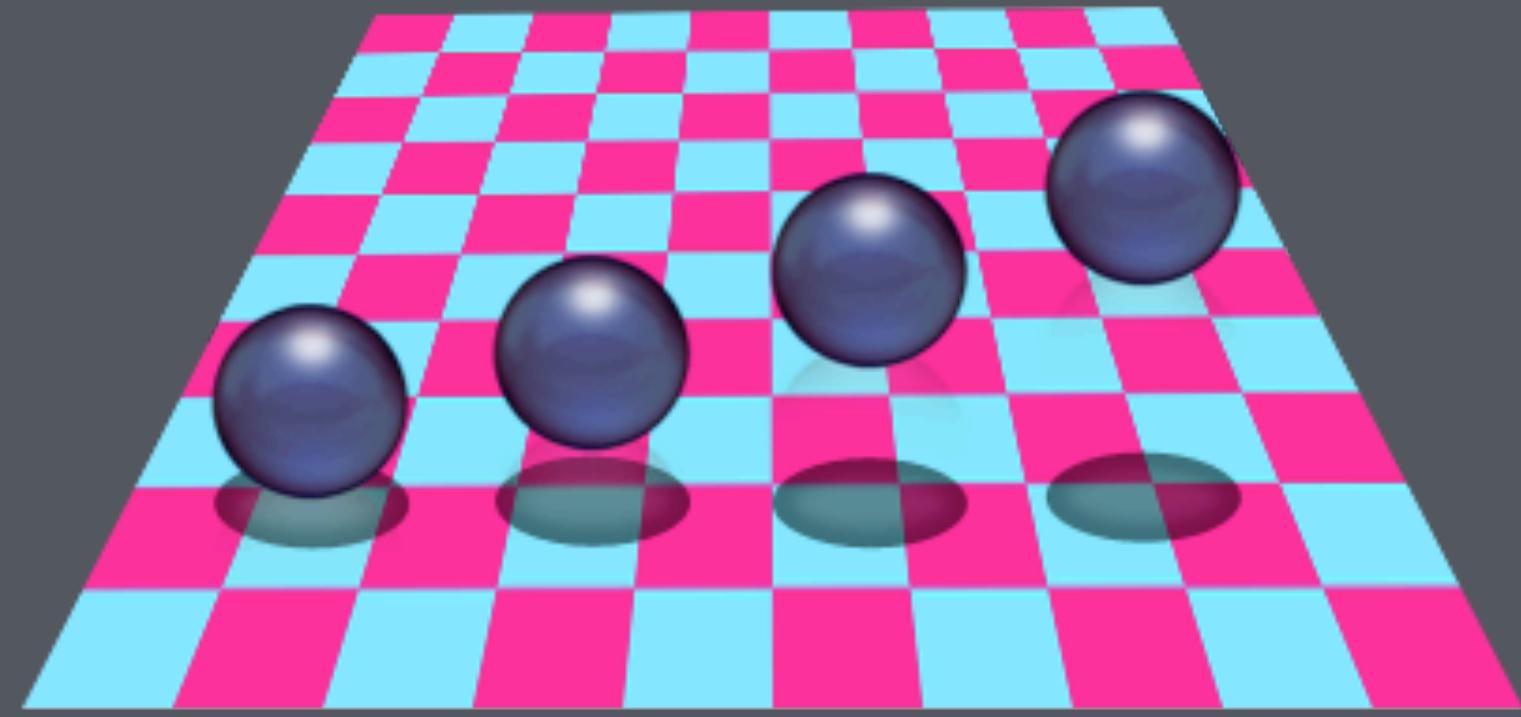
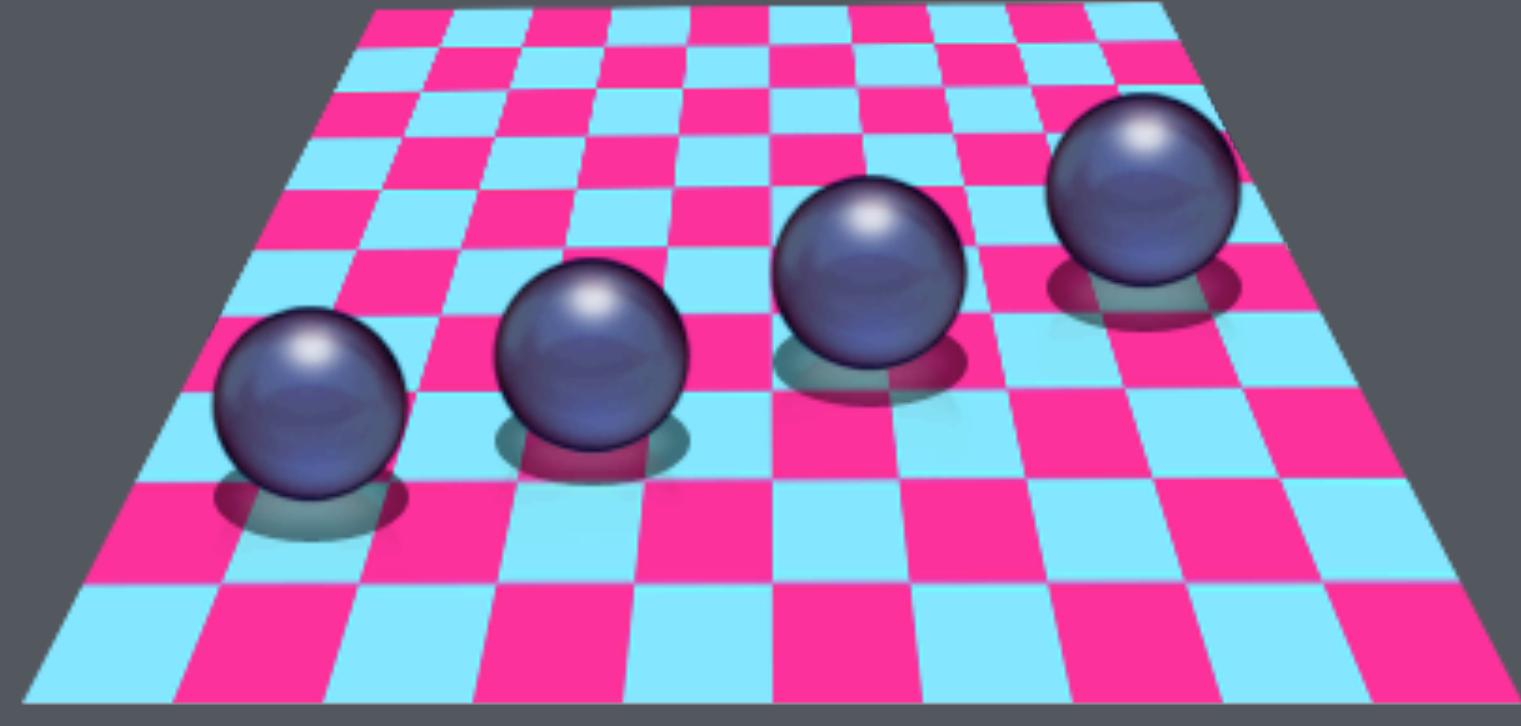


09 Shadow Mapping

Thanks to previous instructor Kavita Bala

Steve Marschner
CS5625 Spring 2019

Shadows as depth cue



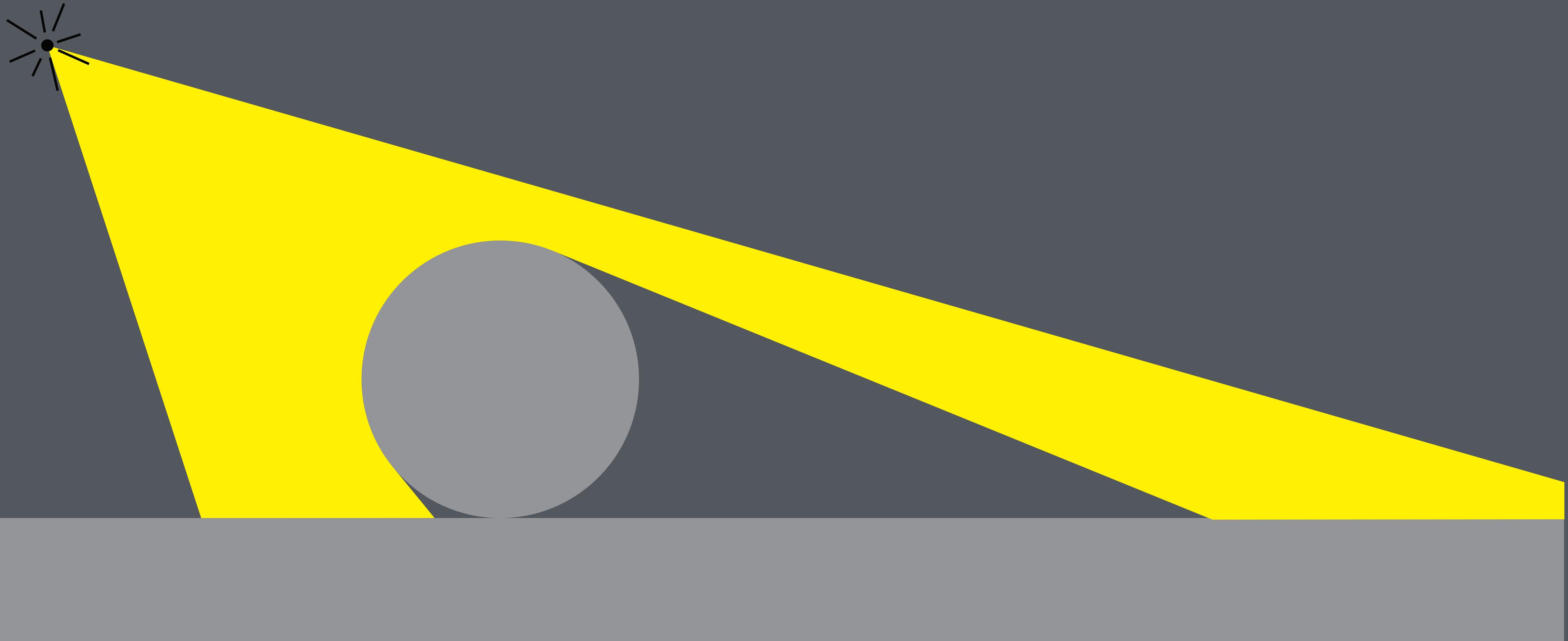
[tricks-and-illusions.com]

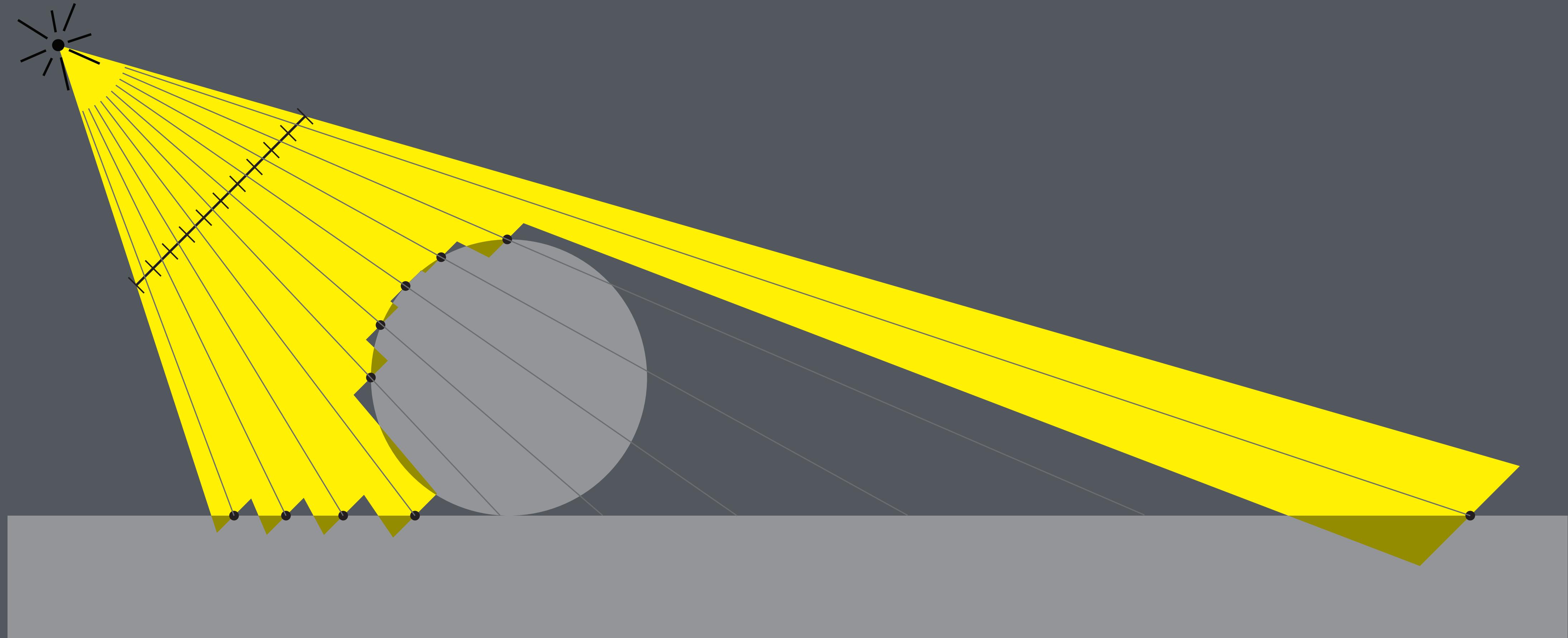
Shadows as anchors

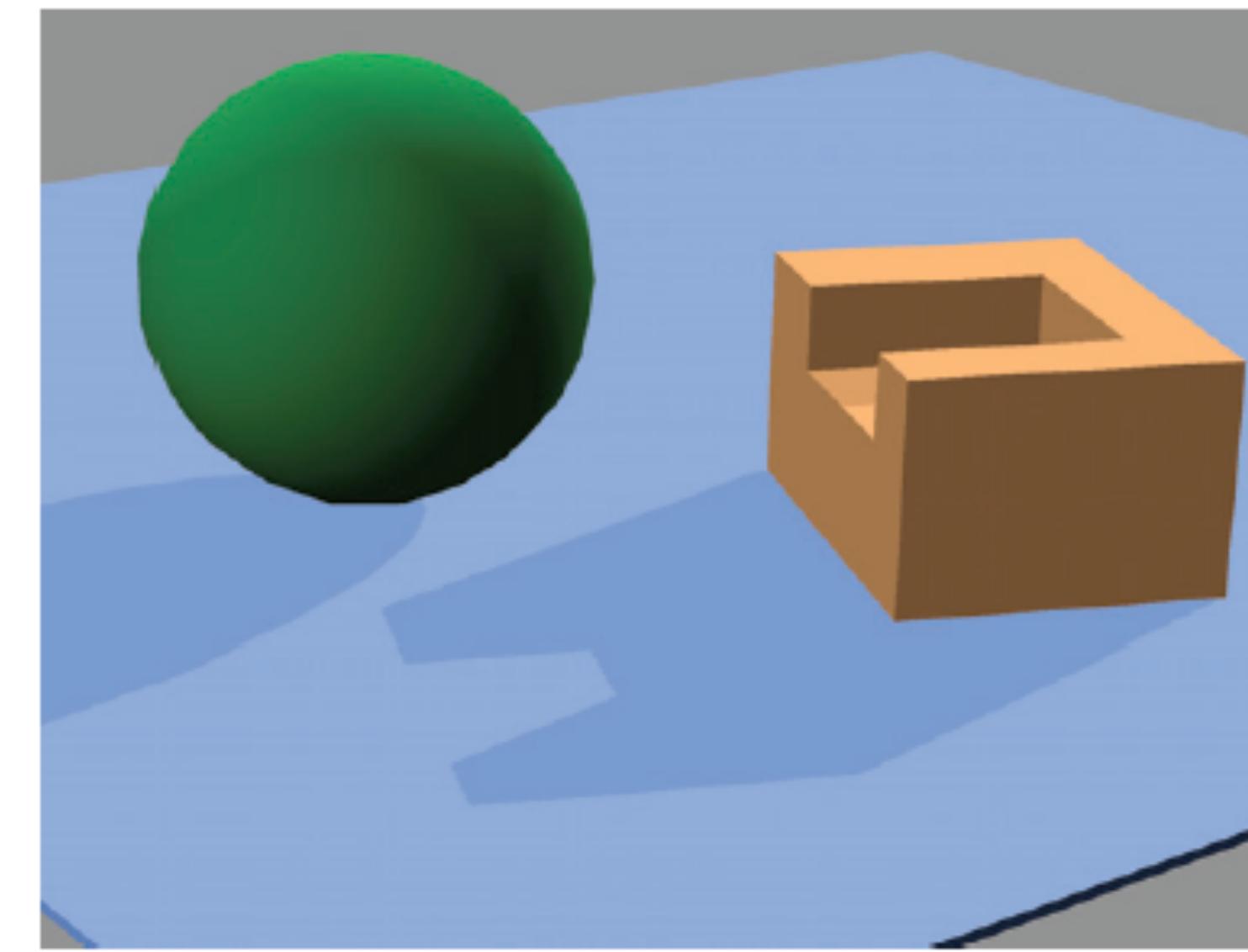
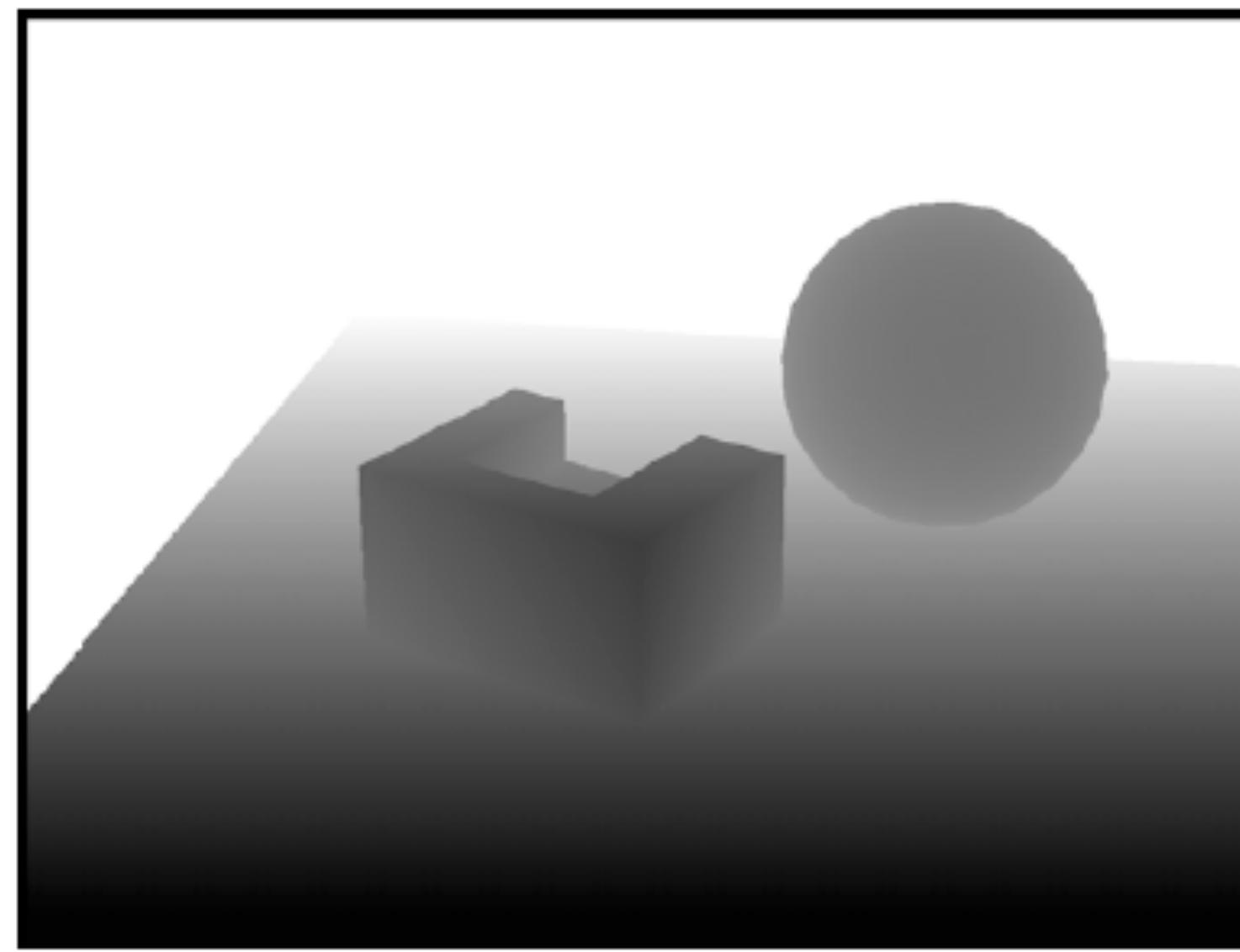
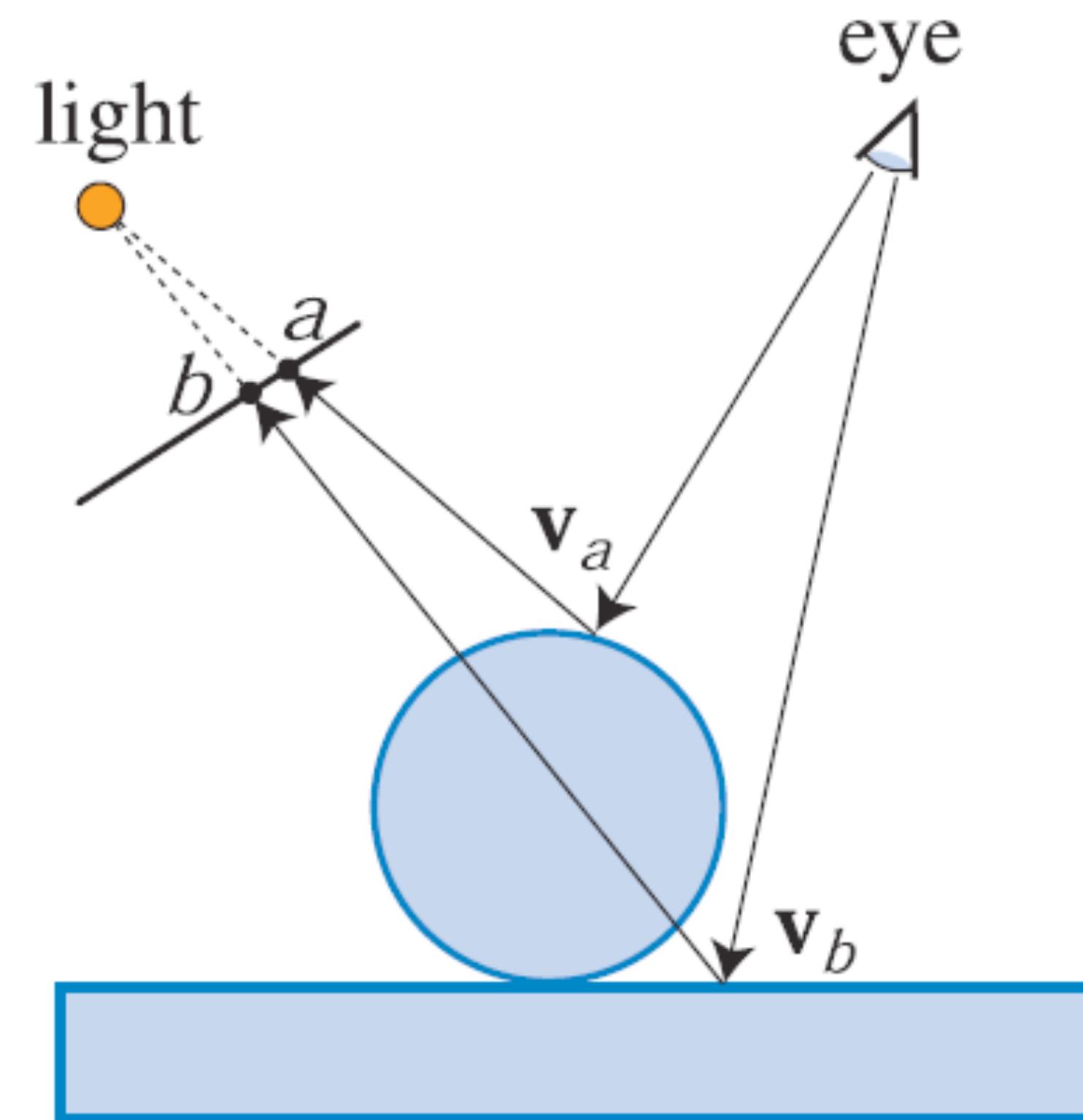
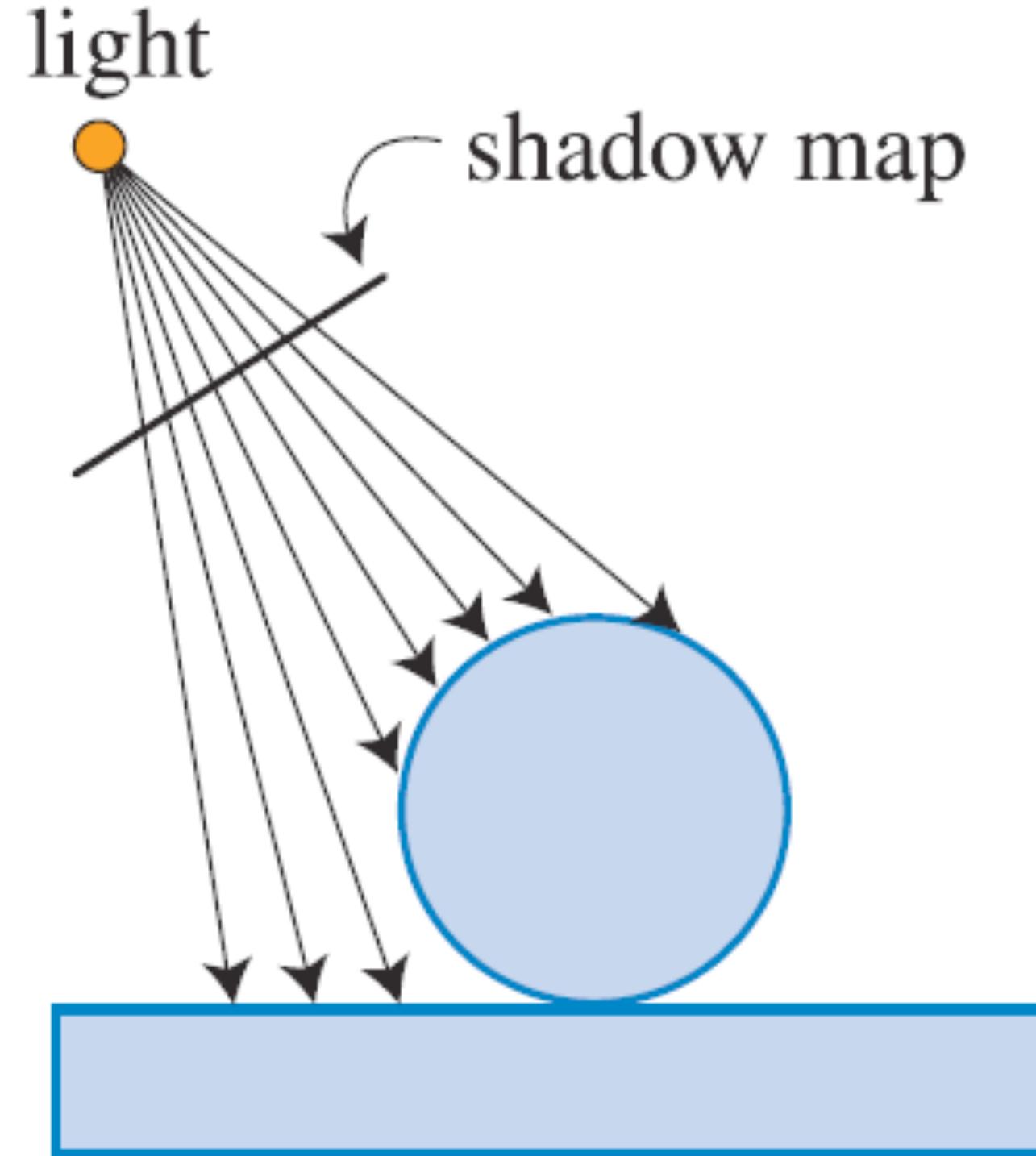


Shadows as anchors

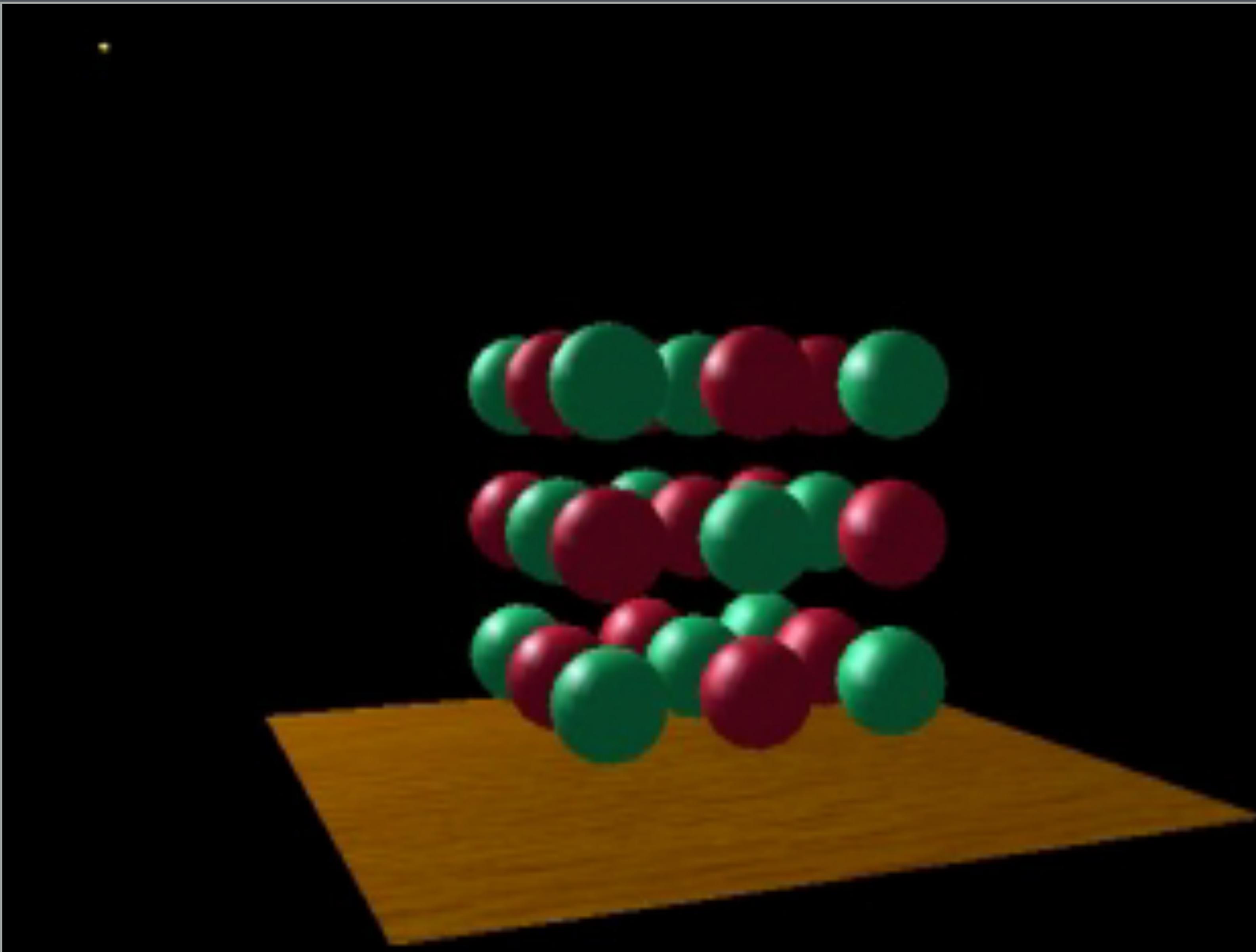




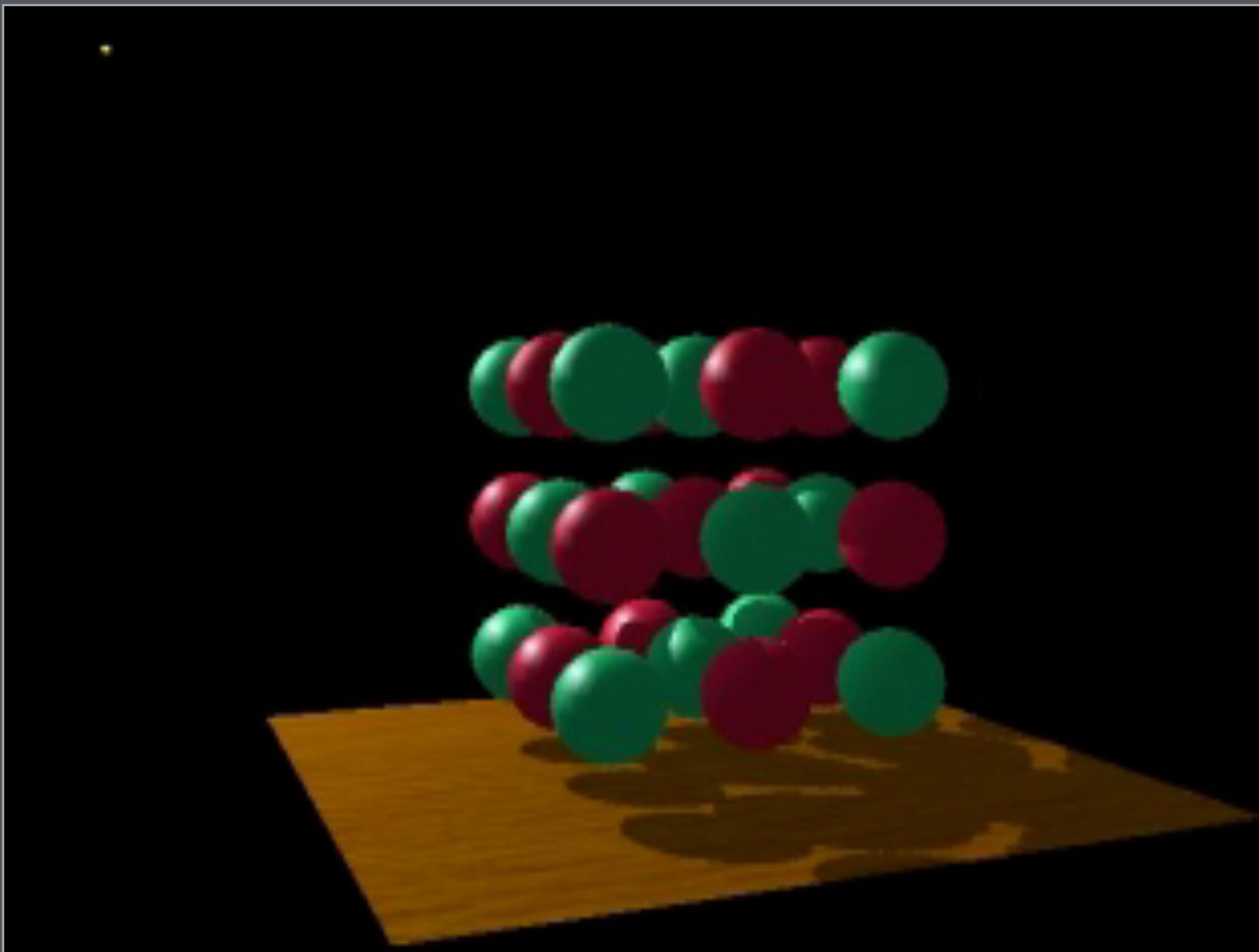




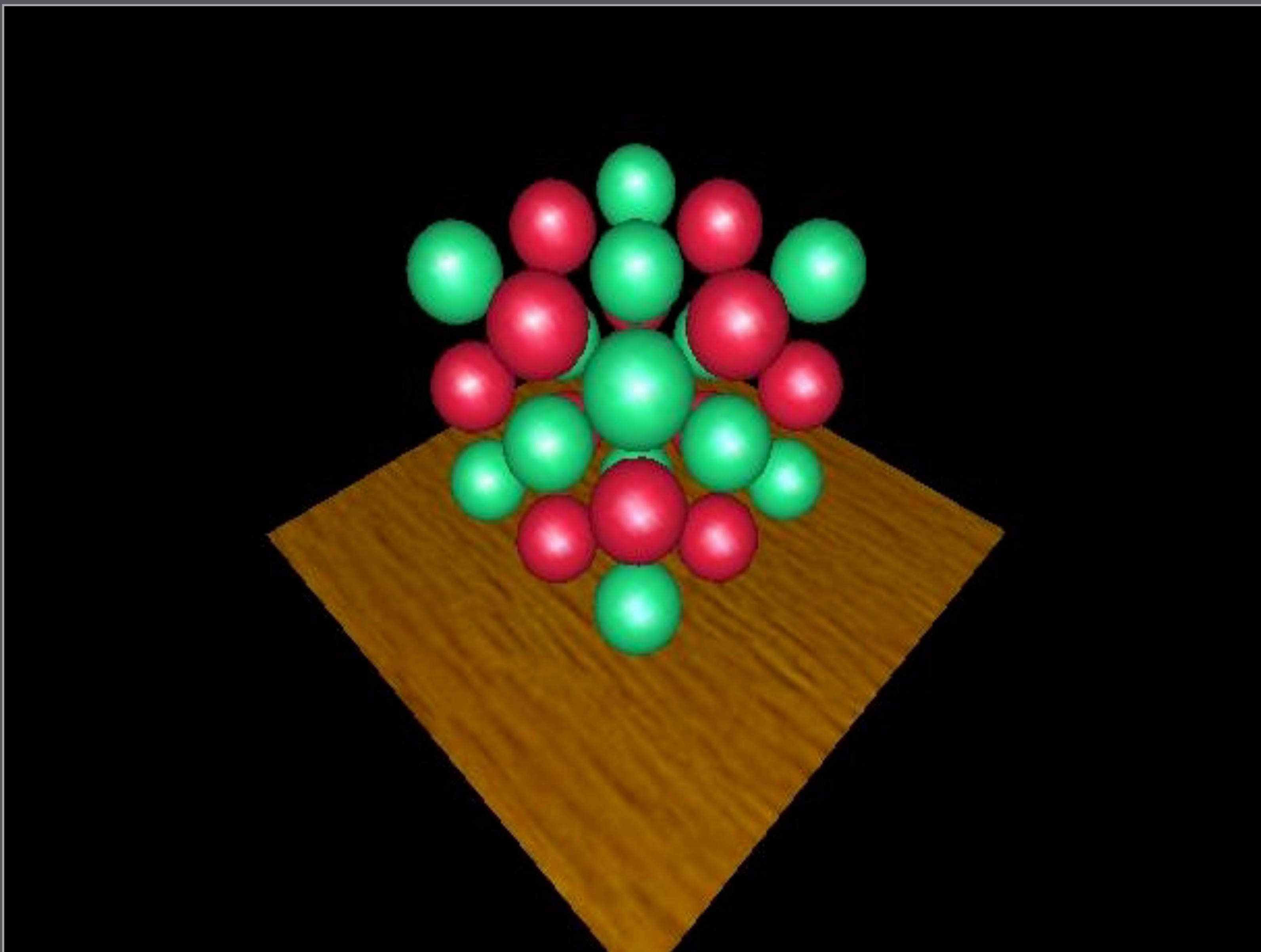
[Möller et al. *RTR*]



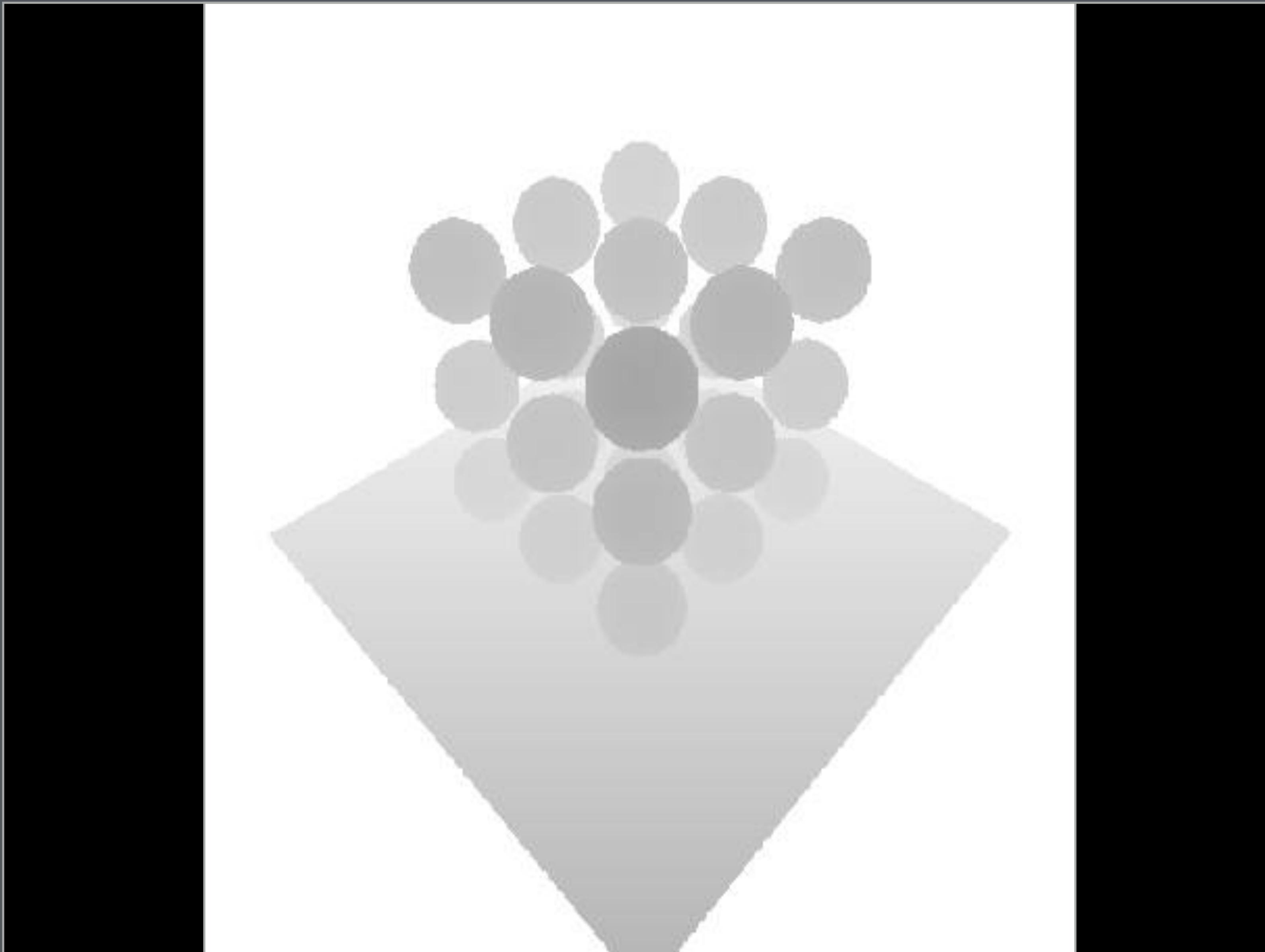
Mark Kilgard



Mark Kilgard



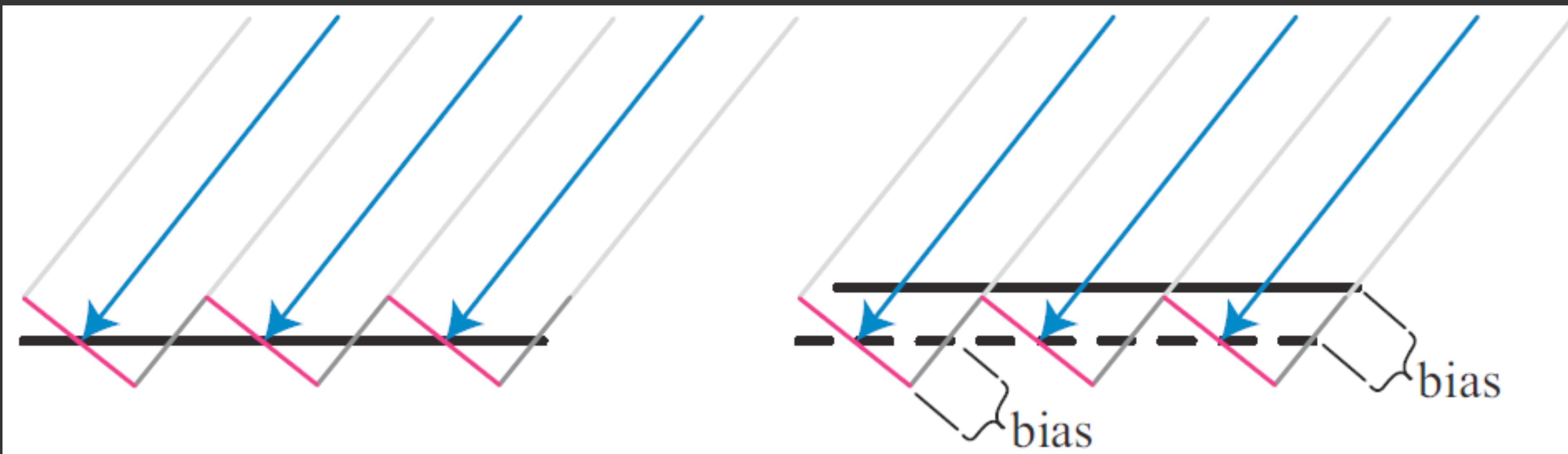
Mark Kilgard

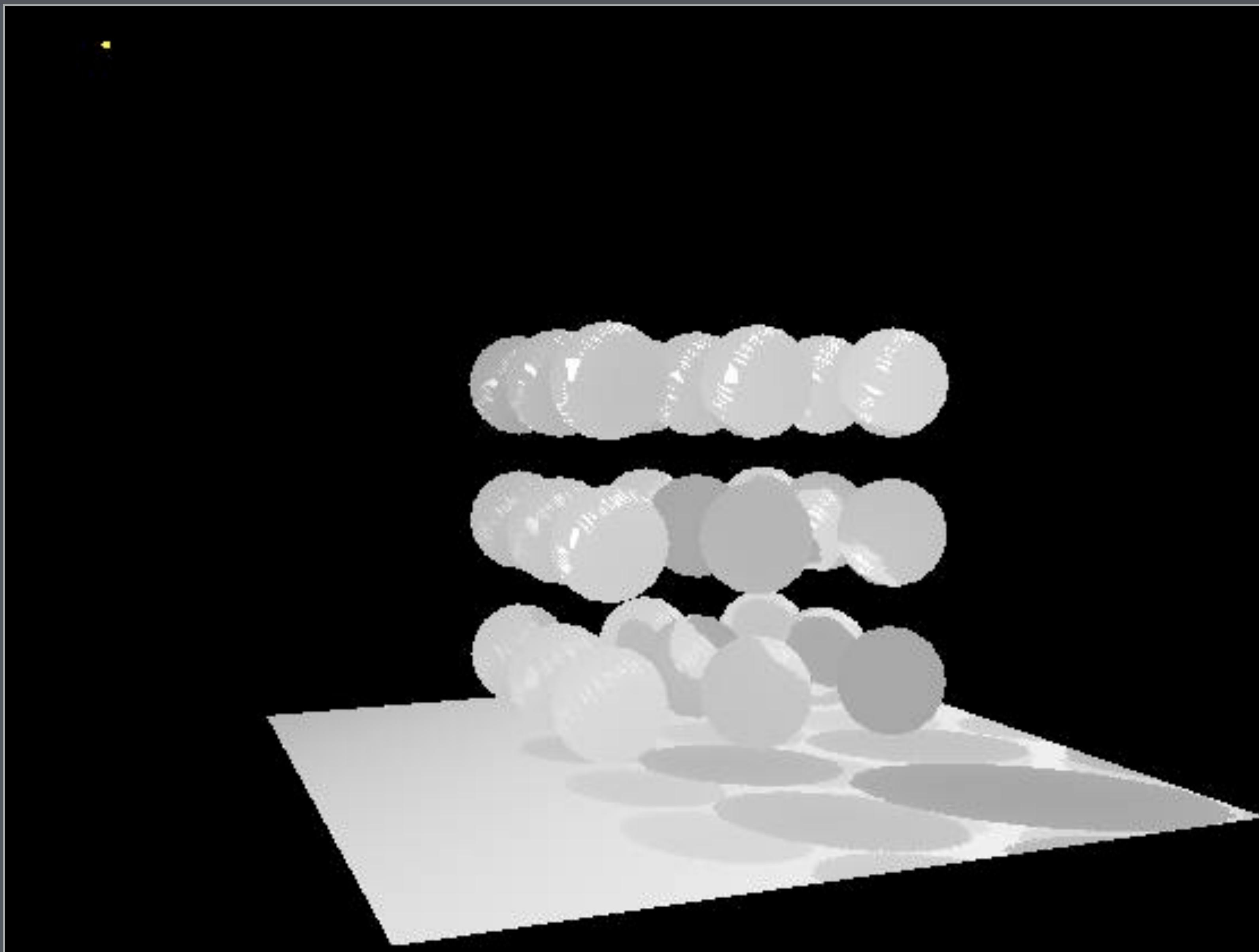


Mark Kilgard

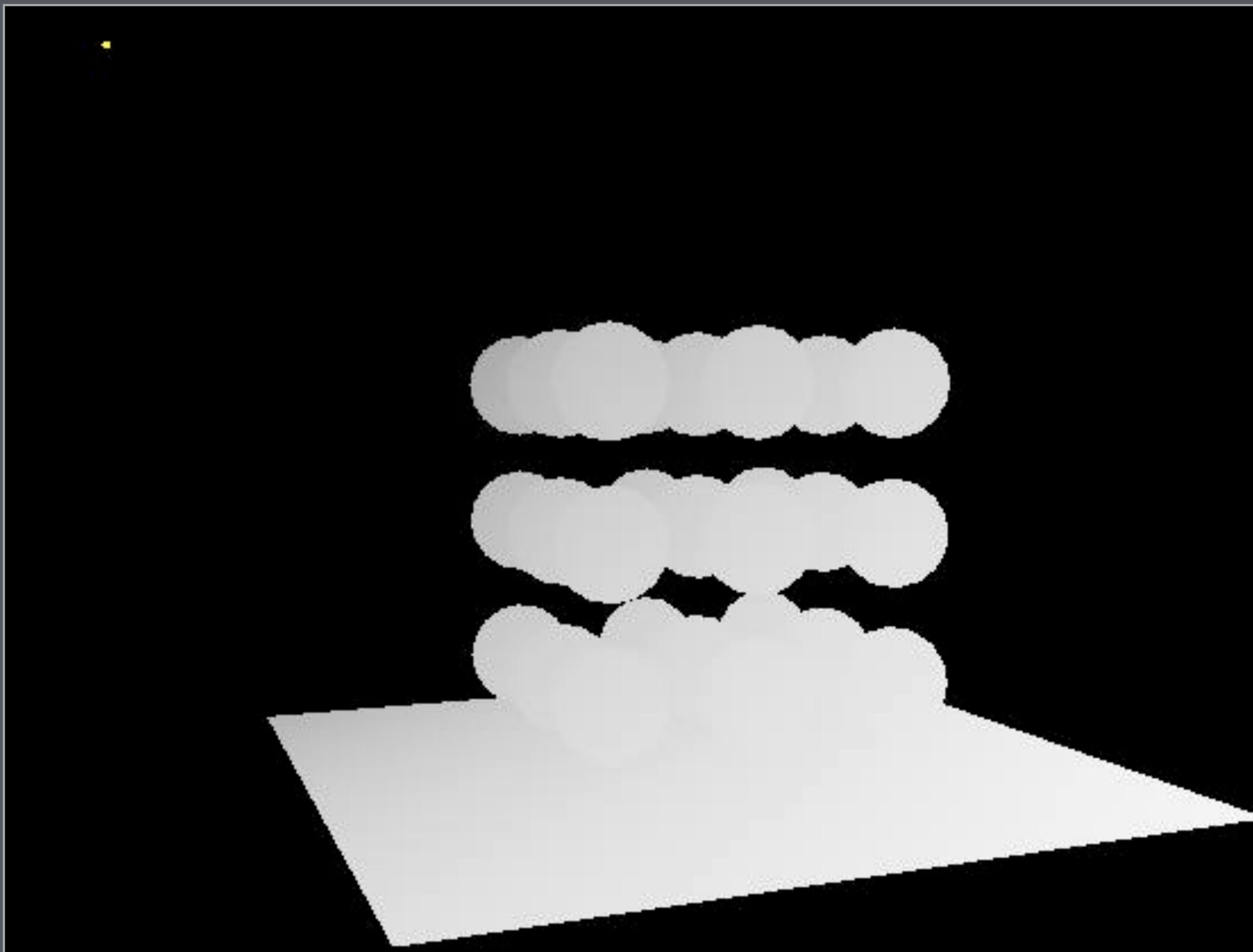
Shadow Map Issues

- if A and B are approximately equal?
- Speckling

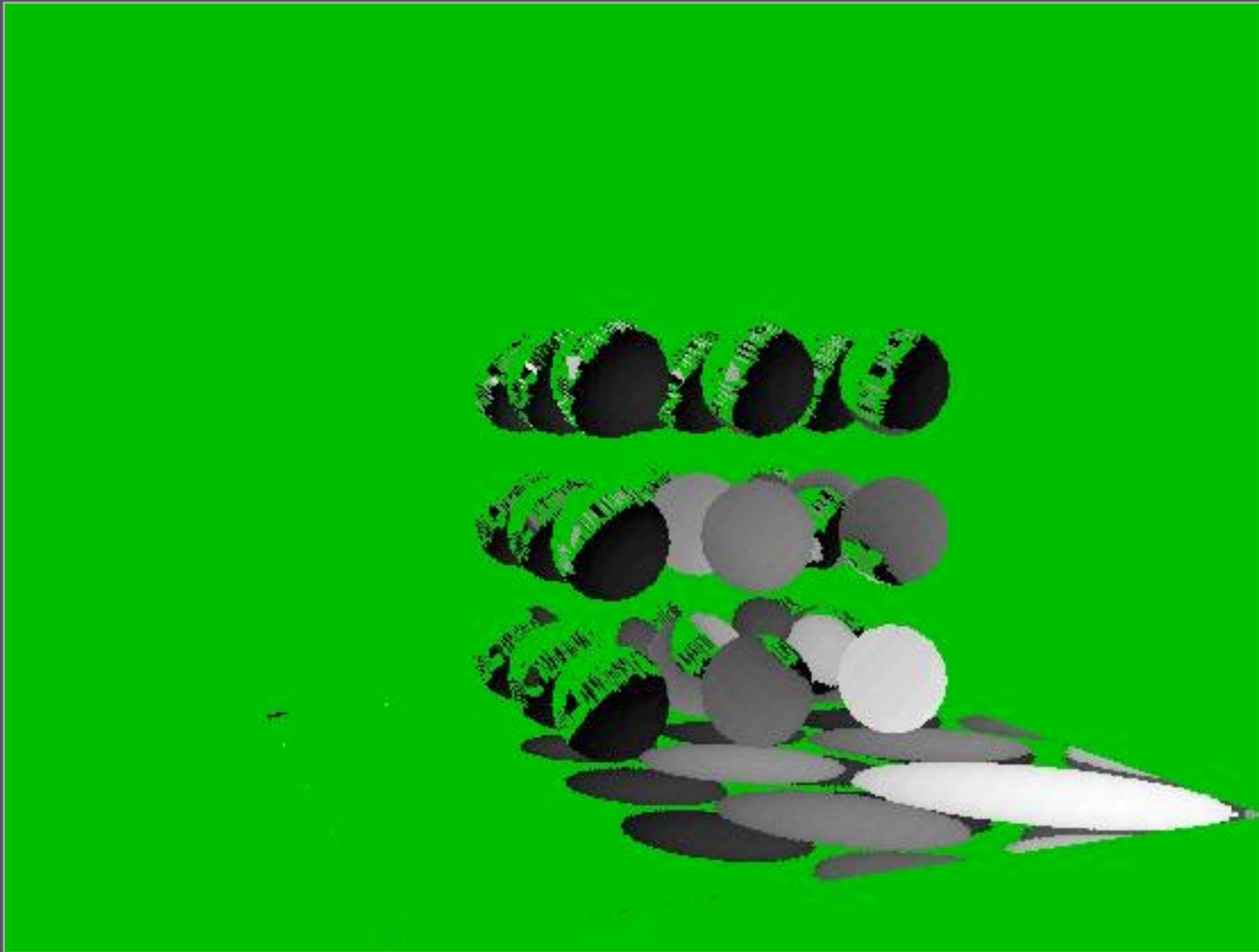




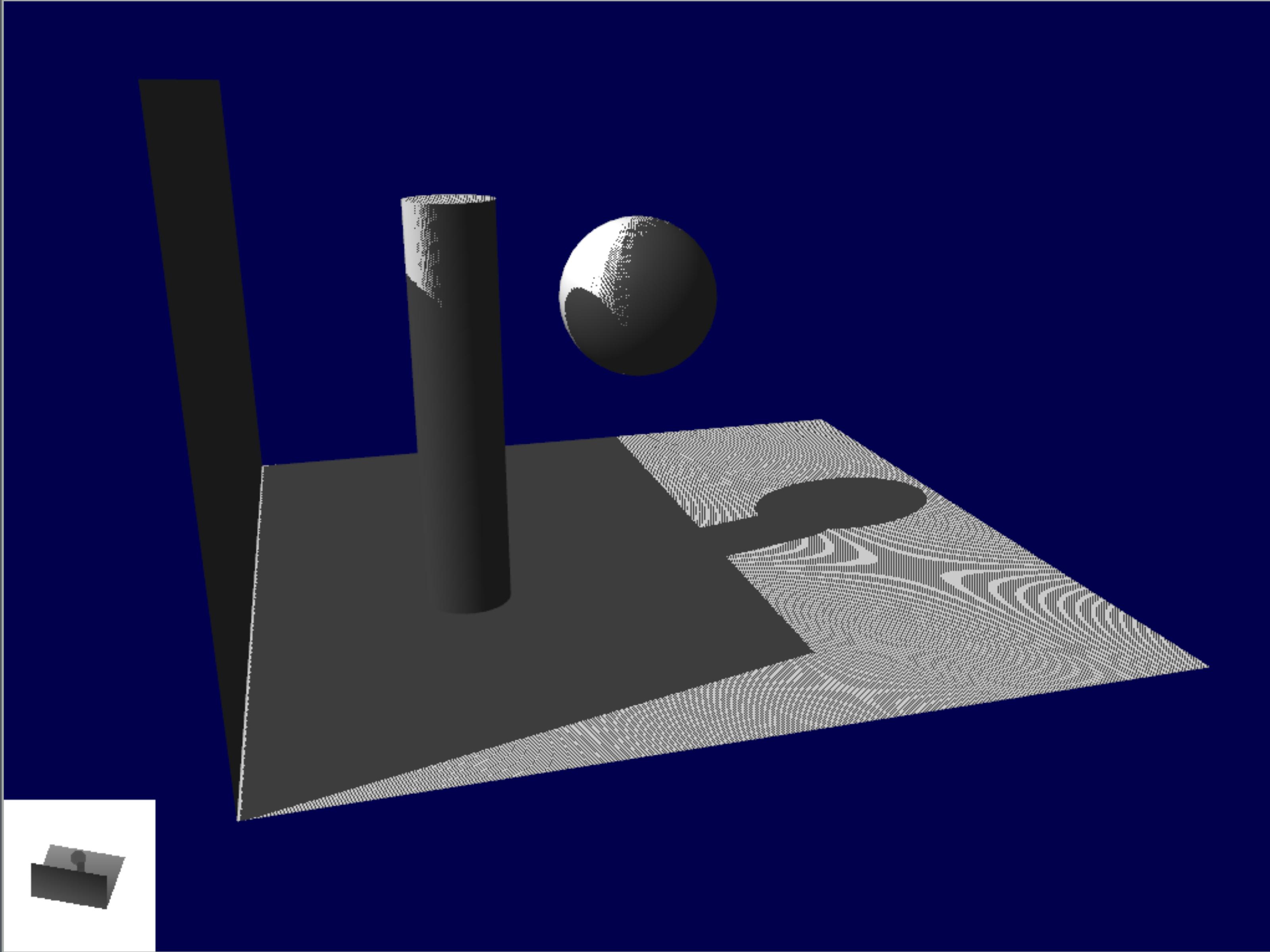
Mark Kilgard



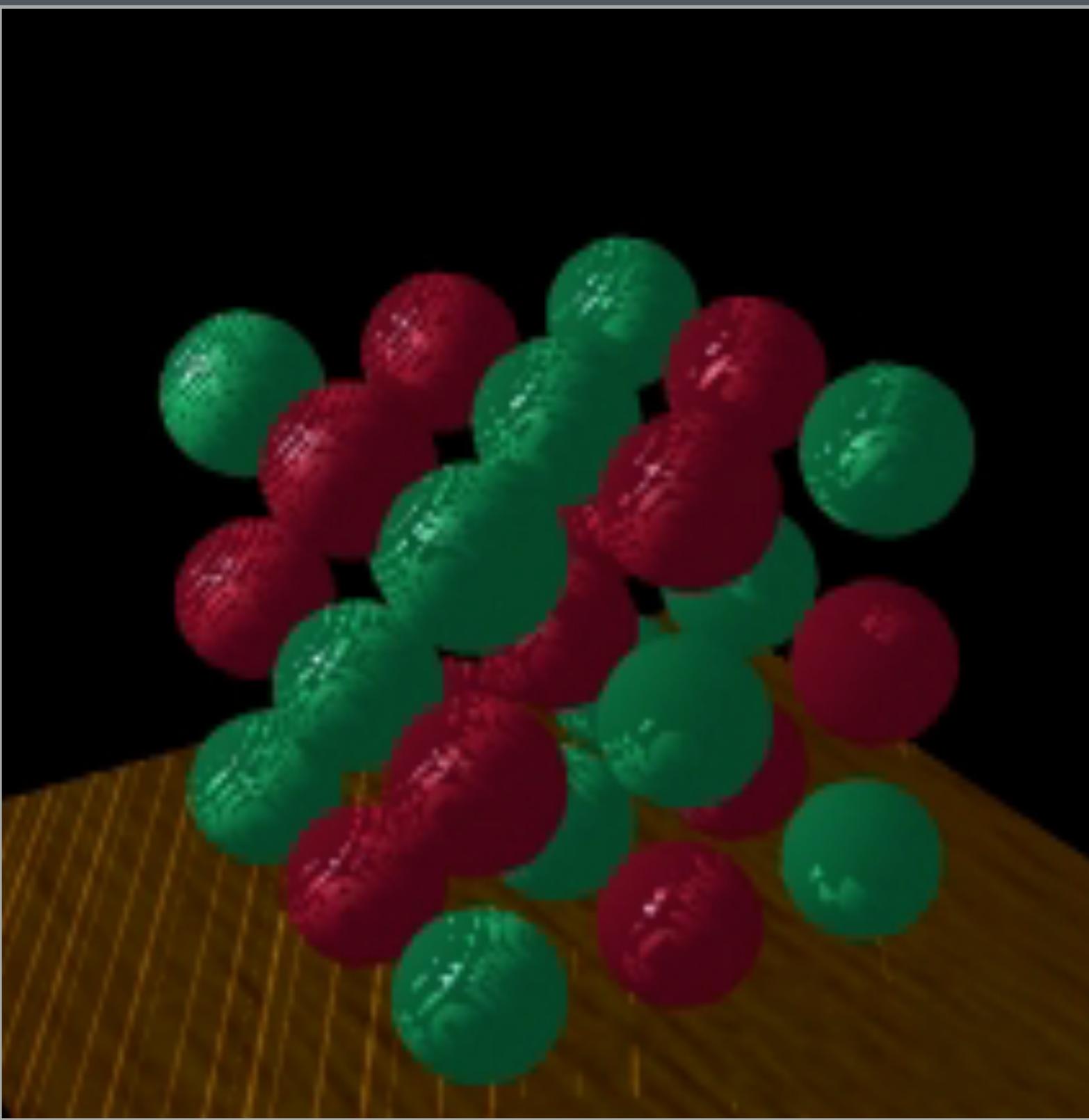
Mark Kilgard



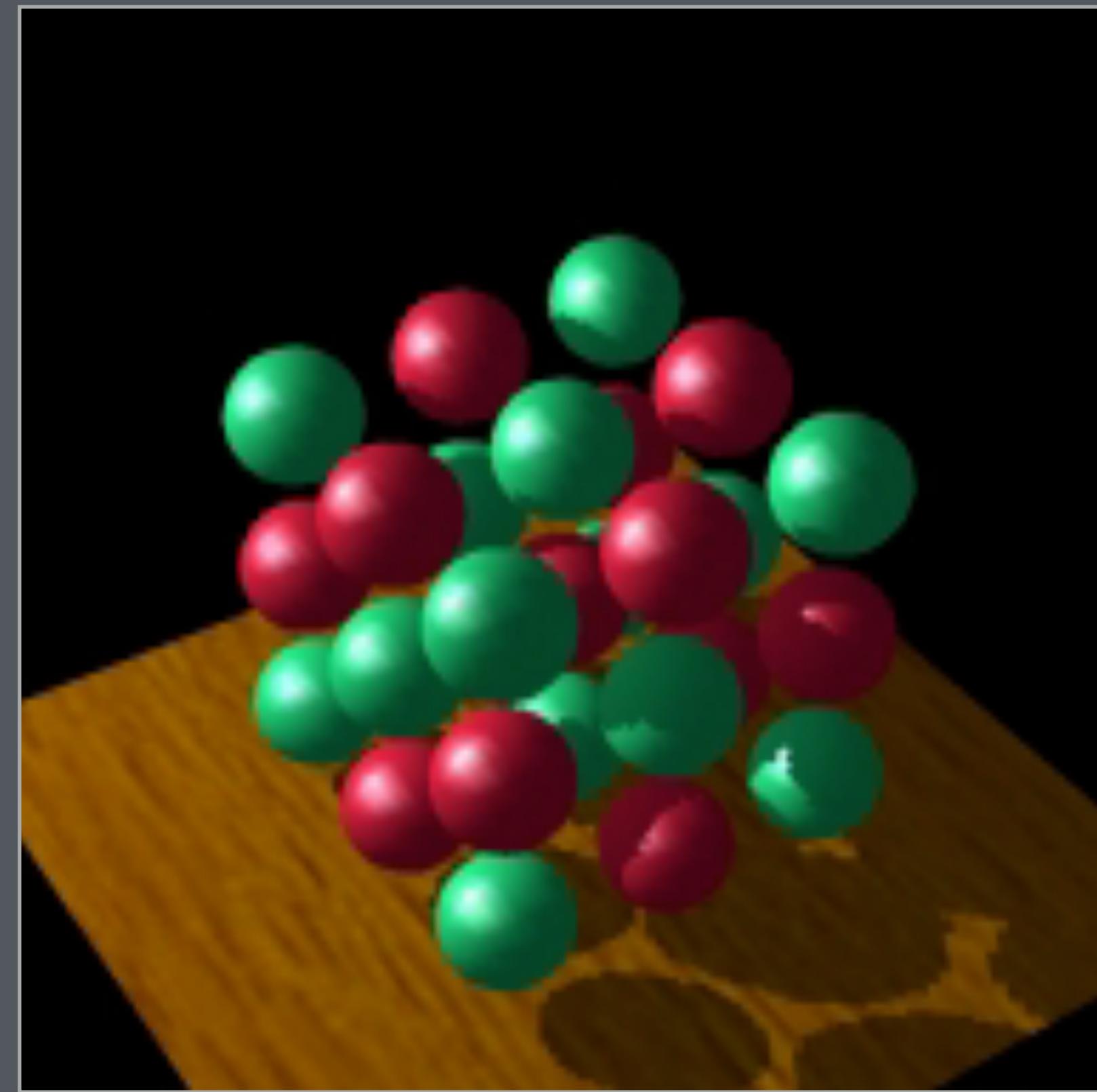
Mark Kilgard



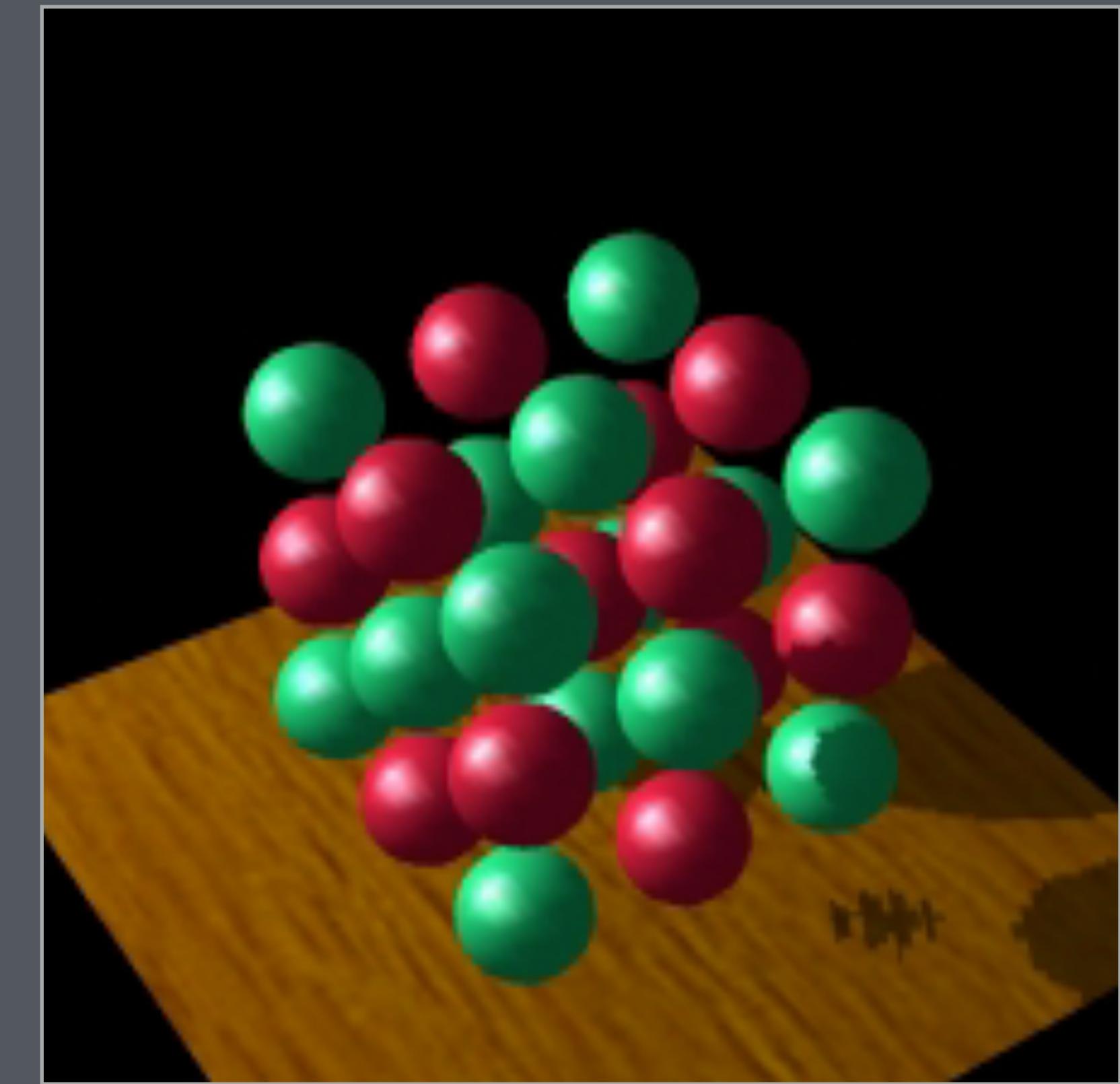
first try at shadow mapping



not enough shadow bias

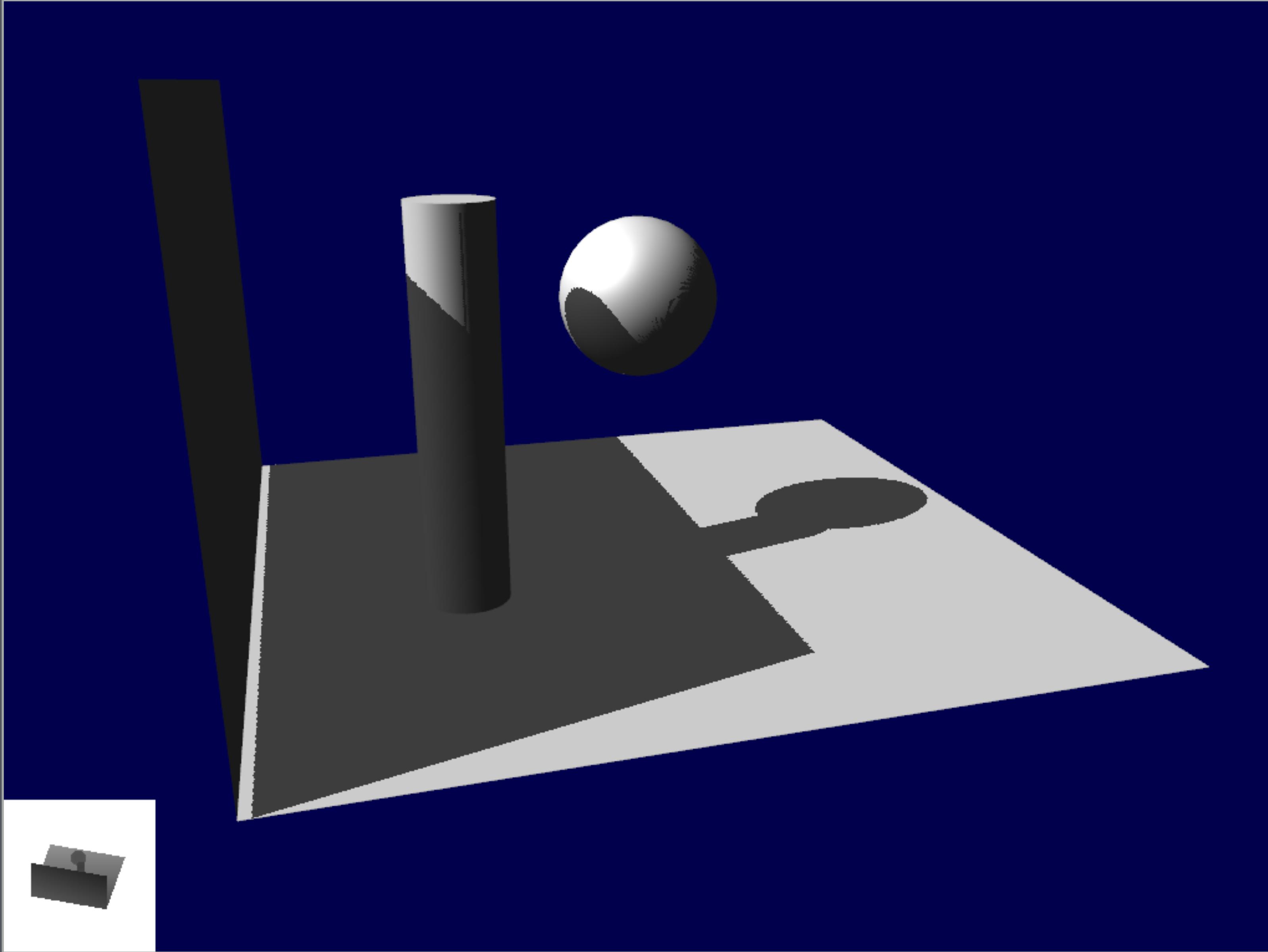


good shadow bias

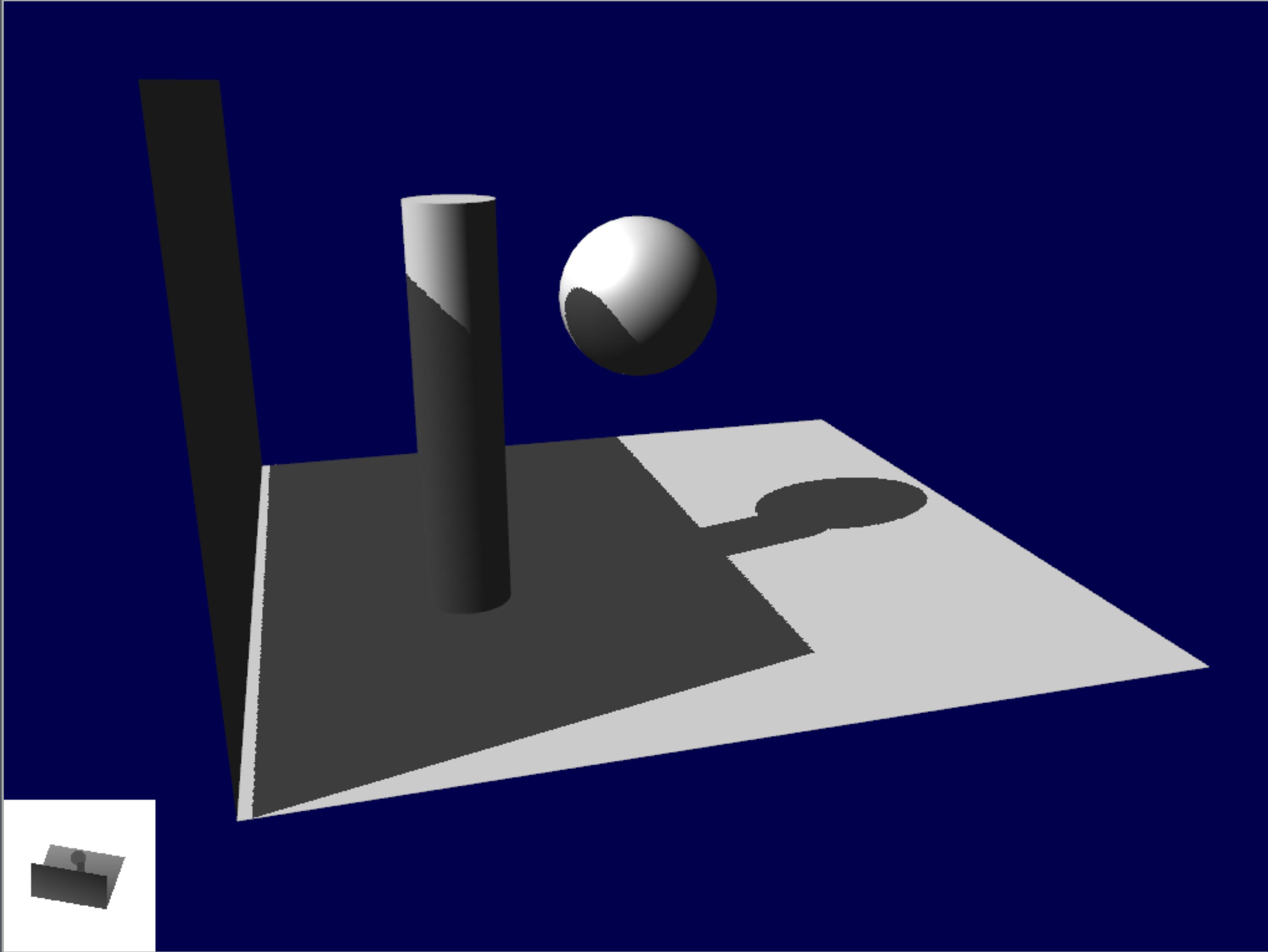


too much shadow bias

Mark Killgard

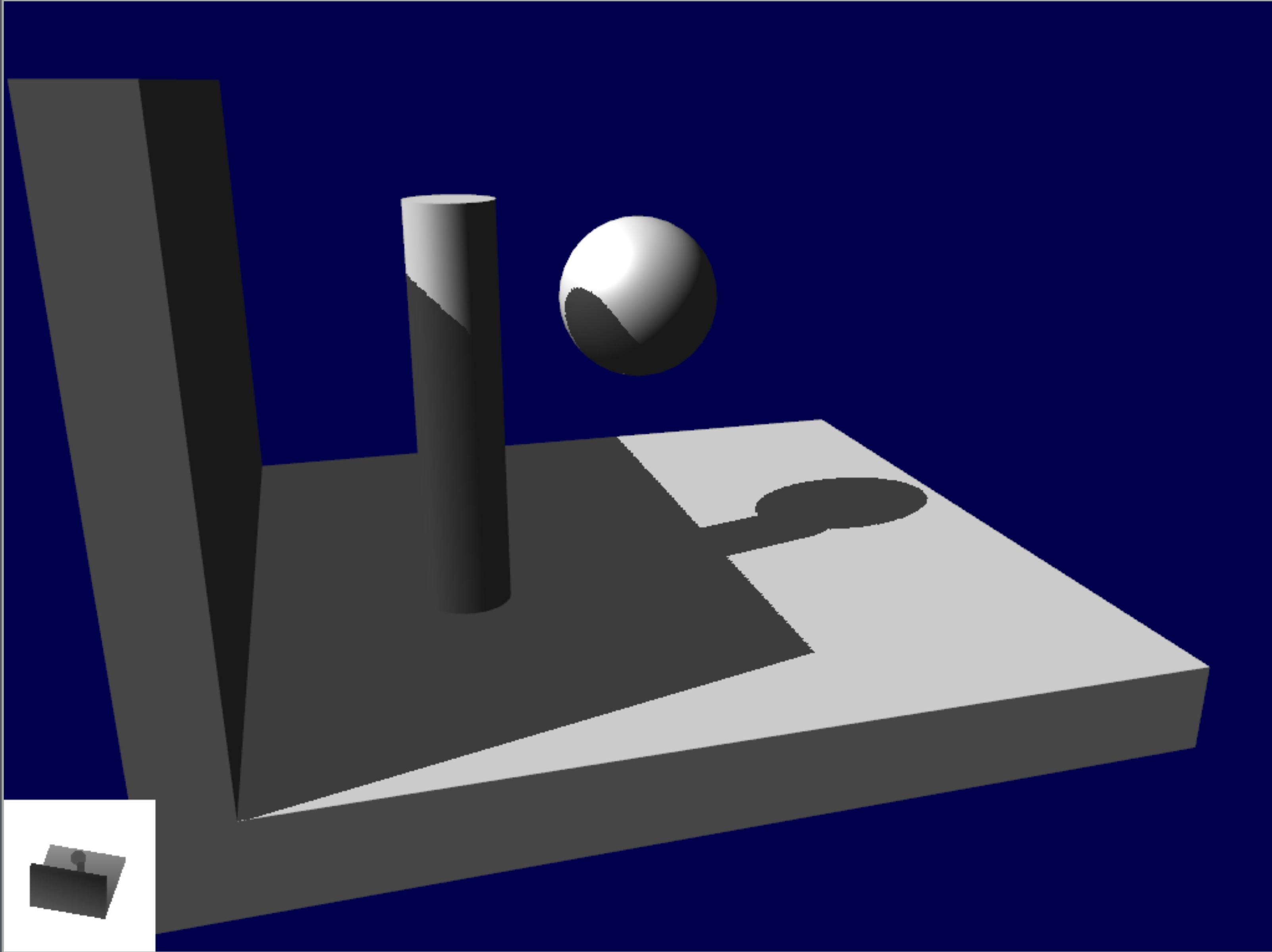


shadow mapping with constant bias

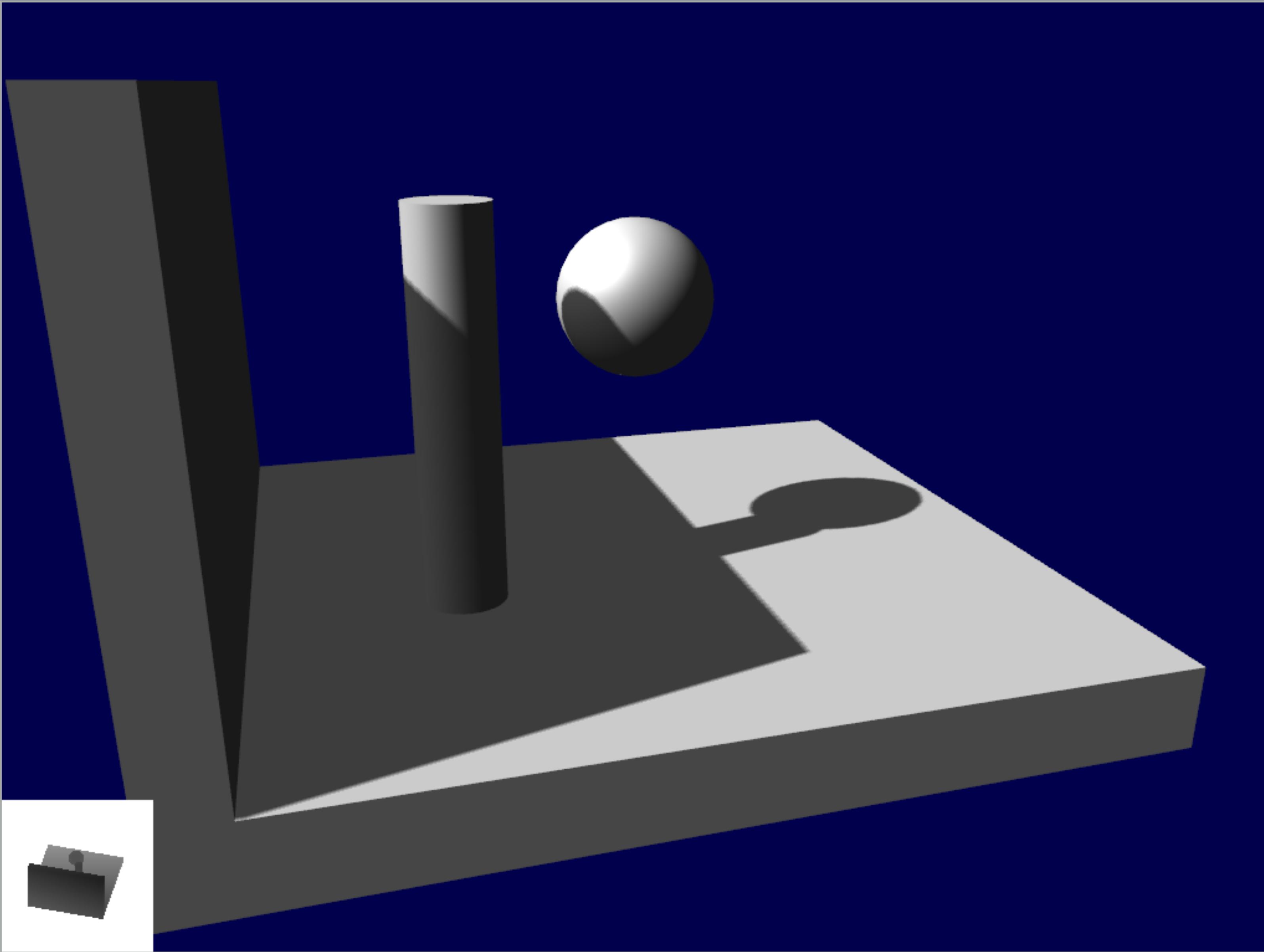


opengl-tutorial.org

shadow mapping with slope-dependent bias



closed surfaces and slope-dependent bias



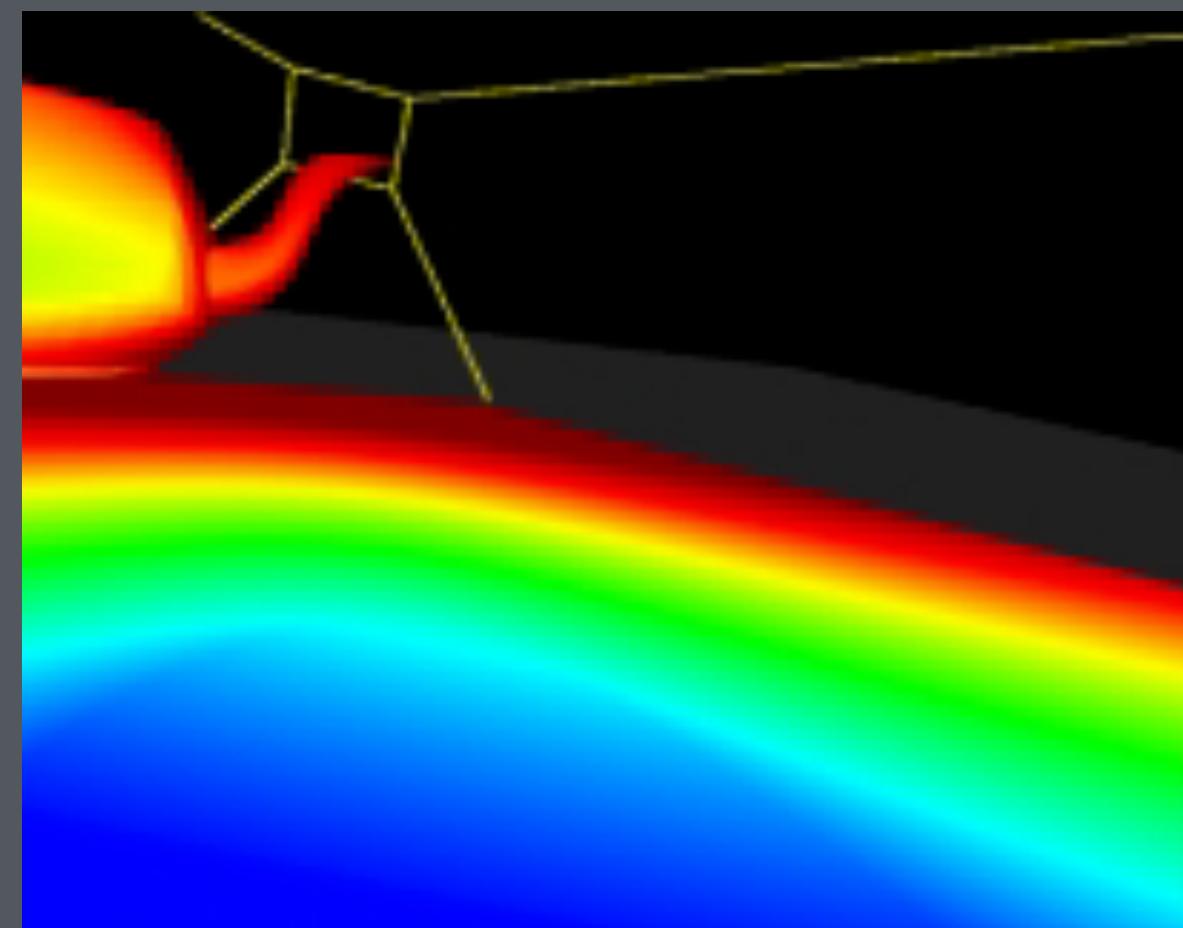
adding percentage-closer filtering

Shadow map sample rate—bad case

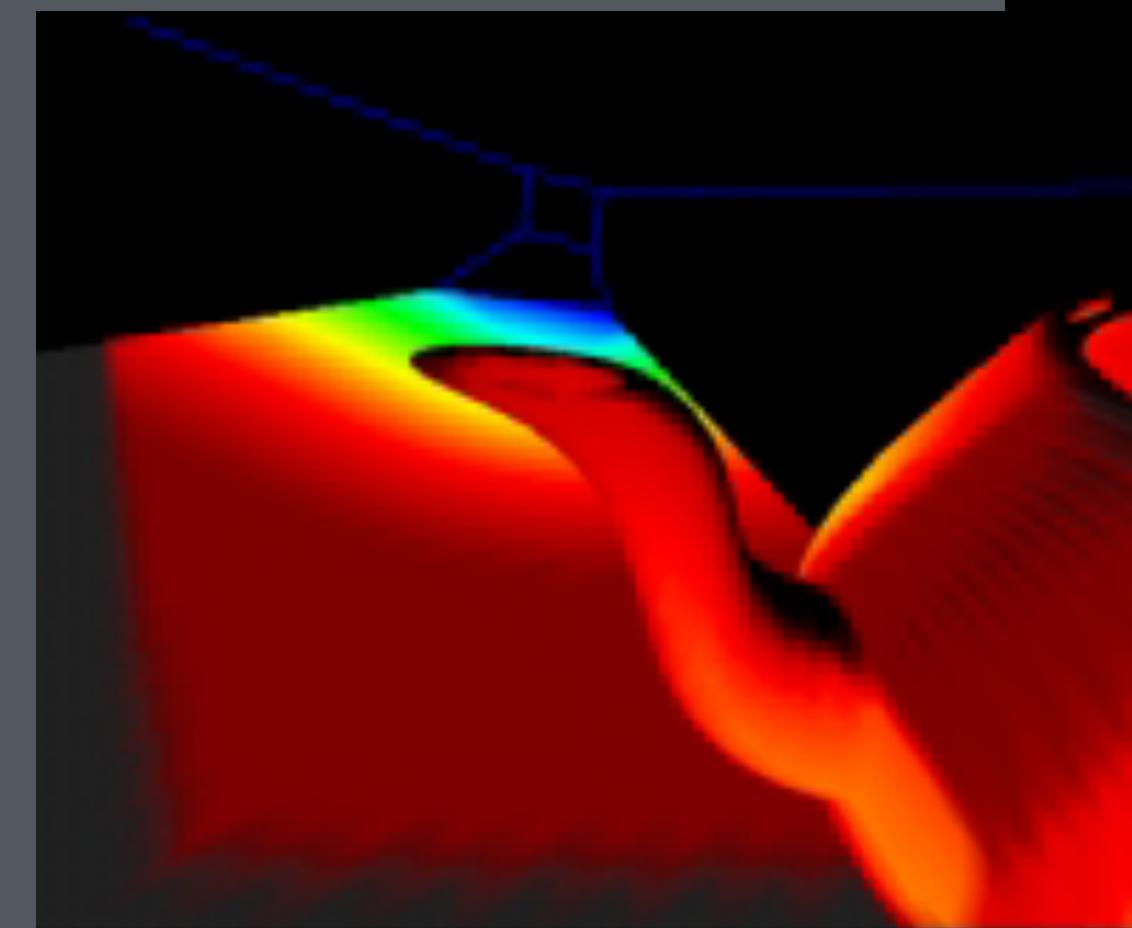
Light behind object

**Light’s “view direction” almost
opposite the eye’s view
direction**

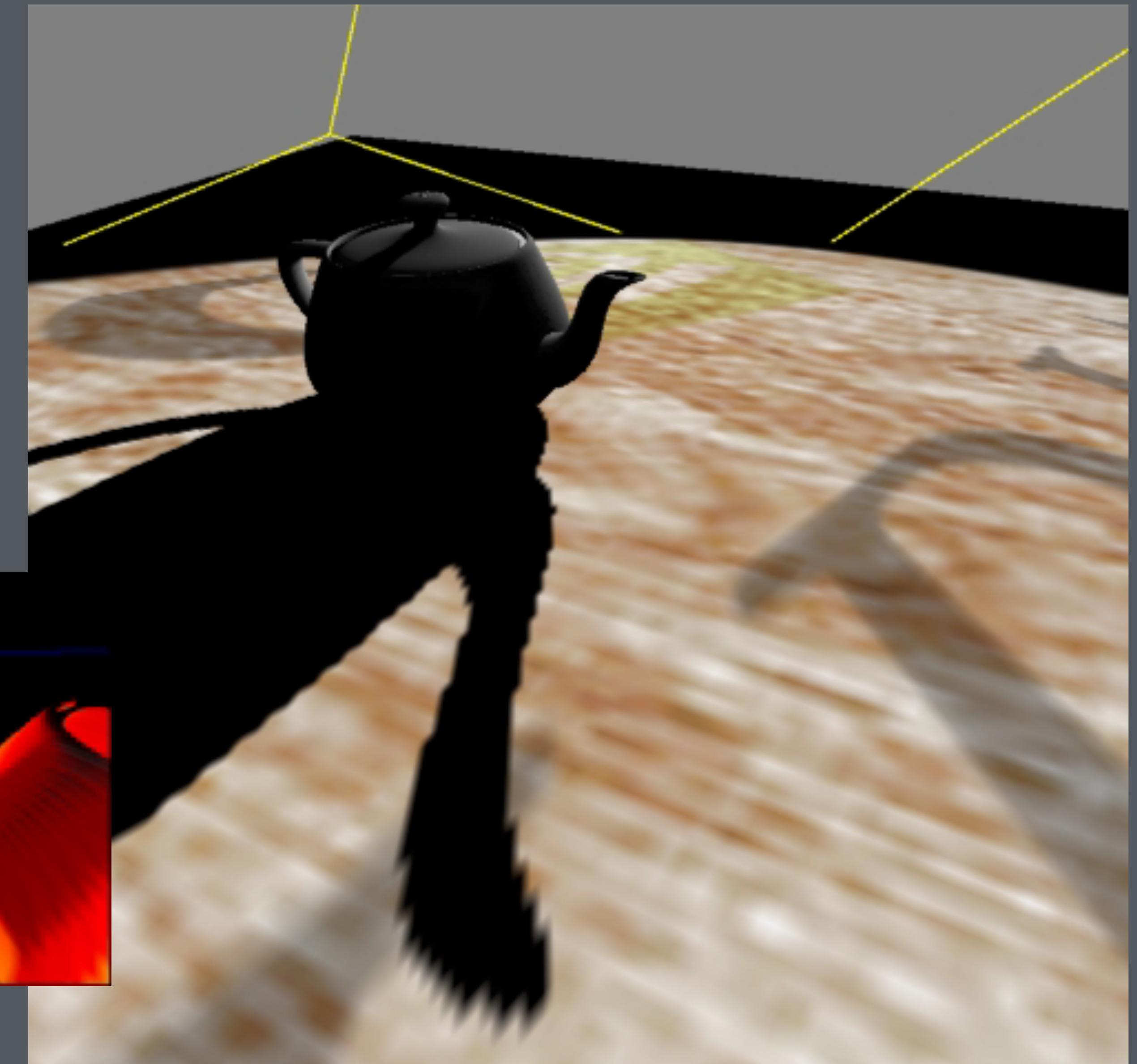
“Dueling frusta”



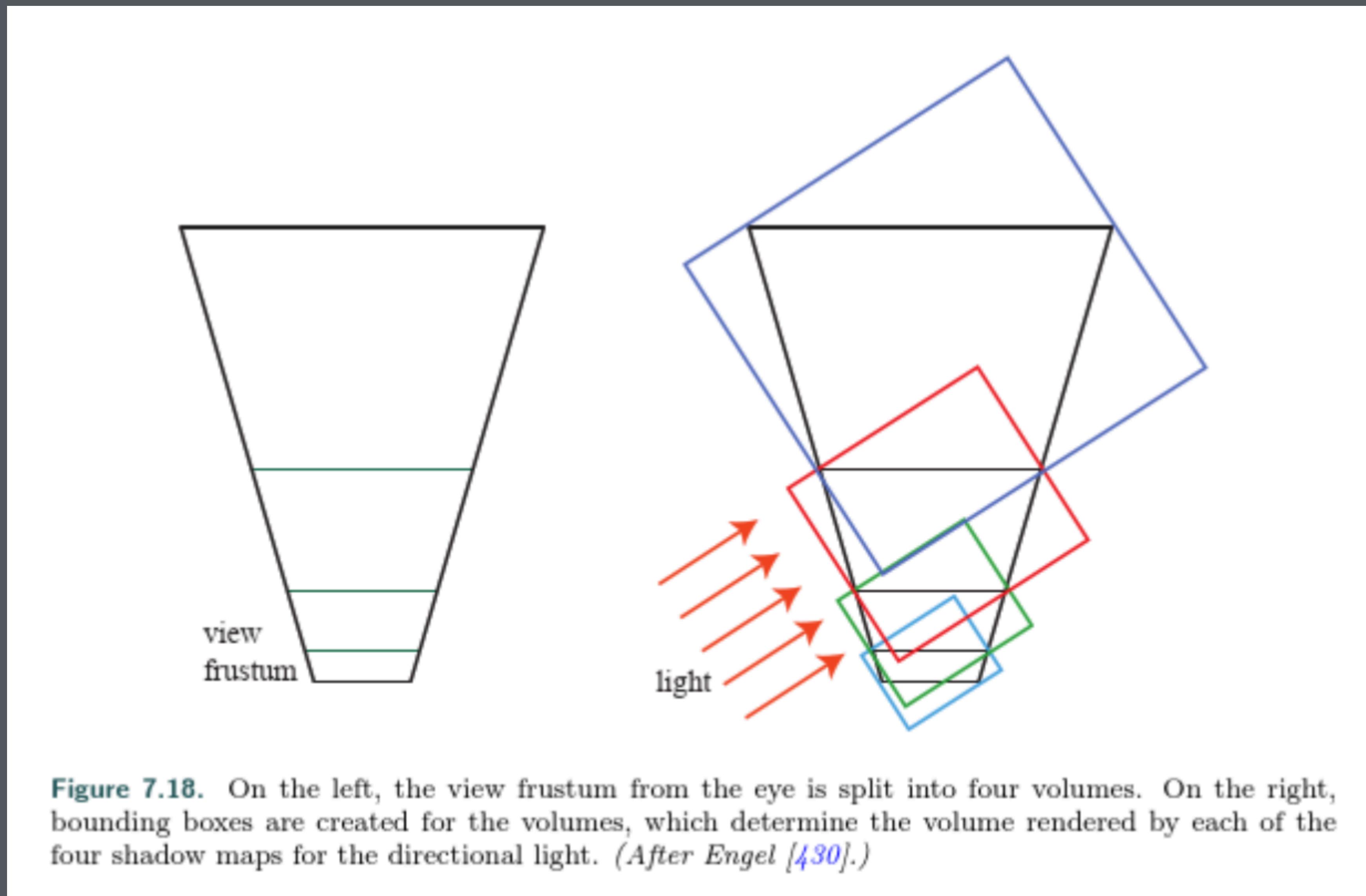
eye view



light view



Cascaded shadow maps (aka. parallel-split SM)





Single shadow map, 2048x2048



Four 1024x1024 shadow maps (equal memory)

Fan Zhang, Chinese U. Hong Kong

Filtering shadow maps

Shadow map lookups cause aliasing, need filtering

As with normal maps, pixel is a nonlinear function of the shadow depth

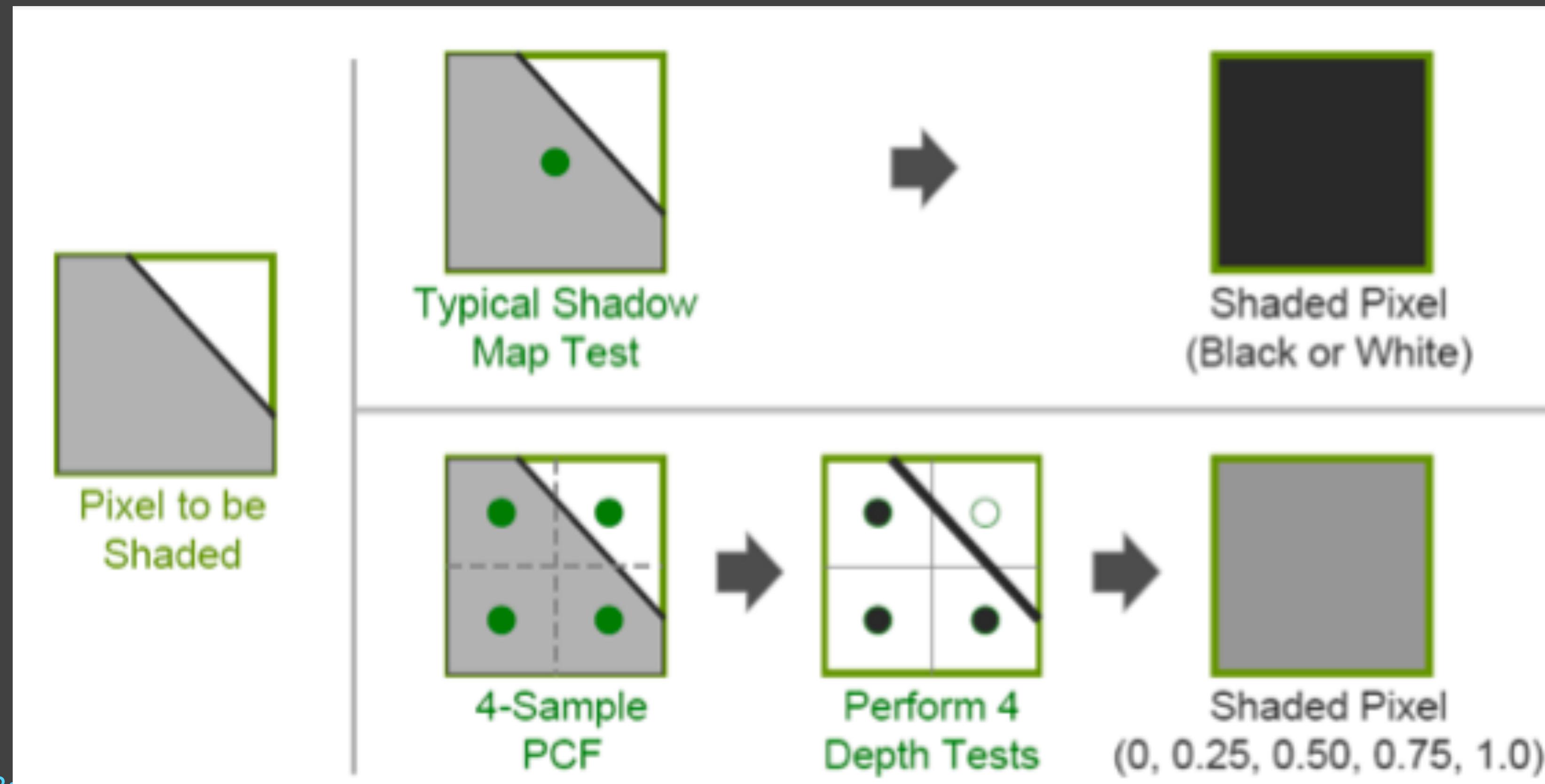
- this means applying a linear filter to the depth is wrong

We want to filter the output, not the input, of the shadow test

- what fraction of samples pass the test
- samples pass the test if they are closer than the shadow map depth
- therefore “percentage closer filtering” or PCF

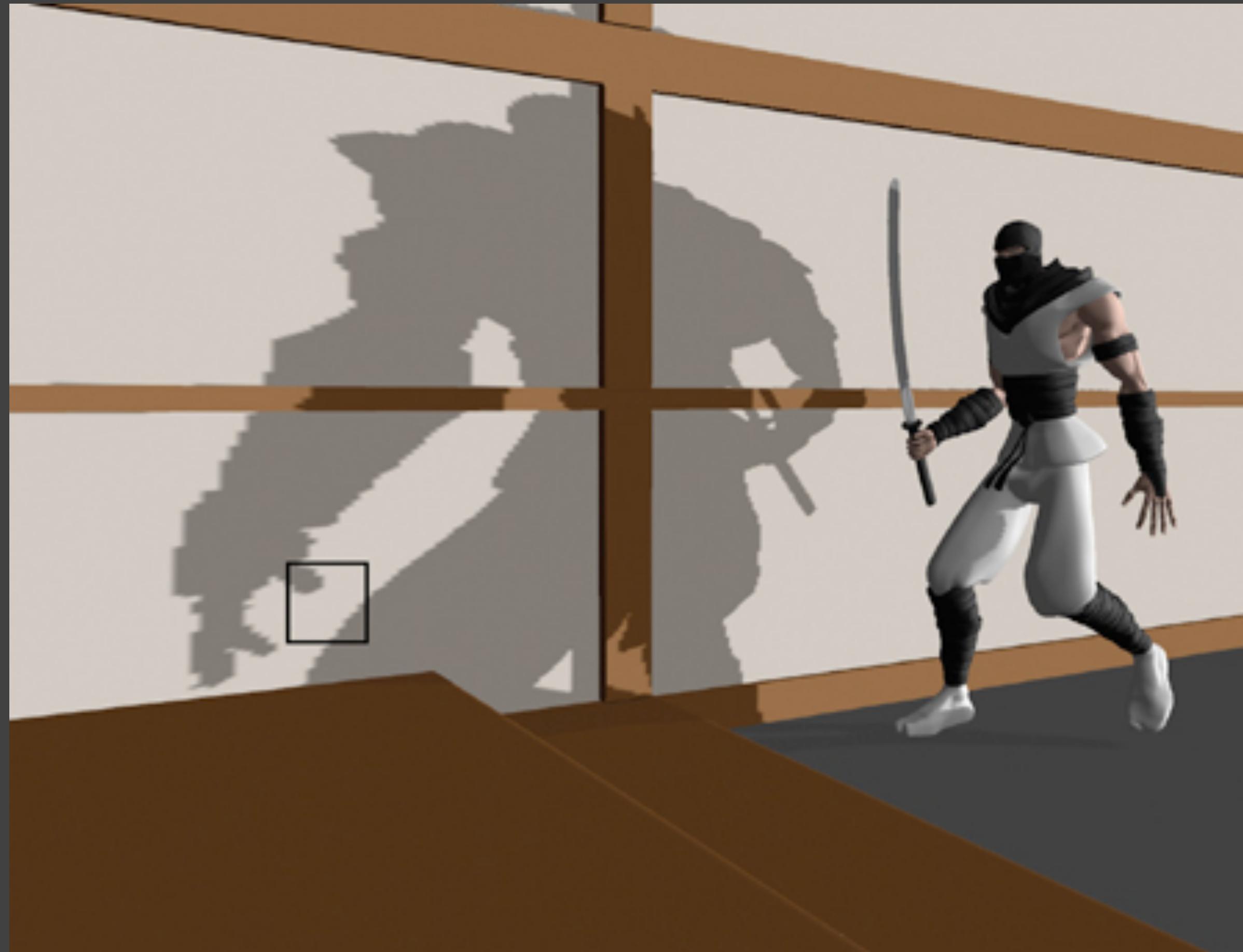
Percentage Closer Filtering

- Soften the shadow to decrease aliasing
 - Reeves, Salesin, Cook 87
 - GPU Gems, Chapter 11

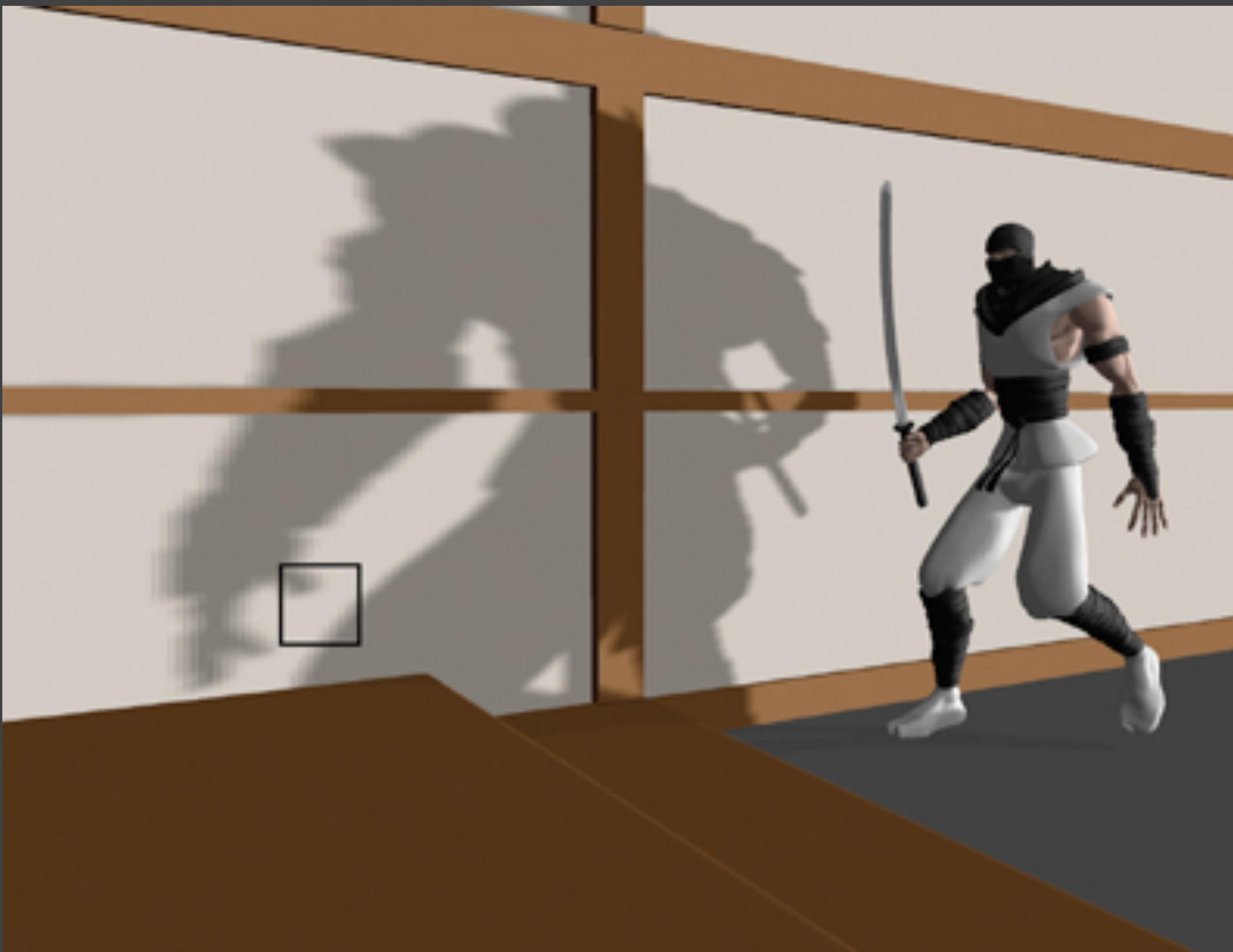


0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	1	1
0	0	0	0	0	1	1	1	1
0	0	0	0	0	1	1	1	1
0	0	0	0	1	1	1	1	1
0	0	0	0	1	1	1	1	1
1	1	1	1	1	1	1	1	1

1 sample SM



4 sample PCF



16 sample PCF



