Problems in ray-tracing

- **Computational load**

- **Aliasing**

- **Lack of realism due to extreme sharpness**

Reducing object-intersection calculations

The same large world problems showing up again!

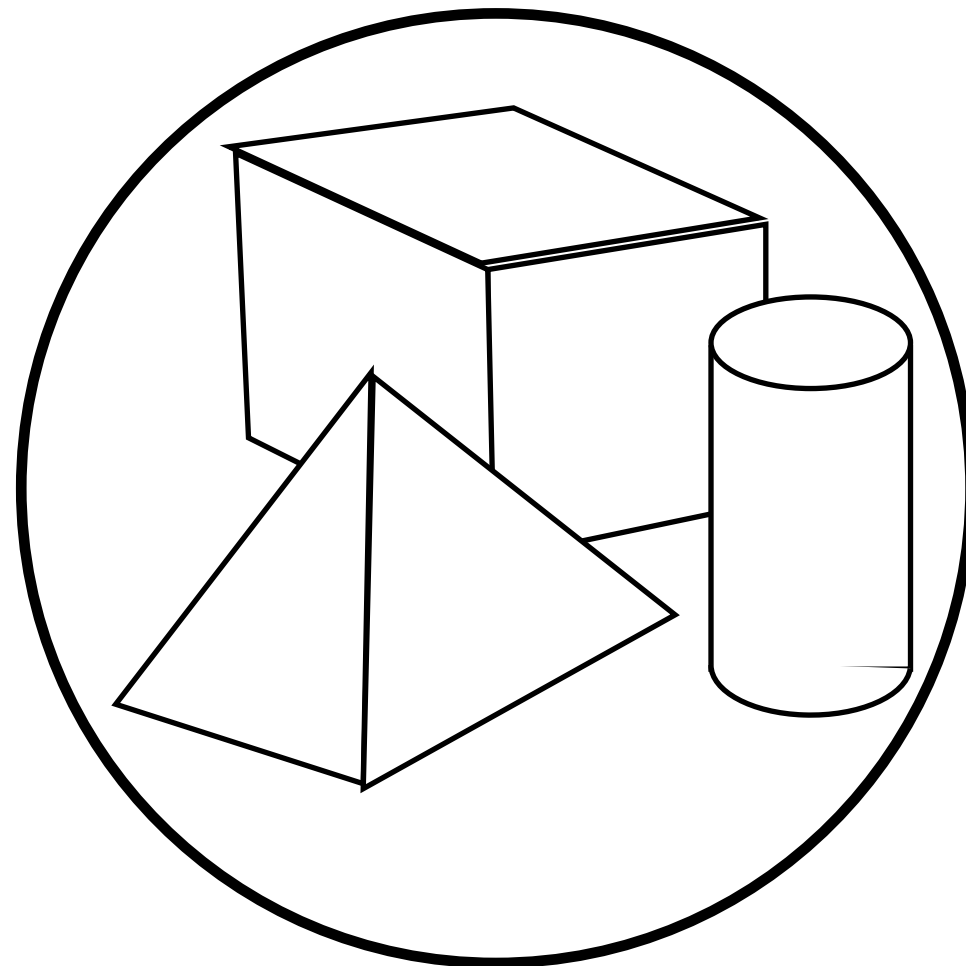**Don't test everything, use some large world structure!**

Reducing object-intersection calculations

Make sure that each ray doesn't have to be tested against all objects!

• Group objects within simple grouping surfaces (e.g. spheres or boxes)

• Divide space into cells
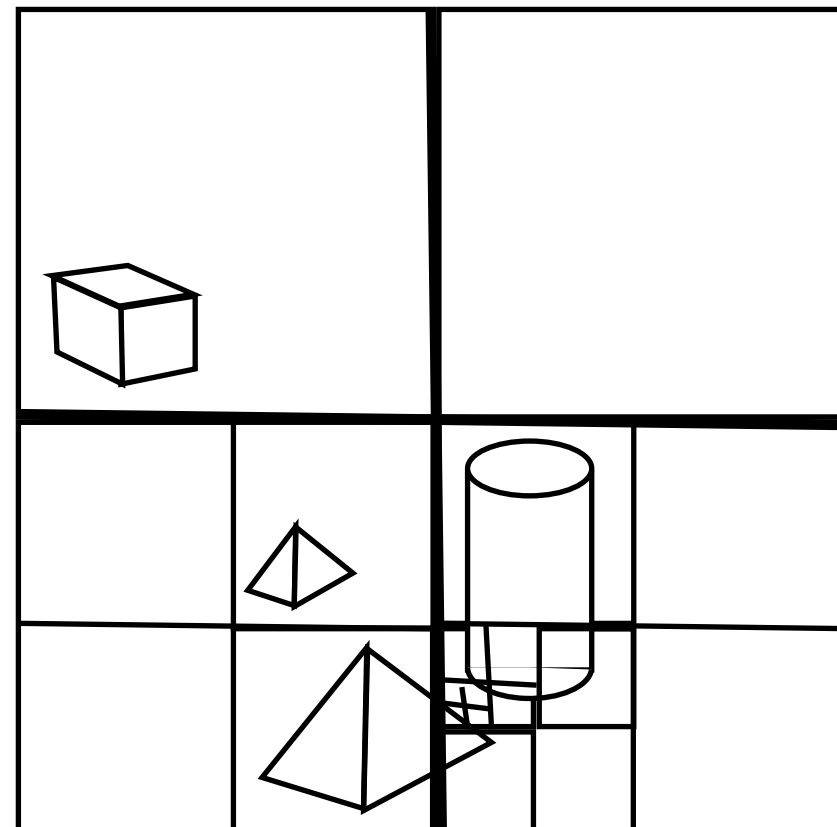 **- uniform or adaptive subdivision**

Group objects into simple bounding objects

Divide space into cells

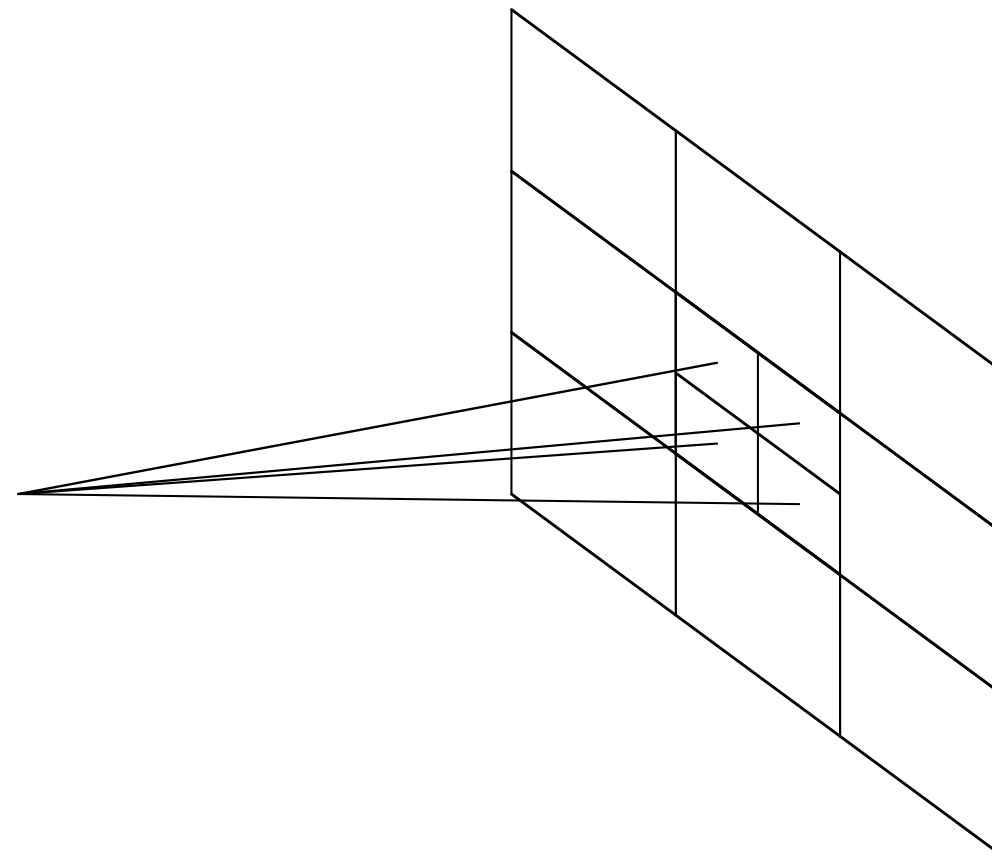**Same principle as in VSD and collission detection**

Anti-aliasing
in ray-tracing

- **Supersampling**

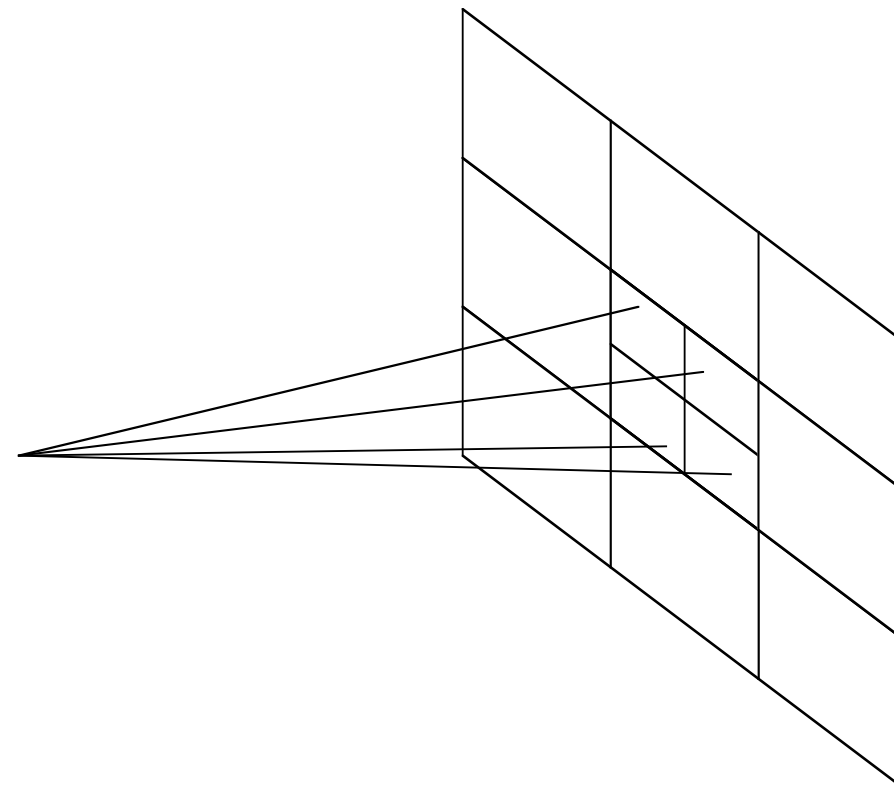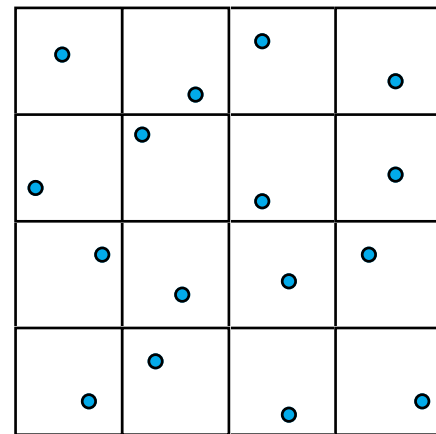- **Distributed ray tracing**

Supersampling
in ray-tracing

Send several rays for each pixel. (Typical: 4 rays)

Distributed ray-tracing

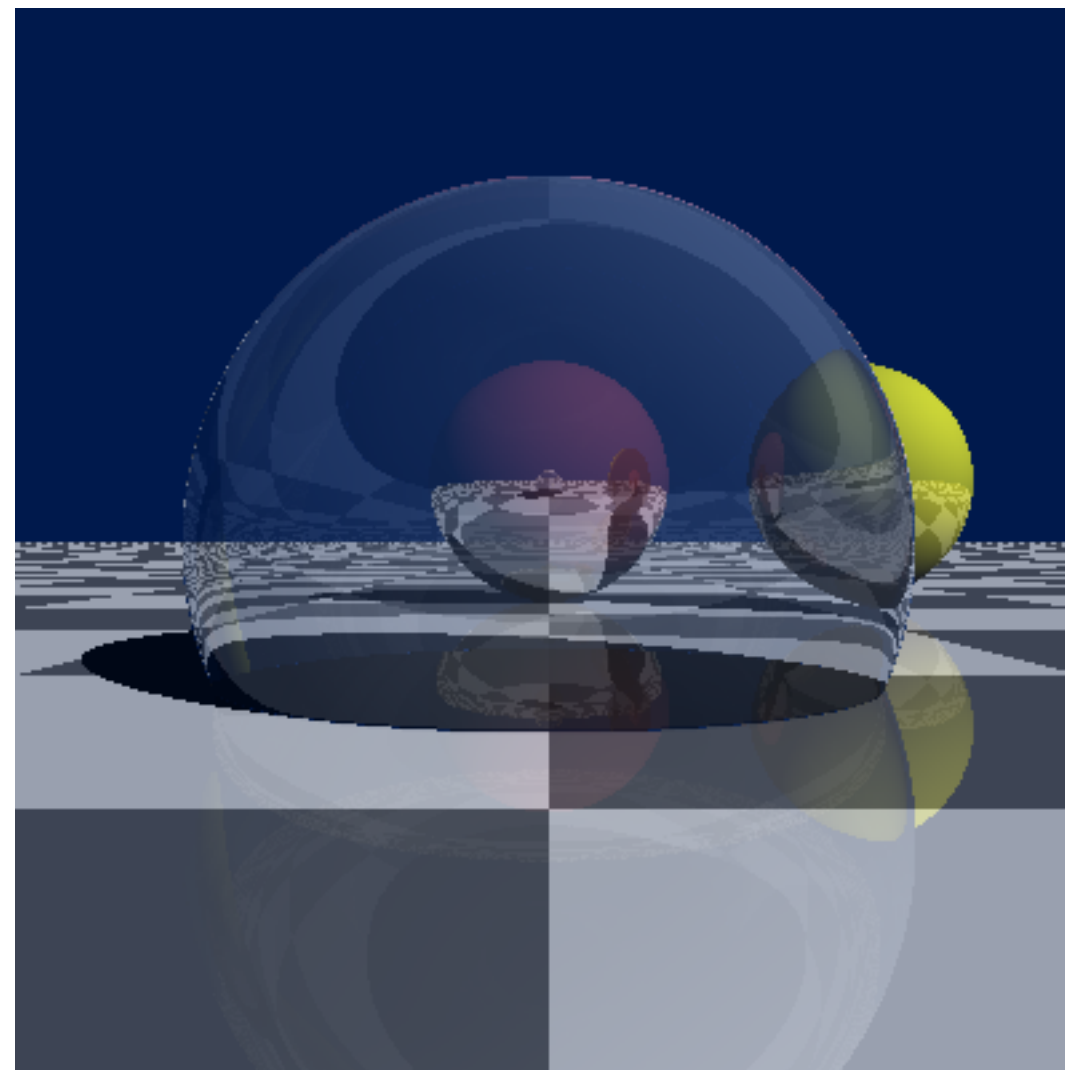**Rays (multiple per pixel) are sent in a randomized pattern. Aliasing is replaced by noise!**
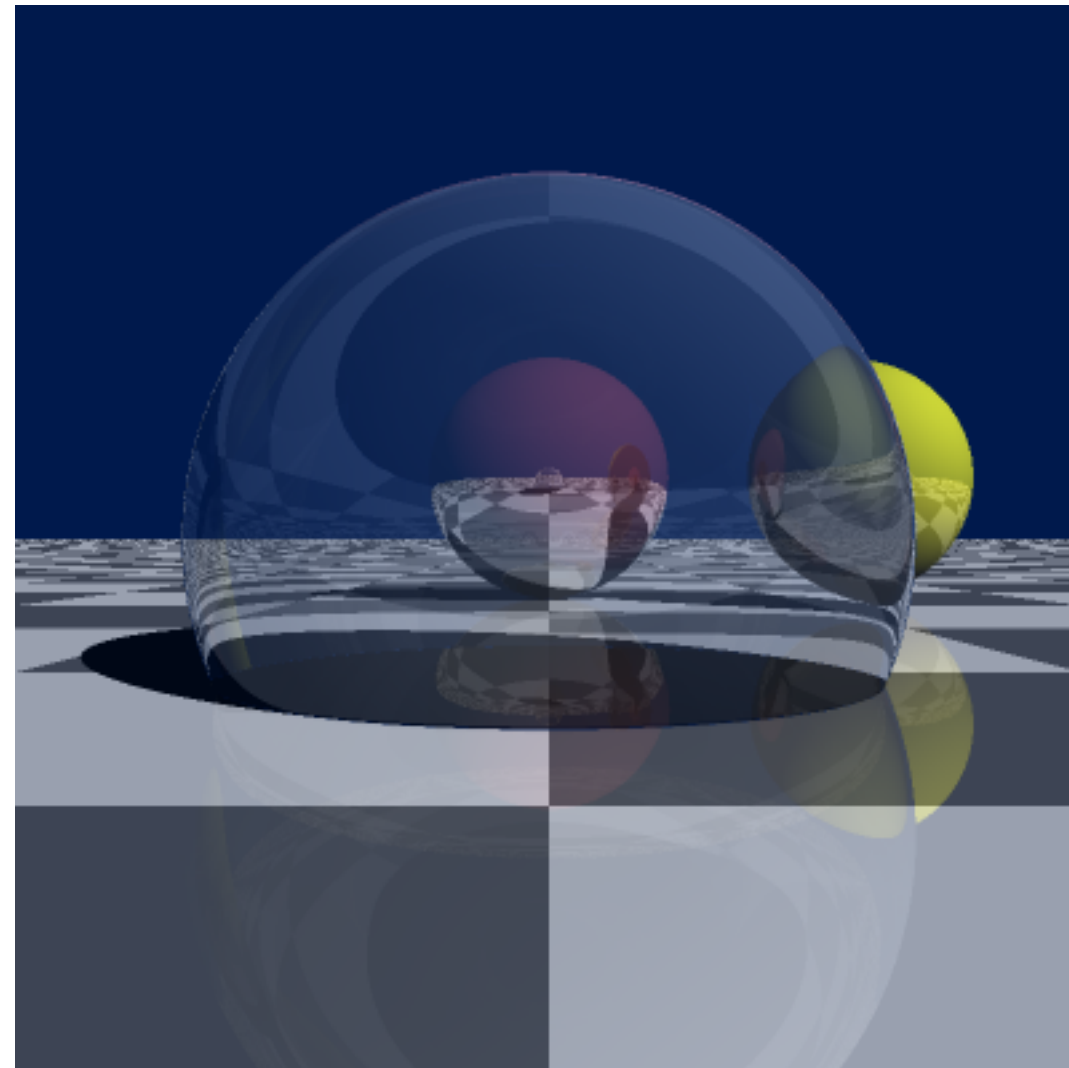
Anti-aliasing in ray-tracing

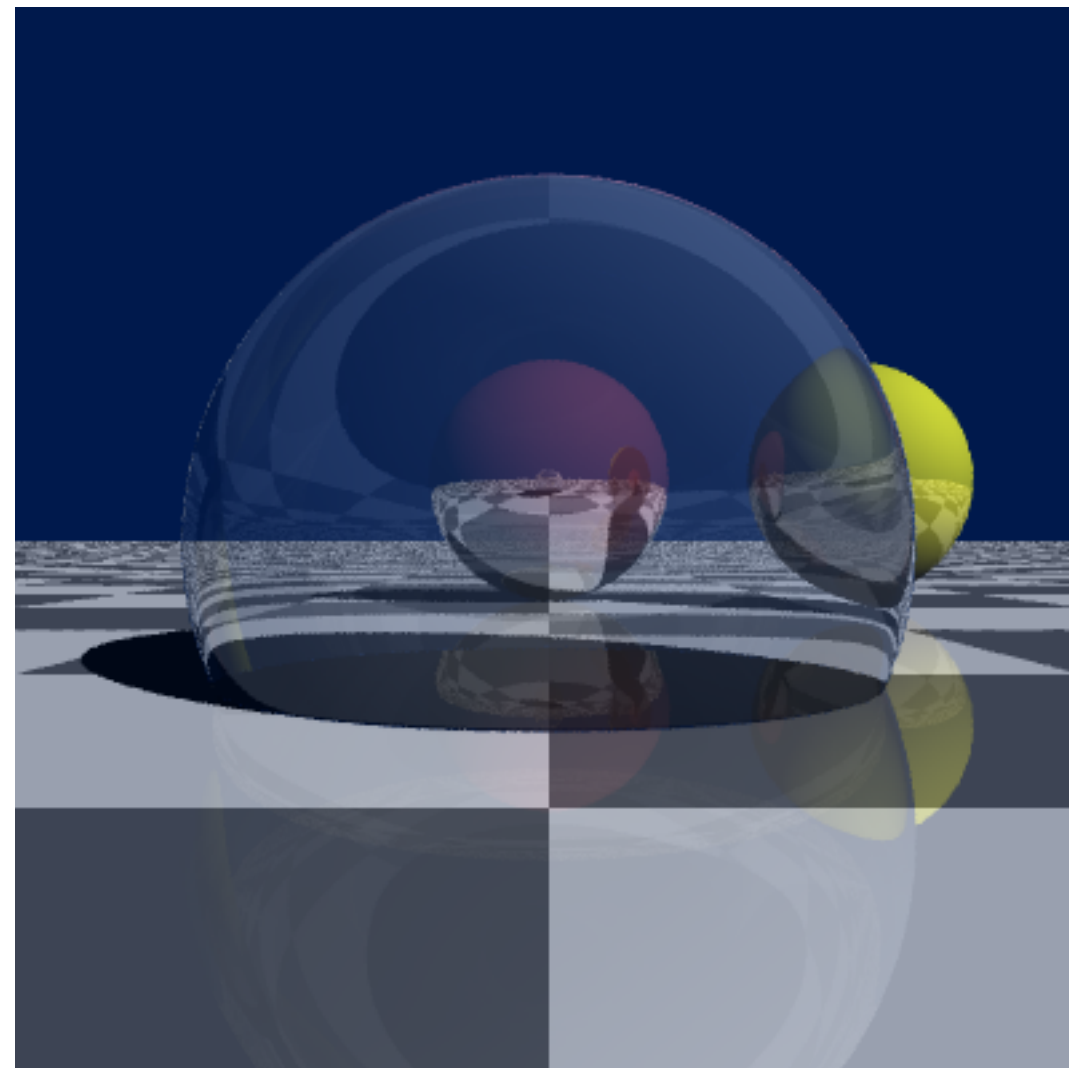**Example: Without anti-aliasing**

Anti-aliasing in ray-tracing

**Example:
Super-
sampling
(2x2)**

Anti-aliasing in ray-tracing

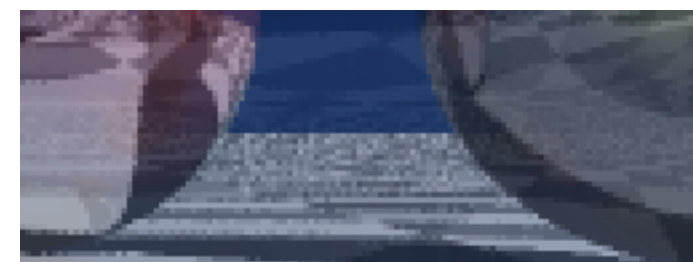**Example: Distributed raytracing (2x2)**

Anti-aliasing in ray-tracing

Zoomed-in detail

Without anti-alias

Super-sampling

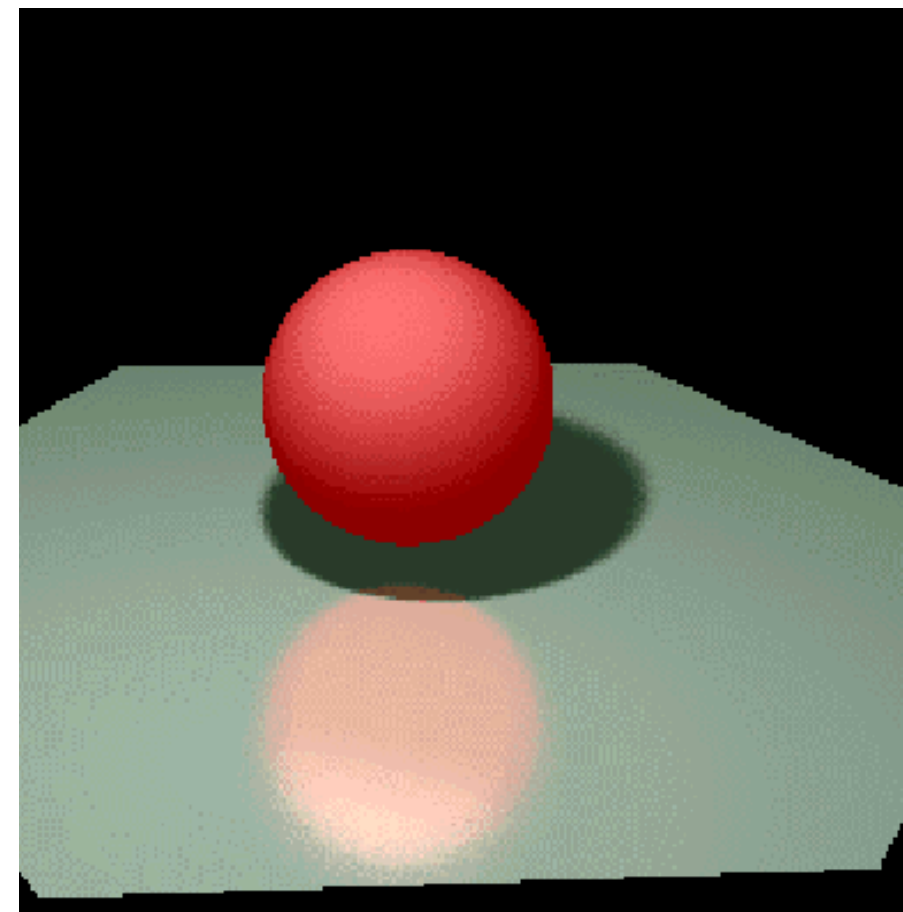**Distributed raytracing**
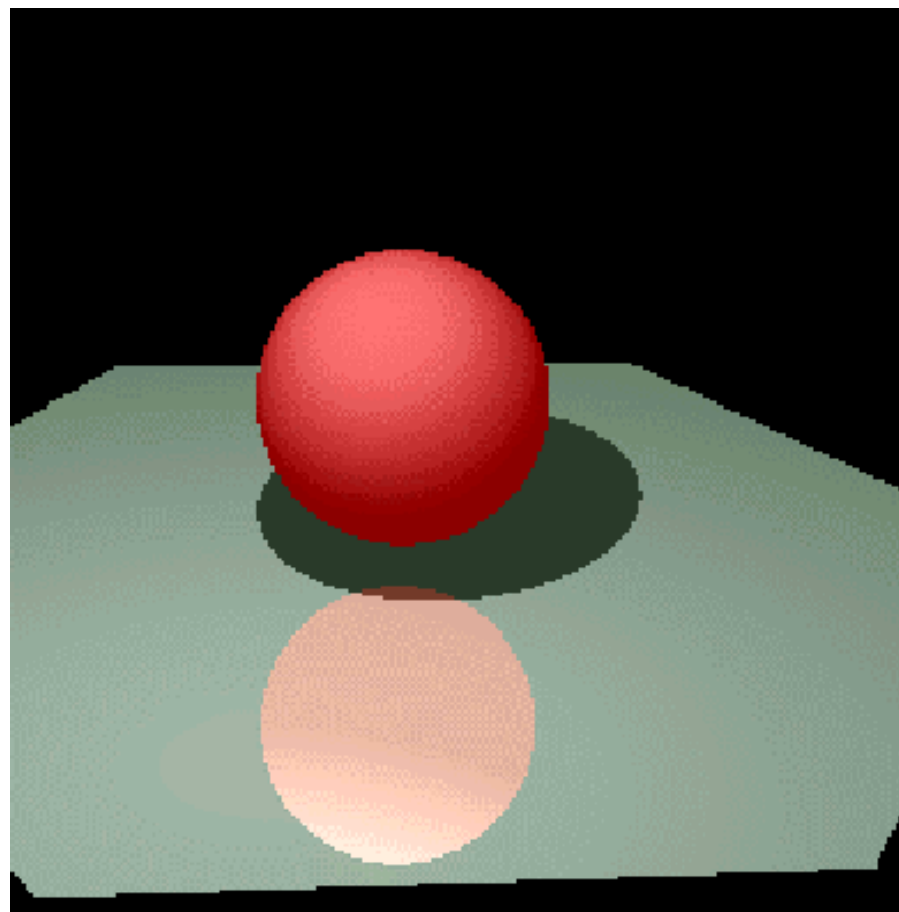
Distributed ray-tracing

Anti-aliasing through stochastic sampling.

Also used for:
- **gloss (fuzzy reflections)**
- **fuzzy translucency**
- **soft shadows**
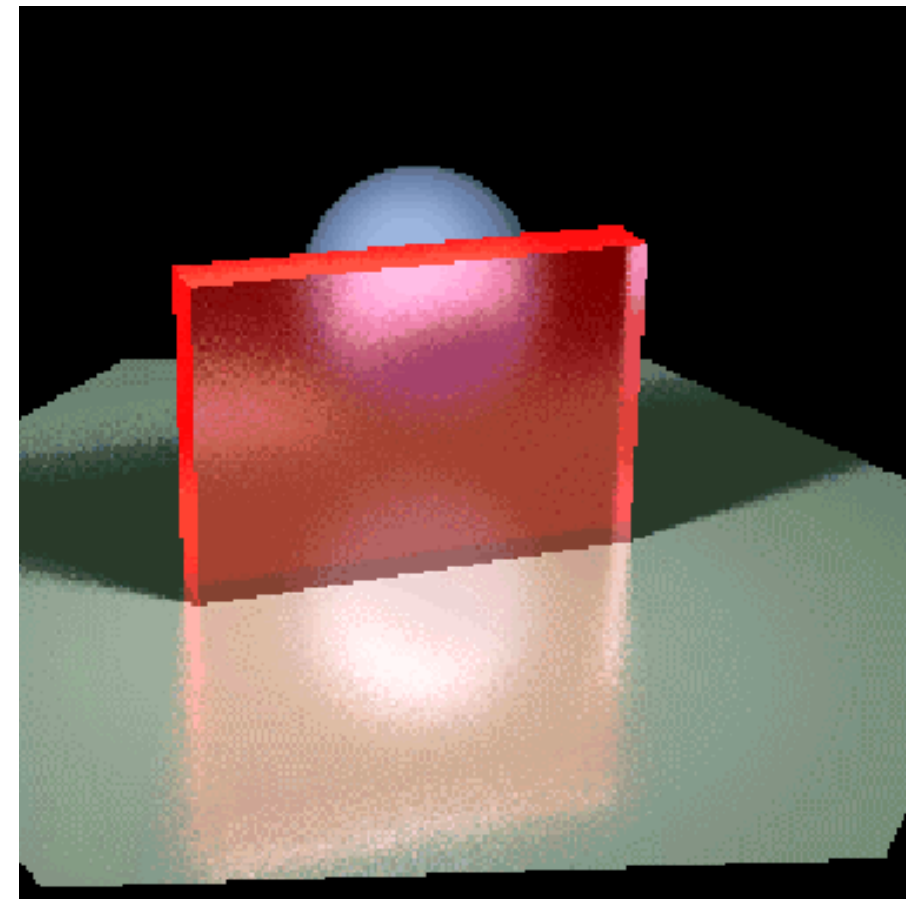- **depth of field (out-of-focus effect)**
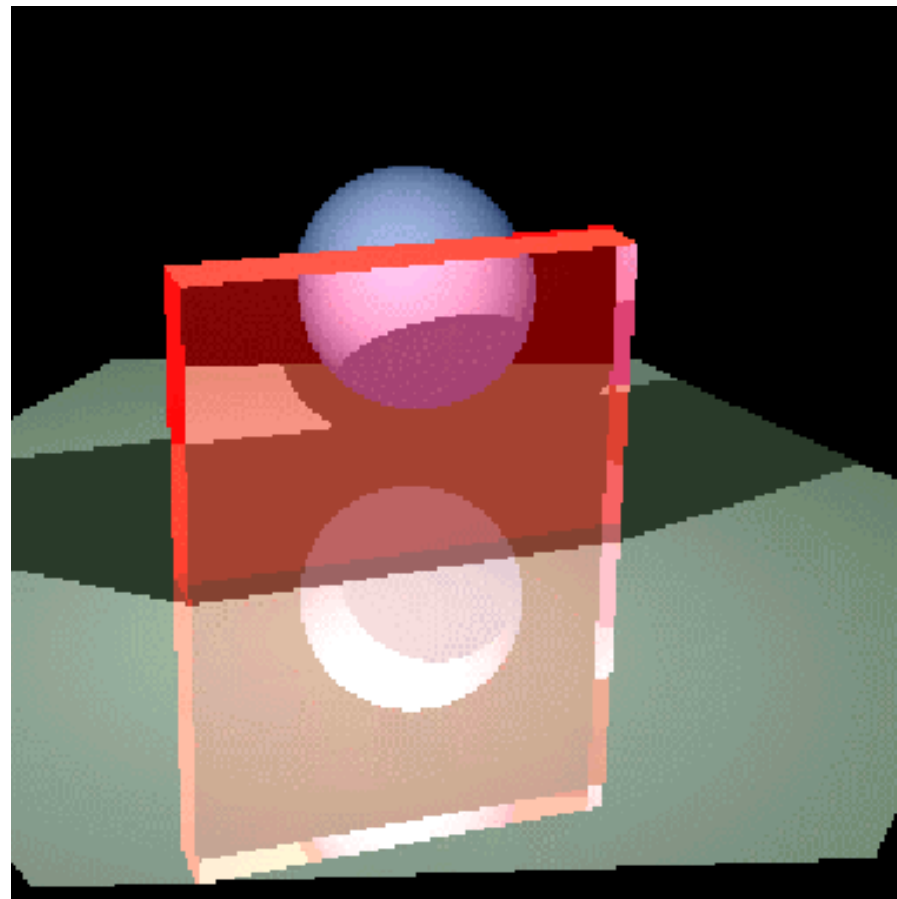- **motion blur**

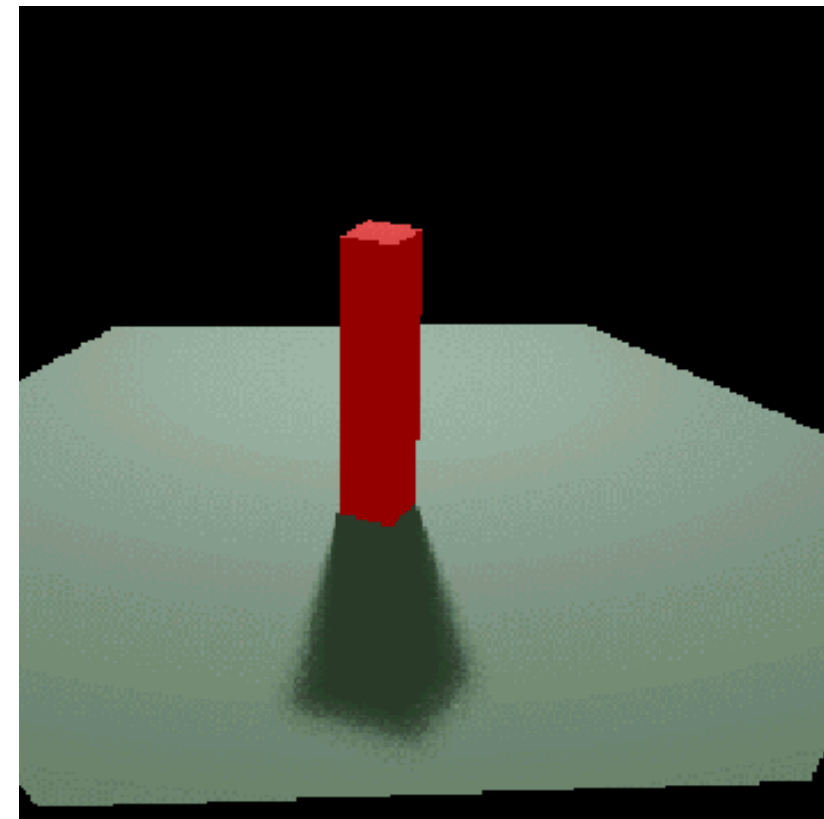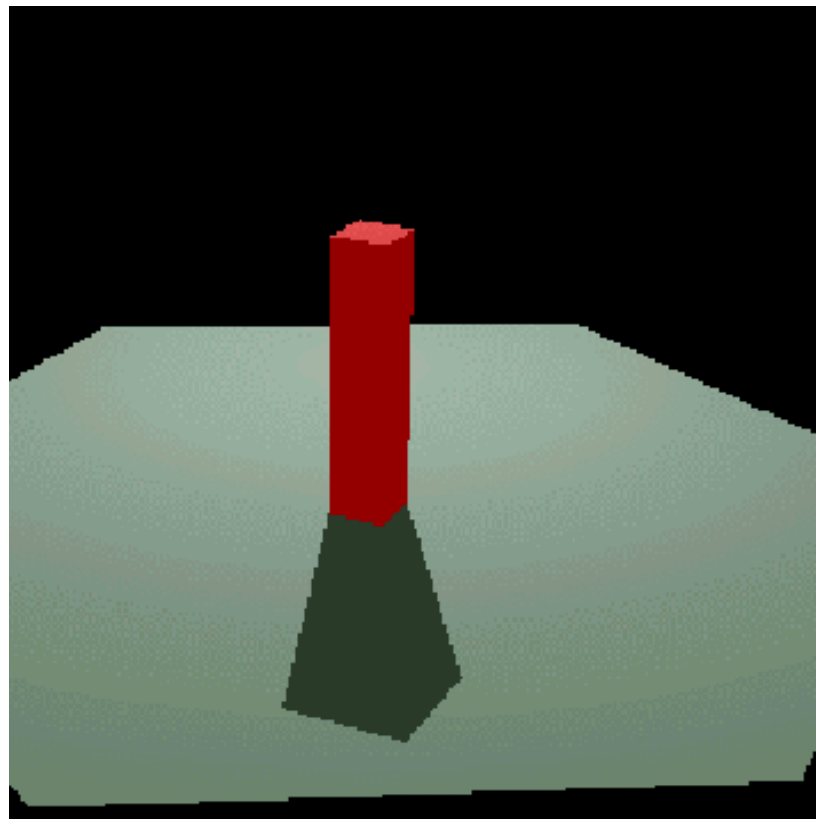# Gloss (fuzzy reflections)

Jittering reflection ray

Fuzzy translucency

Jittering refracion ray

Soft shadows

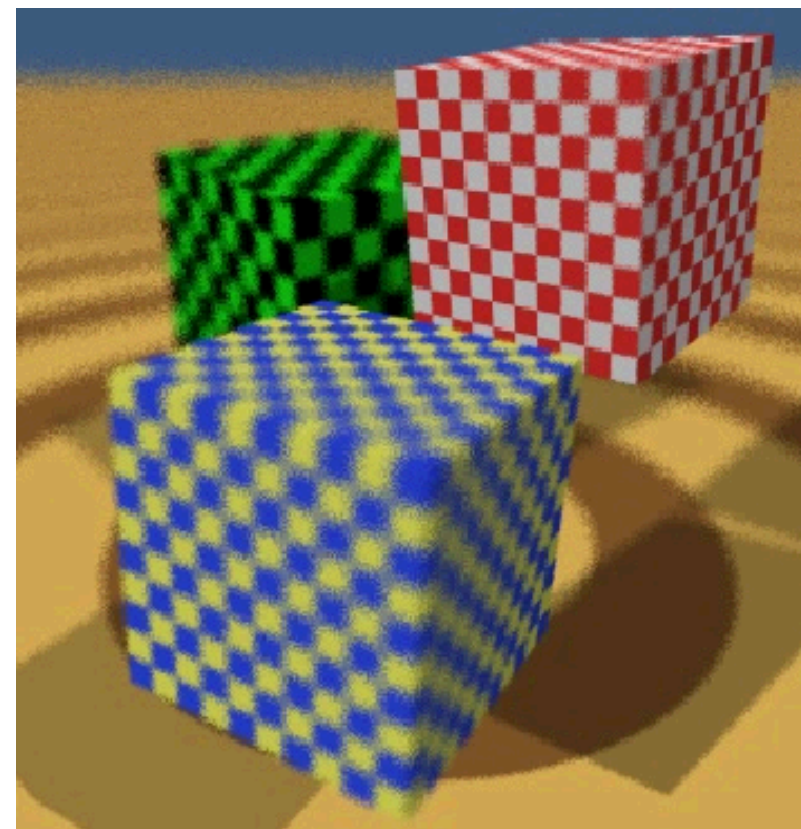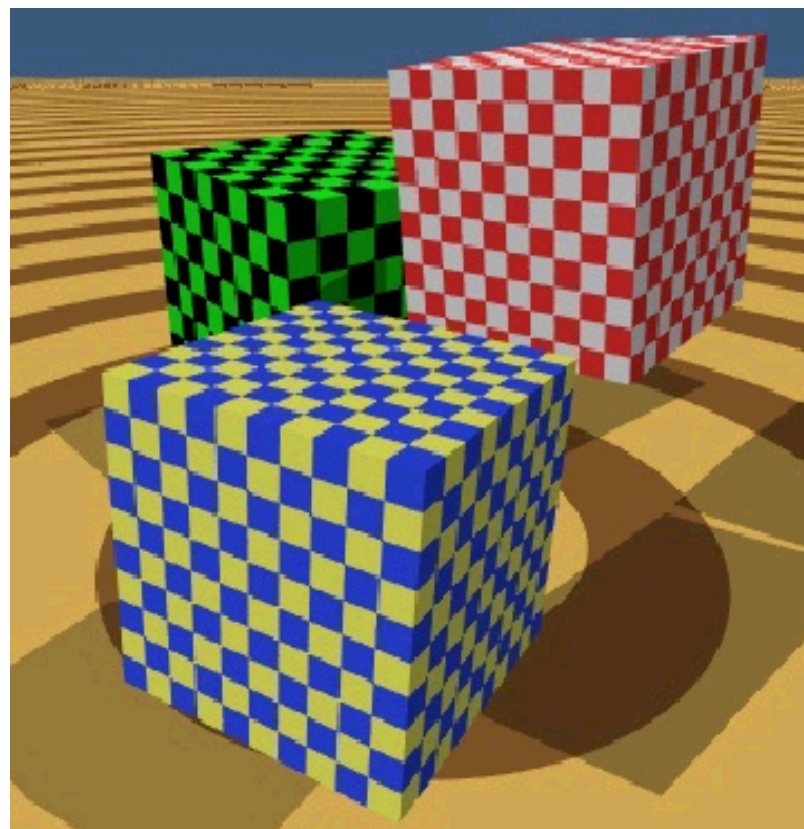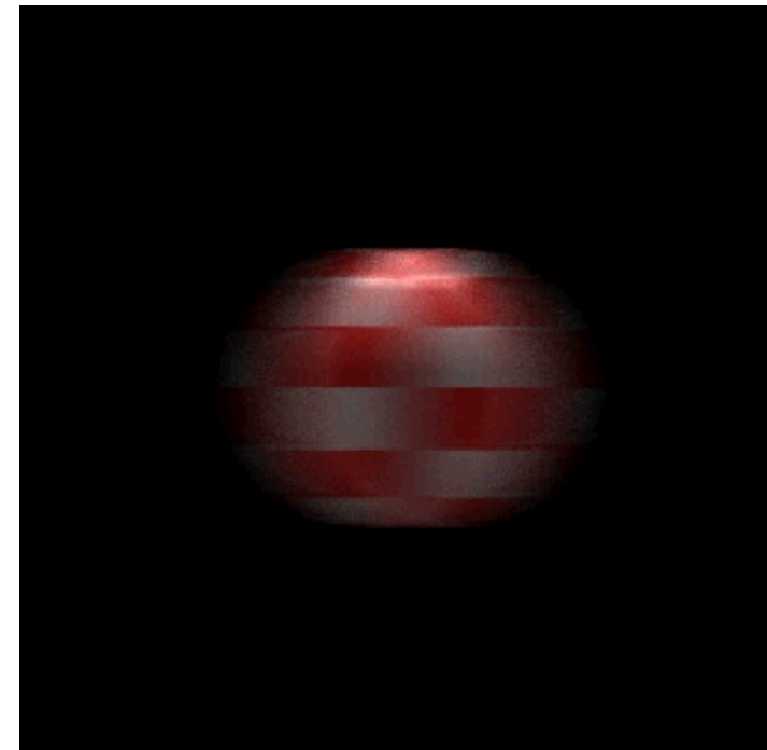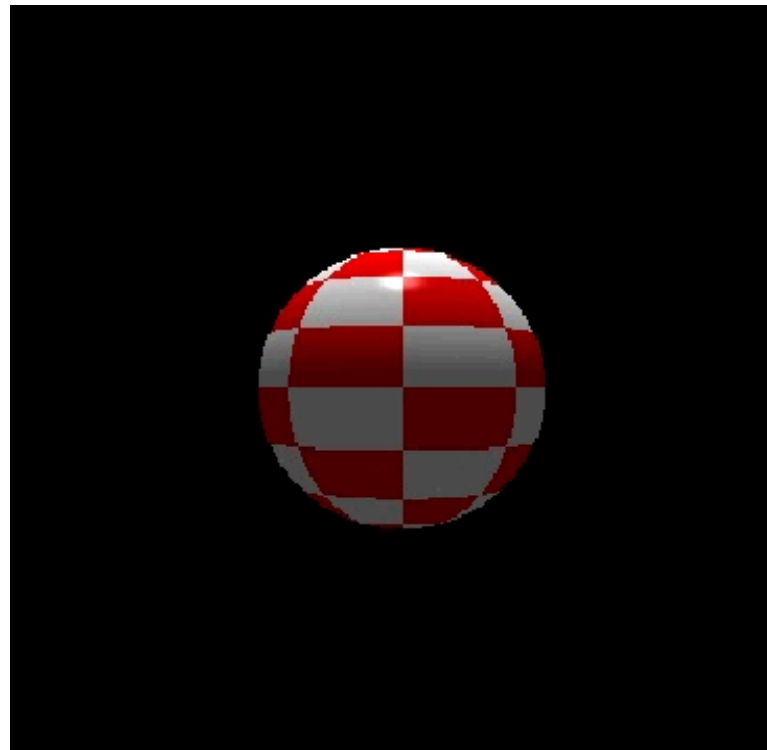
Jittering shadow ray

Depth of field (out-of-focus effect)

Jittering main ray

Motion blur

Jittering time

Off-line vs real-time

Many effects that were previoulsy only possible off-line are moving into on-line.

Mirrors: Simulated by environment mapping (early example: MDK), now getting more are more realistic.

Focus effects, anti-aliasing etc: Done with multi-pass rendering and filter shaders.

Modern GPU's have hundreds of cores!

Ray-tracing in real-time? No longer unreasonable.

Ray-tracing in the GPU

Does not fit the GPU rendering model!

• Recursion not allowed!

• Limited amount of data available to a shader - needs to use textures for input

Not impossible but we may need to use tricks, multi-pass rendering etc.

Ray-tracing on GPU usually done in "GPU computing languages" (CUDA,OpenCL) rather than shaders.