OF LIGHT

⋮

1.4.4 Luminance

Contrary to the definitions of luminous intensity and illuminance, which are strictly valid for the point light source, the definition of luminance assumes the source of real dimensions.

Luminance (L) in a given direction containing a point M on a luminous or reflecting surface is defined as the ratio of the luminous intensity (dI) in that direction and the projected area (dS_n) of a unit area dS of the surface containing point M (dS_n is the projection of dS on a plane perpendicular to the given direction) – see **Fig. 1.10**. Thus,

$$L = \frac{dI}{dS_n} = \frac{d^2\Phi}{d\omega dS_n}. \quad (1.19)$$

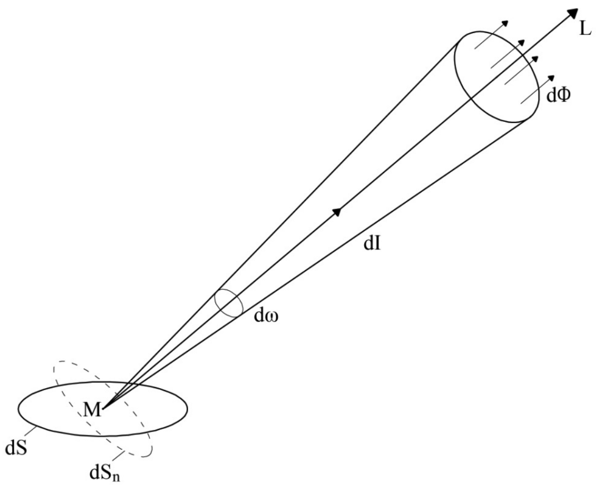

Figure 1.10 Sketch for the definition of luminance

According to **Fig. 1.11**, another formula can also be derived:

$$dE_A = \frac{dI}{r^2} = \frac{L \cdot dS_n}{r^2} = L \cdot d\omega', \quad (1.20)$$

i.e.

$$L = \frac{dE_A}{d\omega'} \quad (1.21)$$

(dE_A is the component of illuminance at point A lying on the observed direction that corresponds to that direction, and ω' the solid angle originating at point A and subtended by dS).

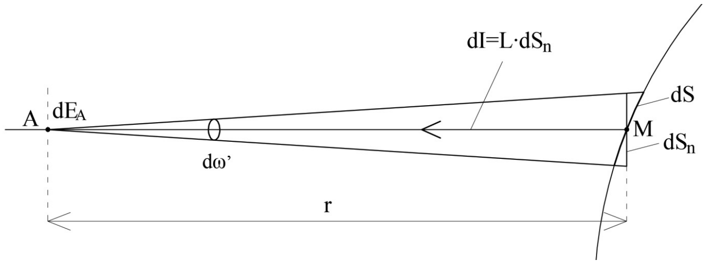

Figure 1.11 Sketch for another definition of luminance

The SI luminance unit is candela per square metre (cd/m^2).

Figure 1.12 shows how the luminance in a given direction, containing the optical centre of a real light source (luminaire), can approximately be calculated under an assumption that the observer is sufficiently distant from the light source, i.e. that the source dimensions are small compared to its distance from the observer. The following formula can be used:

$$L_\gamma = \frac{I_\gamma}{S \cdot \cos\gamma}. \quad (1.22)$$

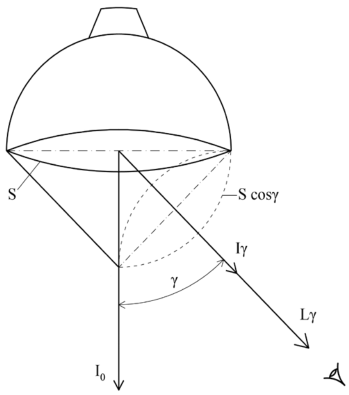

Figure 1.12 Sketch for an approximate calculation of luminance of a real light source (luminaire)

Formula 1.19 and **Fig. 1.10** show that luminance is equal at all points belonging to the considered direction, which was also valid for luminous intensity.

According to **formula 1.22**, small light sources can be characterised by high luminances.

Let us repeat that the definition **formula 1.19** may be applied to calculate the luminance of either luminous or reflecting surfaces.

Sometimes the luminance coefficient is used, defined as the ratio between the surface luminance and its illuminance. It is obvious that it depends on the surface reflection properties and the geometry between the light source, surface and observer (Boyce 2009).

After defining all photometric quantities of light, it can be proved that the intensity of the visual sensation of an object is proportional to its luminance, which is one of the most important facts of the theory of light.

As in Jovanovic (1949), let us consider a very small flat object with a surface S placed normal to the eye axis and viewed by the eye at a solid angle ω (Fig. 1.13). If the object luminance at the eye axis is L and the image of the object covers a certain number of the light sensitive retina's receptors (cones) having an overall surface S_i, the luminous flux reaching the retina can be calculated as:

$$\Phi = S_i \cdot E_i = (1-a) \cdot S_p \cdot E_p, \tag{1.23}$$

where:
E_i – illuminance of the part of the retina covered with the image,
E_p, S_p – illuminance of the pupil and its surface, respectively, and
a – overall absorptance of the eye substances, placed between the pupil and the retina.

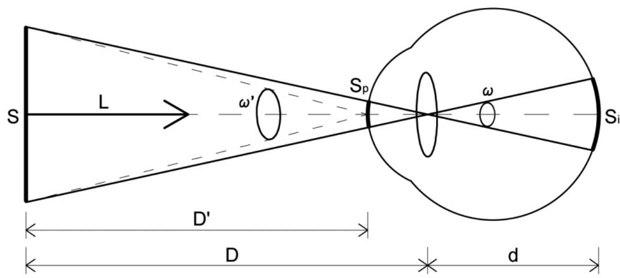

Figure 1.13 A tiny object and its image on the retina

Since the following equation (approximate, but sufficiently accurate) can be derived from formula 1.20:

$$E_p = L\omega' = L\frac{S}{D'^2} \approx L\frac{S}{D^2}, \tag{1.24}$$

the following can be obtained from formula 1.23:

$$\Phi = \frac{(1-a)S_p LS}{D^2} = \frac{(1-a)S_p LS_i}{d^2}, \tag{1.25}$$

i.e.

$$E_i = \frac{\Phi}{S_i} = \frac{(1-a)S_p L}{d^2} = K \cdot L. \tag{1.26}$$

As the factor K has a constant value (it only depends on the eye parameters), it can be concluded that the illuminance of the image is proportional to the luminance of the observed object. On the other hand, the luminous flux density on the cones covered by the image, representing the image illuminance E_i, is a measure of the intensity of the visual impression. Therefore, the intensity of the visual sensation is proportional to the luminance of the observed object.