Local Illumination

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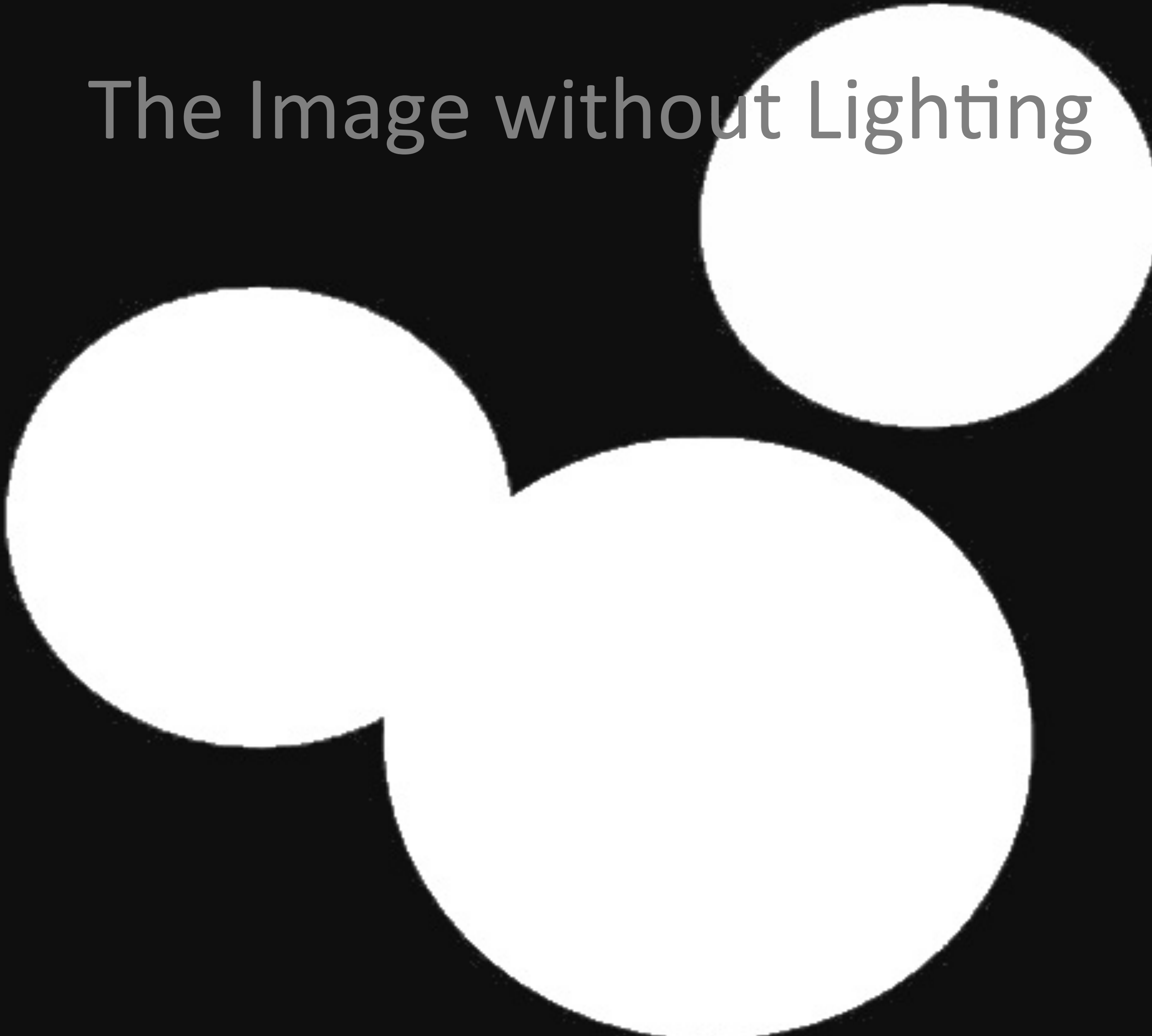
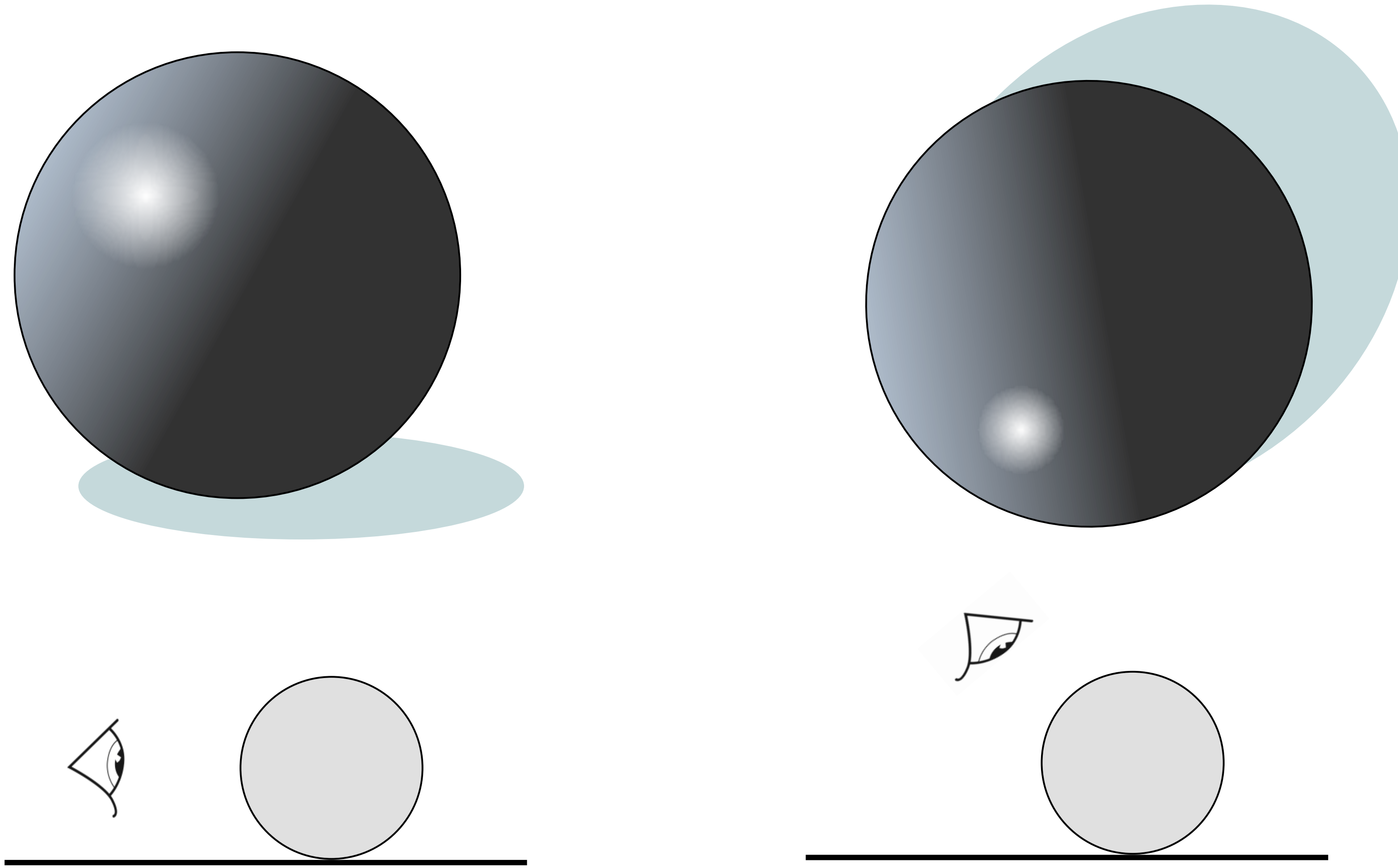
The Image without Lighting



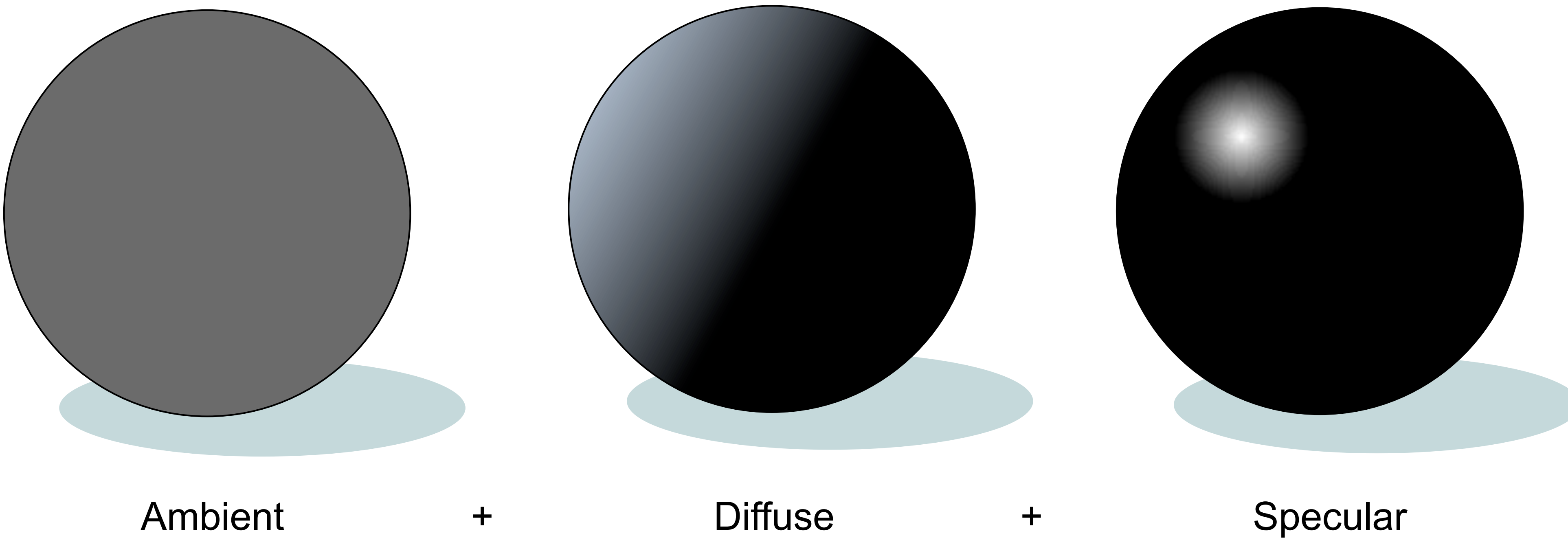
Introduction

- Local illumination
  - **How a point light and one surface location interact**
  - Valid for ray-tracing and for z buffer (projection)
  - Notation
    - I_{r} Intensity radiating from the object (What we're looking for)
    - I_{i} Normalized intensity of the light (Characteristic of the light)
    - k proportion of the light reflected rather than absorbed by the material (Characteristic of the surface; varies with light wavelength)

Visual features

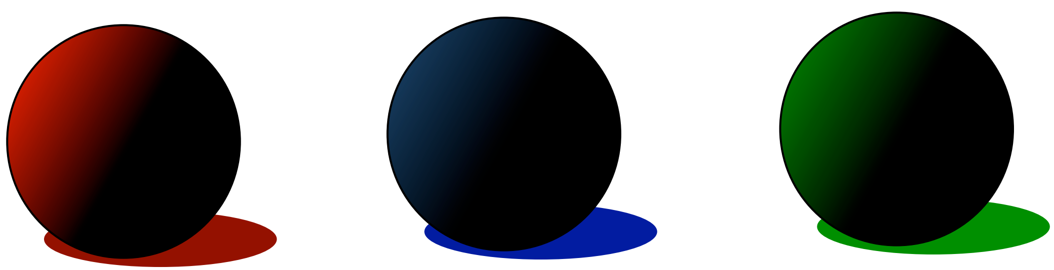


Main idea



Color

- Light has different wavelengths
- Illumination is independent
- Red-in-green-out odes not exist (exception: fluorescencence)
- We do all computation independently on RGB 3-vectors



Ambient Light

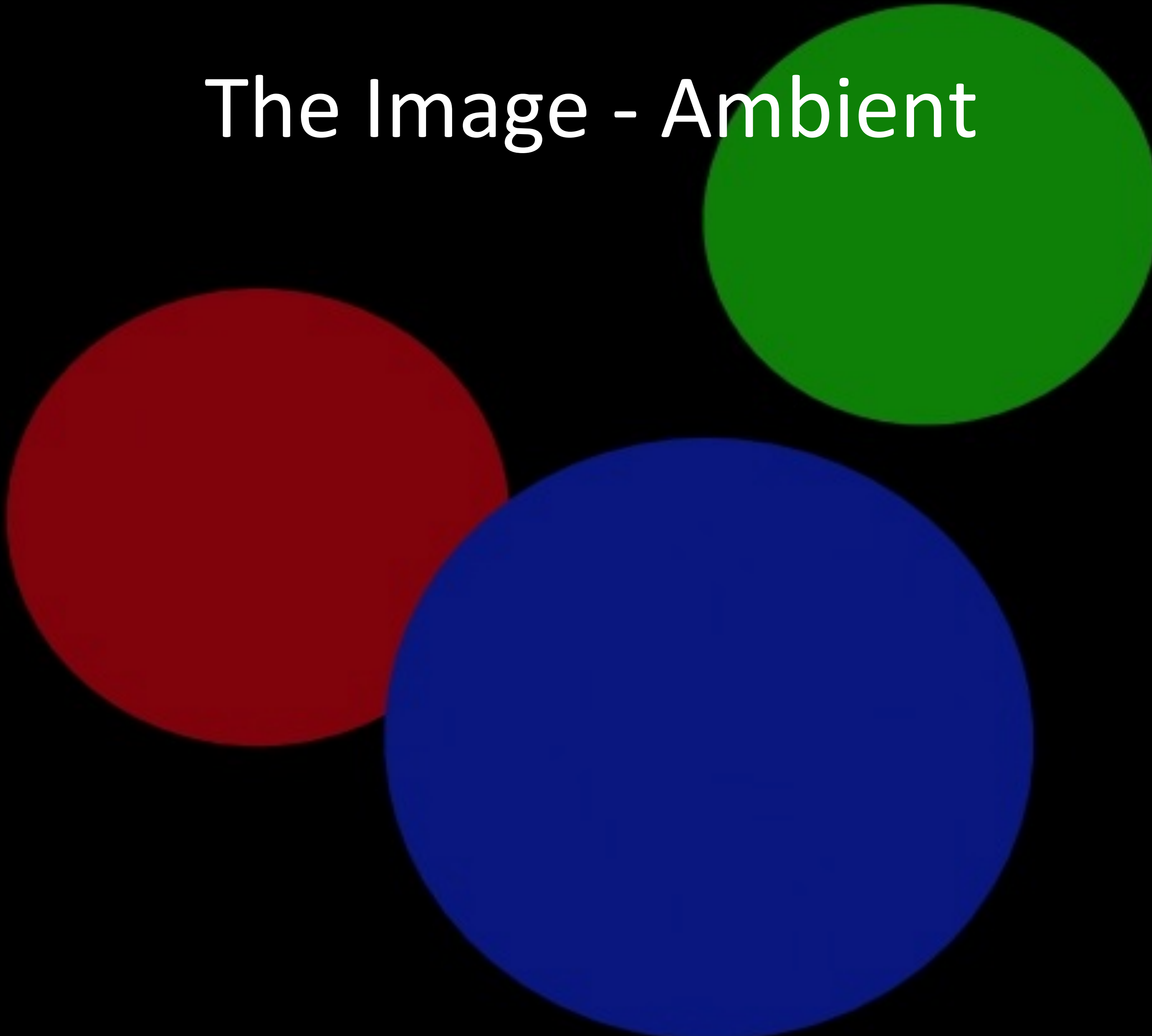
- Approximation to global illumination
  - Each object is illuminated to a certain extent by “stray” light
  - Constant across a whole object

- Often used simply to make sure everything is lit, just in case it isn’t struck by light direct from a light source

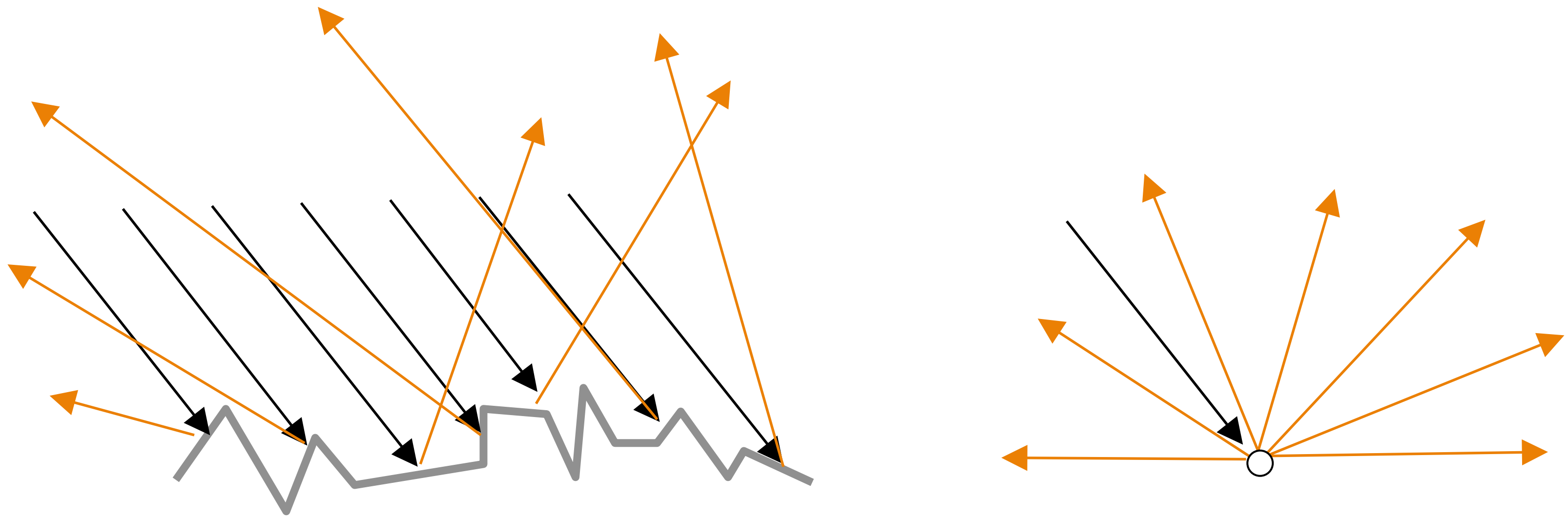
Ambient Light

- Ambient light usually set for whole scene (I_{a})
- Each object reflects only a proportion of that (k_{a})
- So far then $I_{\mathrm{r}} = k_{\mathrm{a}} I_{\mathrm{a}}$

The Image - Ambient

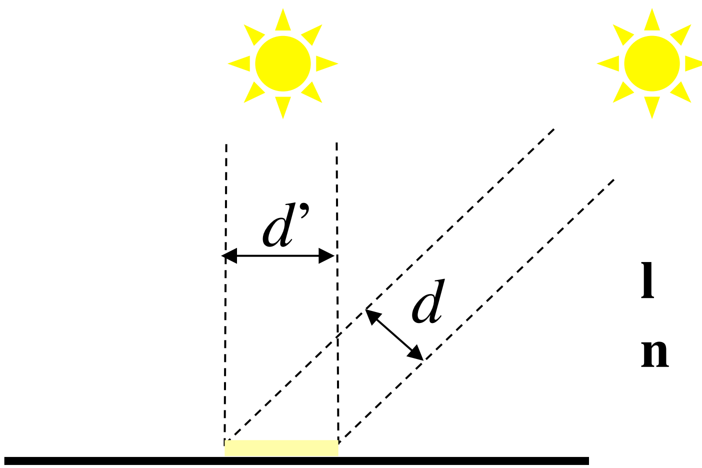


Lambert's Law

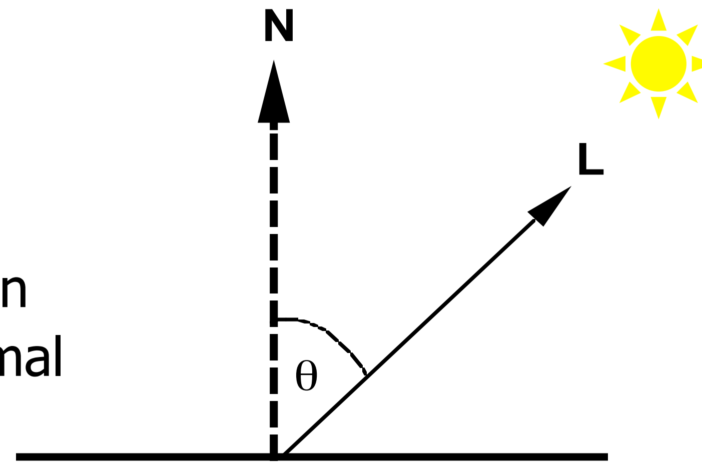


- Diffuse reflector scatters light
- Assume equality in all directions
- Called Lambertian surface
- Angle of incoming light is still critical

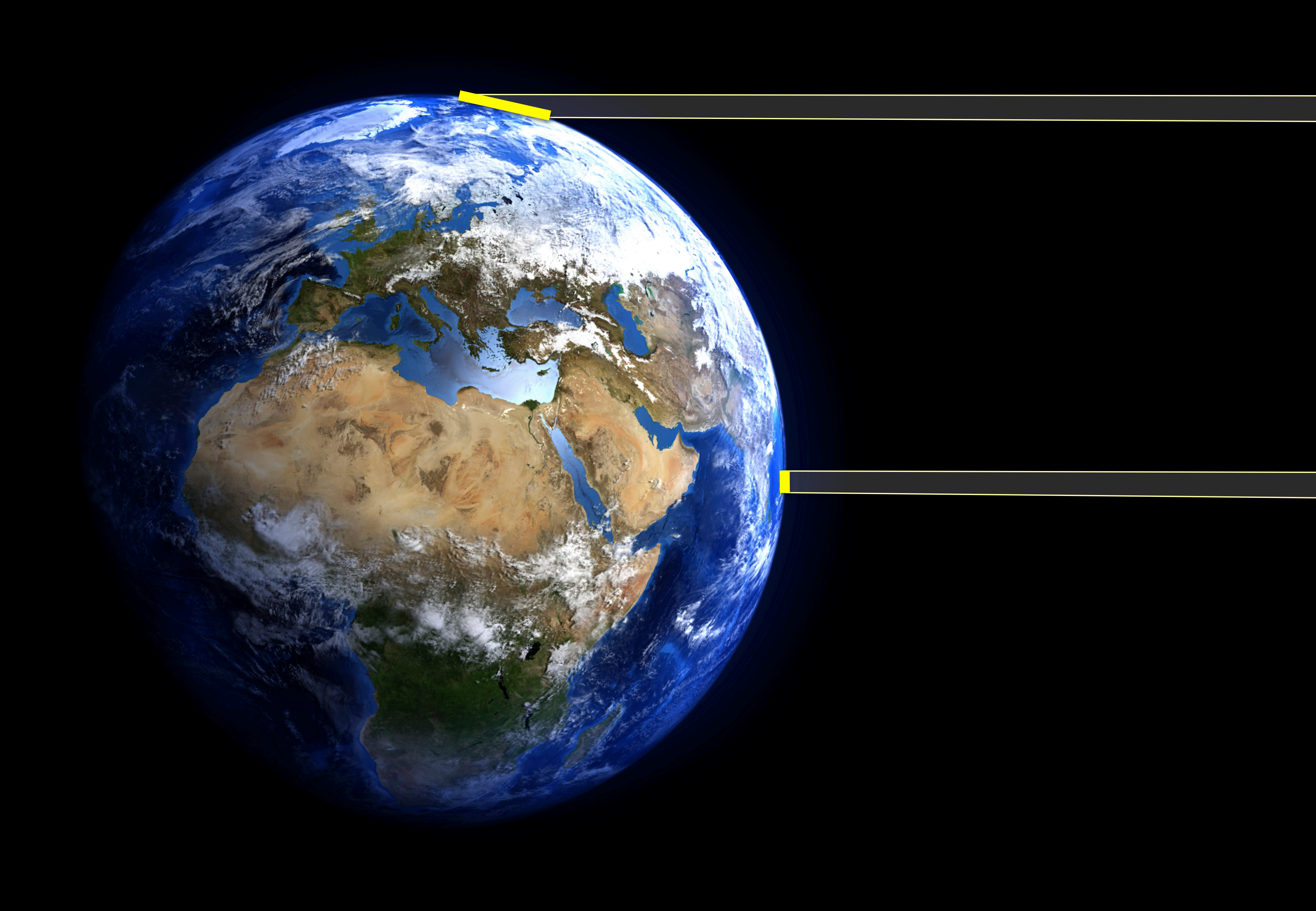
Lambert's Law



$\mathbf{l}$ Light direction
$\mathbf{n}$ Surface normal



- Incoming intensity of light is proportional to d
- d is proportional to $\cos\theta = \langle\mathbf{n}, \mathbf{l}\rangle^{+} = \max(0, \langle\mathbf{n}, \mathbf{l}\rangle)$
- No negative length or light
- Reflected intensity proportional to $\cos\theta$



Diffuse Light

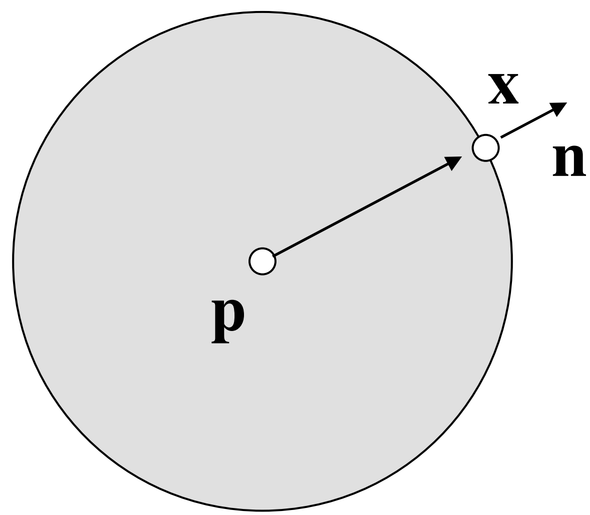
- The normalised intensity of the light incident on the surface due to a ray from a light source

- The light reflected due to Lambert's law

- Proportion of light reflected rather than absorbed (k_{d})

Normals

- To do Lambertian shading, we need the normal $\mathbf{n}$ of a sphere at $\mathbf{p}$ at the intersection point $\mathbf{x}$



Lighting Equation #2

$$I_{\mathrm{r}} = k_{\mathrm{a}} I_{\mathrm{a}} + k_{\mathrm{d}} I_{\mathrm{i}} <\mathbf{n},\mathbf{l}>^{+}$$

- Ambient and diffuse components k_{a} and k_{a}

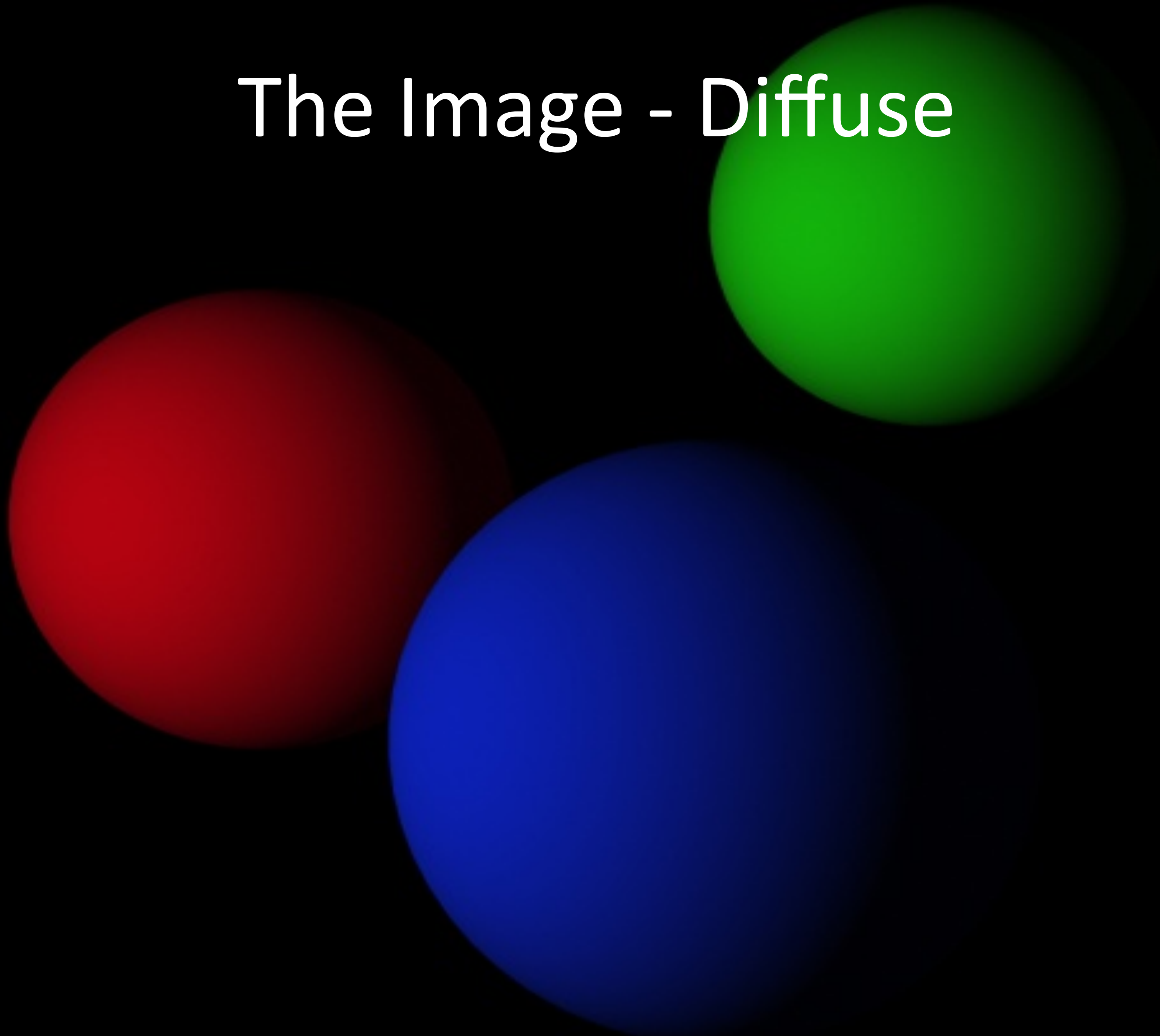
Multiple Lights?

- Light adds linear
- Just add

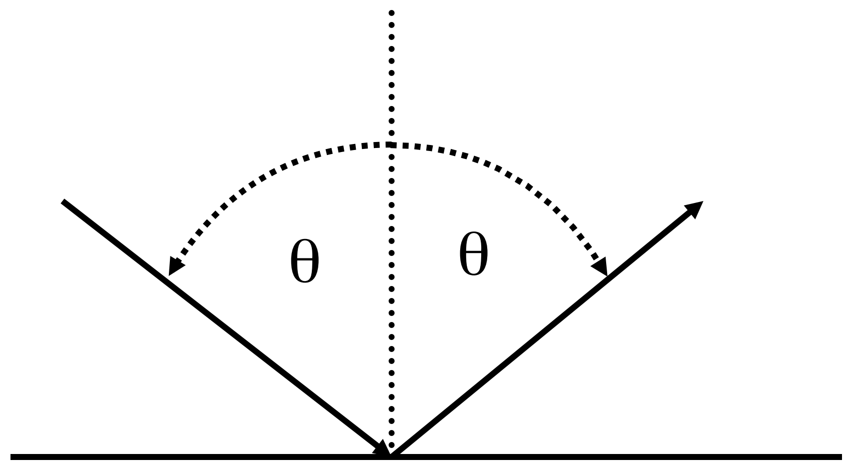
$$I_{\mathrm{r}} = k_{\mathrm{a}} I_{\mathrm{a}} + k_{\mathrm{d}} I_1 < \mathbf{n}, \mathbf{l} >^{+} + k_{\mathrm{d}} I_2 < \mathbf{n}, \mathbf{l} >^{+} + \ldots$$

- We see importance of clamping: Adding without clamping, lights would cancel! Not in this universe

The Image - Diffuse

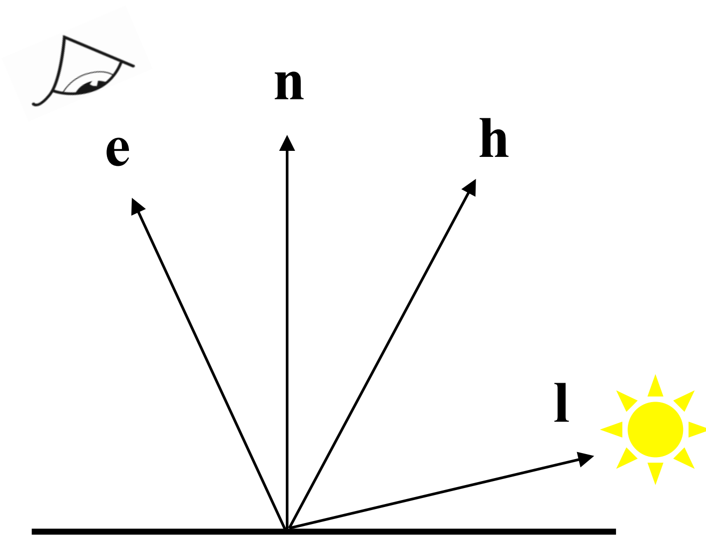


Perfect Specularity



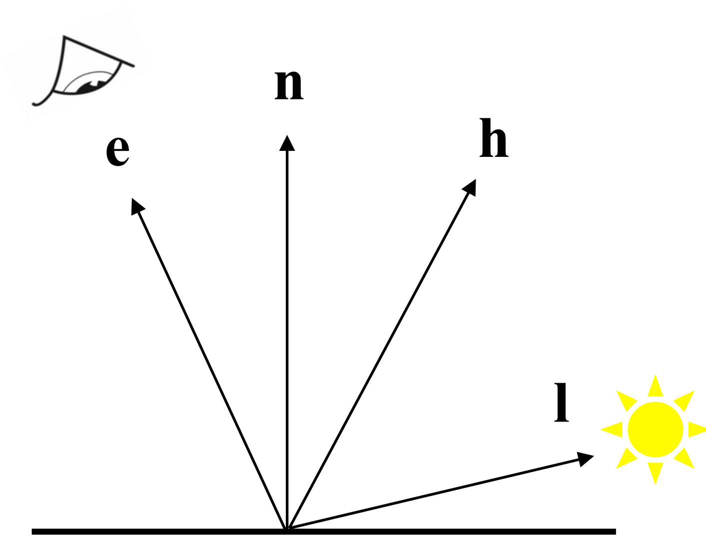
- Would almost never see the specular highlight

Imperfect Specularity (Phong)



- **e** is the direction to the eye
- **n** is the normal
- **l** is the direction to the light
- **h** bisects **e** and **l**

Specular Component

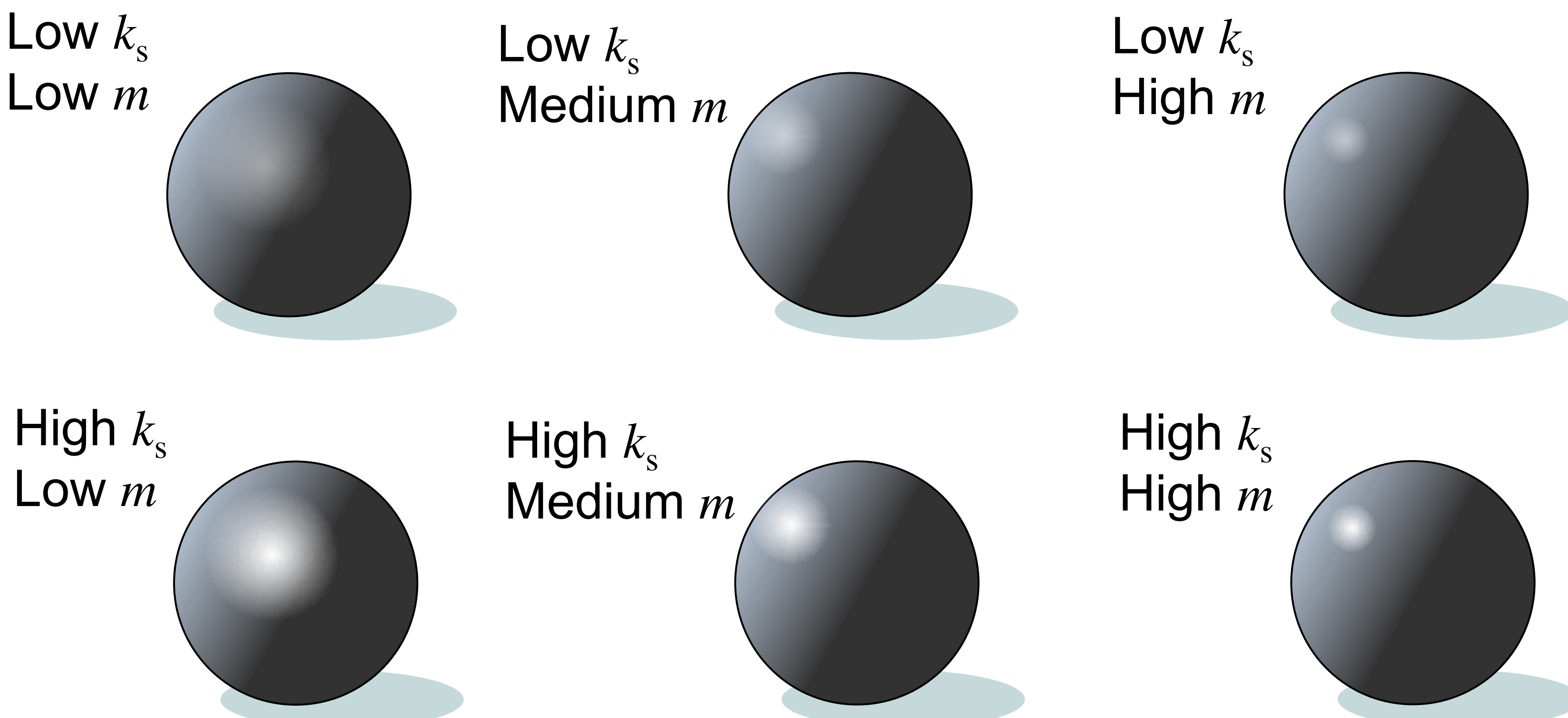


$$k_s I_i \langle \mathbf{h}, \mathbf{n} \rangle^{+m}$$

- m is the power of the light (shininess)
  - High m imply sharp, small highlights
  - Low m imply blurred, large highlights

Specular phenomenology

$$k_{\mathrm{s}} I_{\mathrm{i}} \langle \mathbf{h}, \mathbf{n} \rangle^{m}$$

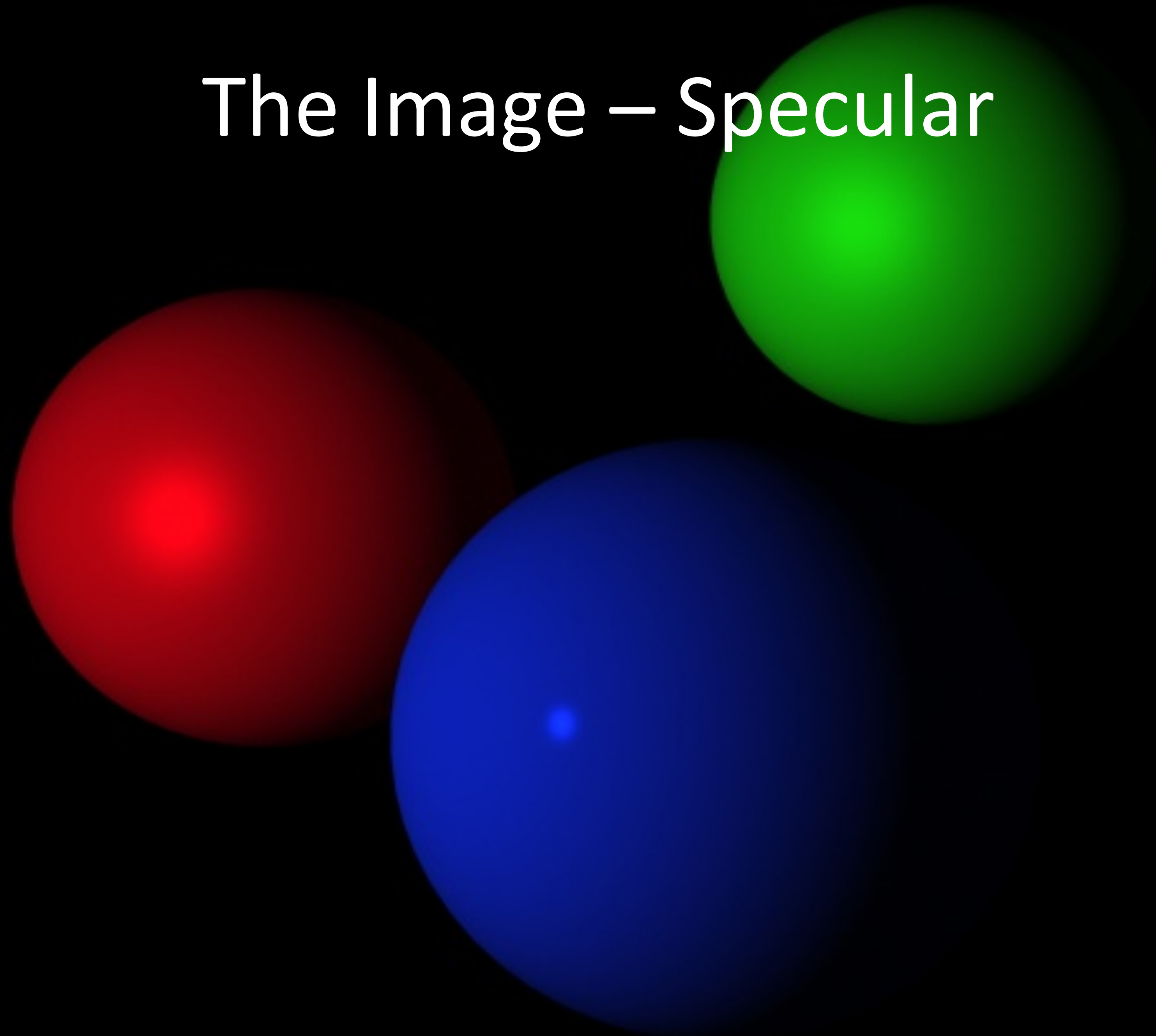


Lighting Equation #3

$$I_{\mathrm{r}} = k_{\mathrm{a}} I_{\mathrm{a}} + I_{\mathrm{i}} \left(k_{\mathrm{d}} < \mathbf{n}, \mathbf{l} >^{+} + k_{\mathrm{s}} (< \mathbf{h}, \mathbf{n} >^{+})^{m}\right)$$

- Ambient, diffuse & specular components
- Again if there are multiple lights there is a sum of the specular and diffuse components for each light

The Image – Specular



Web Page

- Web page for exercises (soon)
- Web page for demos (now)

`cg.cs.ucl.ac.uk`

Conclusions

- We can now colour the pixels by combining
  - Ambient light
  - Diffuse reflections
  - Specular reflections

  Summed over several light sources
- We need
  - Shadows
  - Better model for light reflection of the object: BRDF
  - Global illumination