LIGHTING AND SHADOWS

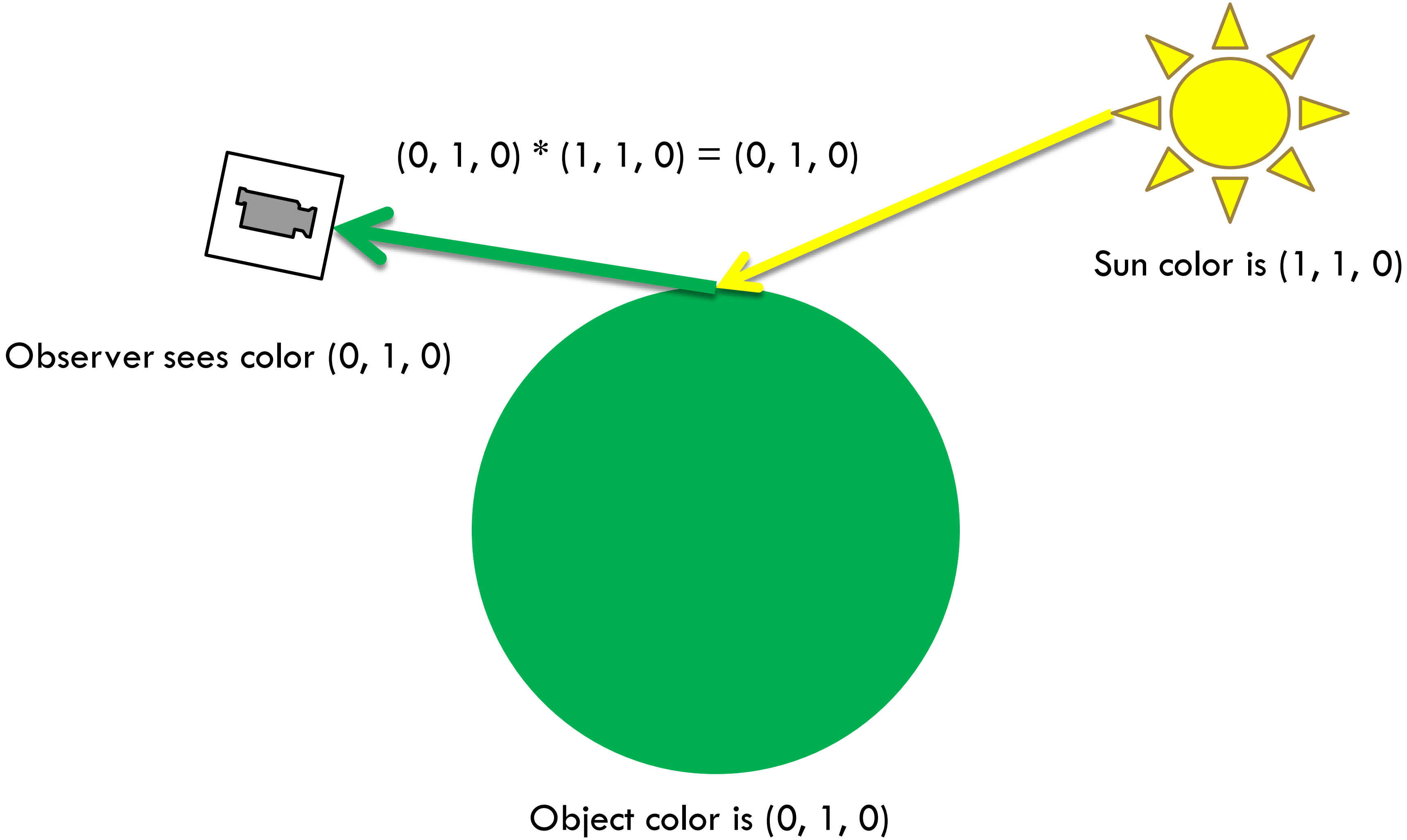
SEMINAR 4

Computer Graphics 2

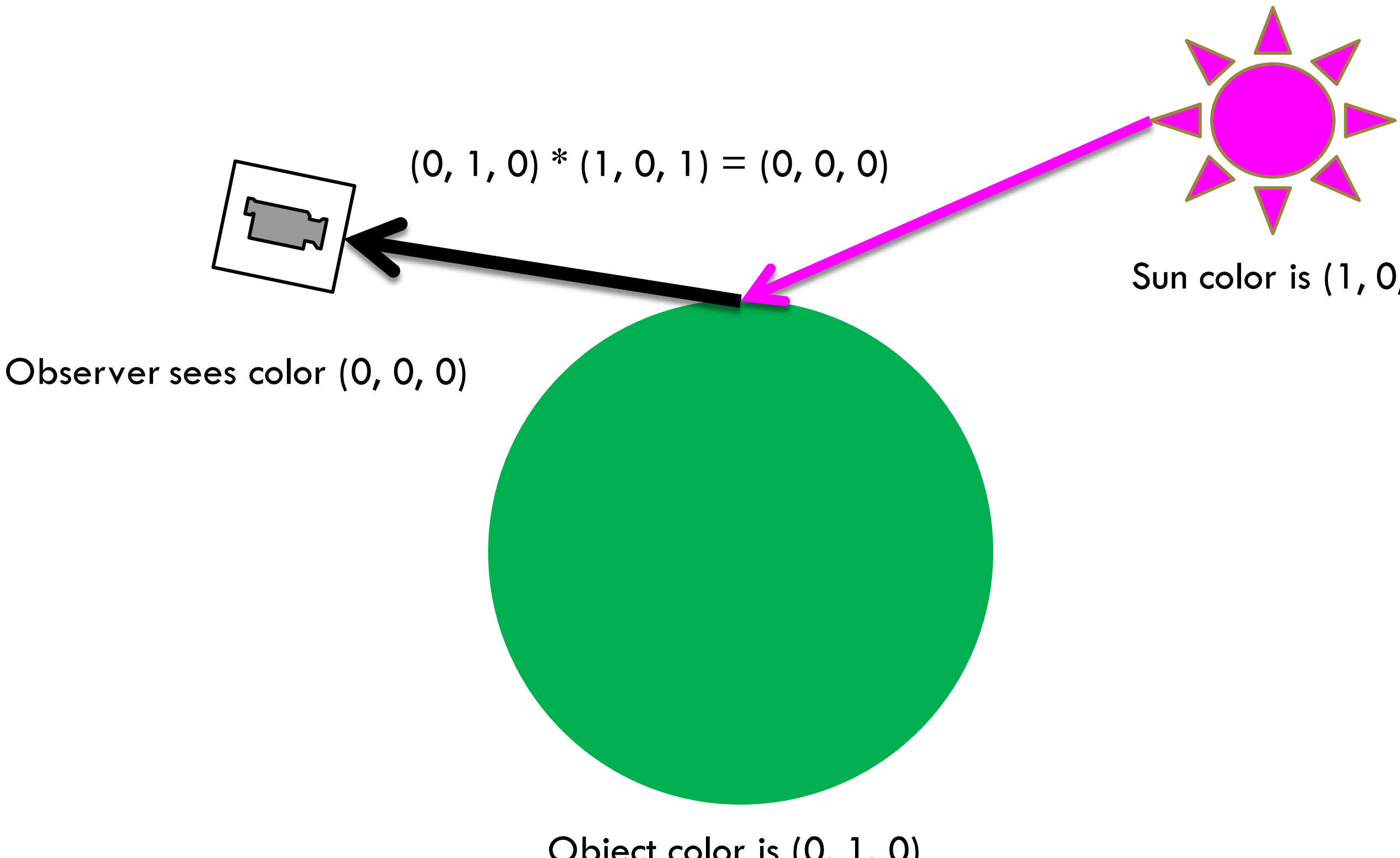
Wavelength

- 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



Wavelength Example 2



Blinn-Phong Reflection Model for Wavelength λ

$$I = k_a I_a + \sum_{i=1}^{n} \left(k_d I_{i,d} (\boldsymbol{l_i} \cdot \boldsymbol{n}) + k_s I_{i,s} (\boldsymbol{h_i} \cdot \boldsymbol{n})^{n_s} \right)$$

BONUS (1%) write the equation from sample code during seminar:

```
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;
}
```

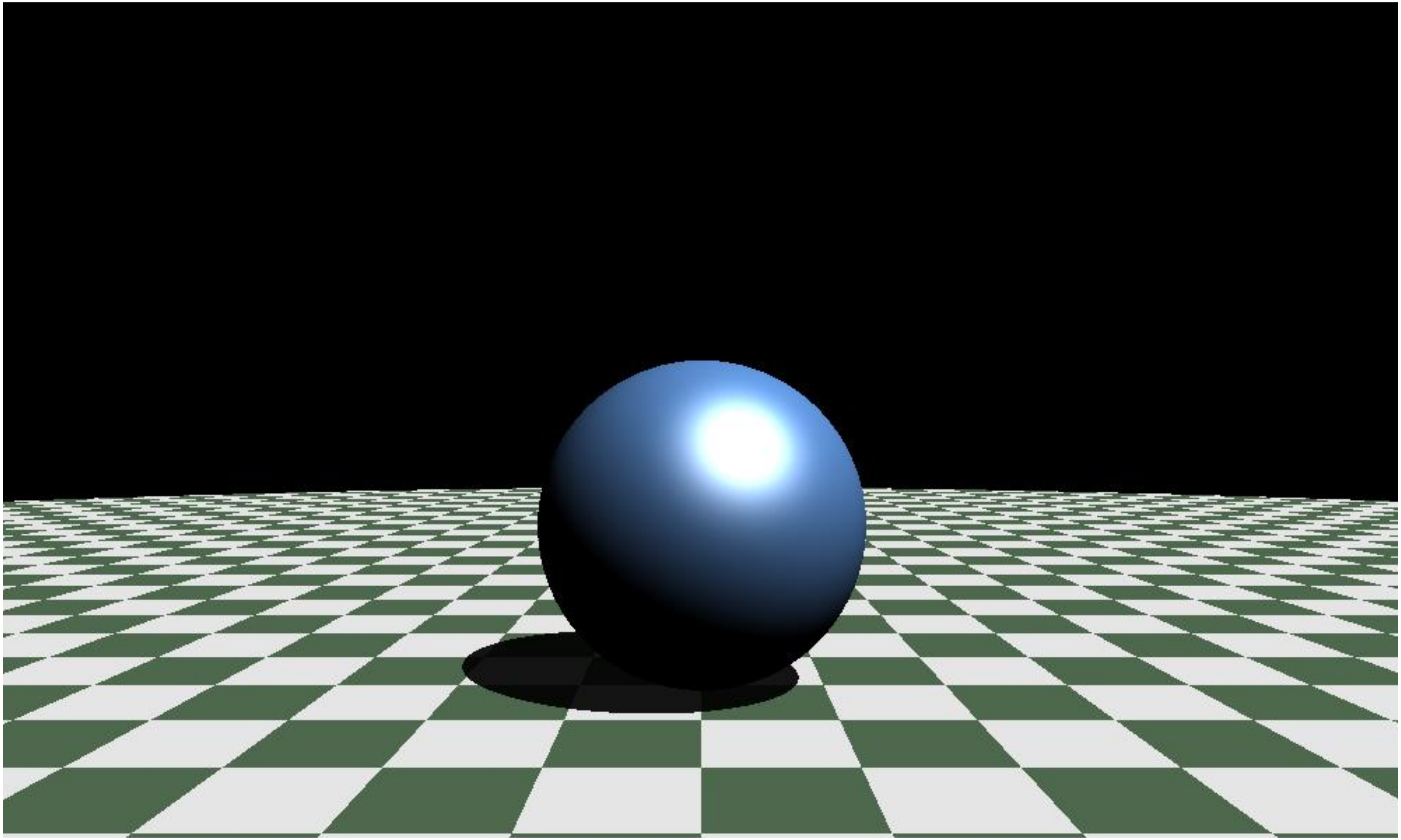
```
public override Vector4 GetColor()
{
    Double diffuseFactor =
        (normal * lightDir) * lightIntensity;
    diffuseFactor = Math.Max(diffuseFactor , 0);
    Vector4 half = (eyeDir + lightDir).Normalized;
    Double specularFactor =
        Math.Pow(normal * half, Shininess) * lightIntensity;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

    return color;
}
```

Light

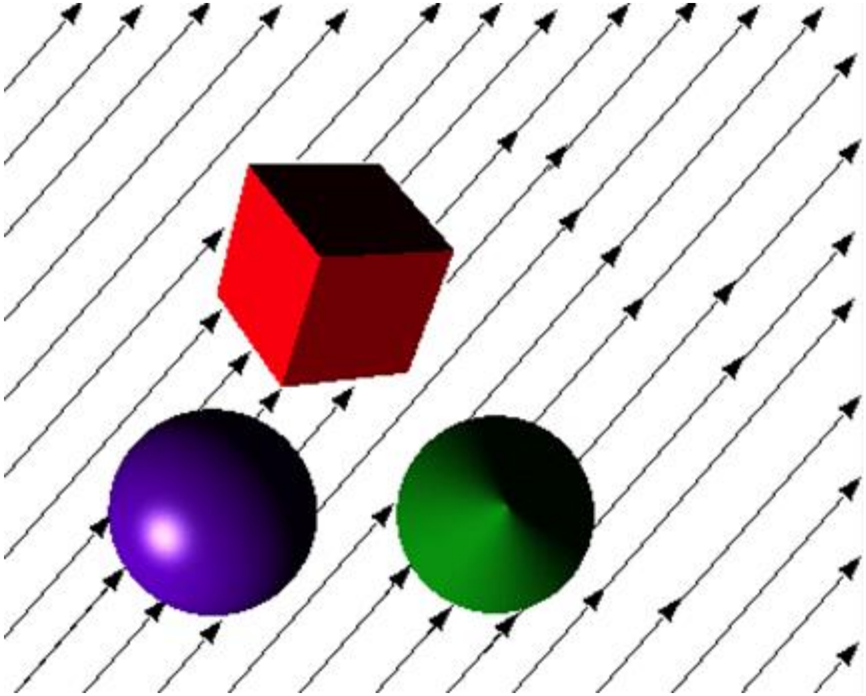
- Various types of light sources
  - Directional light, spot light, point light, area light
- Each light has
  - Intensity – defines strength with which light illuminates the scene
  - Color – defines the color of the light
    - Diffuse color
    - Specular color
    - Ambient color

Example Sun Light Render

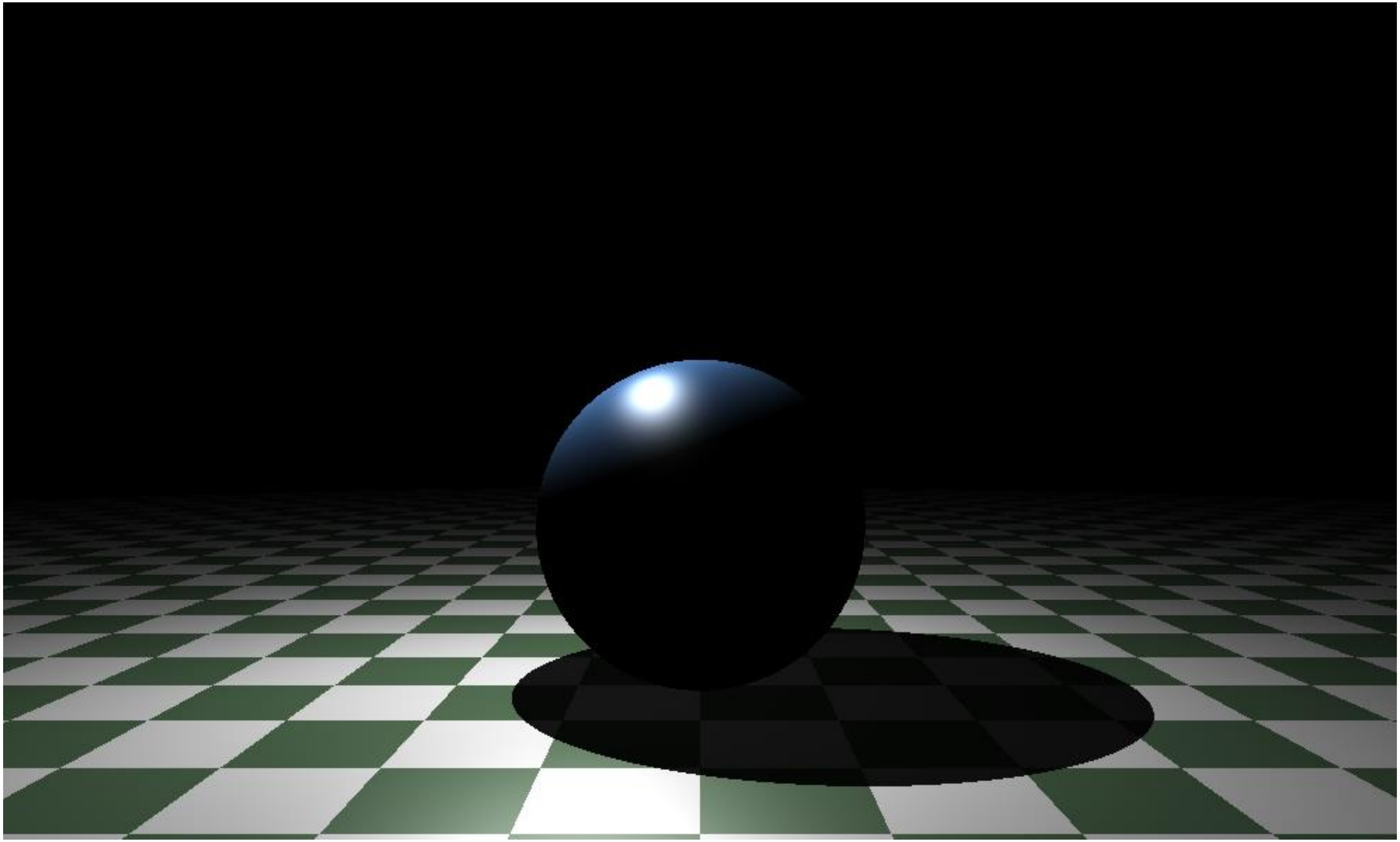


Directional Light - Sun

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



Example Point Light Render



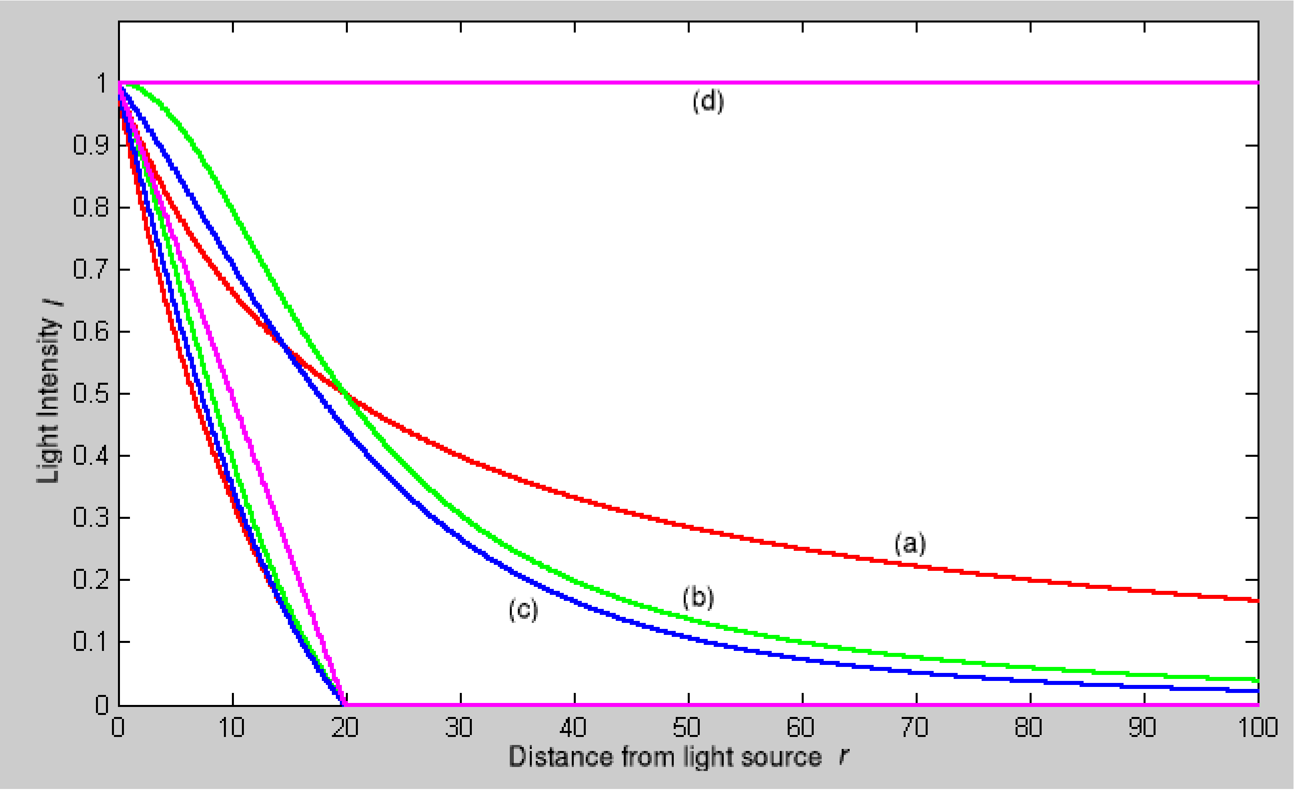
Point Light

- 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

- 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:
  - $FinalIntensity = Intensity * l * q$

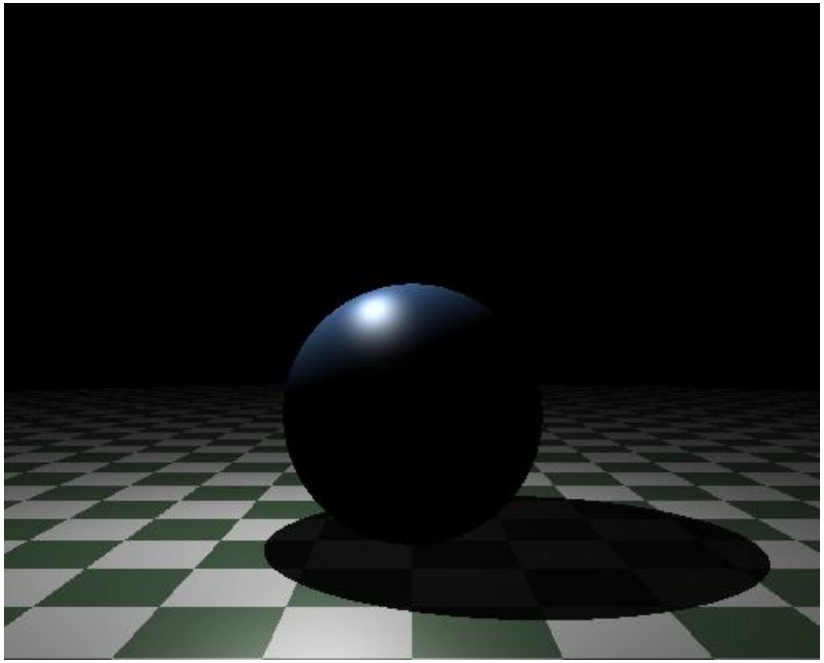
Attenuation Curves



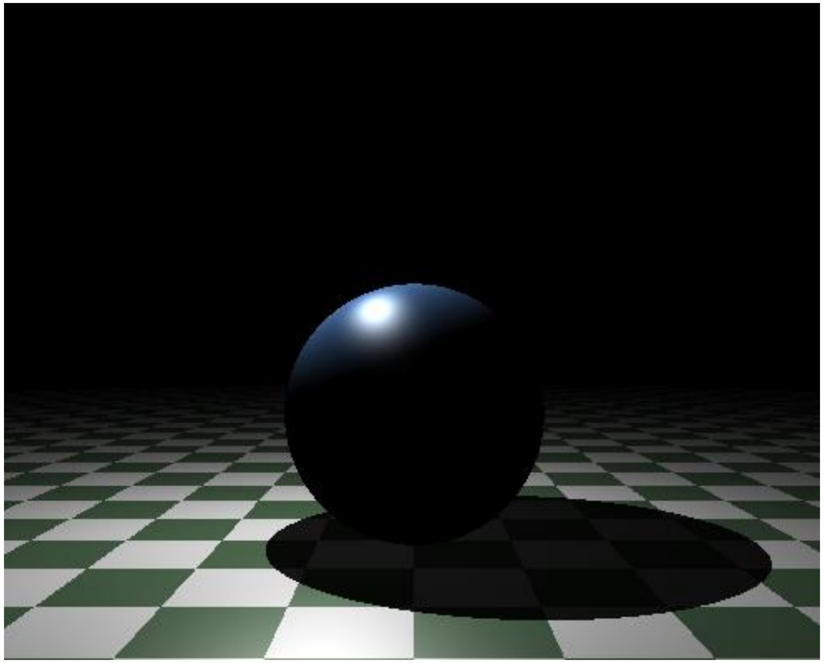
a) Linear attenuation
b) Quadratic attenuation
c) 0.5 Linear and 0.5 Quadratic
d) No attenuation

Linear vs. Quadratic Attenuation

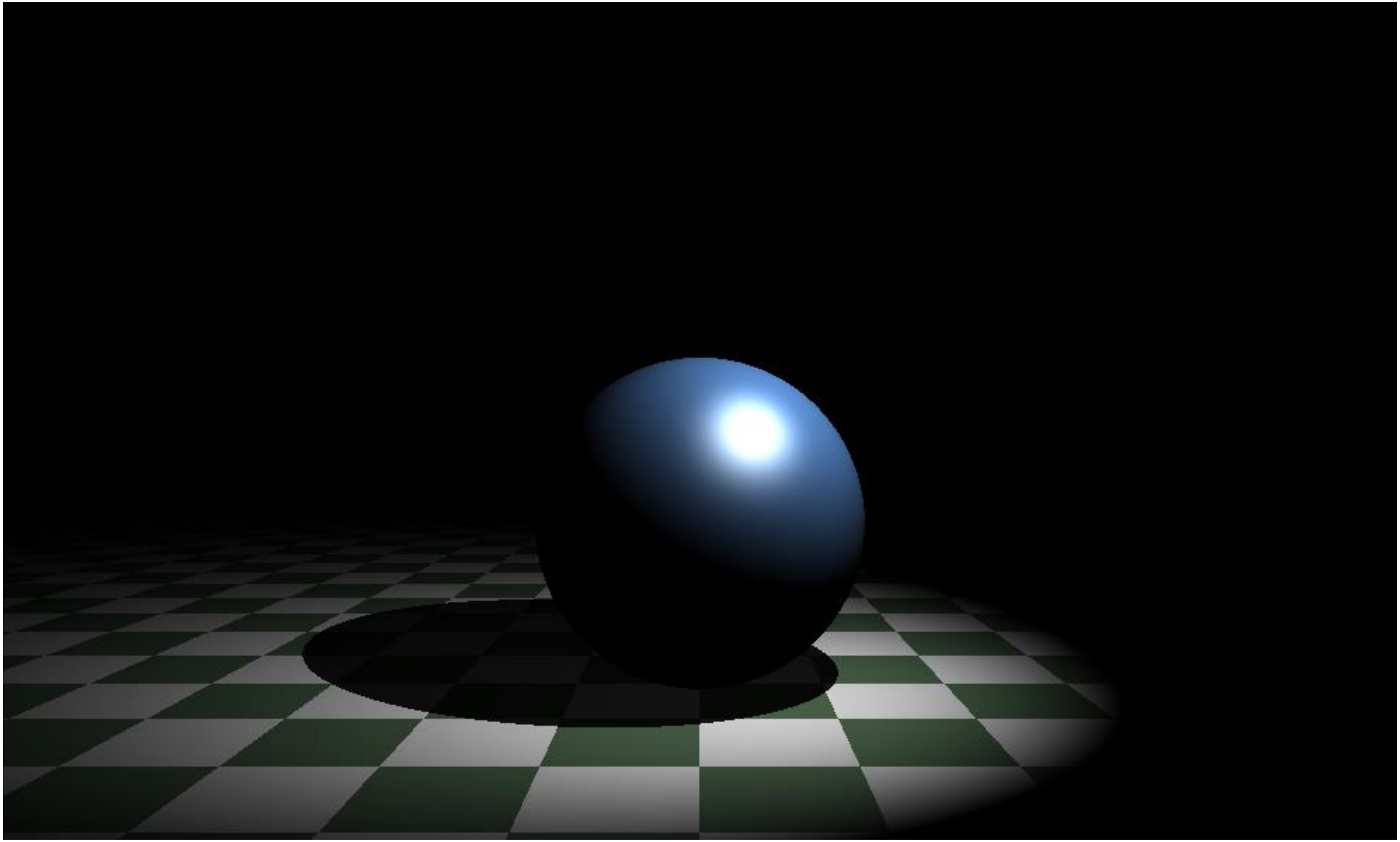
Linear



Quadratic



Example Spot Light Render



Spot Light

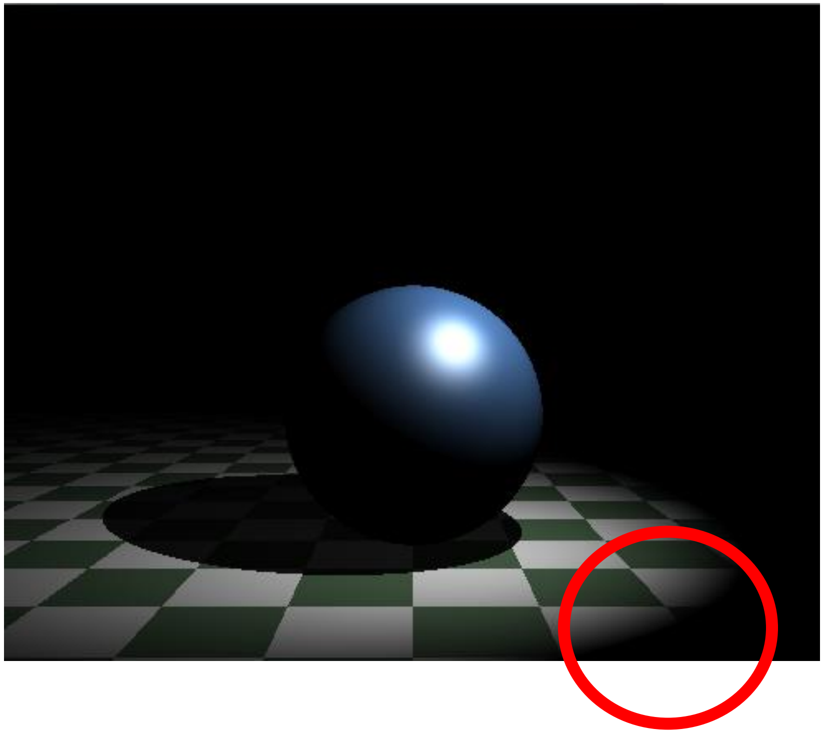
- Emits a cone of light in a given direction
- Based on point light
- Defined using:
  - Direction – direction of the cone
  - Cutoff angle – angle of the cone
  - Exponent – for smooth blending

Spot Light Calculation of Intensity

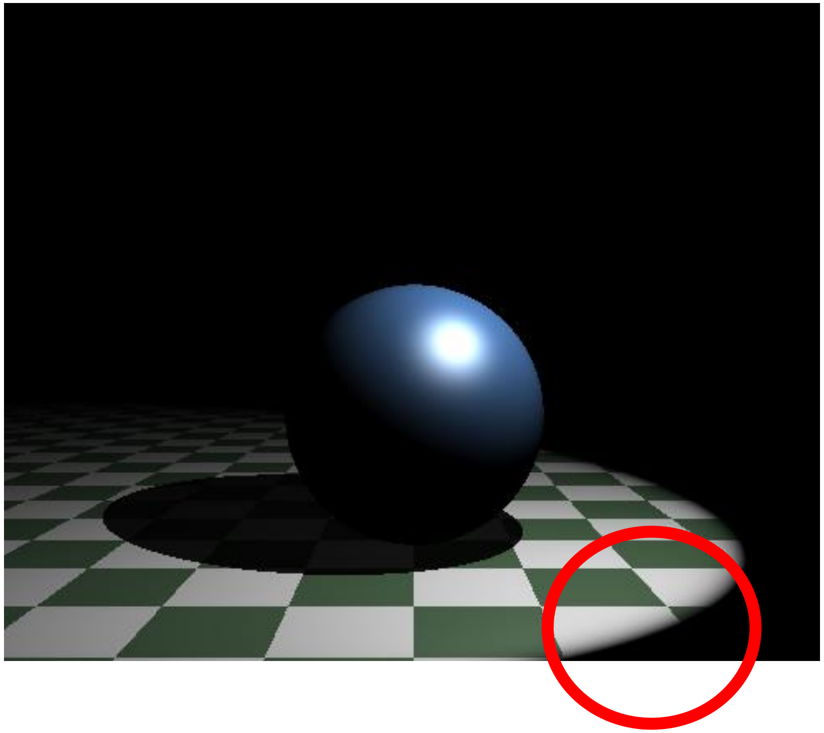
1. Get intensity of point light for point
2. Get angle α between light direction and direction from light to point
3. If α is larger than cutoff return 0
4. Calculate the ratio of α to cutoff angle
5. $decay = 1 - ratio^{Exponent}$

Exponent difference

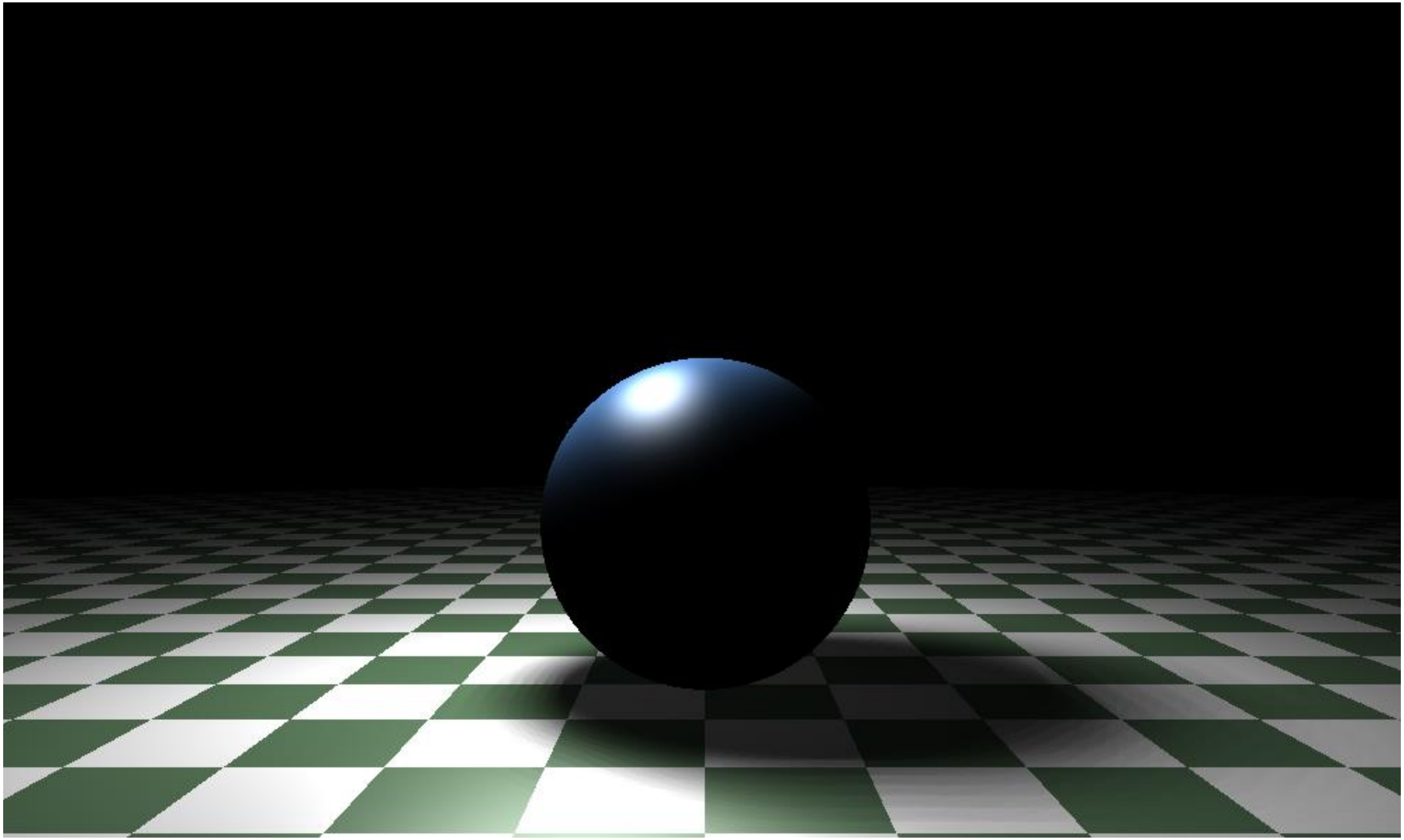
Exponent = 3



Exponent = 30



Example Area Light Render



Area Light

- Approximated using a grid of point lights
- Defined using:
  - Origin – of the area
  - Normal – of the area
  - sx – width of the area
  - sy – height of the area
  - nx – number of lights along the width
  - ny – number of lights along the height

Area Light Setup

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. right = up × n
   4. up = n × 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

Questions?