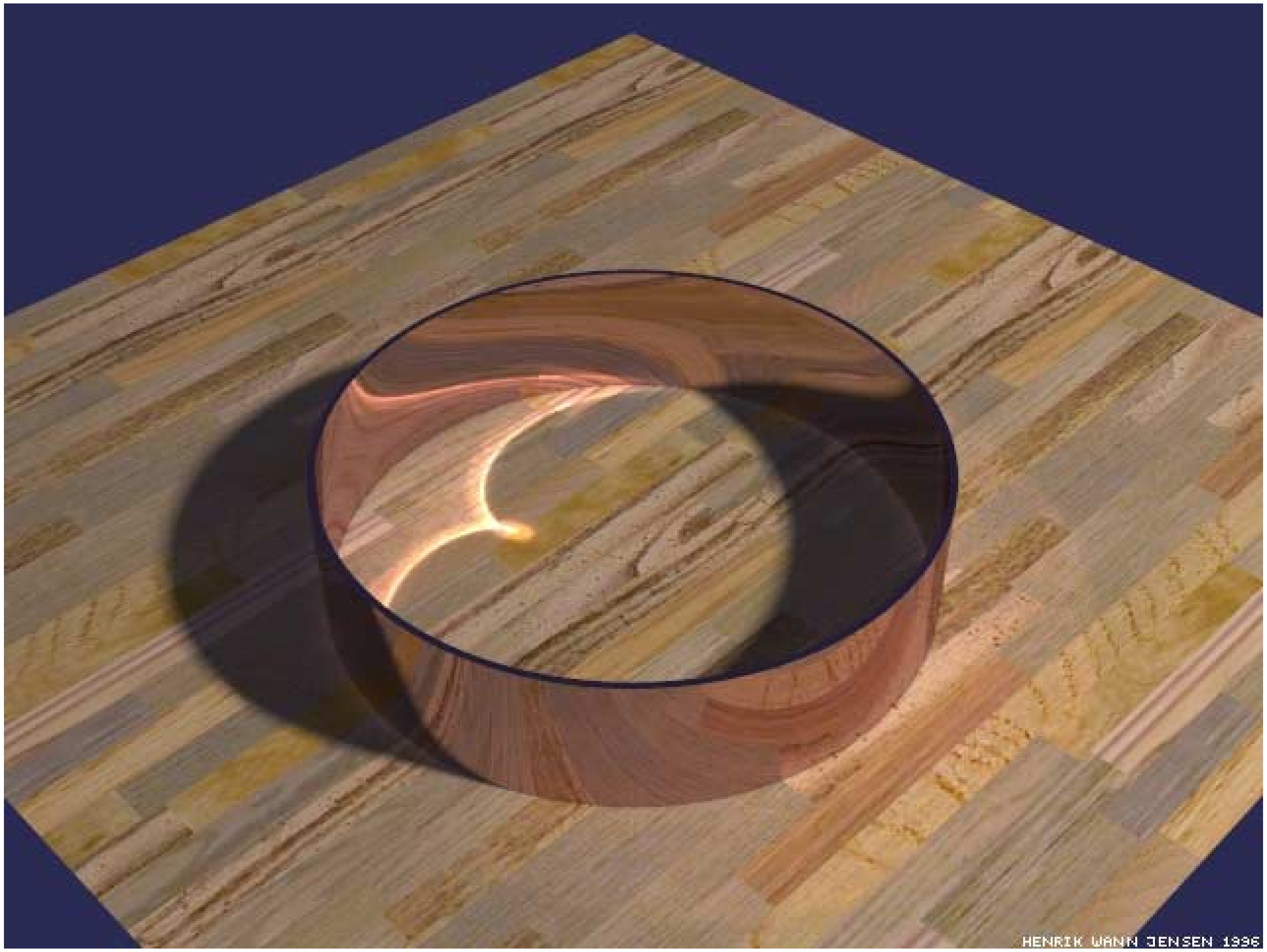
- Caustics:
  - refraction or reflection causes light to be “collected” in some regions.
- Specular-> diffuse transfer
  - source reflected in a mirror
- Can’t render this by tracing rays from the eye - how do they know how to get back to the source?
- Instead, trace rays from the light to the first diffuse surface
  - leave a note that illumination has arrived - an illumination map, or photon map
  - now retrieve this note by tracing eye rays
- Issues
  - efficiency (why trace rays to things that might be invisible?)
  - aliasing (rays are spread out by, say, curved mirrors)

Refraction caustic



Henrik Jensen, http://www.gk.dtu.dk/~hwj

Reflection caustic



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Refraction caustics

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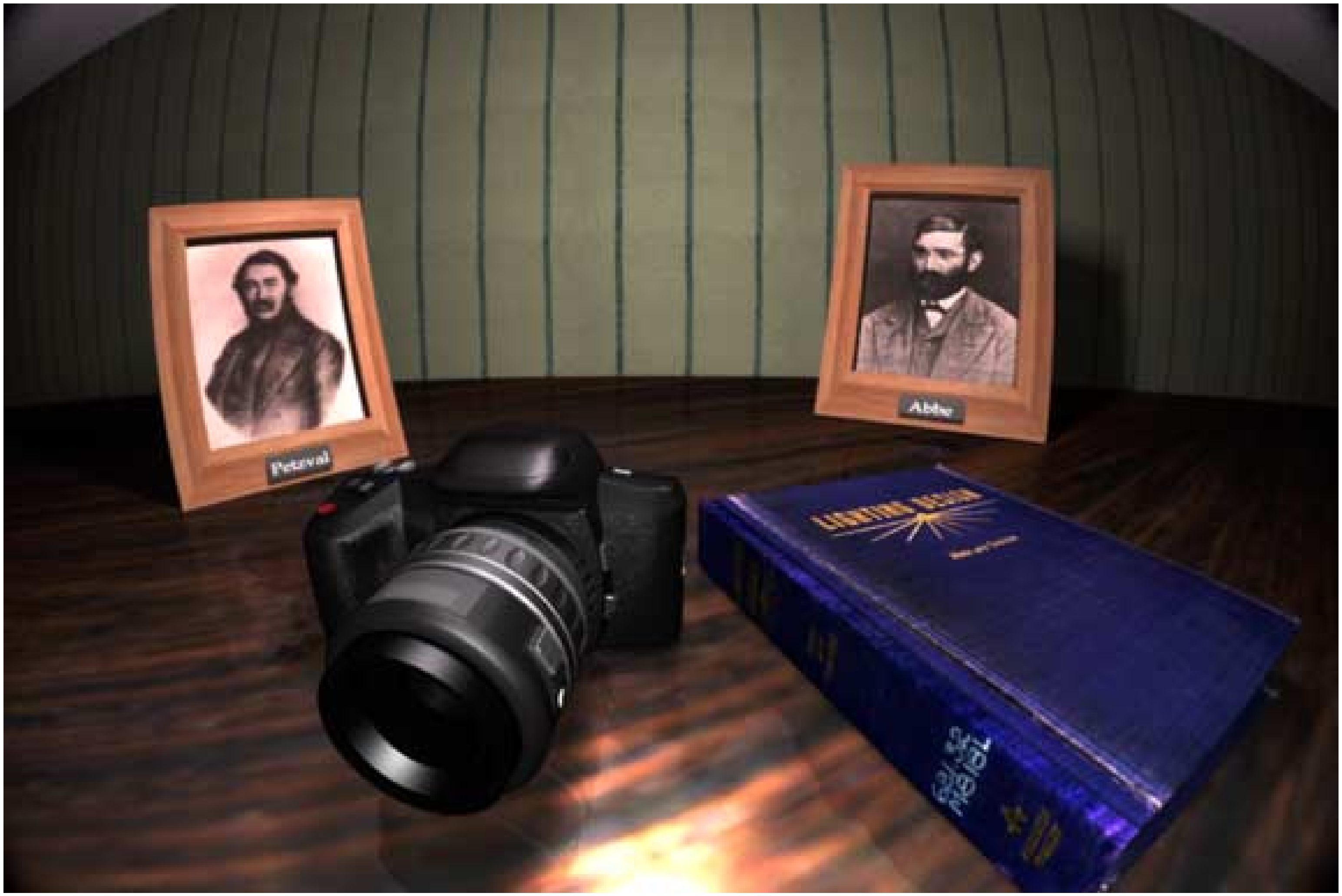
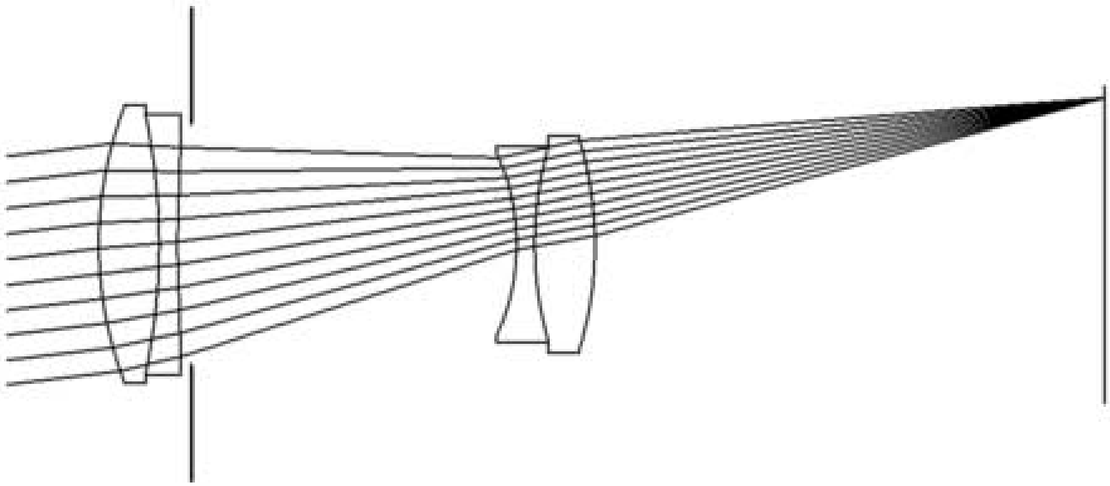


from
A Realistic Camera Model for Computer Graphics
Craig Kolb, Don Mitchell, and Pat Hanrahan
Computer Graphics (Proceedings of SIGGRAPH '95), ACM SIGGRAPH, 1995, pp 317-324



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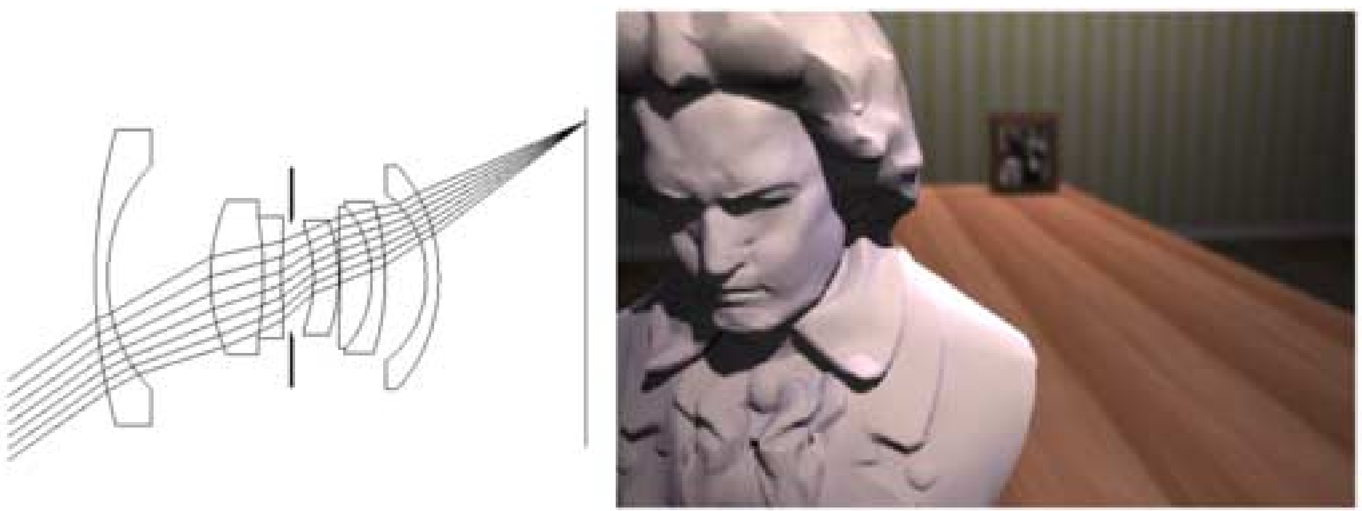

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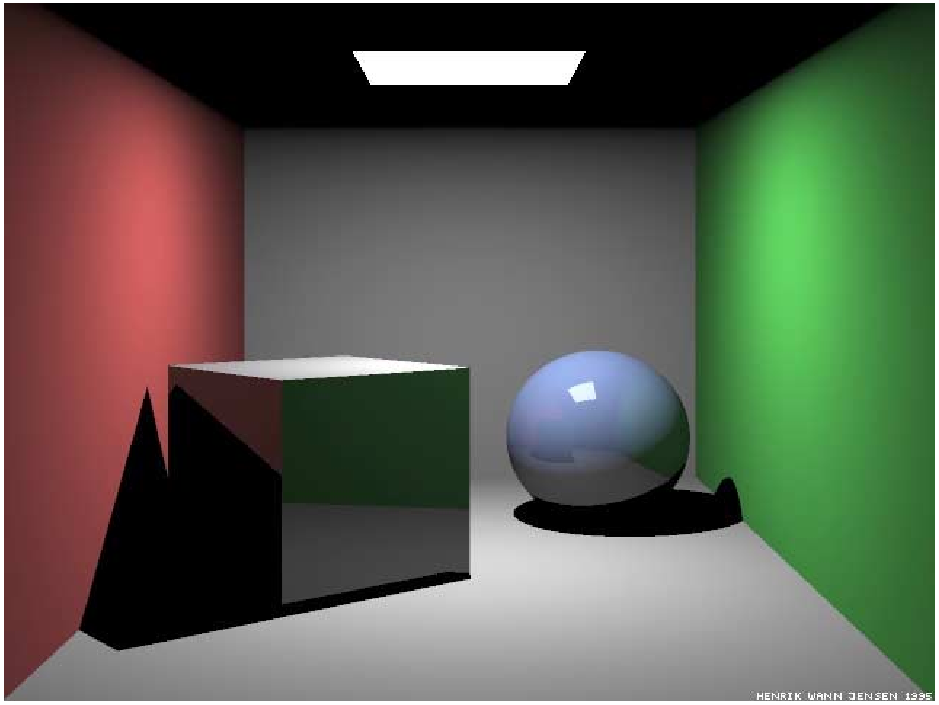
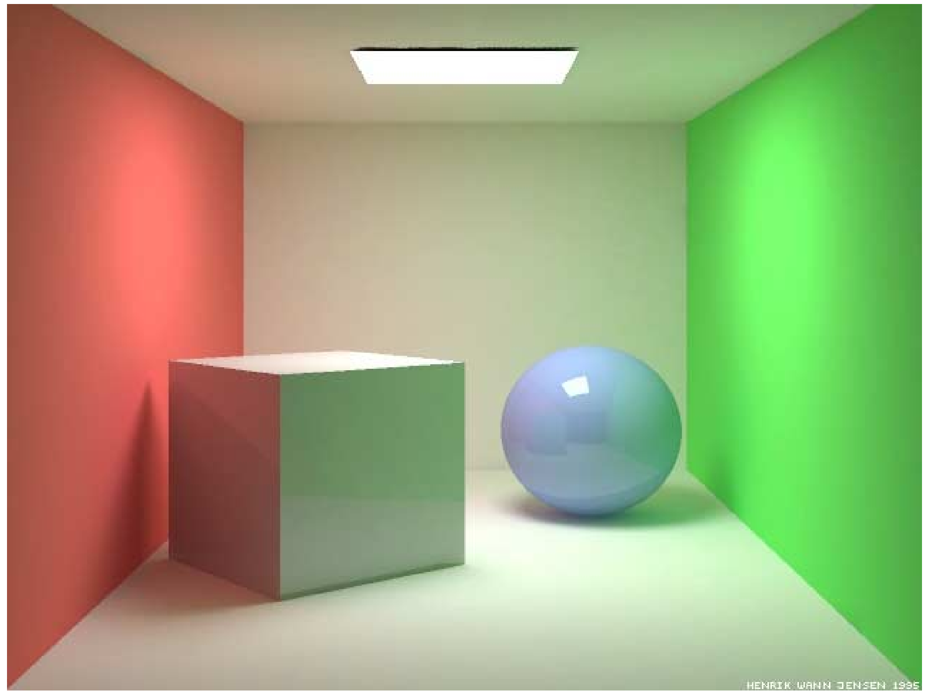
Radiosity



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



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

Radiosity

Want to capture the basic effect that surfaces illuminate each other

Again, following every piece of light from a diffuse reflector is impractical--but combinations of brute force and clever hacks can be done

Another approach: Radiosity methods

Radiosity (see book §14.9)

Think of the "world" as a bunch of patches. Some are sources, (and reflect), some just reflect. Each sends light towards all the others.

Consider one color band at a time (some of the computation is shared among bands).

Each surface, i, *radiates* reflected light, B_i

Each surface, *emits* light E_i (if it is not a source, this is 0).

Denote the albedo of surface i as ρ_i

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Radiosity equation

$$B_i = E_i + \rho_i \sum F_{j \to i} B_i \frac{A_j}{A_i}$$

The form factor $F_{j \to i}$

is the fraction of light leaving dA_i arriving at dA_j taking into account orientation and obstructions

Useful relation

$$A_i F_{i \to j} = A_j F_{j \to i}$$

The equation now becomes

$$B_i = E_i + \rho_i \sum F_{i \to j} B_i$$

Rearrange to get

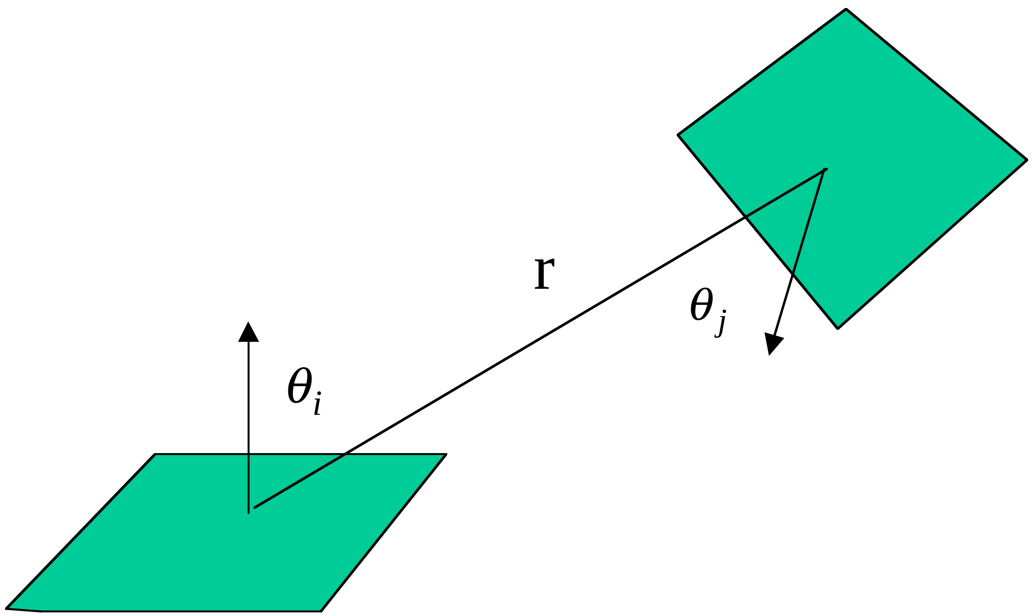
$$B_i - \rho_i \sum F_{i \to j} B_i = E_i$$

In matrix form

$$\begin{bmatrix} 1-\rho_1 F_{1\to 1} & -\rho_1 F_{1\to 2} & \cdots & -\rho_1 F_{1\to n} \\ -\rho_2 F_{2\to 1} & 1-\rho_2 F_{2\to 2} & & -\rho_2 F_{2\to n} \\ & & & \\ -\rho_n F_{n\to 1} & -\rho_n F_{n\to 2} & & 1-\rho_n F_{n\to n} \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \\ \\ B_n \end{bmatrix} = \begin{bmatrix} E_1 \\ E_2 \\ \\ E_n \end{bmatrix}$$

The fun part: Computing the $F_{i \to j}$

Without obstruction $dF_{dj \to di} = \dfrac{\cos\theta_i \cos\theta j}{r^2} dA_j$



See book for “hemi-cube method” of computing and storing the form factors

Big picture

Can reduce calculations by projecting onto hemi-sphere or, even better, hemi-cube

While storing the form factors, can do a z-buffer type visibility analysis.

Previous equation is in terms of energy received

Can also do energy emitted

$$B_j \quad due \;\; to \;\; B_i \;\; is \;\; p_j B_i F_{j \to i}$$

Rewrite as

$$B_j \quad due \;\; to \;\; B_i \;\; is \;\; p_j B_i F_{i \to j} \frac{A_i}{A_j}$$

Now *cast* energy. Advantage: Can do successive approximation (See pseudocode on page 520 of book).