Computer Graphics (COMP0027) 2022/23

Local Illumination

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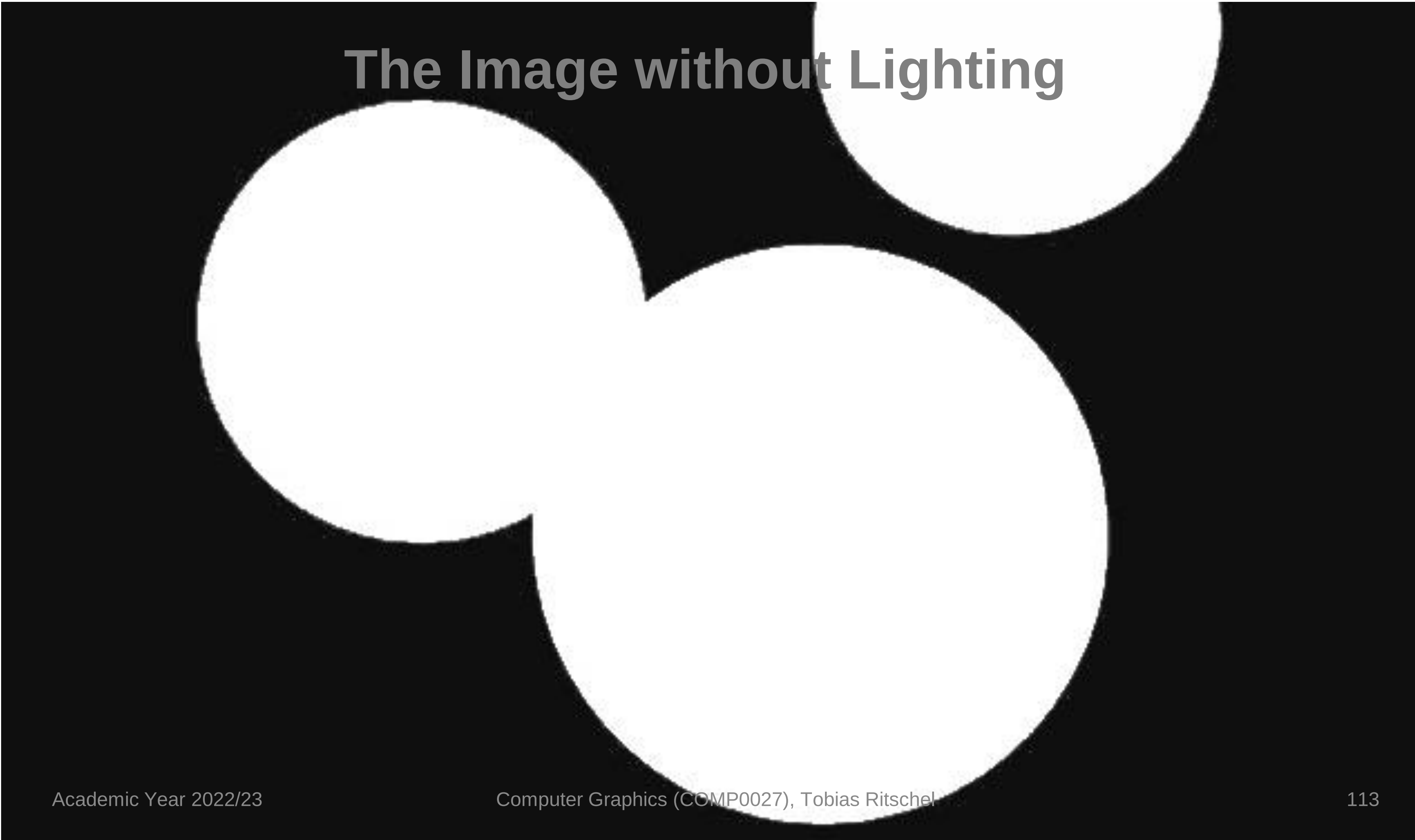
The Image without Lighting



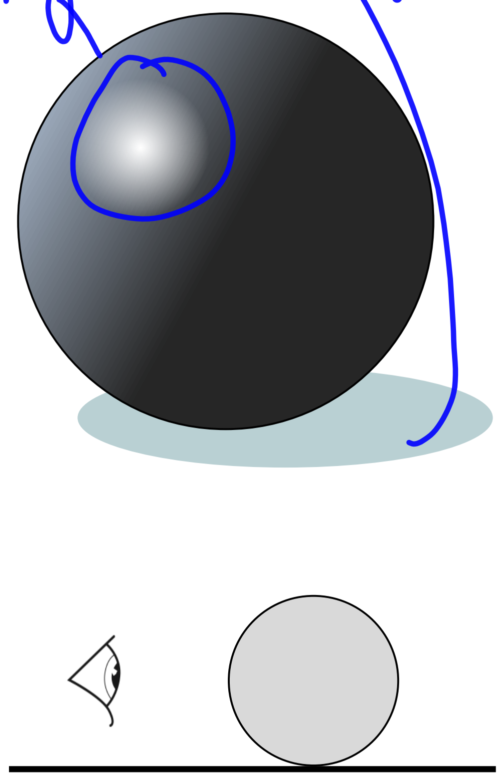
Introduction

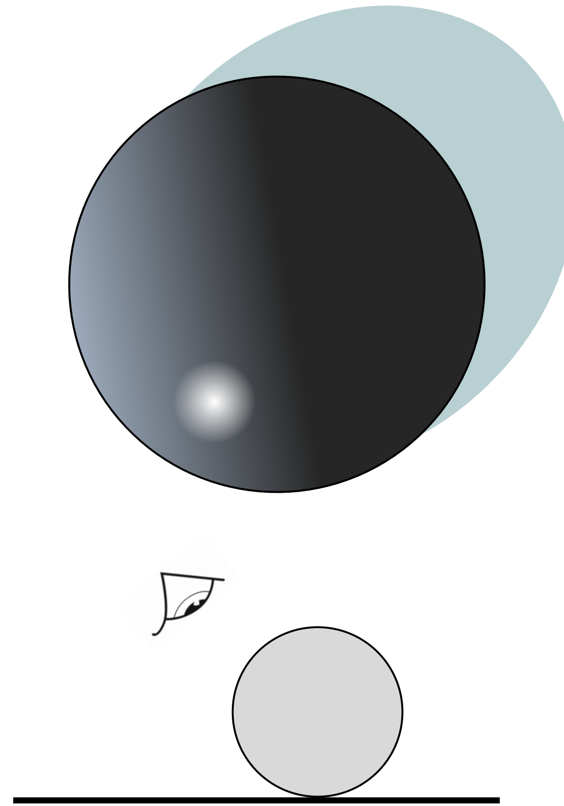
- Local illumination
  - **How a point light and one surface location interact**
  - Valid for ray-tracing and for z buffer (projection)
  - Notation (符号)
    - I_r Intensity radiating from the object (What we’re looking for)
    - I_i Normalized intensity of the light (Characteristic of the light)
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

Visual features

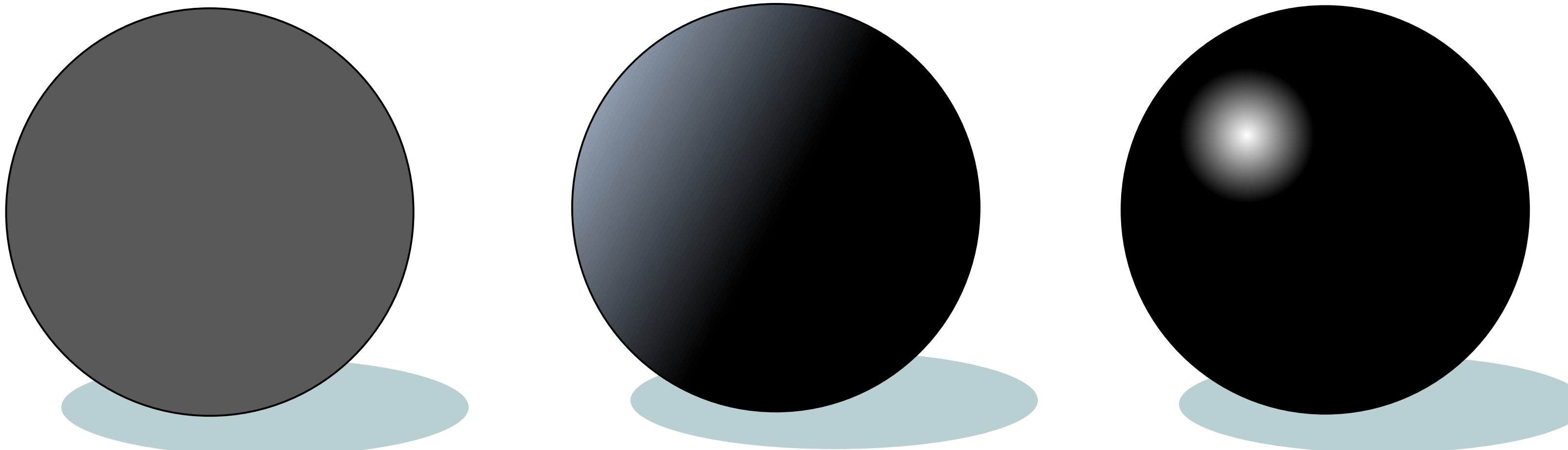
change highlight & shadow

doesn't change





Main idea

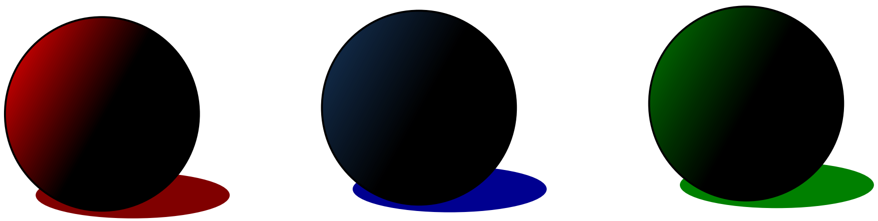


Ambient + Diffuse + Specular

light_pos

Color

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

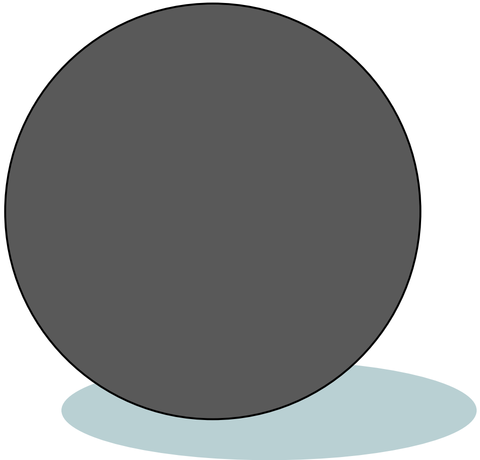


Ambient Light

近似于

- 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

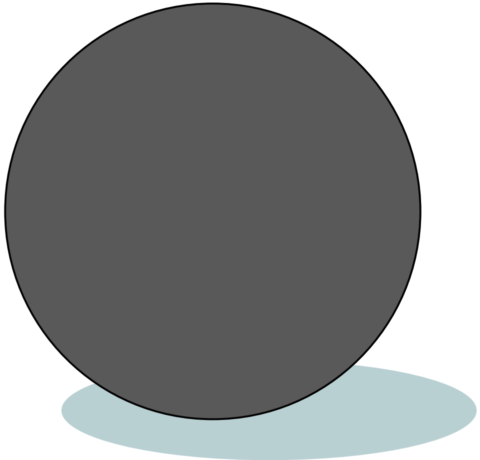


Ambient Light

- Ambient light usually set for whole scene (I_a)
- Each object reflects only a proportion of that (k_a)
- So far then $I_r = k_a I_a$

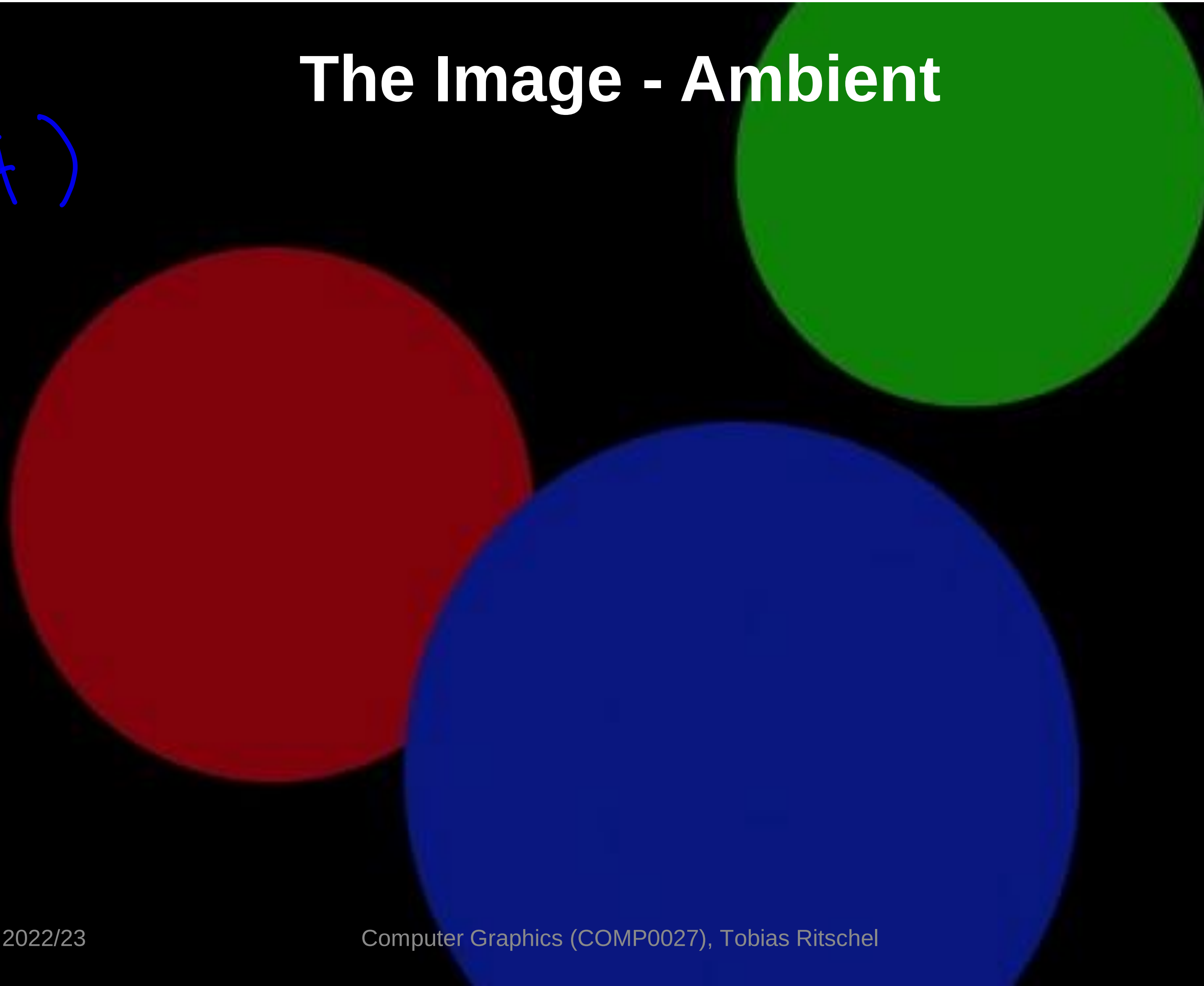
全局

each object



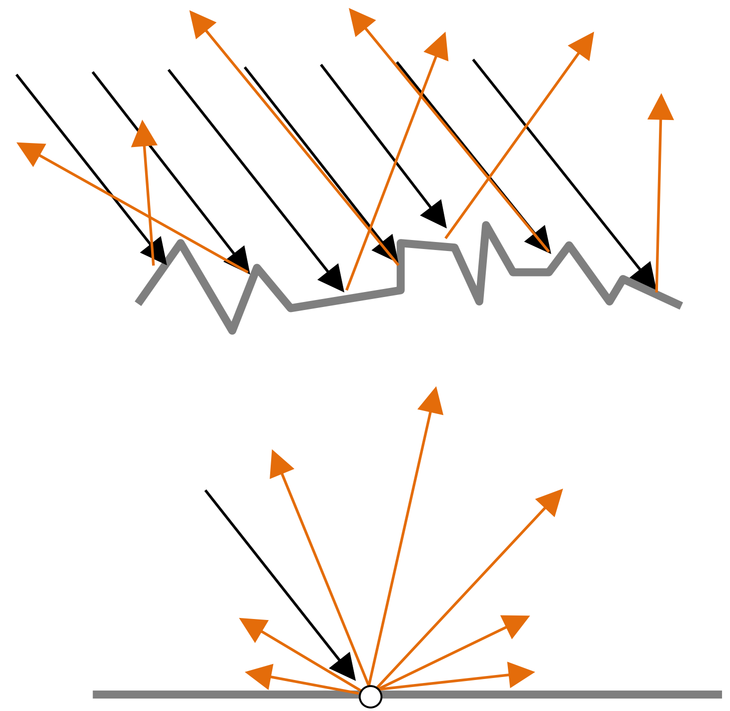
The Image - Ambient

ka
kambient)

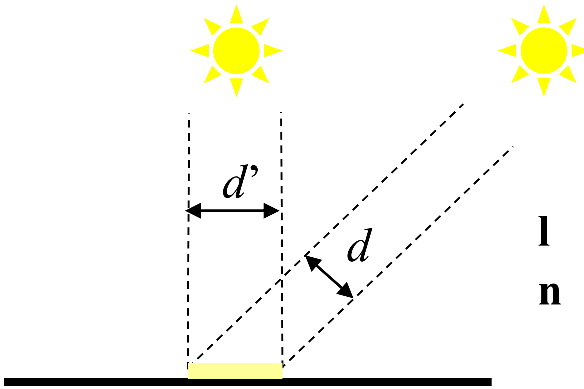


Lambert's Law

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

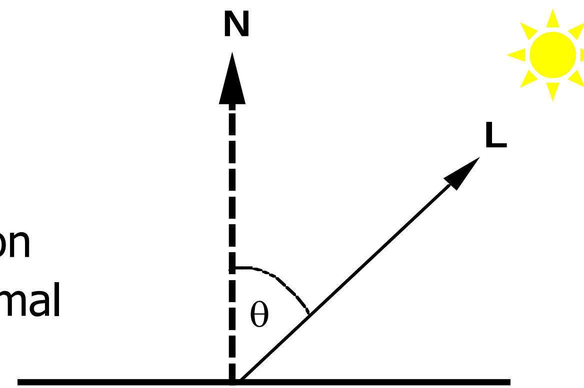


Lambert's Law



l Light direction

n Surface normal



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

正比于

a

d

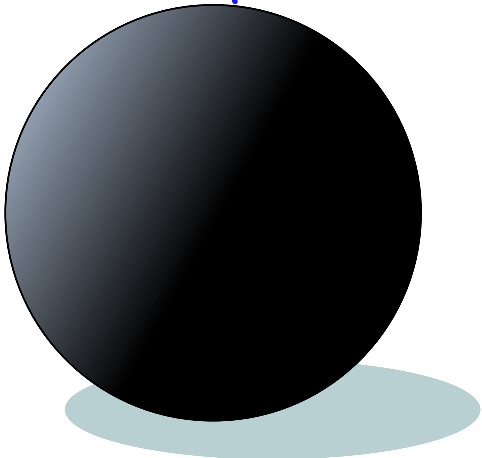
a比b浅 不是
因为 distance

b

d

Diffuse Light

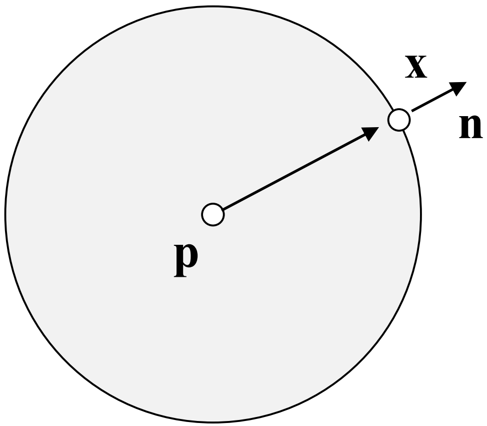
scatter to all directions



- 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

- Ambient and diffuse components k_a and k_a

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

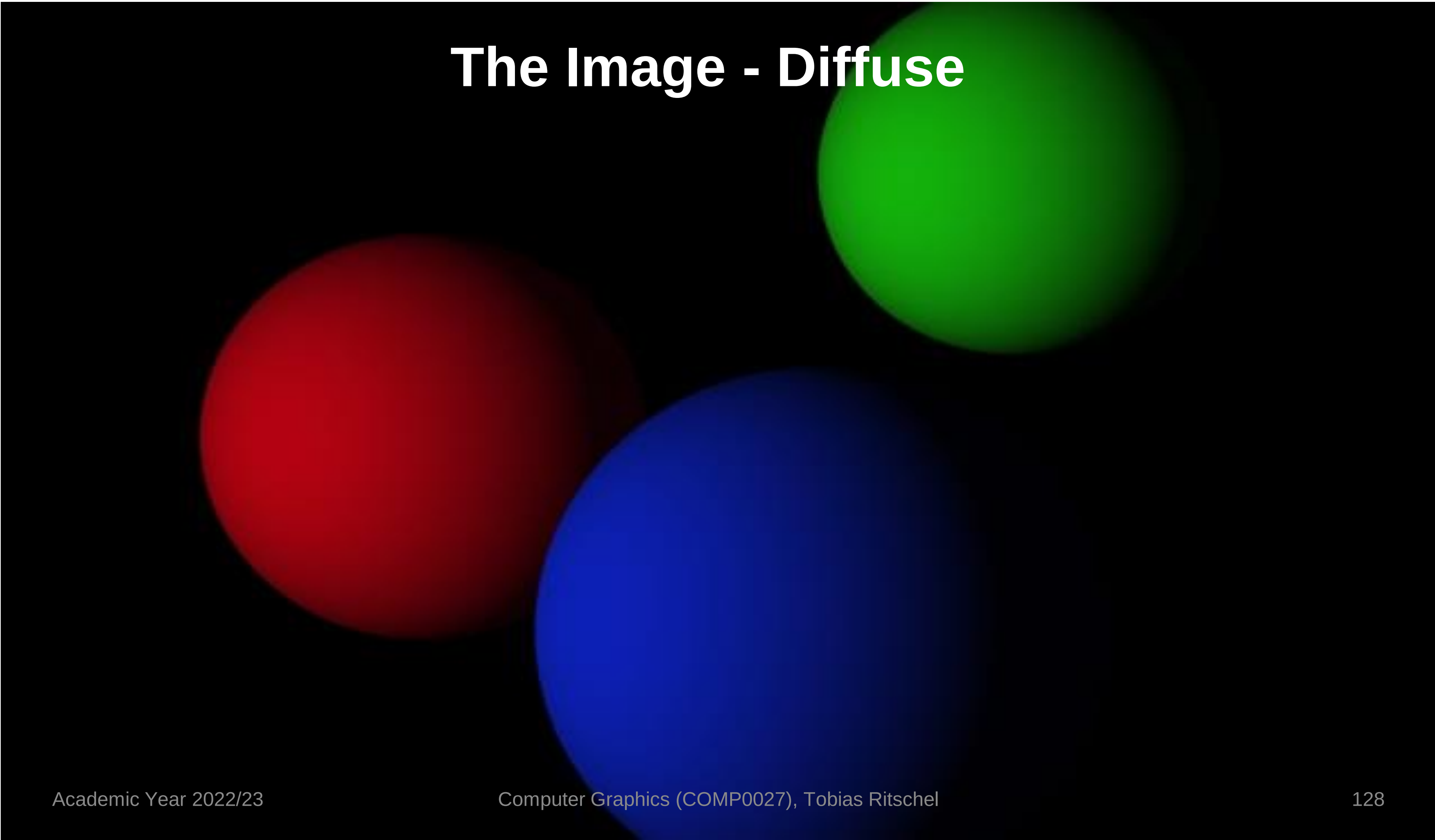
Multiple Lights?

- Light adds linear
- Just add

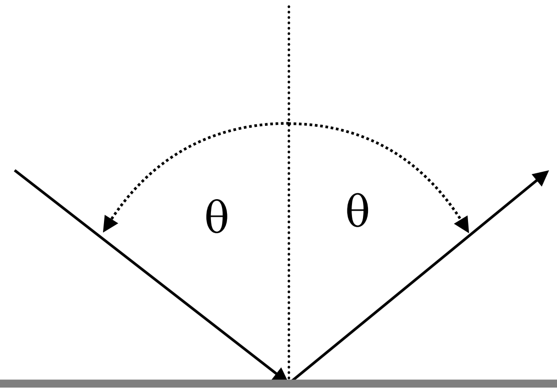
$$
\begin{aligned}
I_r = \quad & k_a I_a + \\
& k_d I_1 <\mathbf{n},\mathbf{l}_1>^+ + \\
& k_d I_2 <\mathbf{n},\mathbf{l}_2>^+ + \\
& \ldots
\end{aligned}
$$

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

The Image - Diffuse



Perfect Specularity (mirror

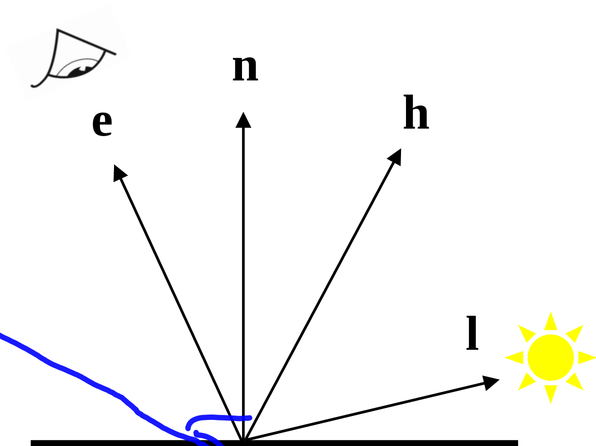


- Would almost **never** see the specular highlight

Imperfect Specularity (Phong)

不是因为方便计算用n.h

和网上不一样



r

n·r

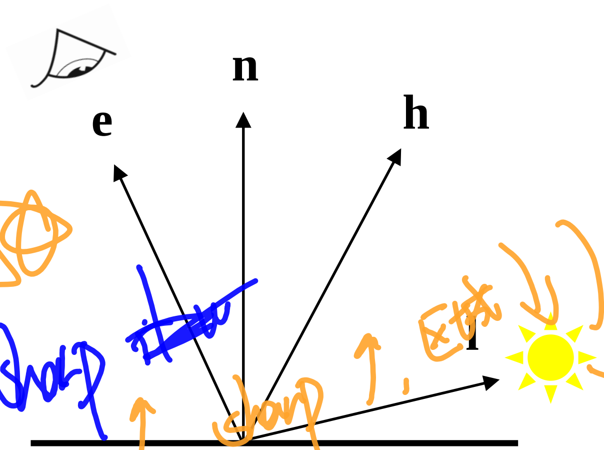
n·h

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

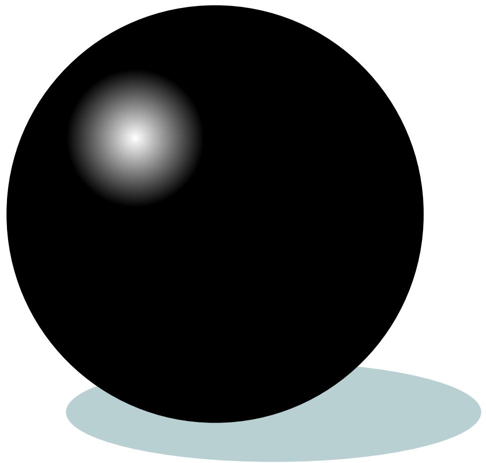
而是：

对10°, n·r 很小，为了让这个也比较大用h.

Specular Component



$$k_s I_i \left(\langle \mathbf{h},\mathbf{n}\rangle^+\right)^m$$



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

how sharp

m ↑, sharp ↑

m

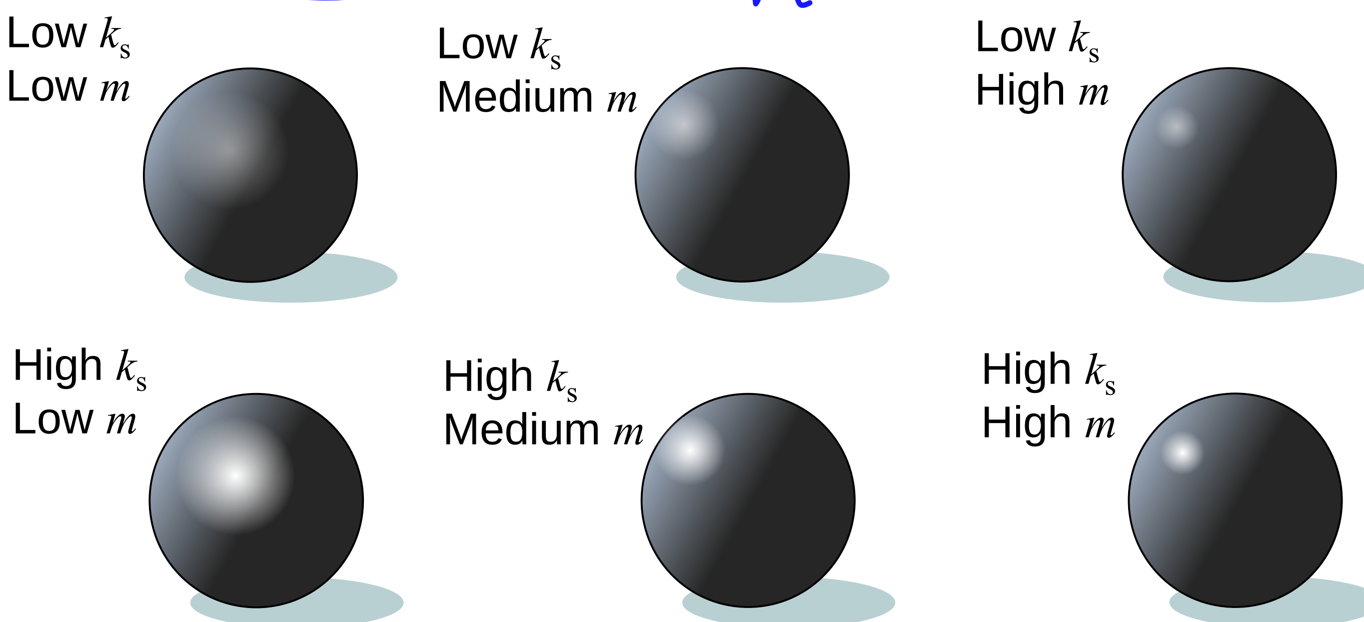
phong

Specular phenomenology

$$k_s I_i <\mathbf{h},\mathbf{n}>^m$$

m

concentrate.



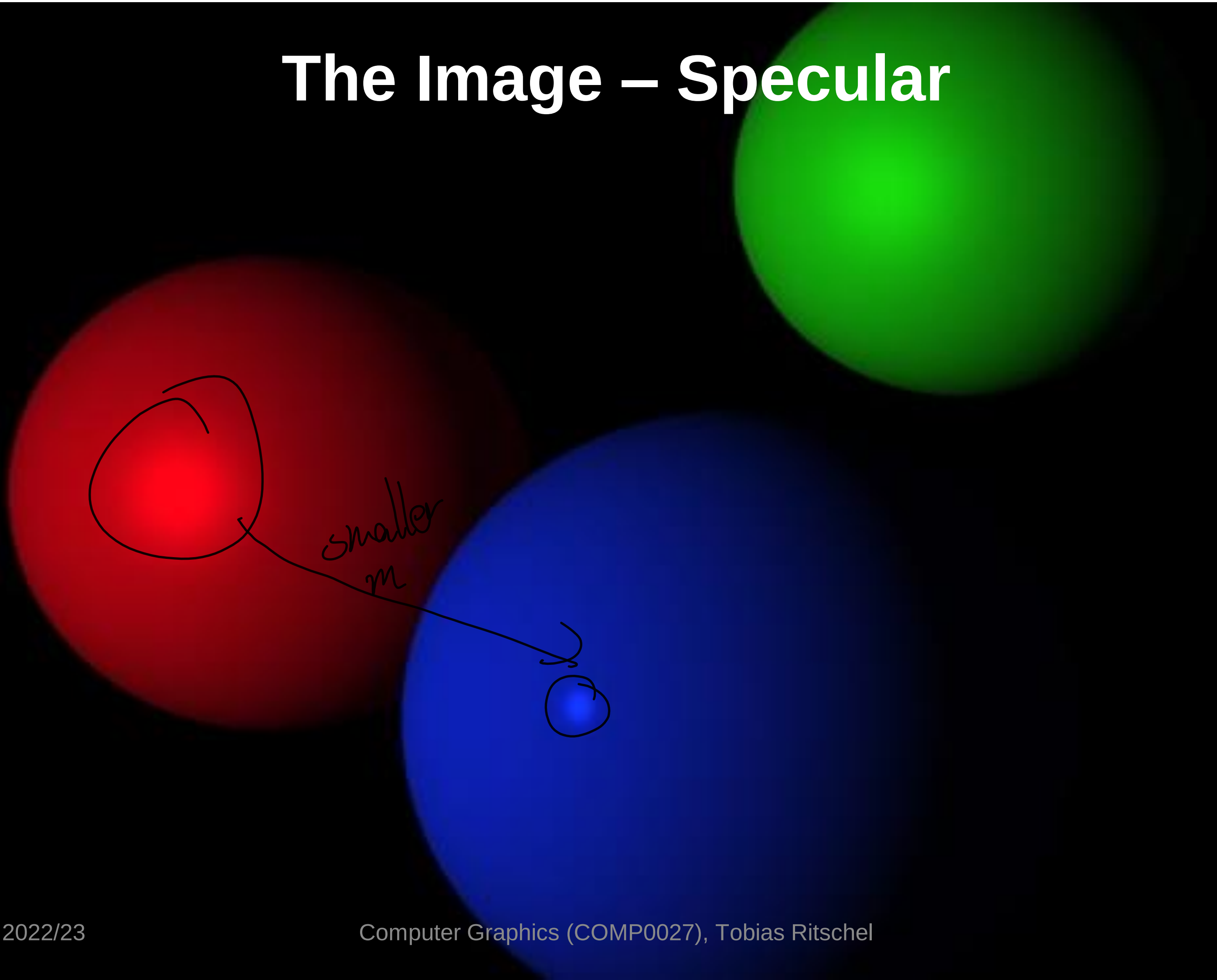
Lighting Equation #3

k 和 each object 有关

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

- 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)

`uclcg.github.io/uclcg/`

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