# Scattering aerosol effect about colour and range
# Angström's law

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## Scattering aerosol calculate

The night, light attenuation is principally due to aerosol scattering effect (=Mie scattering). For visibility smaller than 25M, molecular scattering (=Rayleigh scattering) is a lot less important than aerosol scattering. In visible spectrum, absorption phenomenon is insignificant.

Scattering aerosol is due principally to marine aerosol (water droplet and NaCl crystals), urban aerosol (city dwellers) and rural aerosol. Without experimental measures, Angström's law is a good approximation of the atmospheric extinction coefficient (compromise between the different aerosols).

In Allard law :

$E = \frac{1}{D^2} \int I(\lambda) \times e^{-zD}$ with z the extinction coefficient $z = \frac{3}{V}$

=> $E = \frac{1}{D^2} \int I(\lambda) \times 0.05^{\frac{D}{V}} d(\lambda)$

=> $E = \frac{1}{D^2} I \times 0.05^{\frac{D}{V}}$ *(Allard formula)*

In Angström law :

z the extinction coefficient $z = \frac{3}{V} \left(\frac{\lambda}{550}\right)^{-1.3}$ *(Angström formula)*

for V>2000m, V in meters and λ in nm

=> $E = \frac{1}{D^2} \int I(\lambda) \times 0.05^{\frac{D}{V}\left(\frac{\lambda}{550}\right)^{-1.3}}$ *(modified Allard formula)*

With the modified Allard formula we can see that:

- colour of light changes with distance of observation (visibility)
- range depend of type and colour of light

## Colours shift

Colour of one light will seem to be different when distance of observation increases (or visibility decreases). Short wavelengths are scattered (blue and green), long wavelengths become predominant.

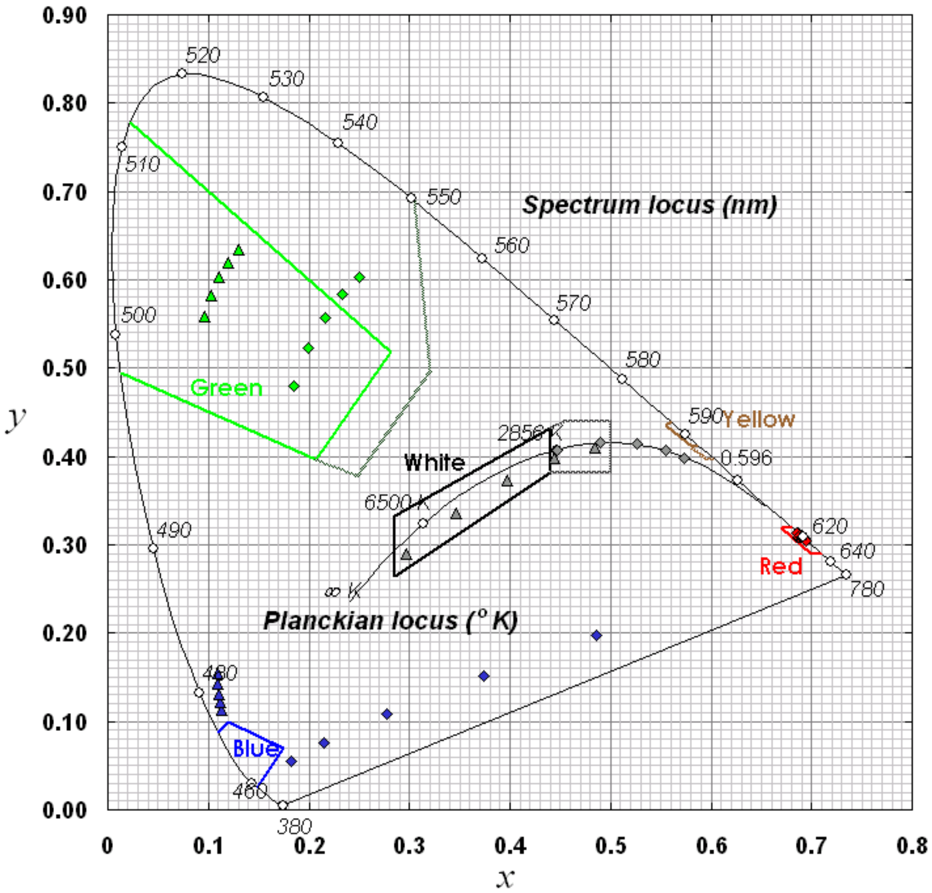


*Figure 1 : Colours shift with distance of observation (triangle : LED, diamond : halogen lamp) - CIE 1931*

► Blue light :

Scattering effect are the most important for blue. In case of halogen lamp, red part of the light becomes more important. In case of LED, spectral distribution is narrow. We have a quick attenuation of light but a little colour shift.

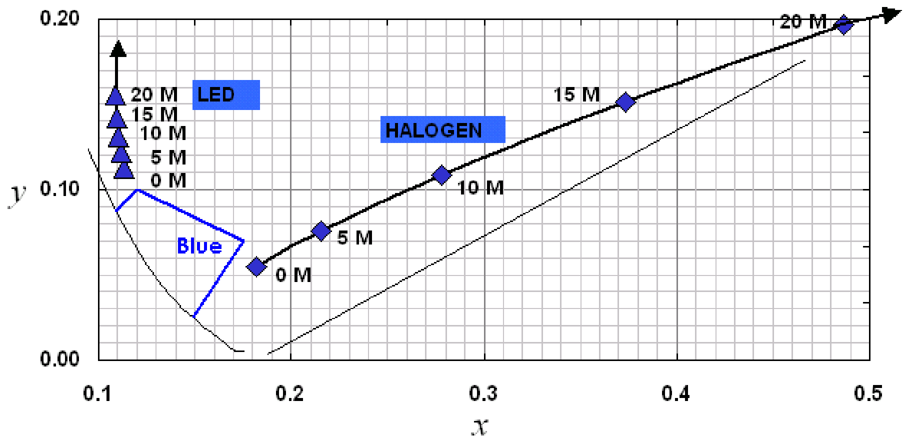


*Figure 2 : Blue light colour shift with distance of observation (triangle : LED, diamond : halogen lamp) - CIE 1931*

► Green light :

Scattering effect are important for green. In case of halogen lamp, yellow part of the light becomes more important, but no risk of confusion. In case of LED, spectral distribution is narrow. We have a quick attenuation of light but a little colour shift.

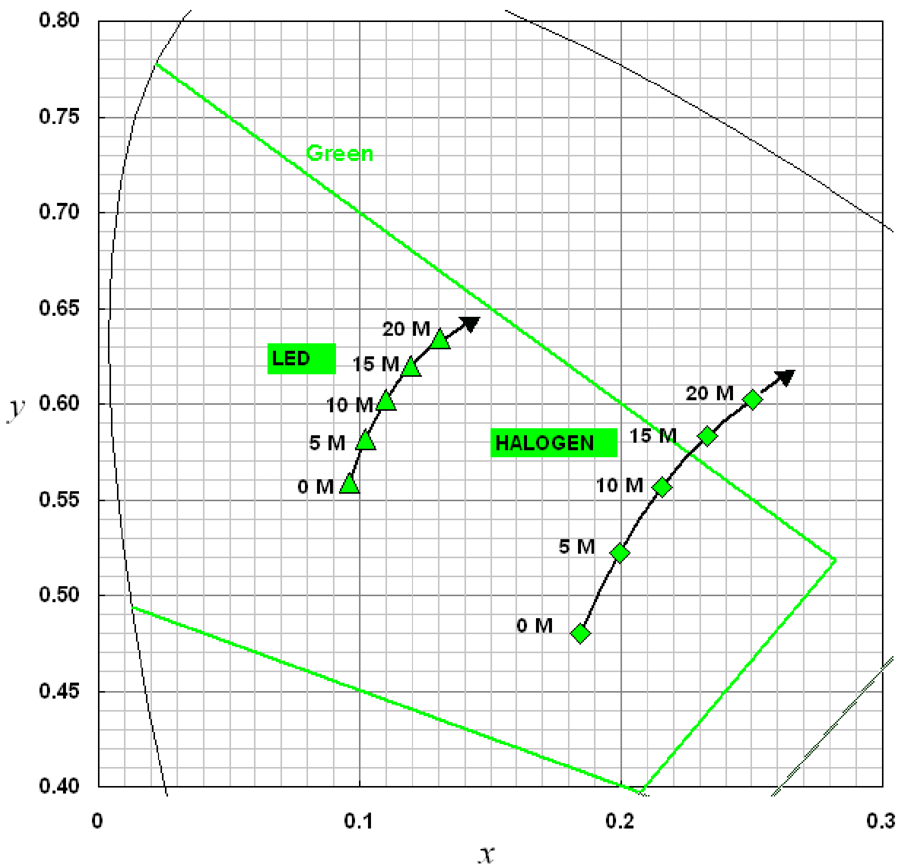


*Figure 3 : Green light colour shift with distance of observation (triangle : LED, diamond : halogen lamp) - CIE 1931*

► White light :

In case of halogen lamp, yellow/red part of the light becomes more important, with risk of confusion with yellow. In case of LED, we have a quick attenuation of blue part and yellow part becomes more important, but no risk of confusion.

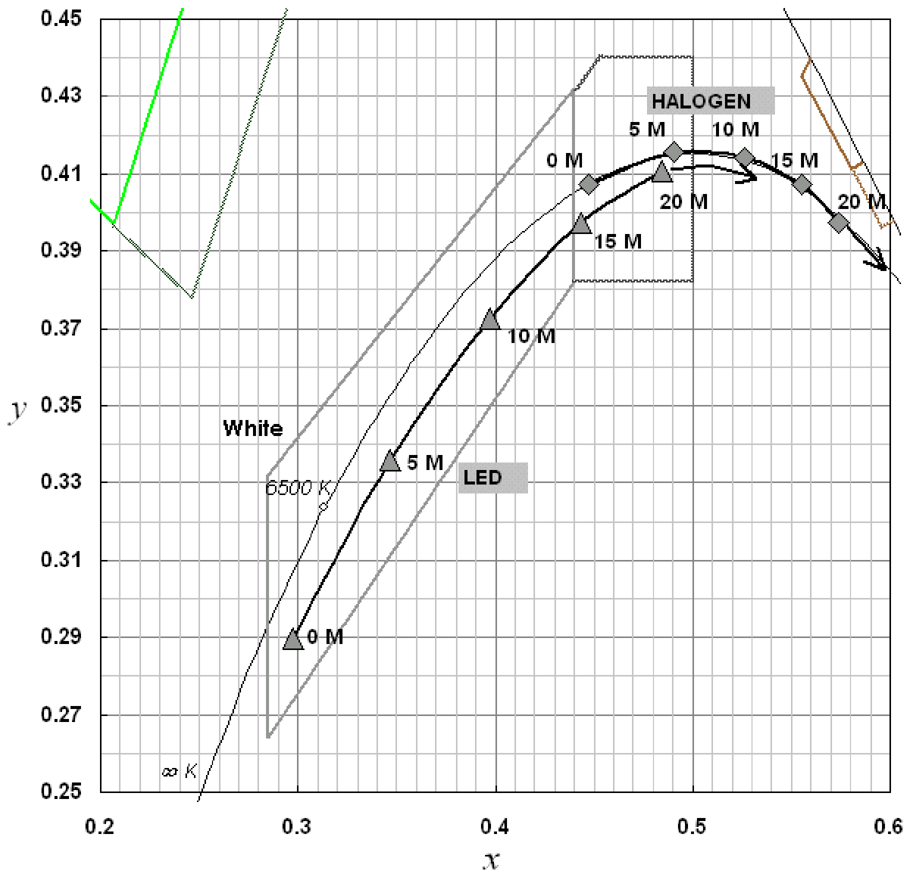


*Figure 4 : White light colour shift with distance of observation (triangle : LED, diamond : halogen lamp) - CIE 1931*

► Red light :

Scattering effect are the least important for red, with a little colour shift.

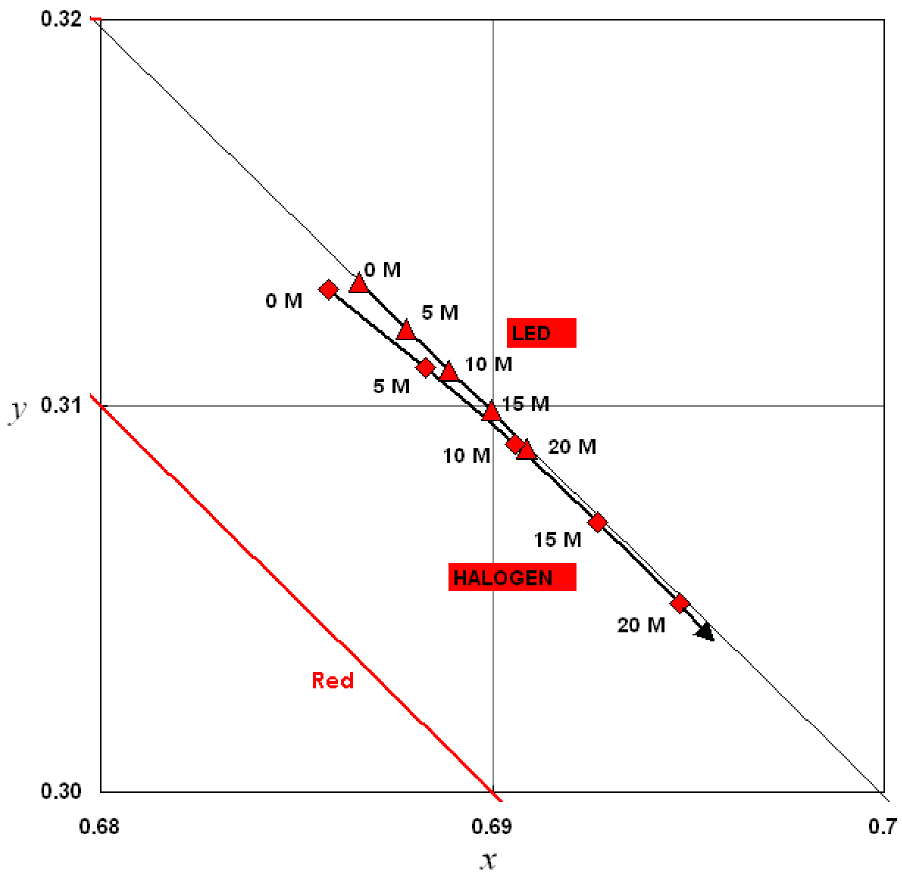


*Figure 5 : Red light colour shift with distance of observation (triangle : LED, diamond : halogen lamp) - CIE 1931*

## Range

IALA recommendation doesn't make difference between colours for calculation of luminous intensity necessary for a range.

Because scattering effect is more important for short wavelength and less important for long wavelength, we could reduce luminous intensity for red and white light and we should increase luminous intensity for green and blue light. Tendency is more important for long range and short visibility.

For example, at 10M visibility for a range of 20M, we could reduce luminous intensity of 60% in red, 32% in white, and we should increase luminous intensity of 22% in green.

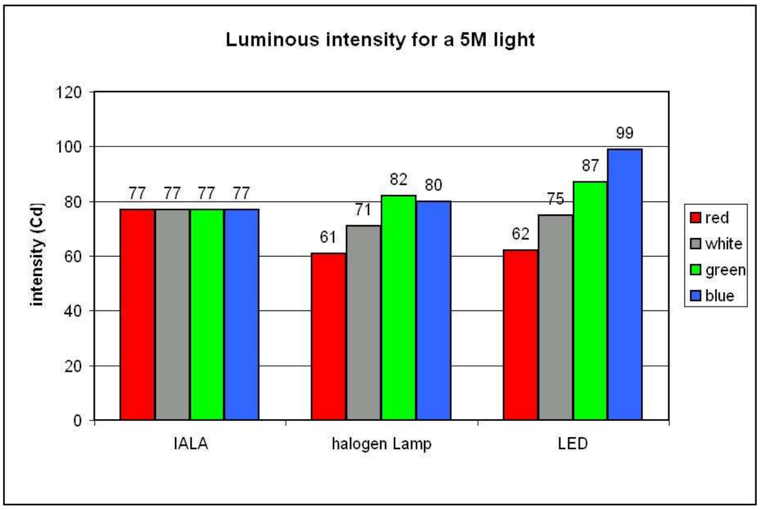


*Figure 6 : Luminous intensity of a 5M light (IALA Allard law and modified Allard law for halogen lamp and LED)*

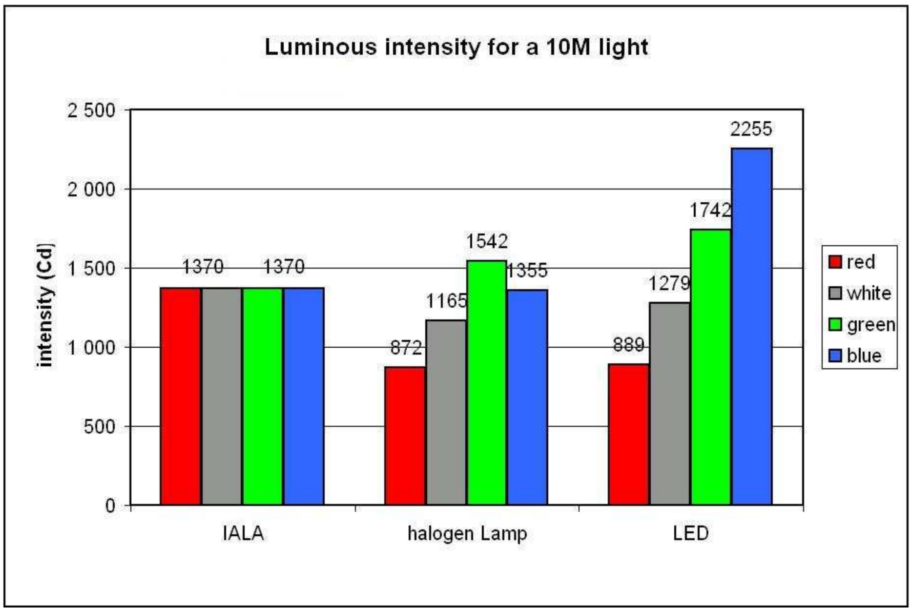


*Figure 7 : Luminous intensity of a 10M light (IALA Allard law and modified Allard law for halogen lamp and LED)*

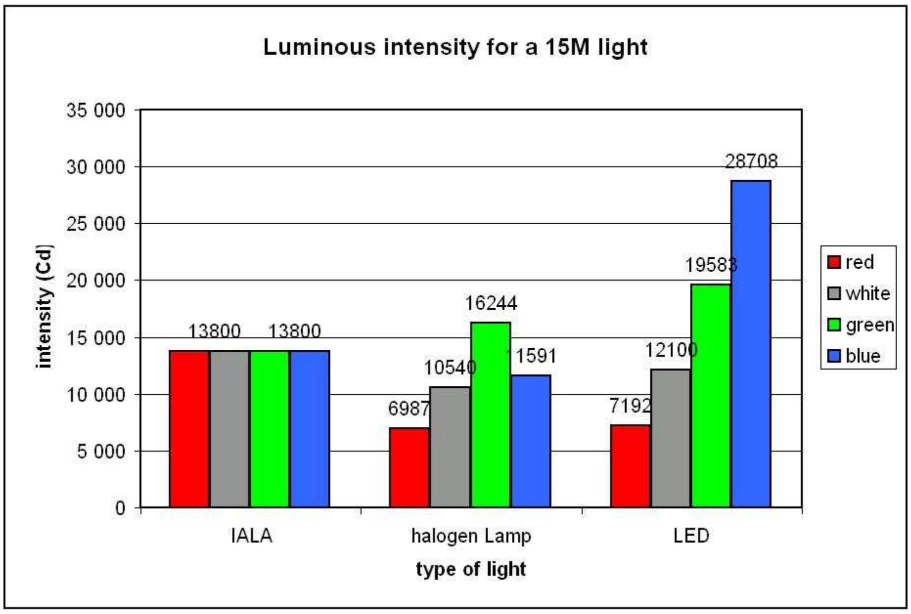


*Figure 8 : Luminous intensity of a 15M light (IALA Allard law and modified Allard law for halogen lamp and LED)*

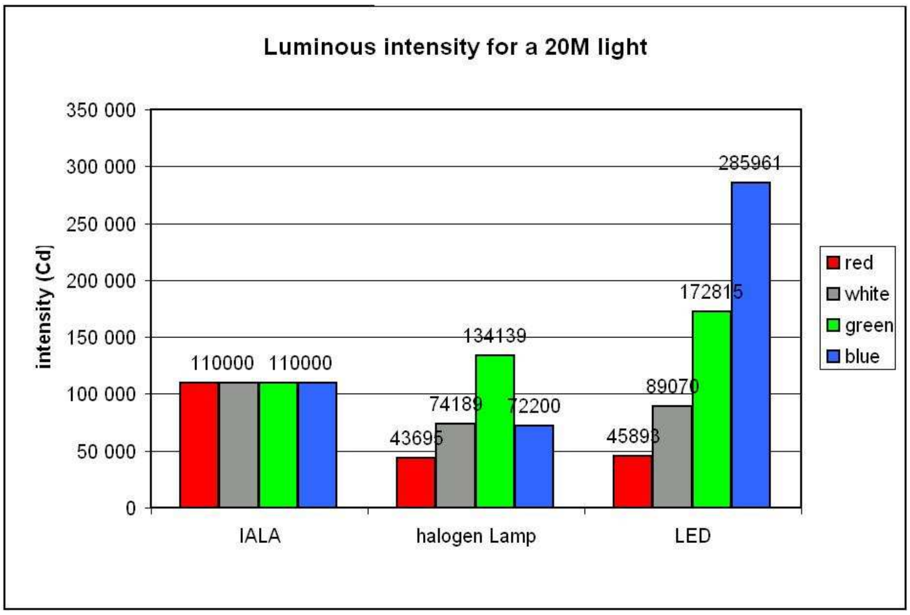


*Figure 9 : Luminous intensity of a 20M light (IALA Allard law and modified Allard law for halogen lamp and LED)*