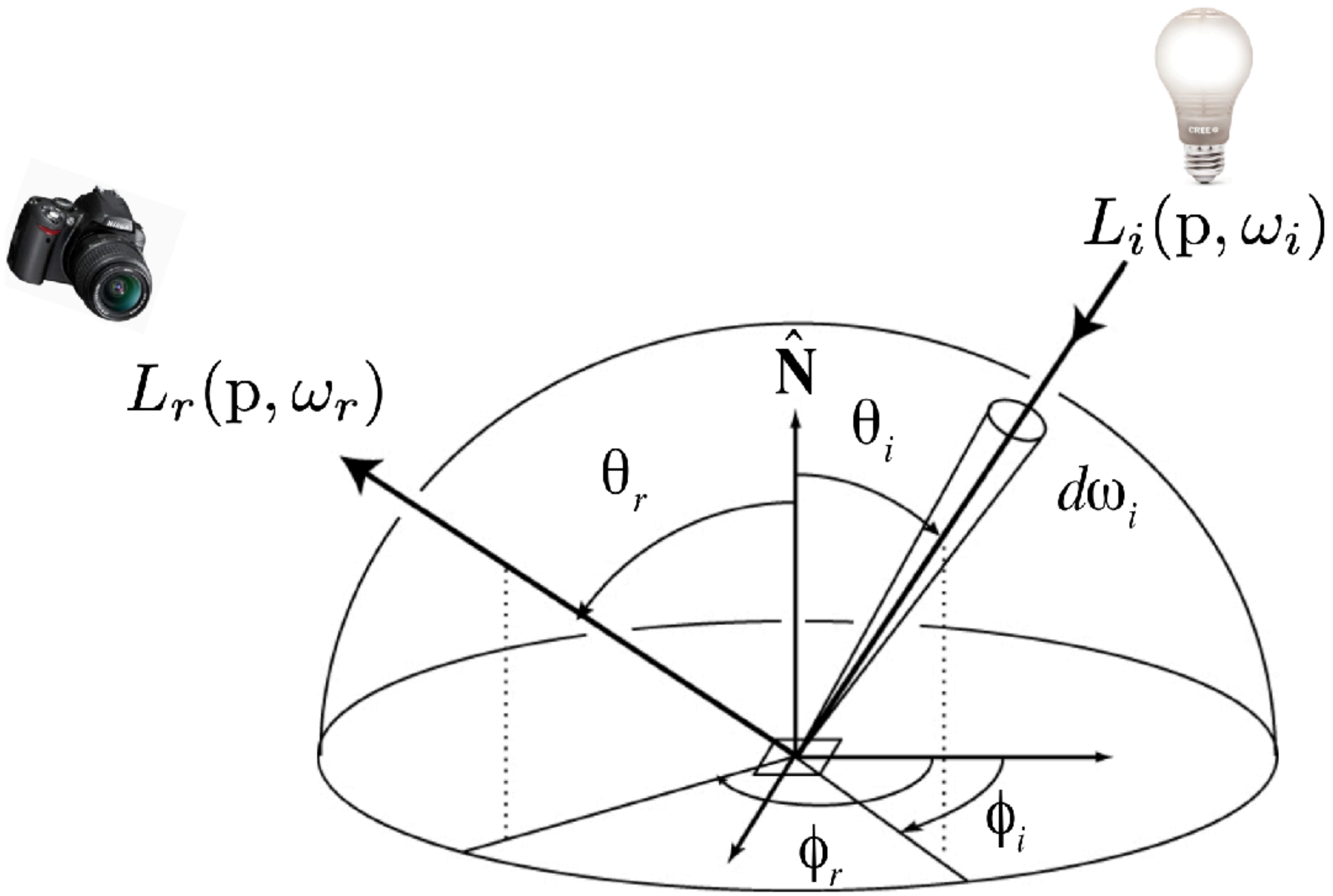
COL781: Computer Graphics

37. Real-Time Rendering

Digital Image Design



$$L_o(\mathbf{x}, \boldsymbol{\omega}_r) = L_e(\mathbf{p}, \boldsymbol{\omega}_o) + \int_{H^2} f_r(\boldsymbol{\omega}_i \rightarrow \boldsymbol{\omega}_r)\, L_i(\mathbf{x}, \boldsymbol{\omega}_i) \cos(\theta_i)\, \mathrm{d}\boldsymbol{\omega}_i$$

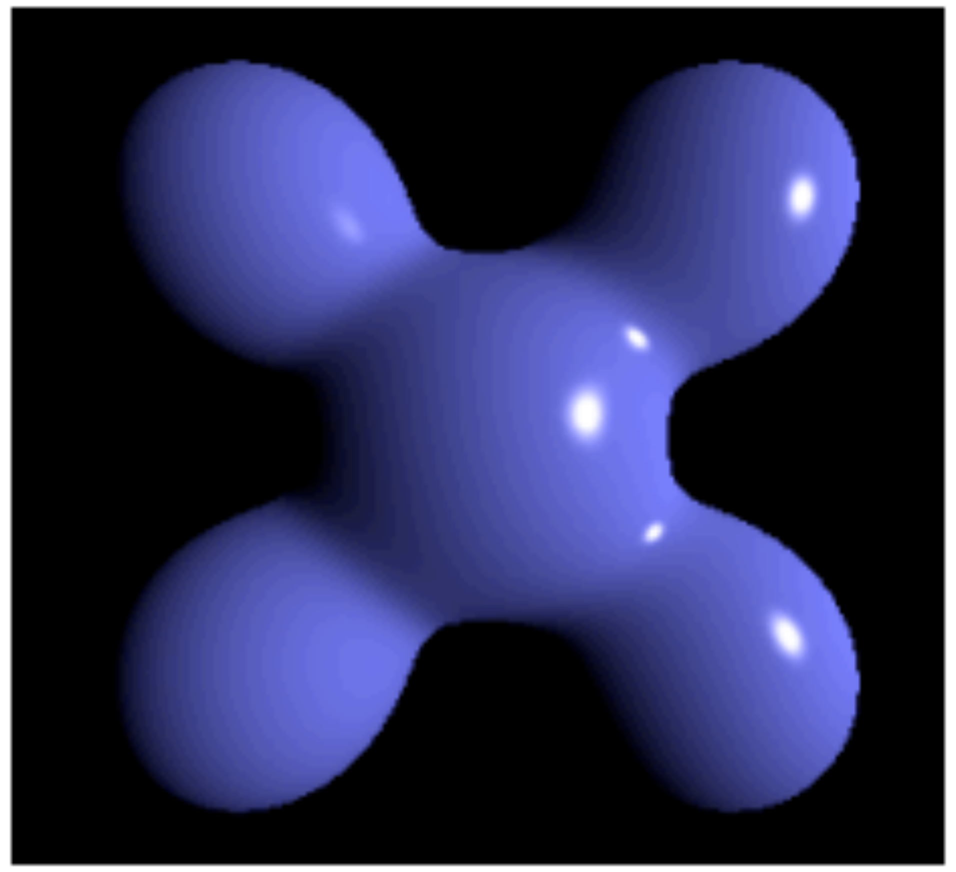
How to do realistic rendering in rasterization?

~~$L_o = k_a I_a + k_d I \max(0, \mathbf{n} \cdot \boldsymbol{\ell}) + k_s I \max(0, \mathbf{n} \cdot \mathbf{h})^p$~~

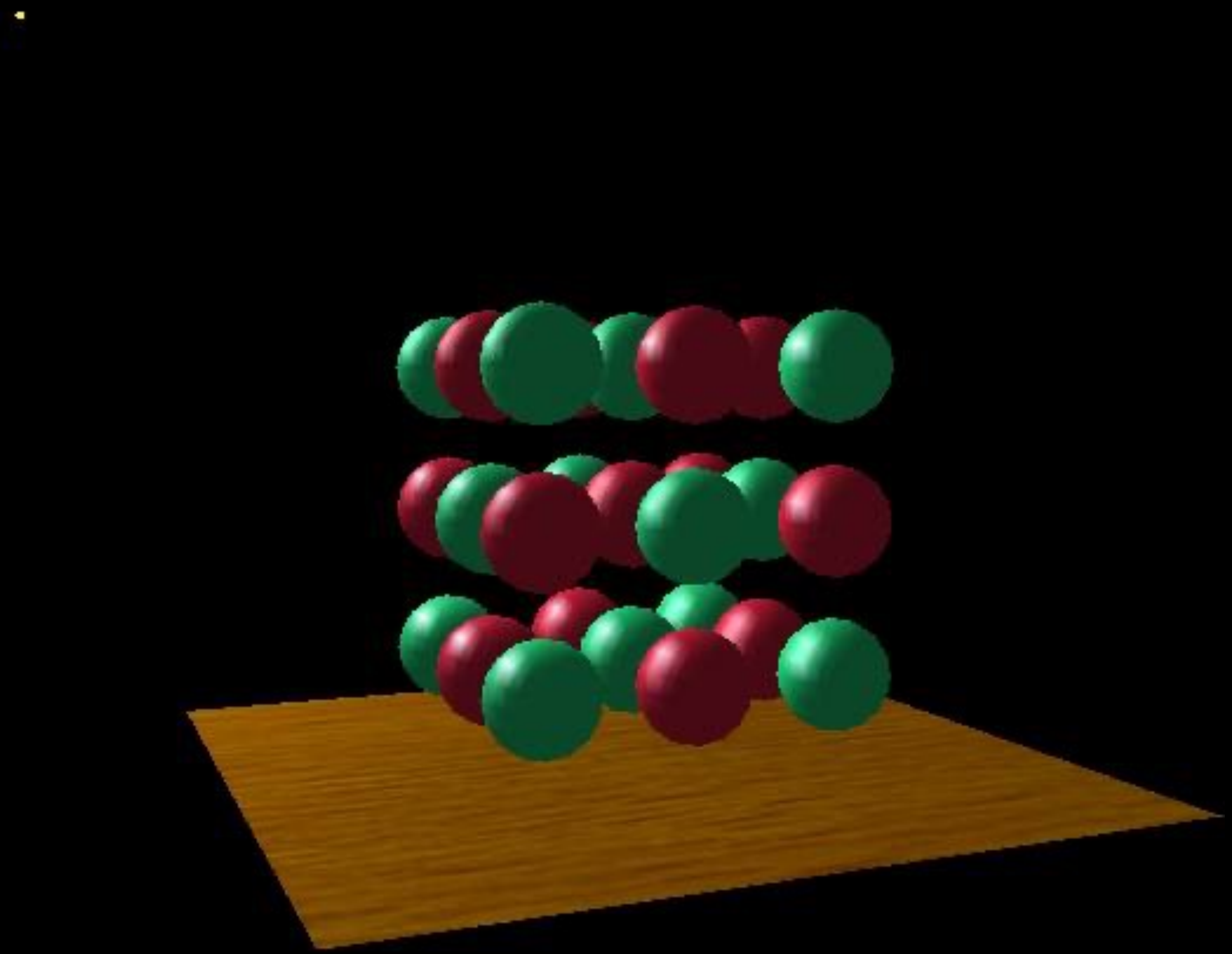
$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = L_e(\mathbf{p}, \boldsymbol{\omega}_o) + \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \to \boldsymbol{\omega}_o)\, L_i(\mathbf{p}, \boldsymbol{\omega}_i) \cos(\theta_i)\, d\boldsymbol{\omega}_i$$

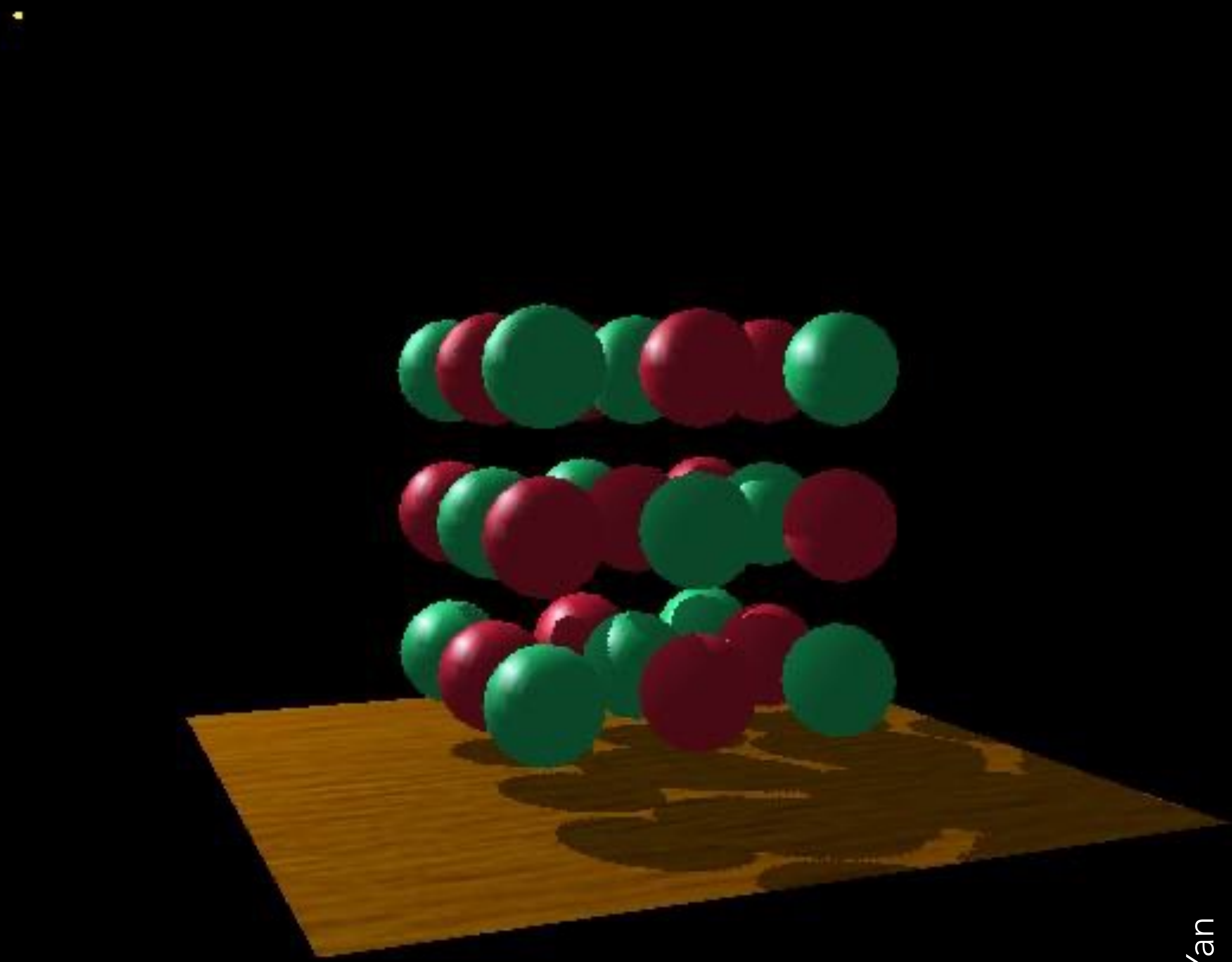
approximate

approximate



Shadows





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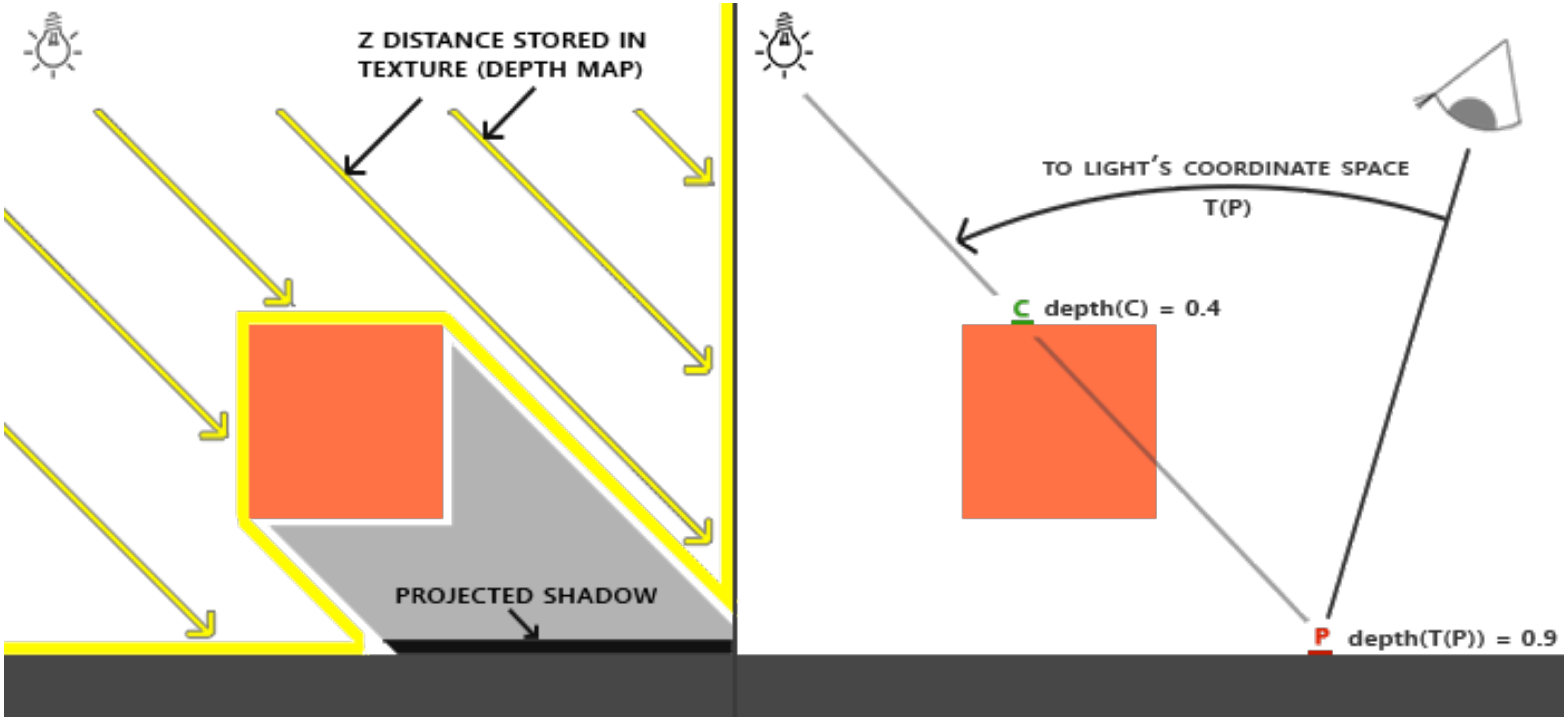
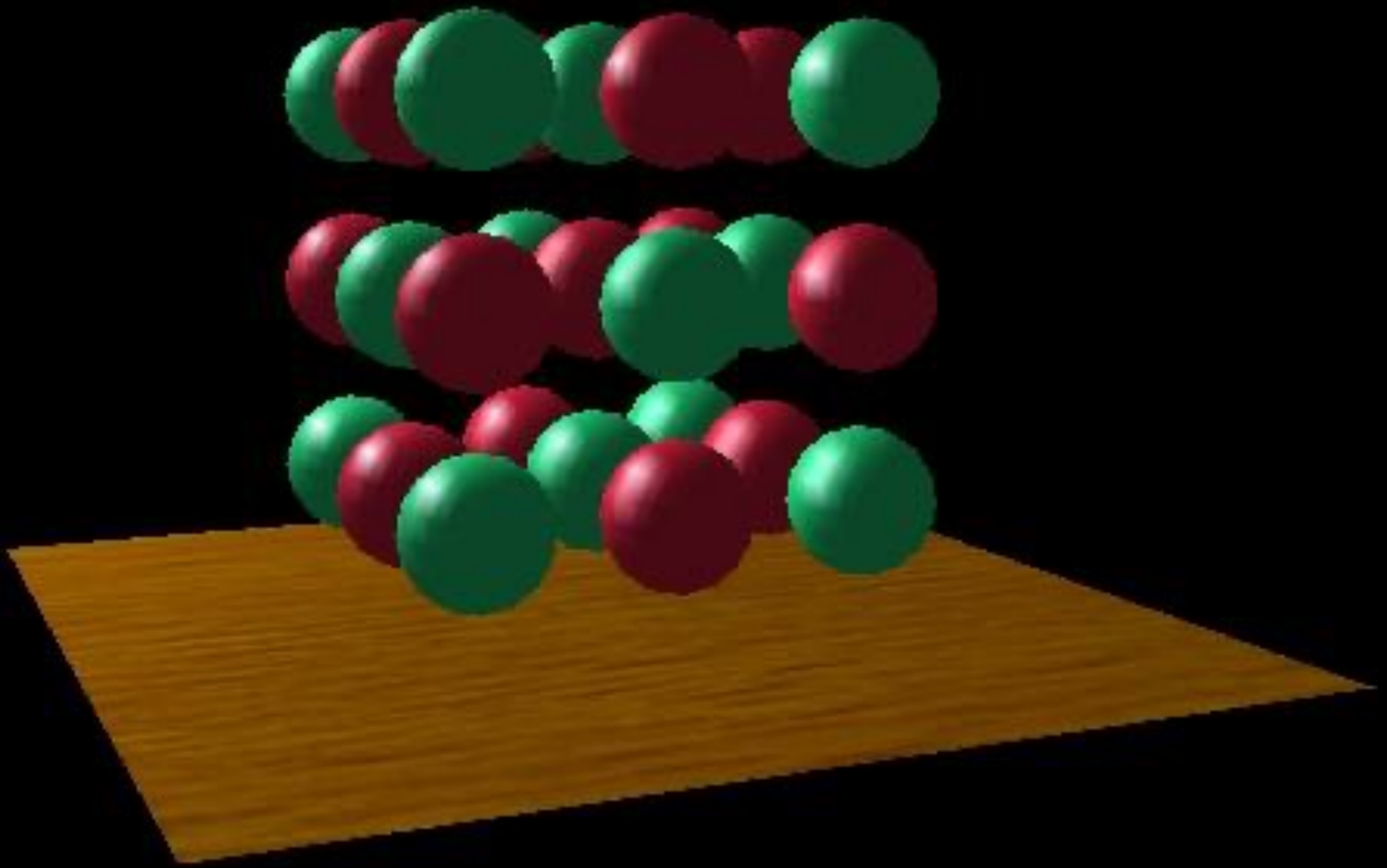
Assume only direct illumination from a point light **p′**.

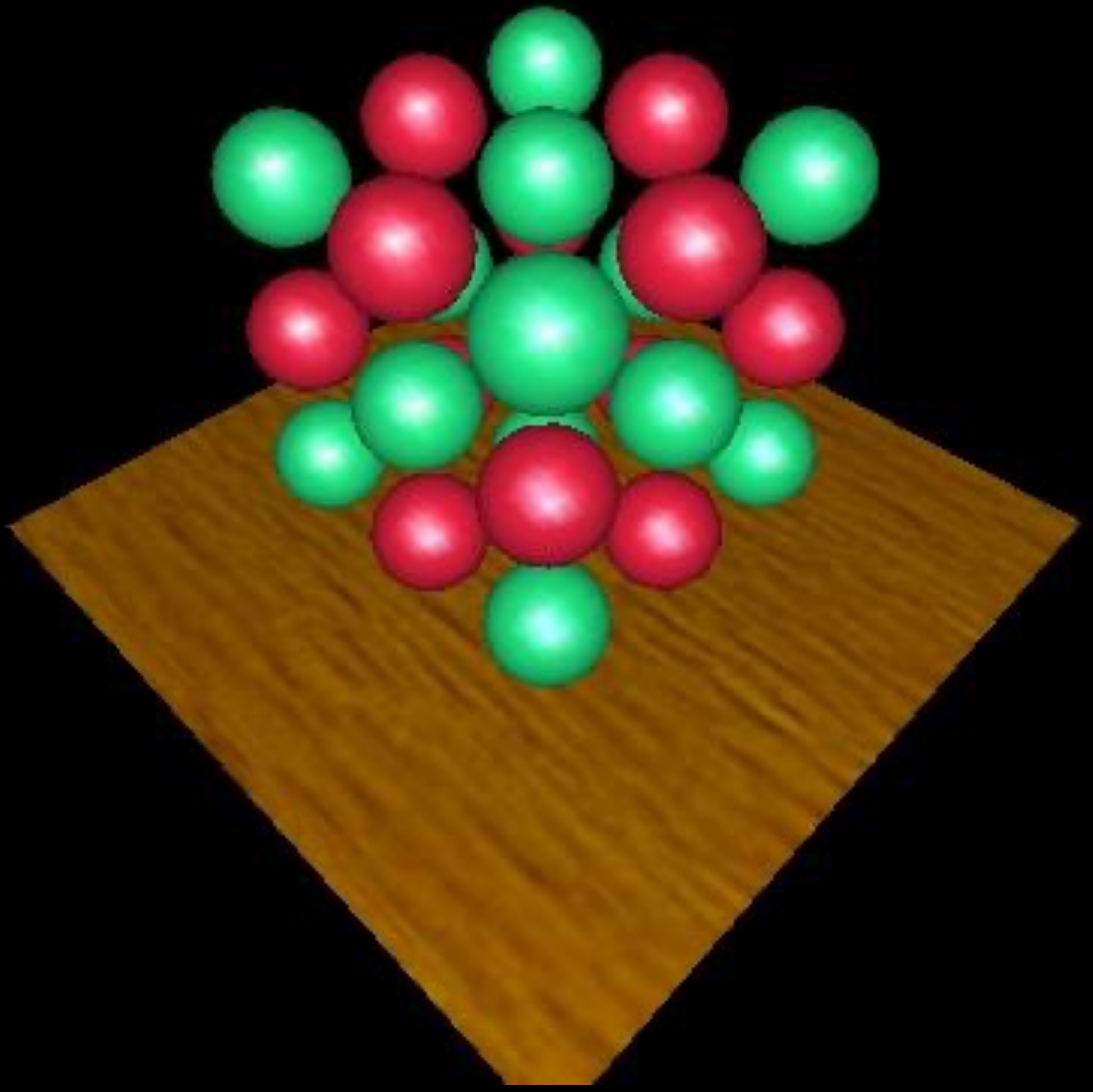
$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = f_r(\mathbf{p}, \boldsymbol{\omega}_i \to \boldsymbol{\omega}_o)\, I_o(\mathbf{p}', \boldsymbol{\omega}')\, V(\mathbf{p}, \mathbf{p}')$$

Shadow maps



LearnOpenGL.com





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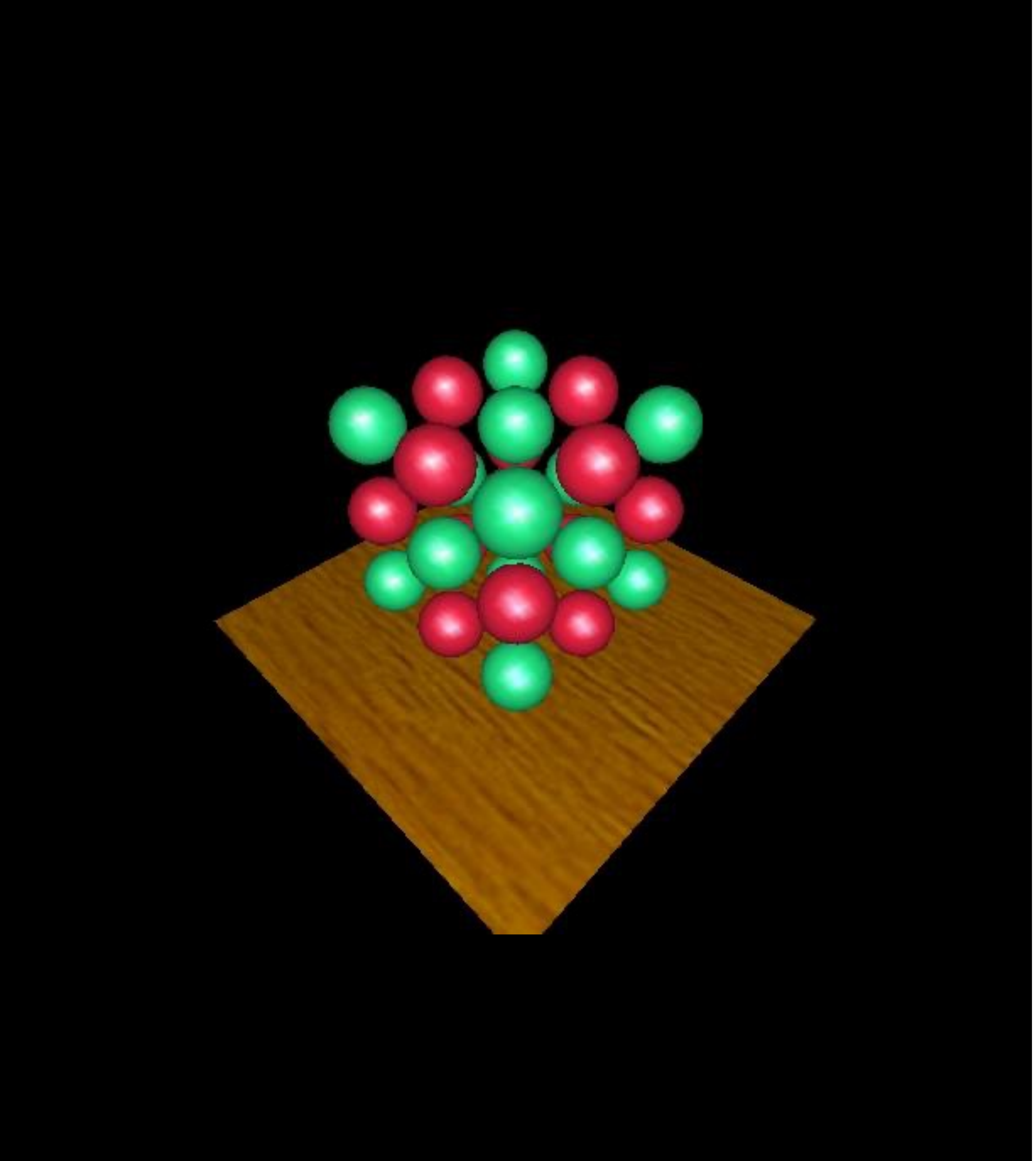

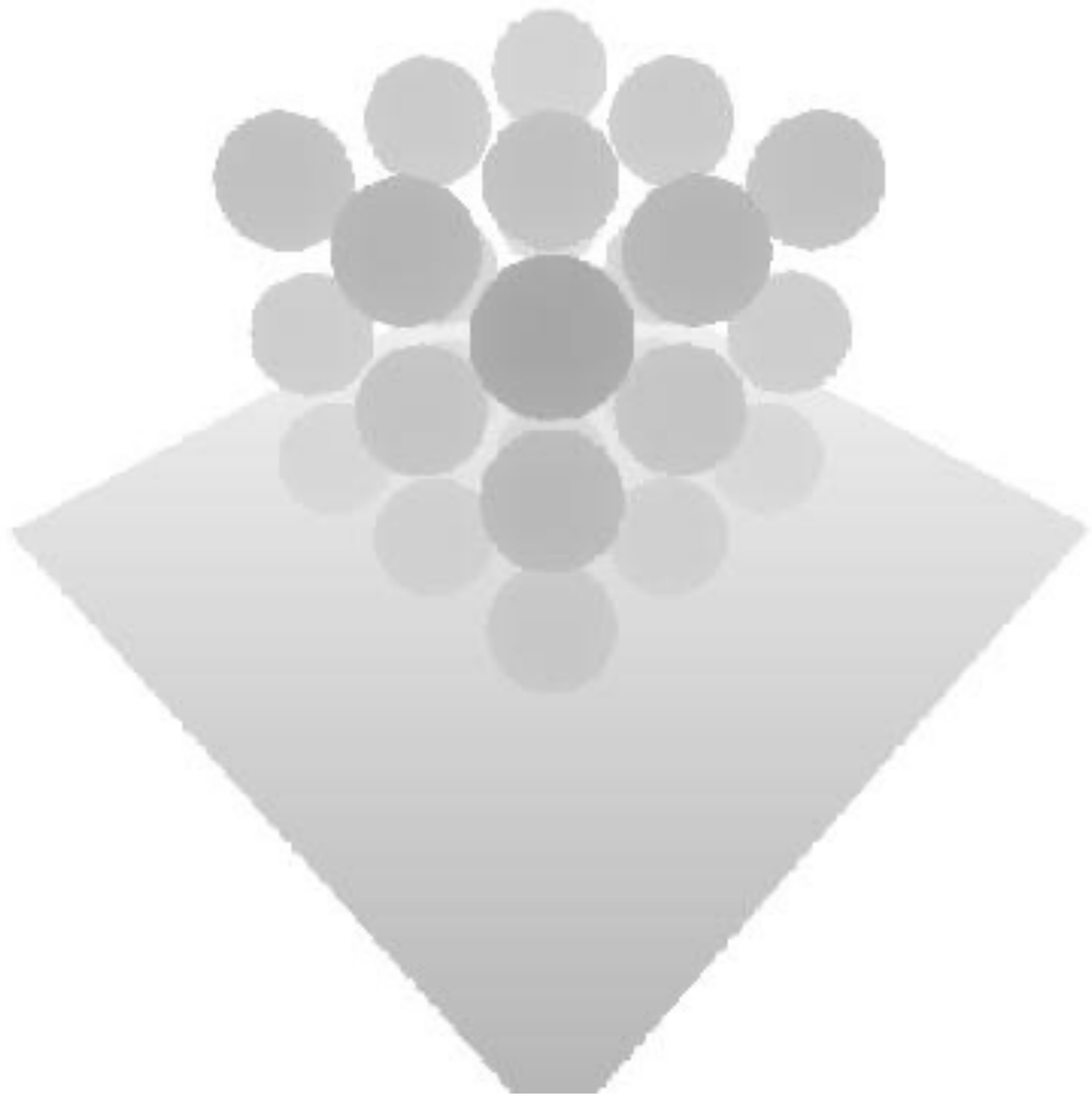

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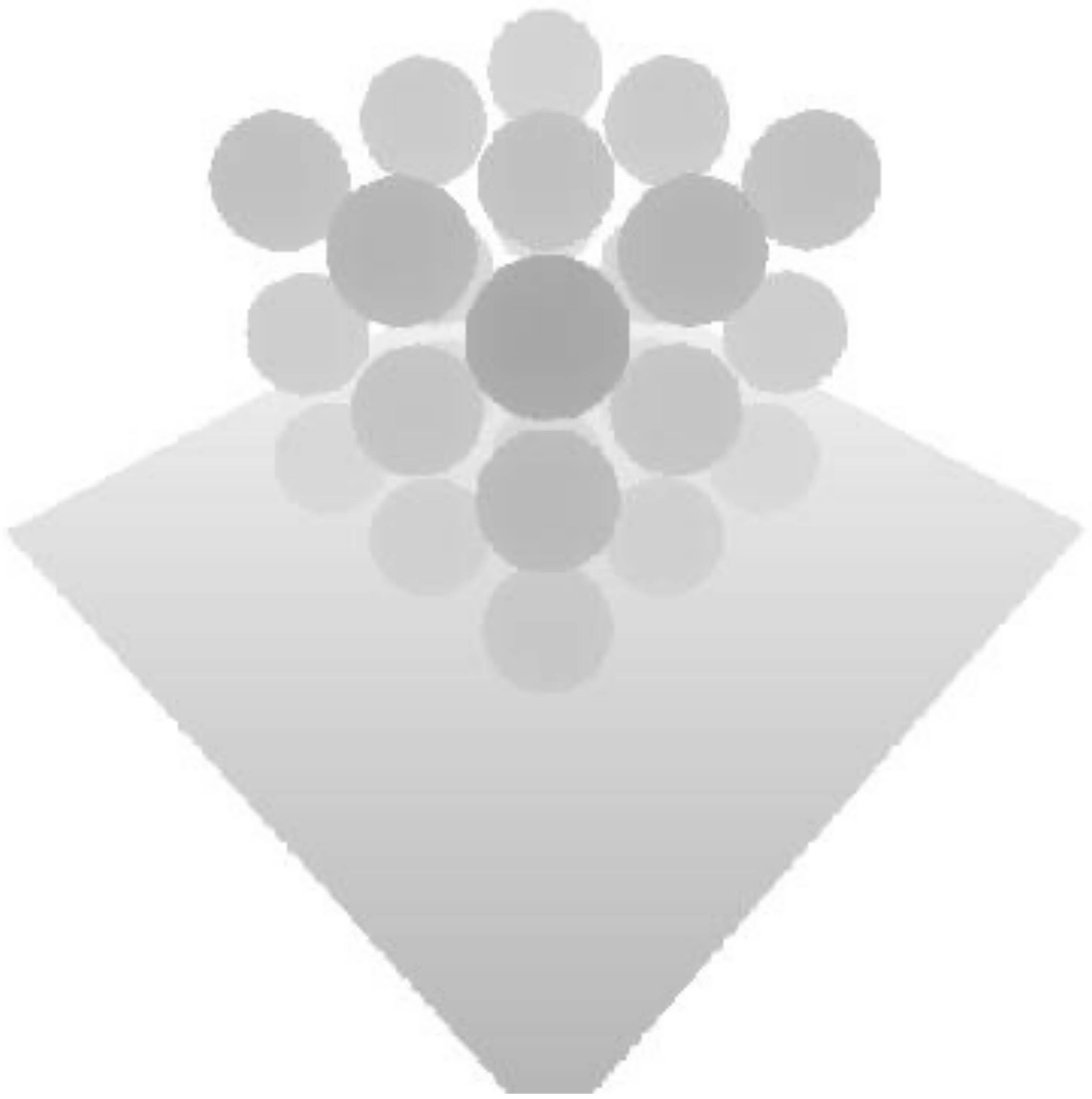

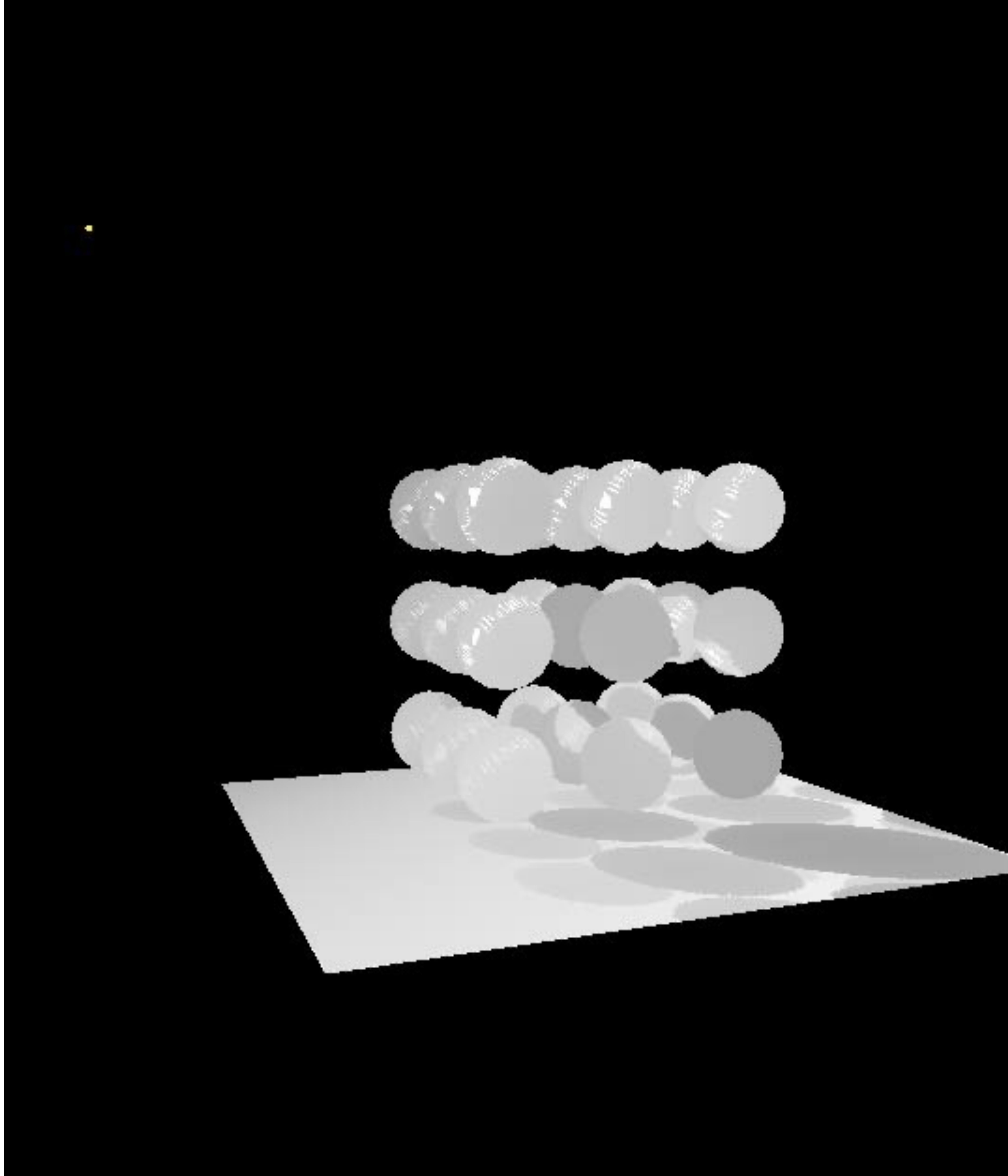

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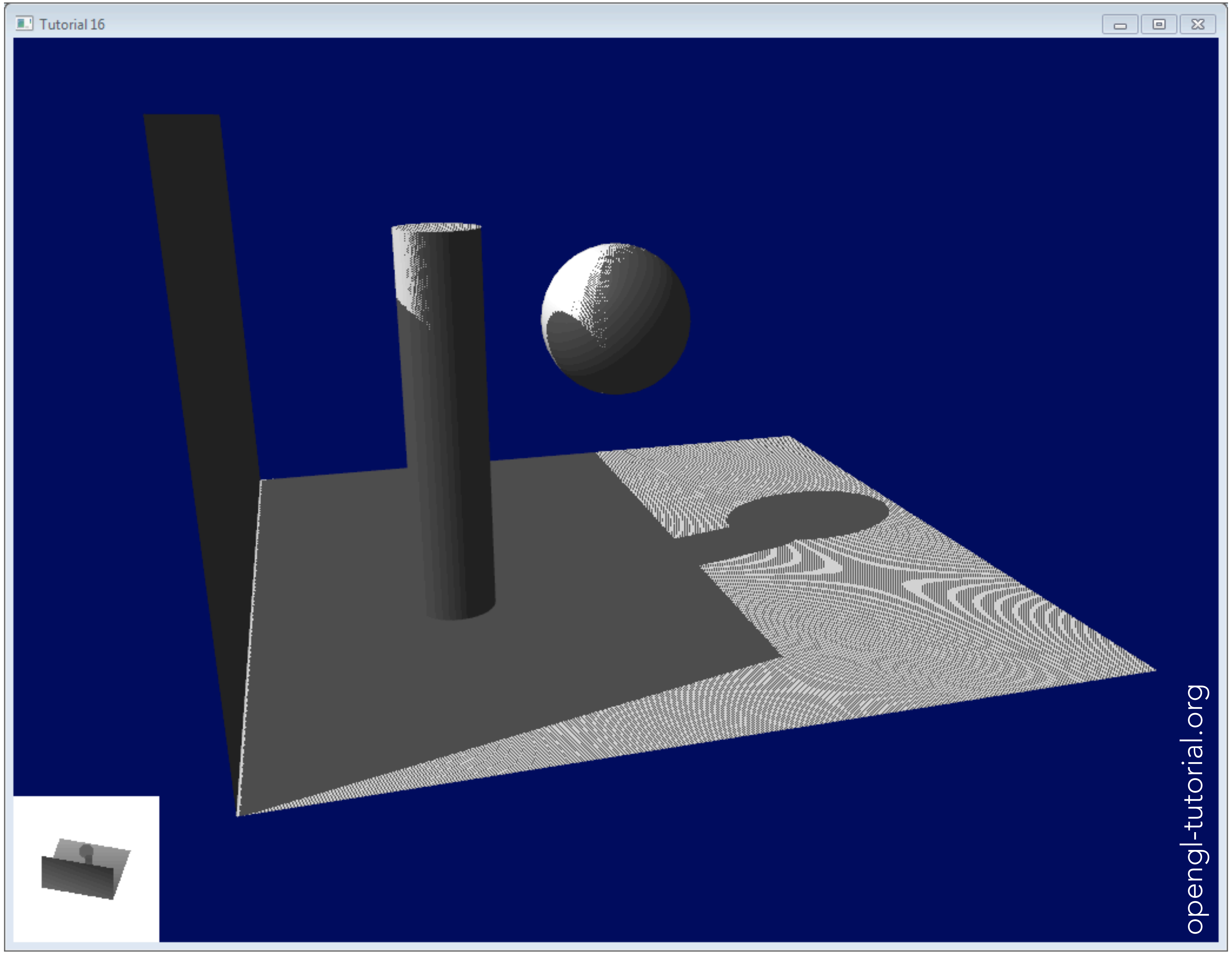
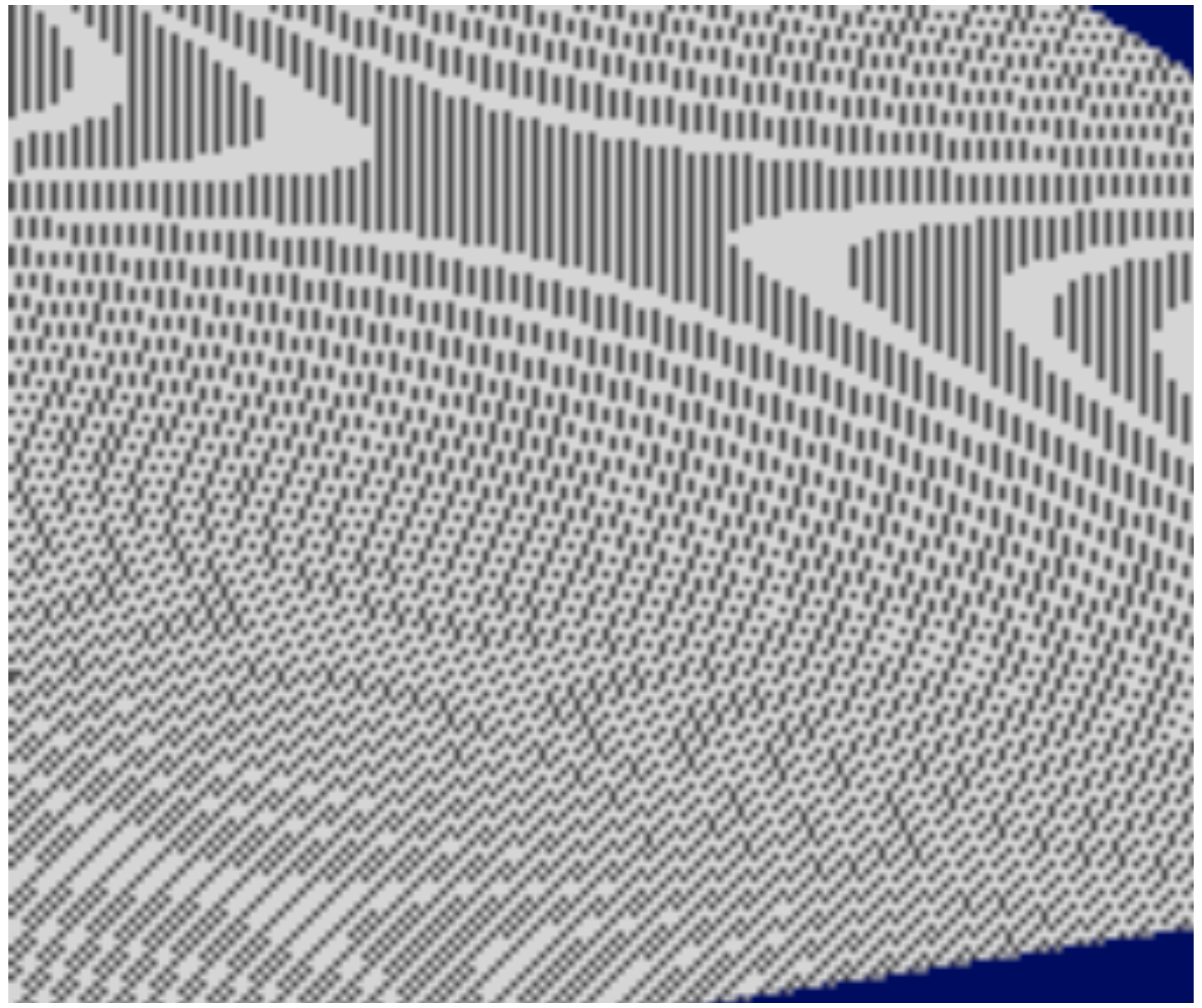
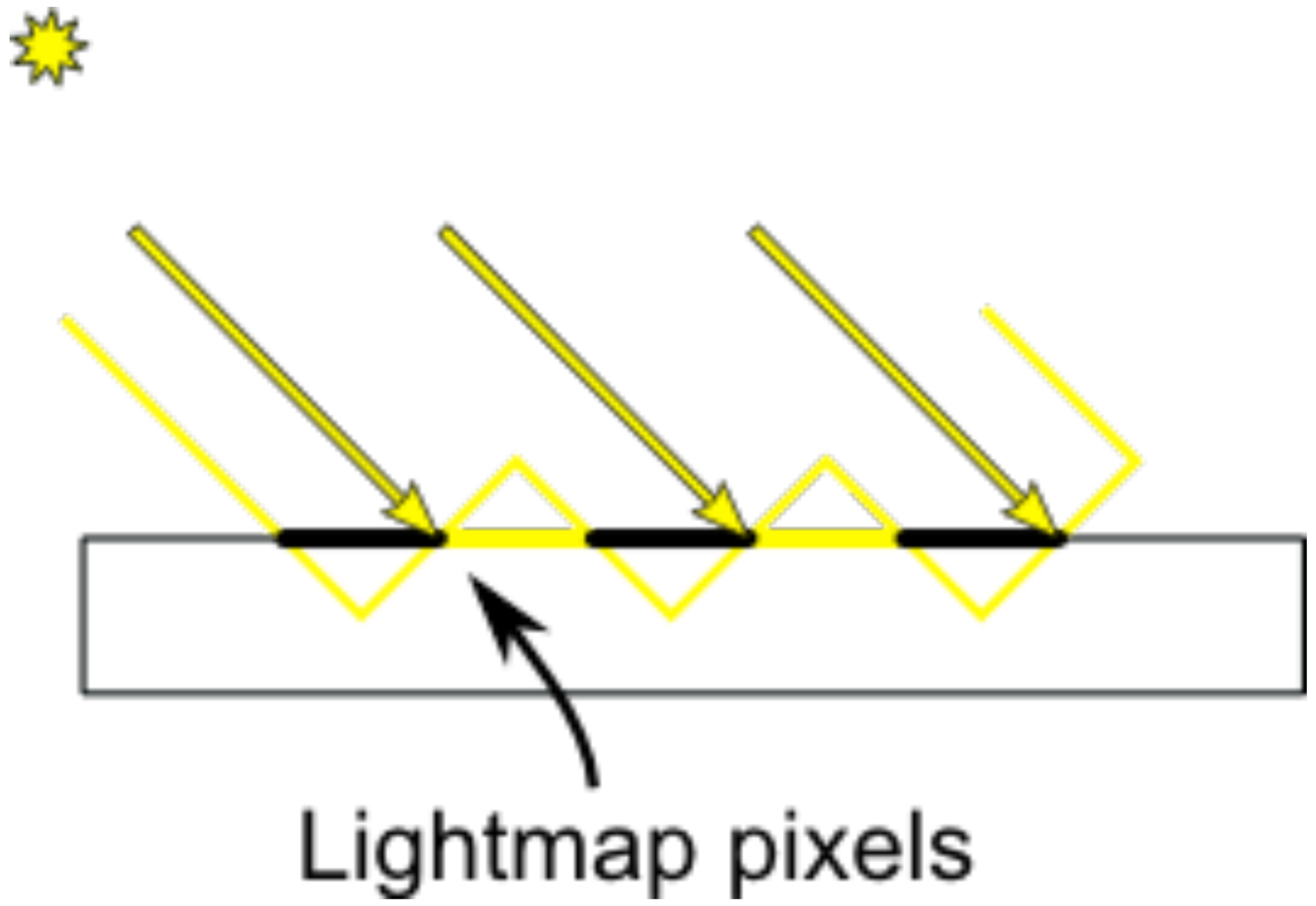
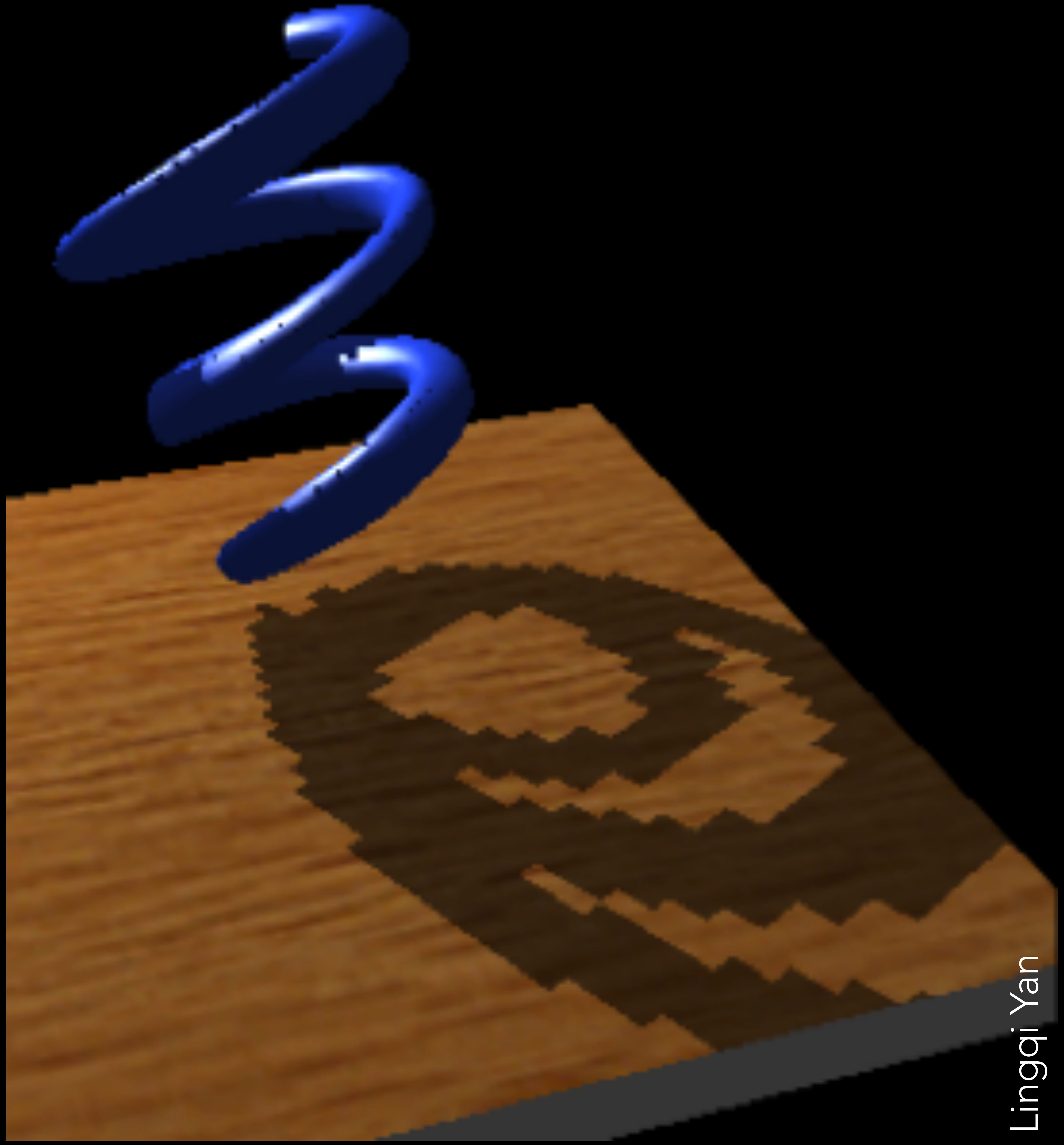




"Shadow acne"



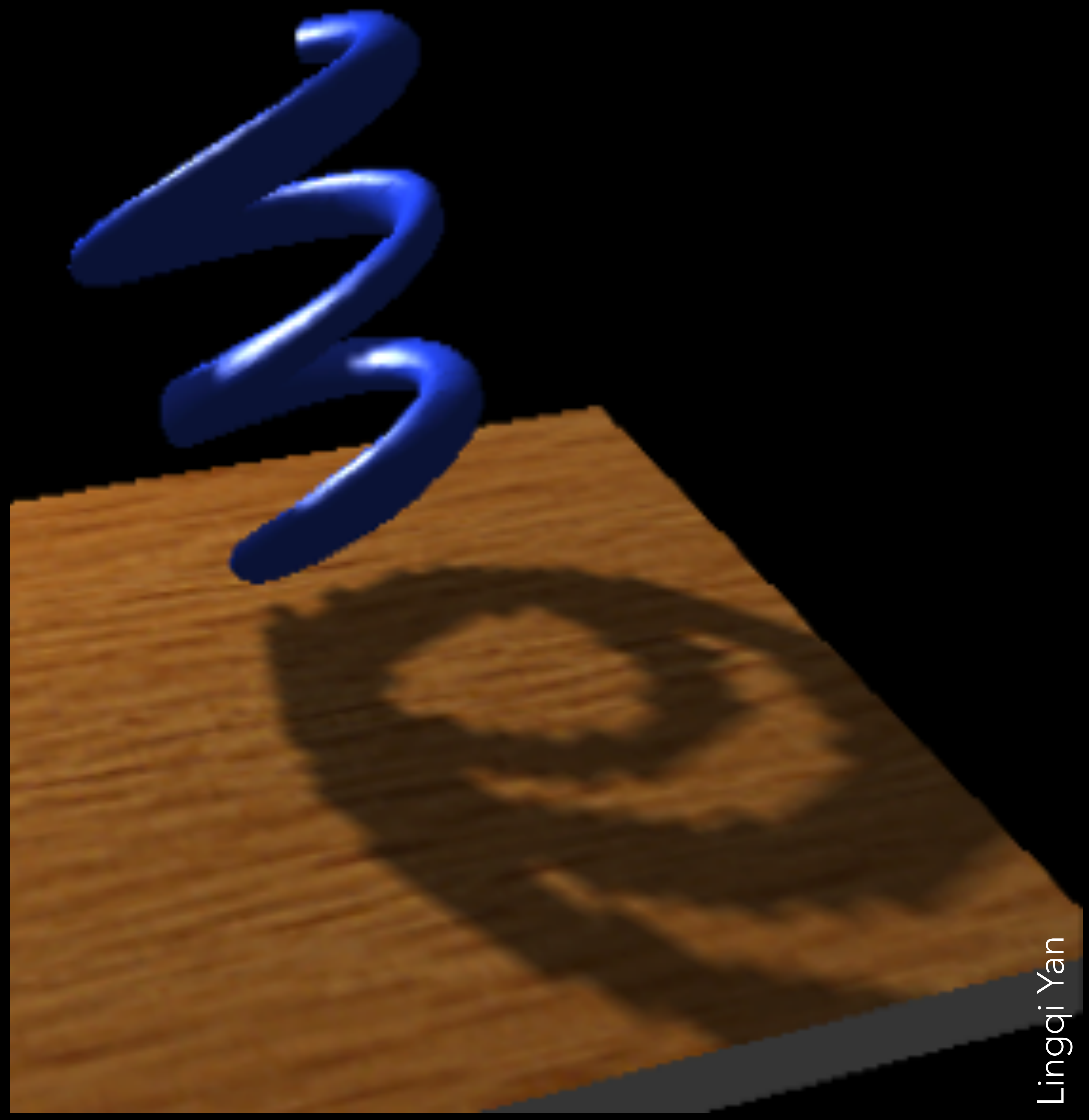
Aliasing



Percentage closer filtering (PCF)

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

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



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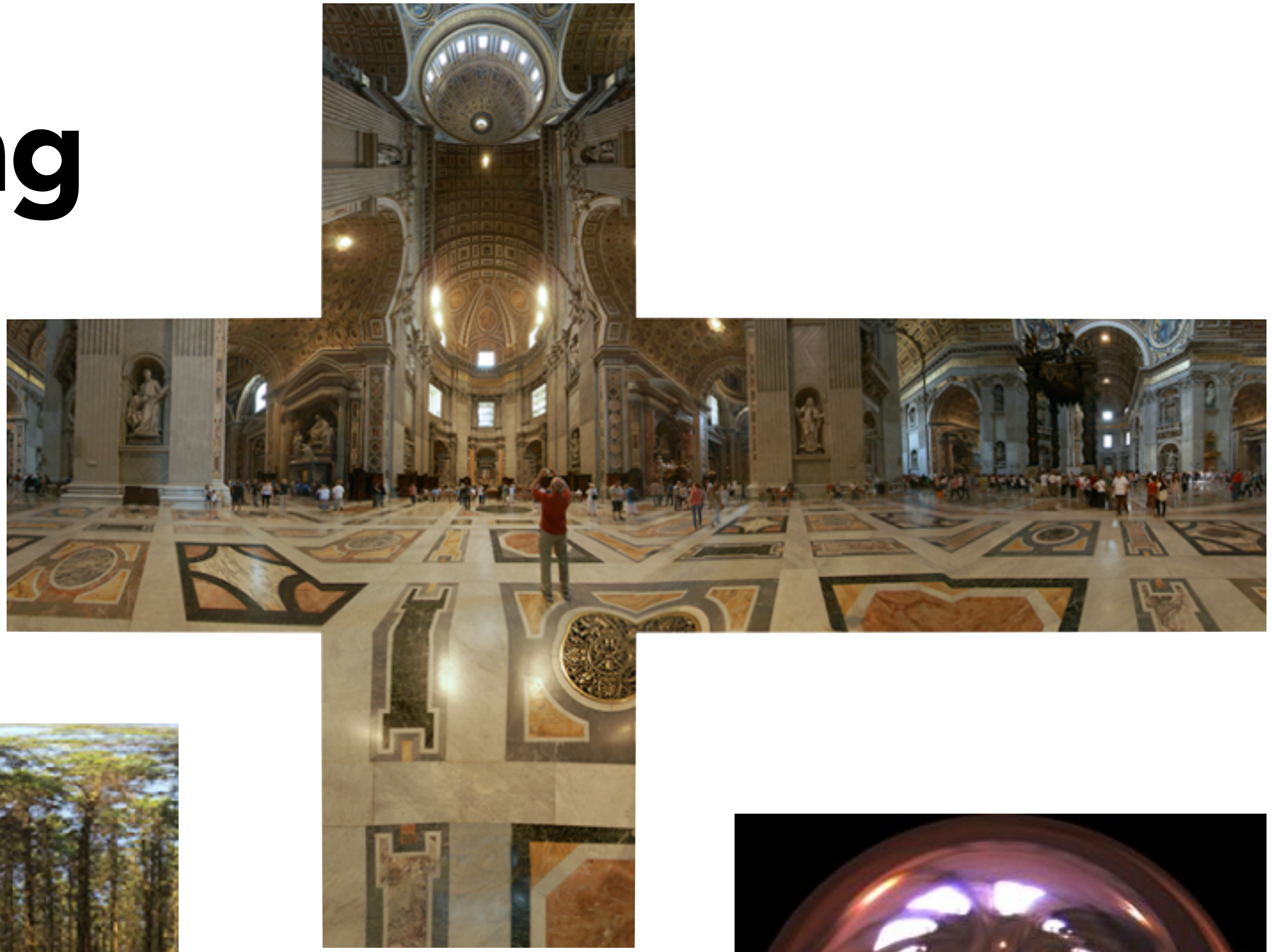
Moral(s) of the story:

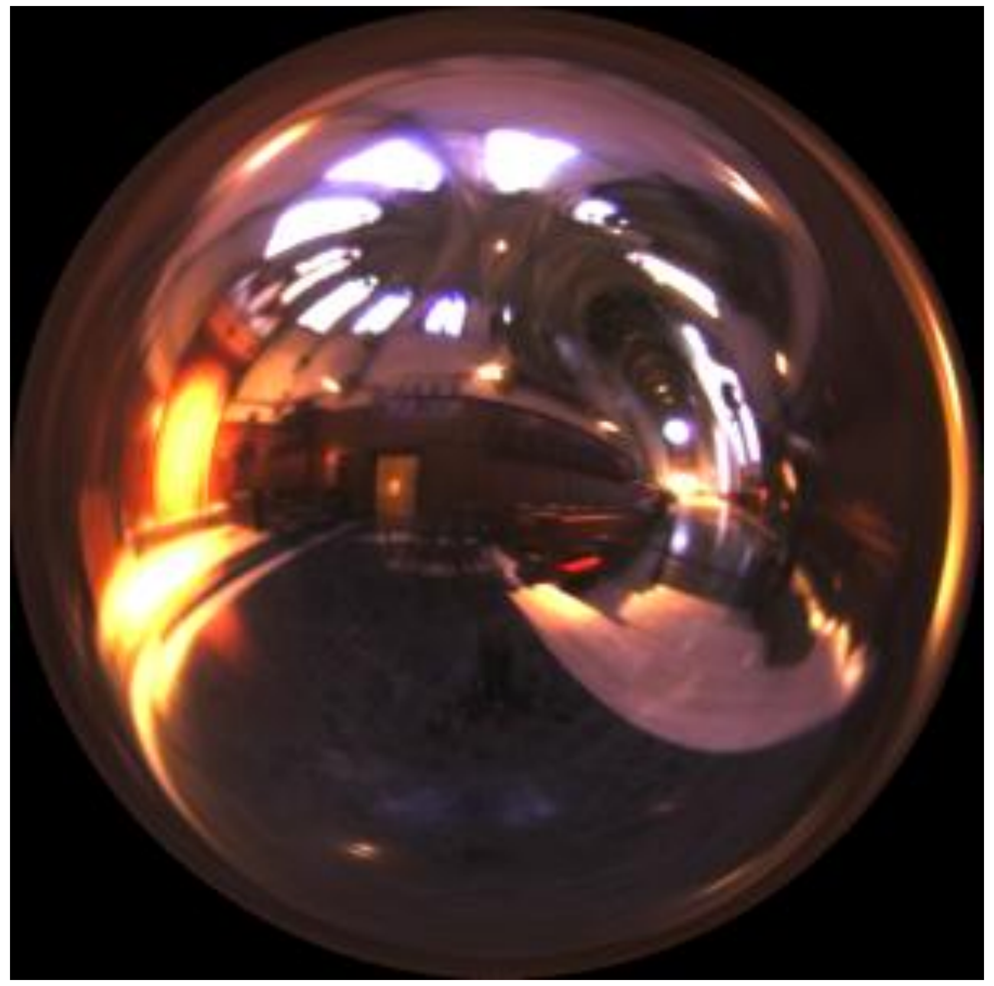
1. Precompute as much as possible!

2. Render the scene from the right viewpoint to replace geometric queries with image lookups

Environment mapping

A.K.A. image-based lighting





Assume all incident light is from environment map (i.e. ignore all other objects in the scene!)

$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \rightarrow \boldsymbol{\omega}_o)\, L_i(\boldsymbol{\omega}_i) \cos(\theta_i)\, d\boldsymbol{\omega}_i$$

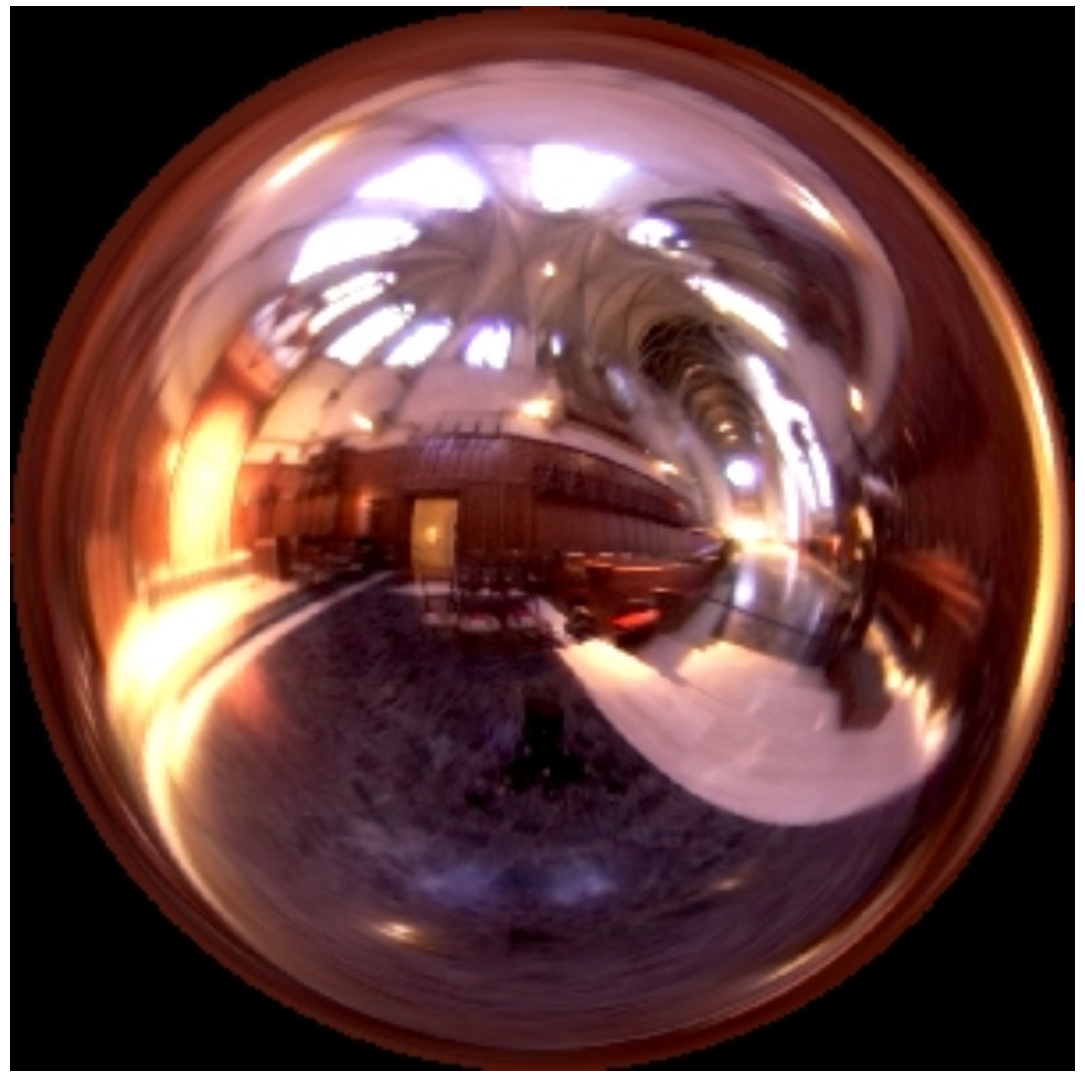
Easy case: perfect specular reflection

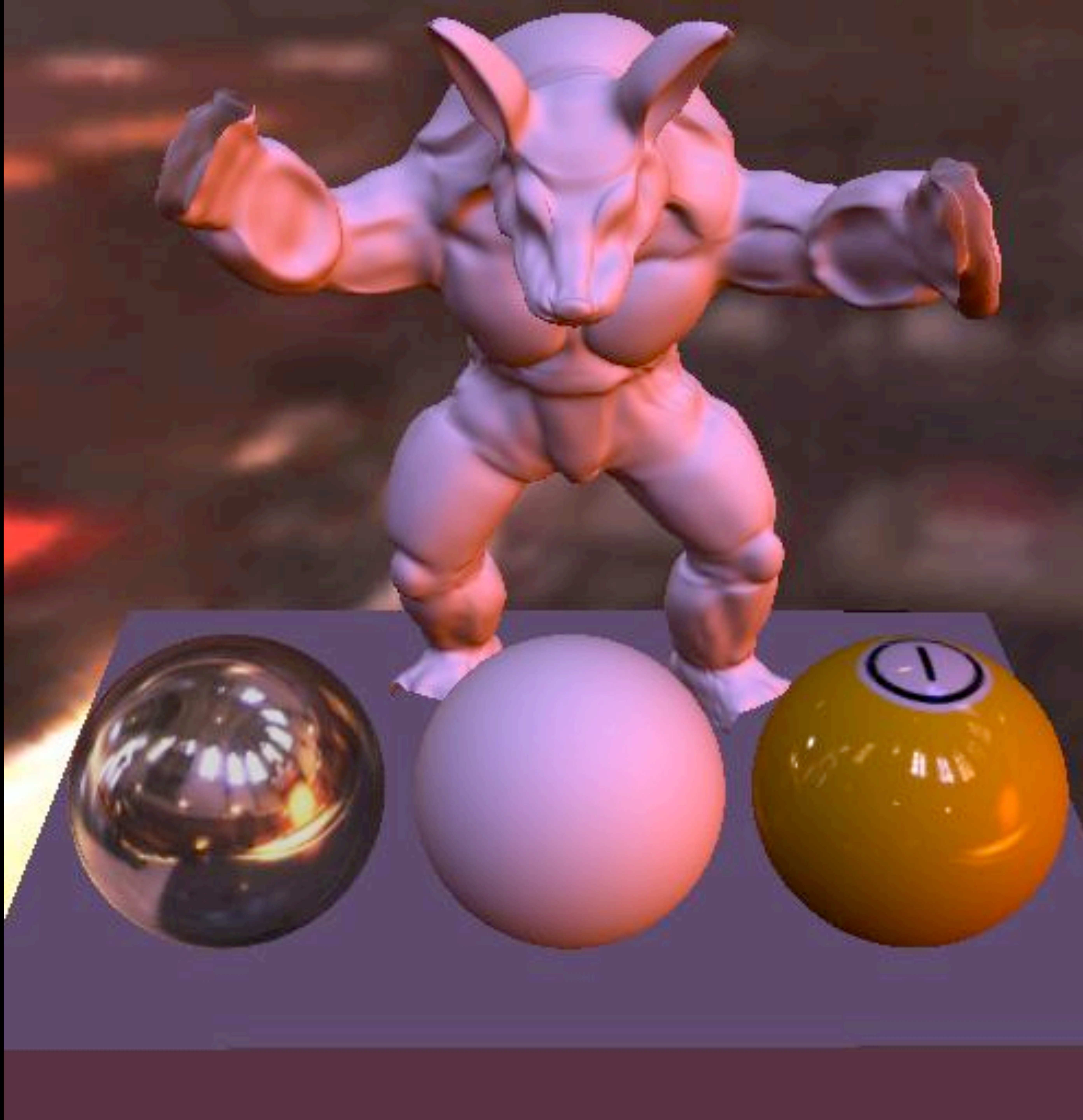
Another easy case: diffuse surface

$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = f_r \int_{H^2} L_i(\boldsymbol{\omega}_i) \cos(\theta_i)\, d\boldsymbol{\omega}_i$$

$$= f_r\, I_i(\mathbf{n})$$

Precompute $I_i(\mathbf{n})$: **irradiance environment map**





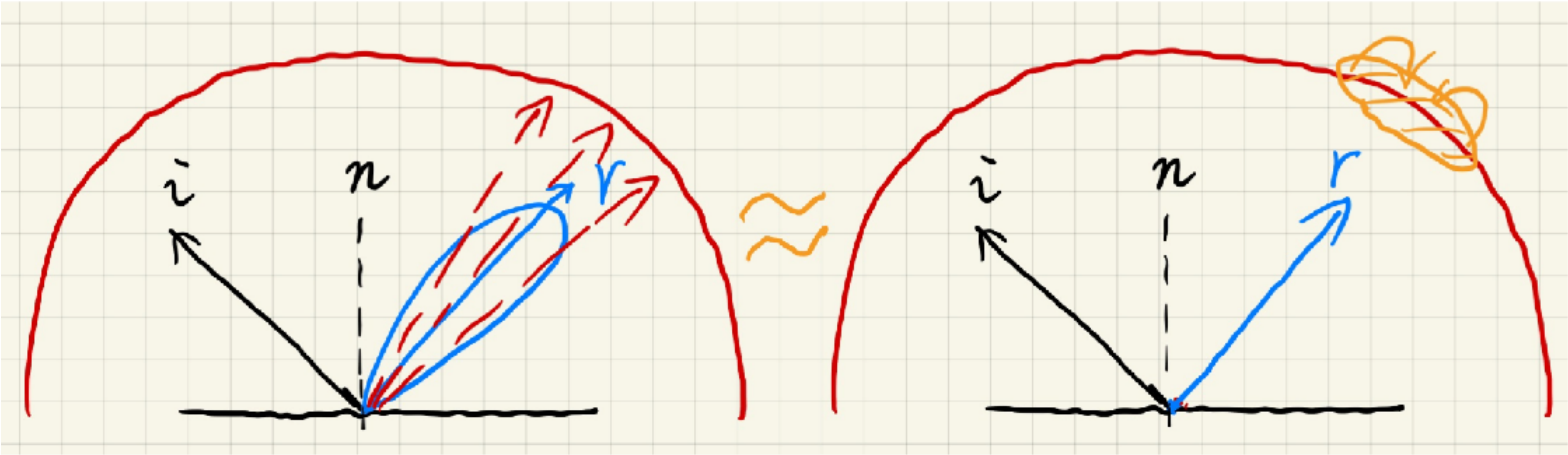
Ramamoorthi and Hanrahan 2001

What about glossy surfaces? "**Split sum approximation**"

$$\int f(x)g(x)\,\mathrm{d}x = \left(\frac{\int f(x)g(x)\,\mathrm{d}x}{\int f(x)\,\mathrm{d}x}\right)\cdot \int f(x)\,\mathrm{d}x$$

$$L_o(\mathbf{p}, \boldsymbol{\omega}_o) = \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \to \boldsymbol{\omega}_o)\, L_i(\mathbf{p}, \boldsymbol{\omega}_i) \cos(\theta_i)\, \mathrm{d}\boldsymbol{\omega}_i$$

$$= [\text{weighted average of } L_i] \cdot \int_{H^2} f_r(\mathbf{p}, \boldsymbol{\omega}_i \to \boldsymbol{\omega}_o) \cos(\theta_i)\, \mathrm{d}\boldsymbol{\omega}_i$$



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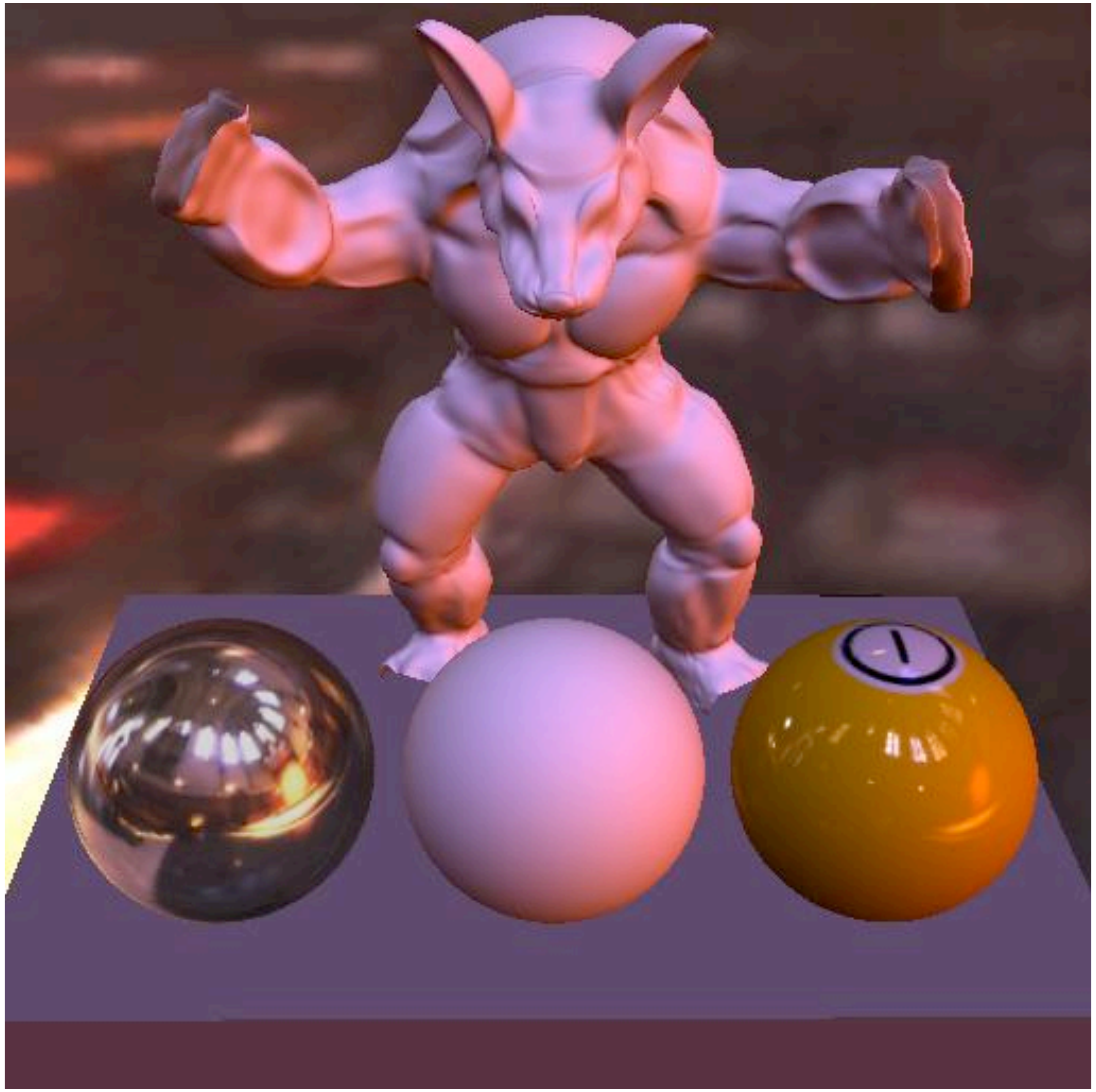
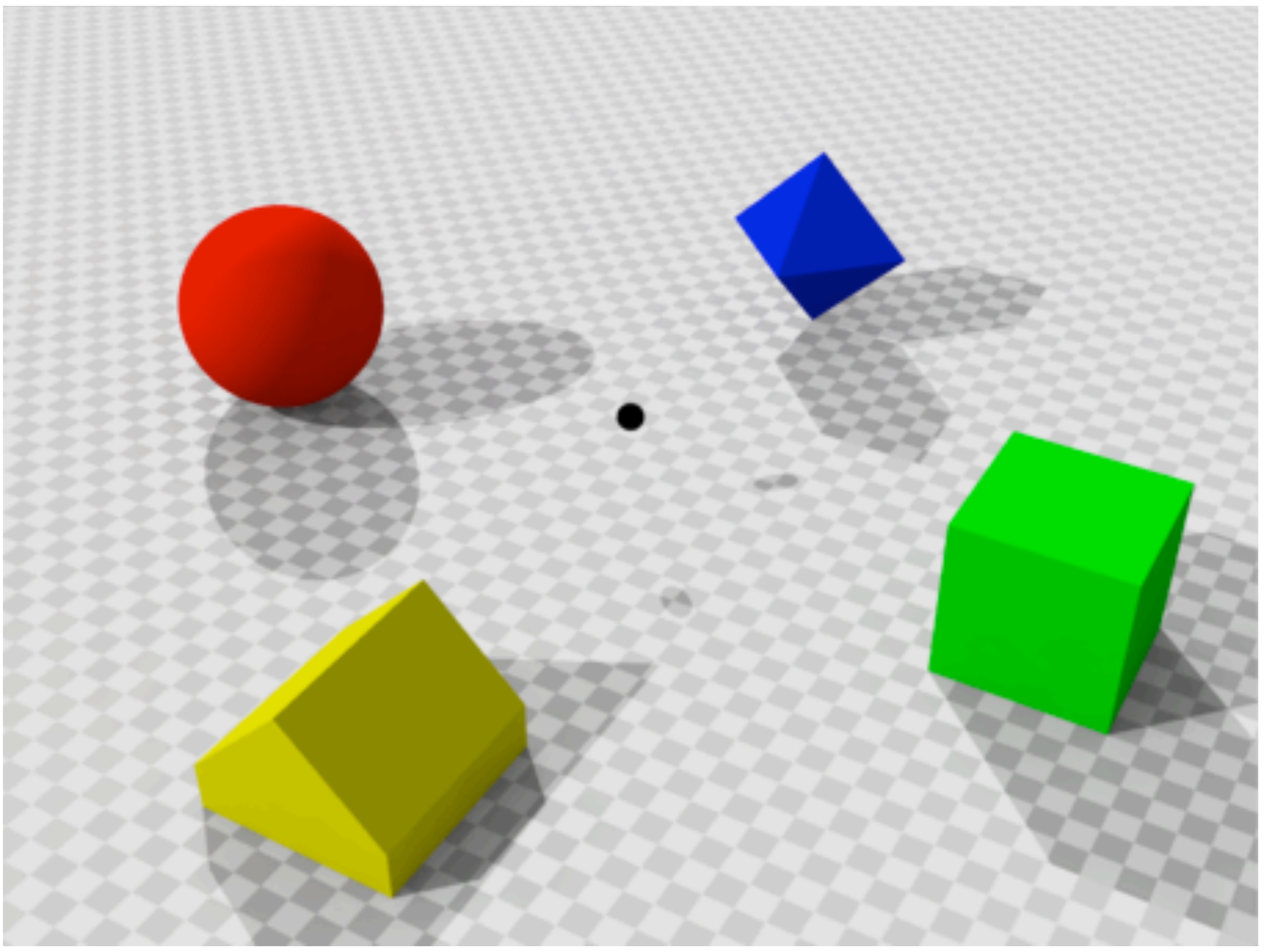
Reference
Split sum
Split sum + prefiltering
Karis 2013

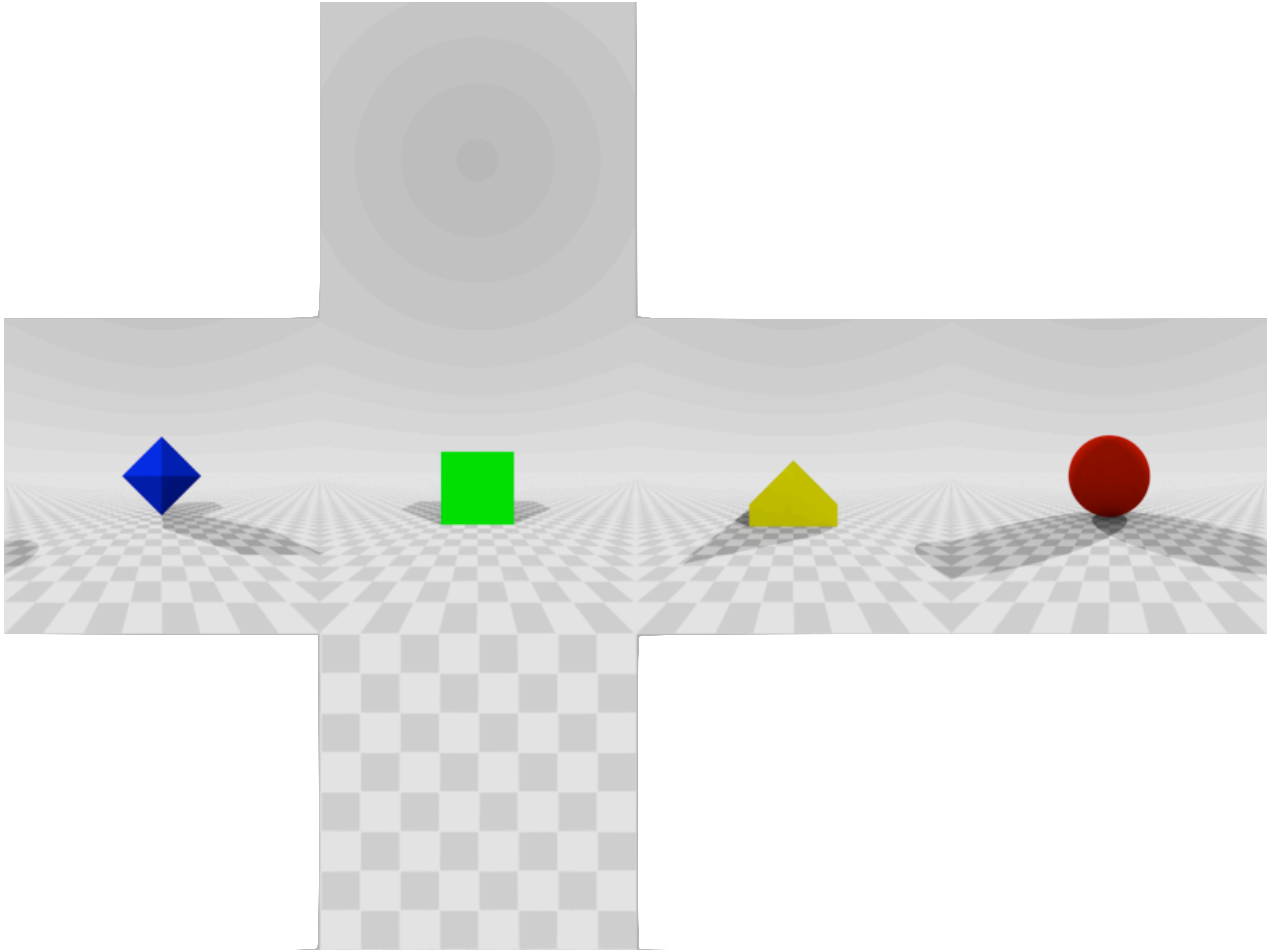
Problems with basic environment maps:

- No reflections of other objects
- No shadows



Light probes





Reflection probes assume incident light is coming from infinitely far away…