



LIGHTING AND SHADOWS

SEMINAR 4

Computer Graphics 2

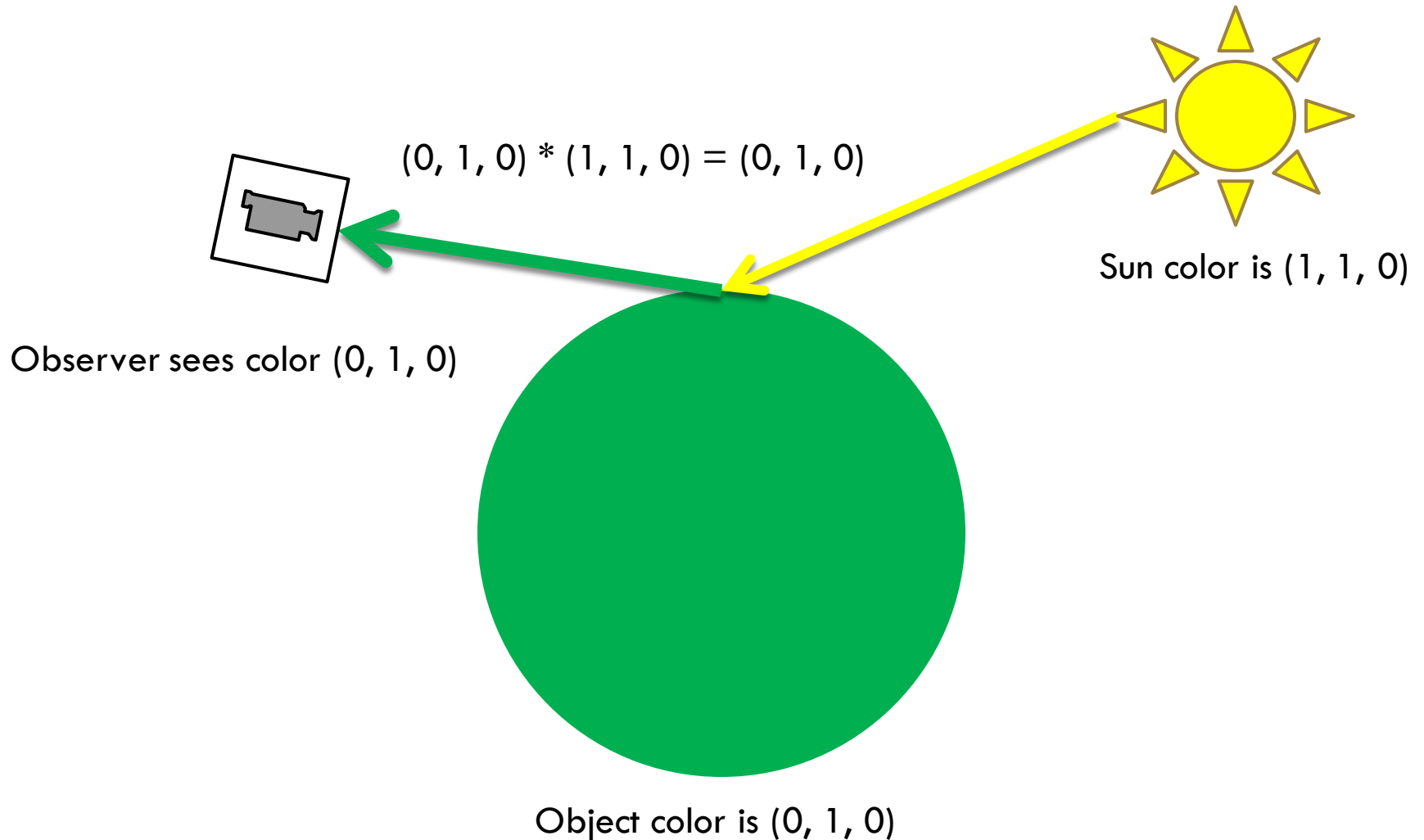
Wavelength

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- Light source emit spectral radiance with wavelength λ
- The final color of objects depends on reflection and absorption of wavelengths with different λ
- Colors in computers are reproduced using a combination of red, green and blue light
- Human eye is sensitive to red, green and blue color

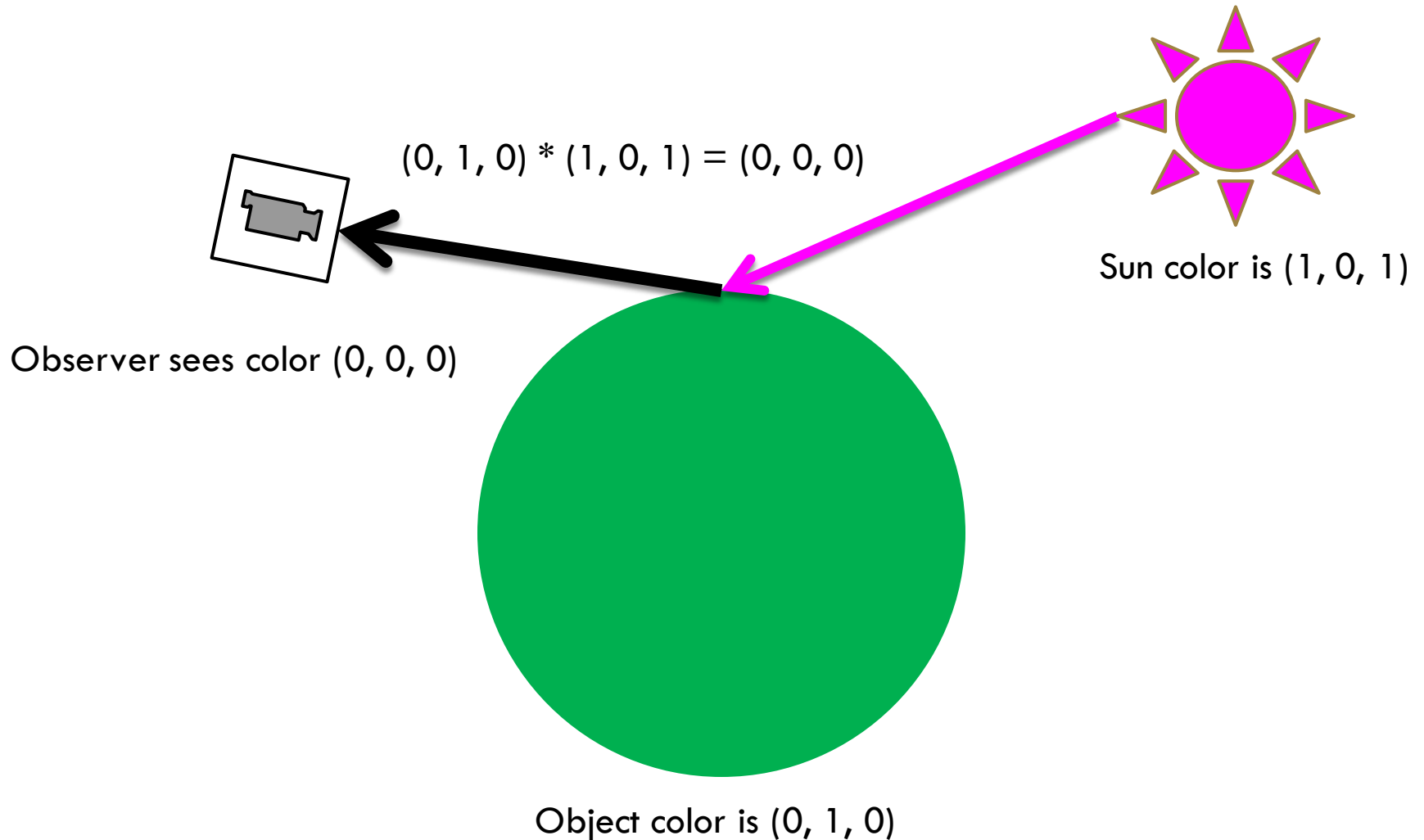
Wavelength Example 1

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Wavelength Example 2

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Blinn-Phong Reflection Model for Wavelength λ

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$$I = k_a I_a + \sum_{i=1}^n (k_d I_{i,d} (\mathbf{l}_i \cdot \mathbf{n}) + k_s I_{i,S} (\mathbf{h}_i \cdot \mathbf{n})^{n_s})$$

BONUS (1%) write similar equation from sample code:

```
public Vector4 RayTrace(Ray ray)
{
    foreach (Light light in World.Lights)
    {
        Vector4 contactPoint = ray.GetHitPoint();
        Ray lightRay = new Ray();
        light.SetLightRayAt(contactPoint, lightRay);
        World.Collide(lightRay);
        if (lightRay.HitModel == null || !UseShadows)
            color += ray.HitModel.Shader.GetColor();
    }
    return color;
}
```

```
public override Vector4 GetColor()
{
    Double diffuseFactor =
        (normal * lightDir) * lightIntensity;
    diffuseFactor = Math.Max(diffuseFactor, 0);
    Vector4 half = (eyeDir + lightDir).Normalized;
    Double specularFactor =
        Math.Pow(normal * half, Shininess) * lightIntensity;
    Vector4 color = new Vector4();
    color += diffuseFactor * (DiffuseColor ^ light.DiffuseColor);
    color +=
        specularFactor * (SpecularColor ^ light.DiffuseColor);
    color += AmbientColor;

    return color;
}
```

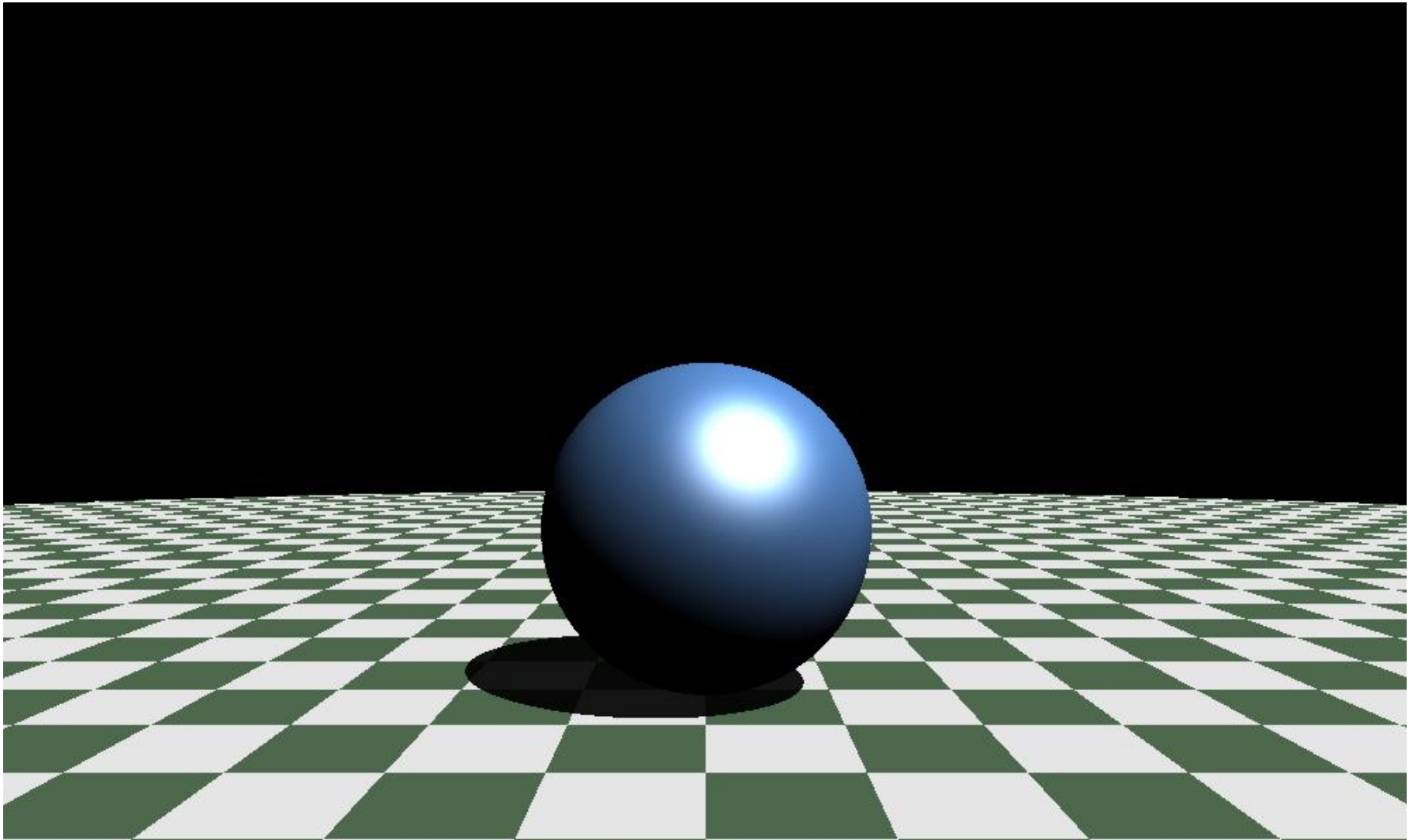
Light

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- Various types of light sources
 - ▣ Directional light, spot light, point light, area light
- Each light has
 - ▣ Intensity – defines strength with which light illuminates the scene
 - ▣ Color – defines the color of the light
 - Diffuse color
 - Specular color
 - Ambient color

Example Sun Light Render

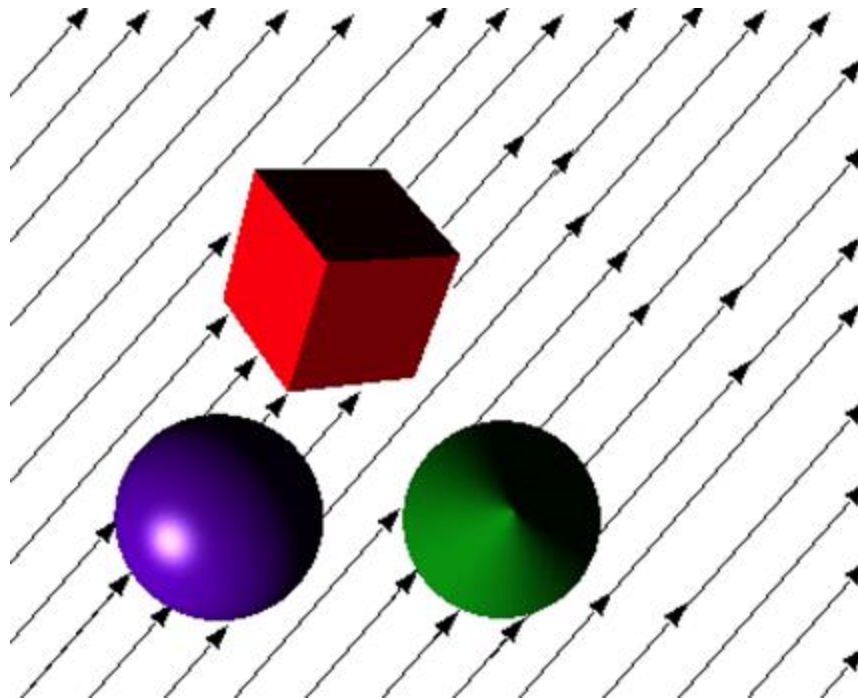
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Directional Light - Sun

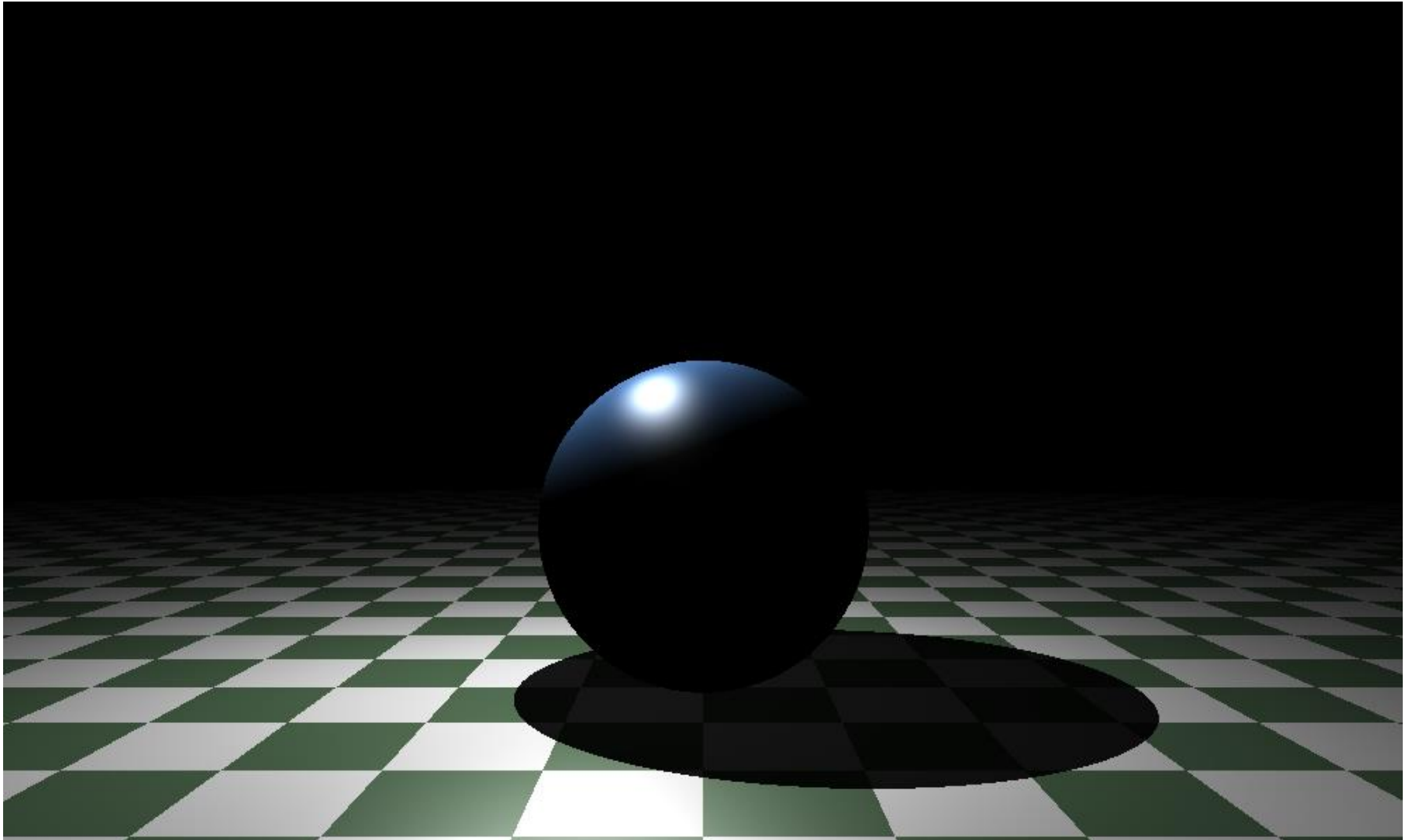
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- Infinite distance from the scene
- Light rays emanate in single parallel direction
- Equal intensity in the whole scene



Example Point Light Render

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Point Light

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- Defined using:
 - Origin – of the point light
 - Range – of the light
 - Linear attenuation – decay of light intensity
 - Quadratic attenuation – decay of light intensity

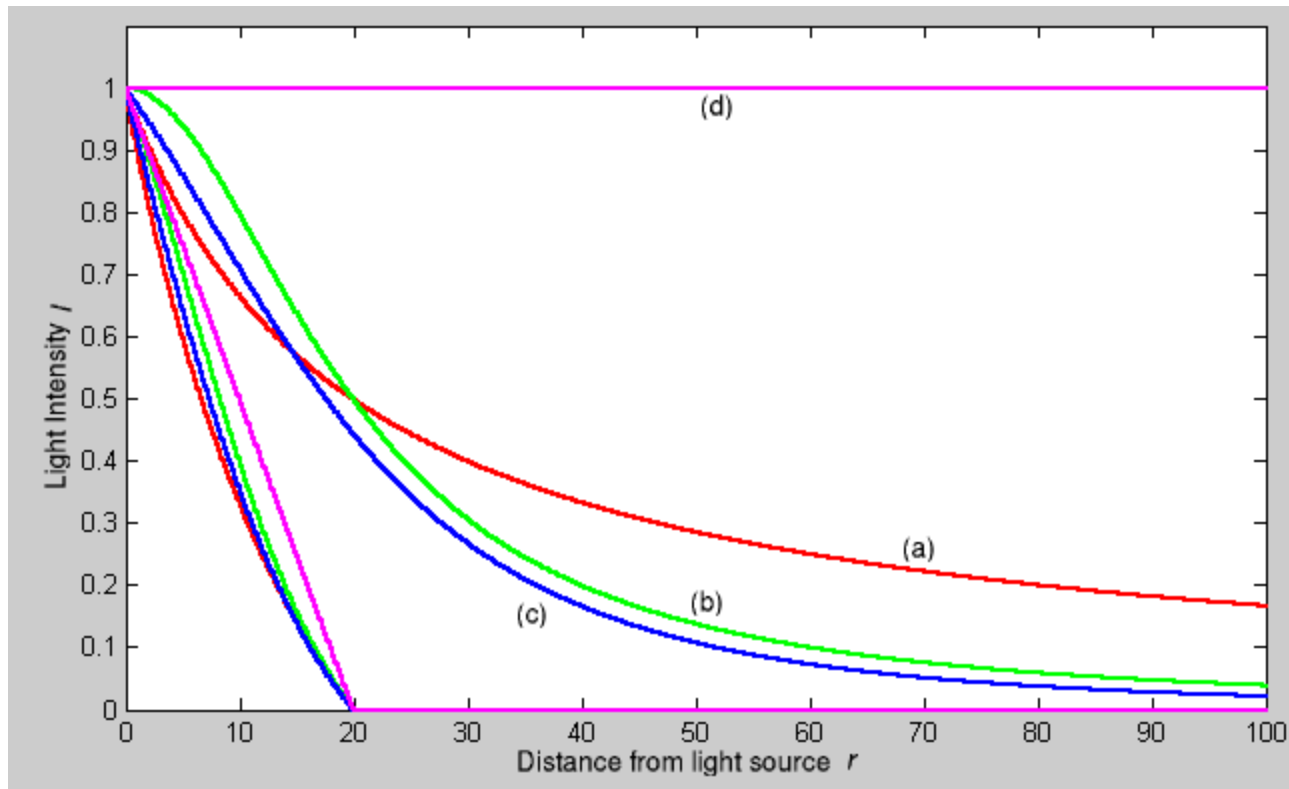
Point Light Intensity Calculation

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- Calculate distance d from light origin to point
- Calculate linear attenuation using:
 - $l = \frac{Range}{Range + LinearAttenuation * d}$
- Calculate quadratic attenuation using:
 - $q = \frac{Range^2}{Range^2 + QuadraticAttenuation * d^2}$
- Combine for final intensity:
 - $FinalIntensity = Intensity * l * q$

Attenuation Curves

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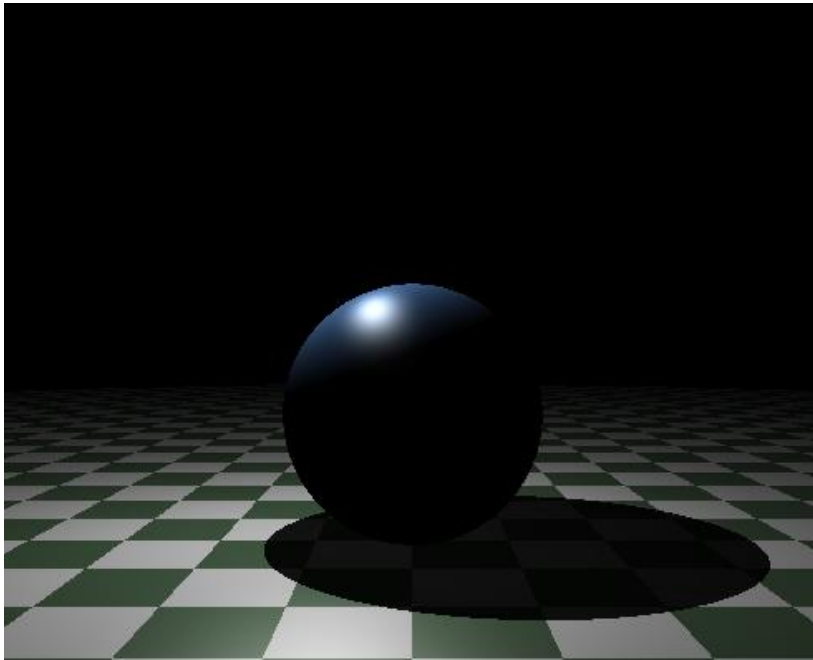


- a) Linear attenuation
- b) Quadratic attenuation
- c) 0.5 Linear and 0.5 Quadratic
- d) No attenuation

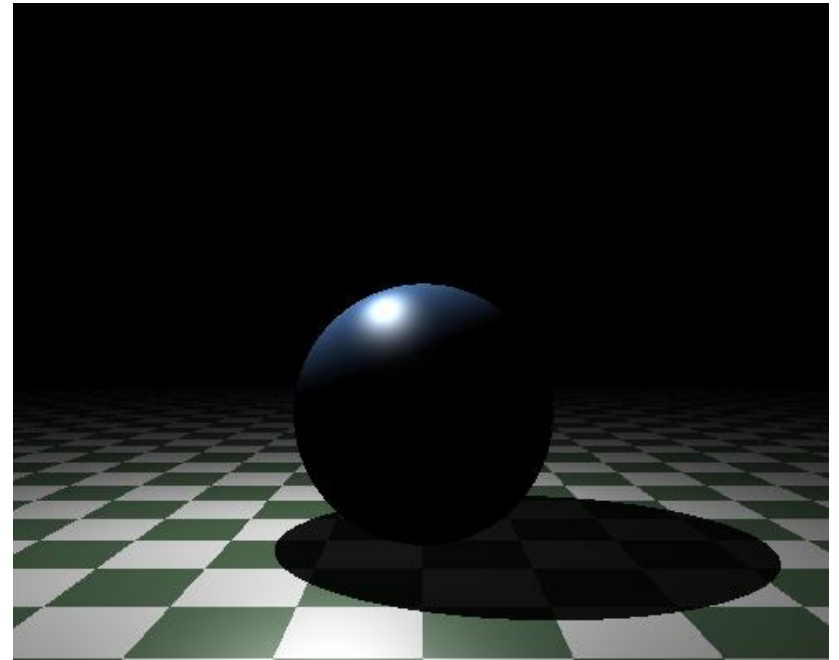
Linear vs. Quadratic Attenuation

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Linear

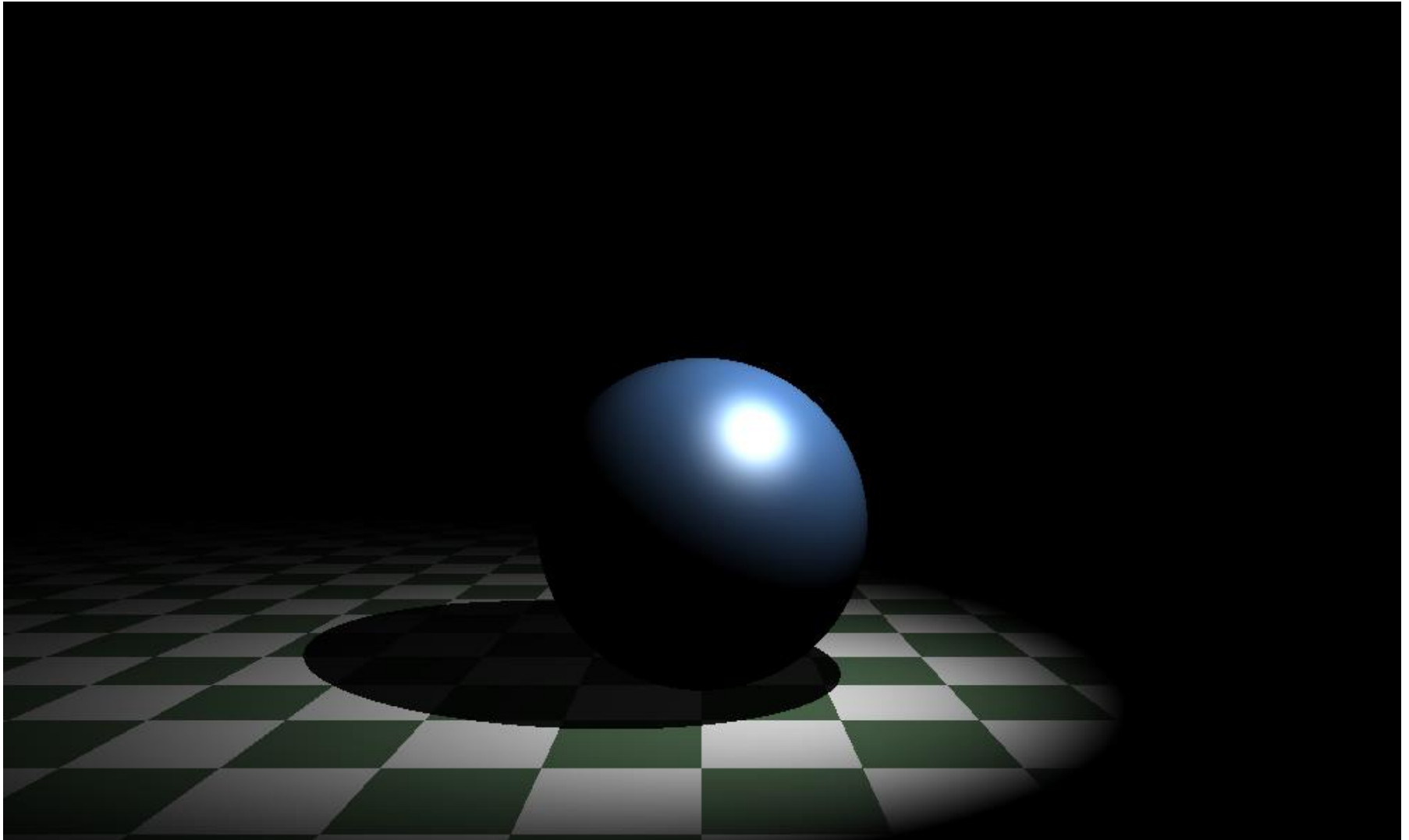


Quadratic



Example Spot Light Render

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Spot Light

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- Emits a cone of light in a given direction
- Based on point light
- Defined using:
 - ▣ Direction – direction of the cone
 - ▣ Cutoff angle – angle of the cone
 - ▣ Exponent – for smooth blending

Spot Light Calculation of Intensity

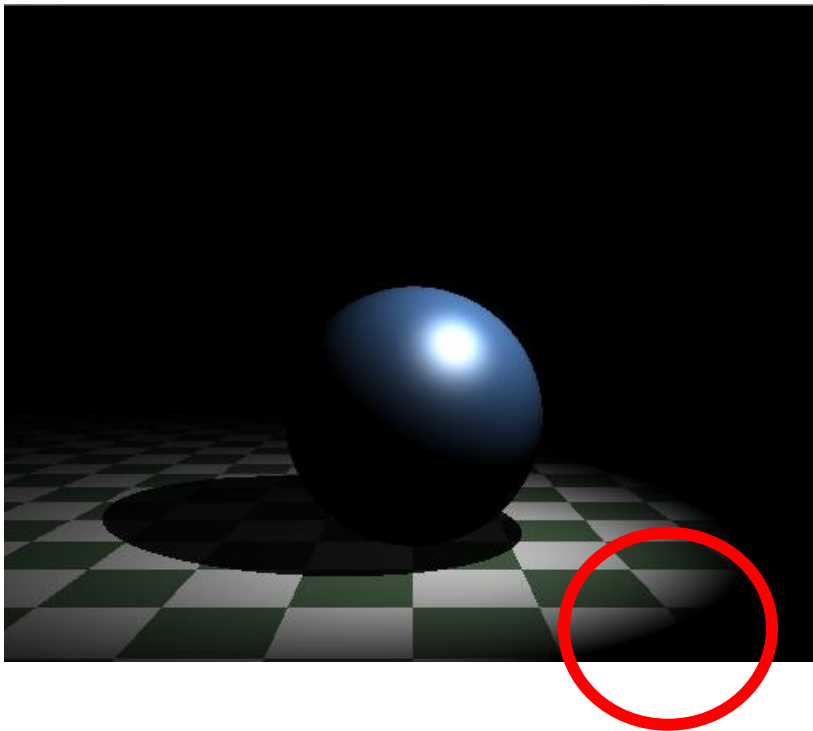
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1. Get intensity of point light for point
2. Get angle α between light direction and direction from light to point
3. If α is larger than cutoff return 0
4. Calculate the ratio of α to cutoff angle
5. $decay = 1 - ratio^{Exponent}$

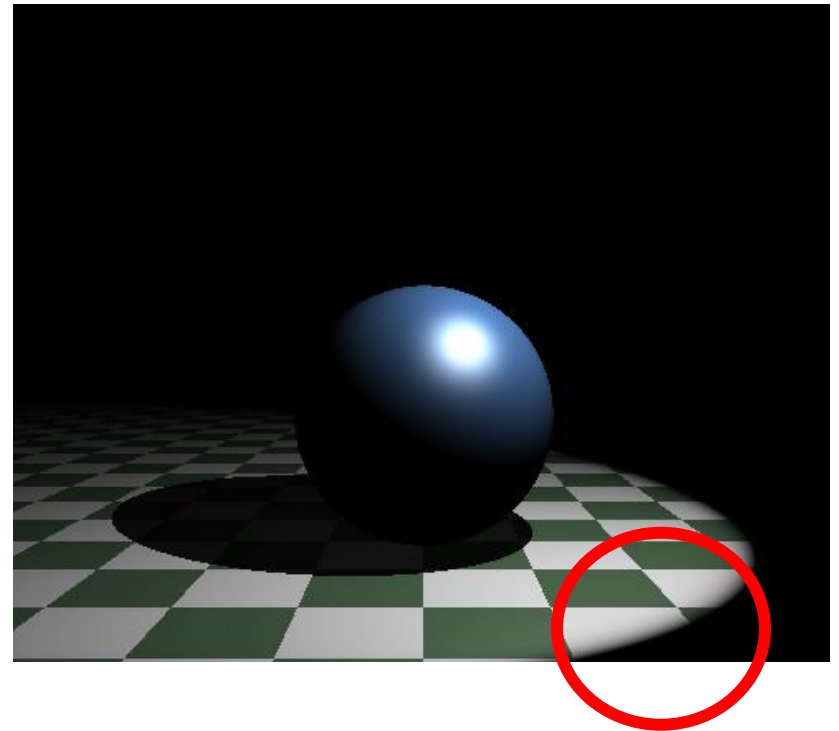
Exponent difference

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Exponent = 3

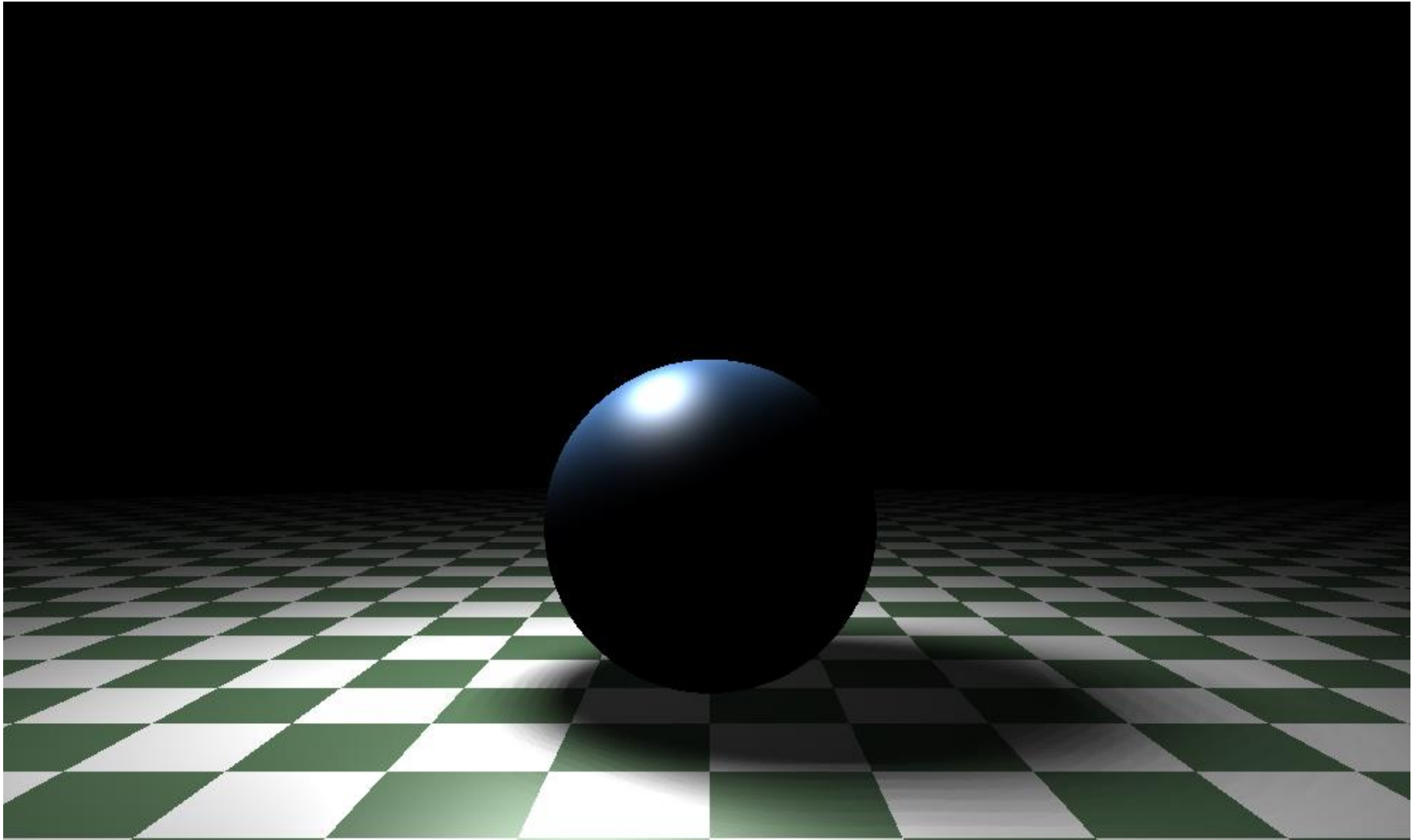


Exponent = 30



Example Area Light Render

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Area Light

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- Approximated using a grid of point lights
- Defined using:
 - ▣ Origin – of the area
 - ▣ Normal – of the area
 - ▣ s_x – width of the area
 - ▣ s_y – height of the area
 - ▣ n_x – number of lights along the width
 - ▣ n_y – number of lights along the height

Area Light Setup

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1. Calculate local space
 1. normal is direction from point light to $O(0, 0, 0)$
 2. up is $(0, 0, 1)$ - can it be always?
 3. $\text{right} = \text{up} \times \text{n}$
 4. $\text{up} = \text{n} \times \text{right}$
2. Calculate delta x and delta y
3. Iterate over the area of area light
 - ▣ Create point light at each stop
 - ▣ Insert created point lights into a list

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Questions?