More Than Meets The Eye

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IR Thermal & Blue Light Hazard

Dr. O. Lischtschenko, OceanOptics BV

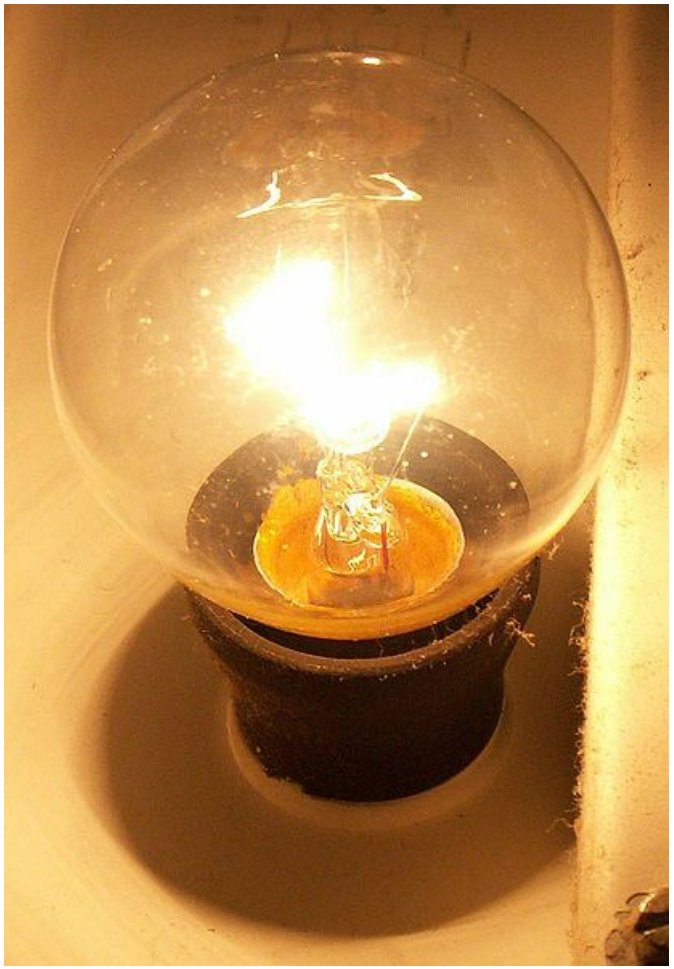
Welcome to the 24/7/365 Society

- The society that never sleeps!

→ People start to sleep insufficiently

- Some studies say that in industrialized nations 40% of the people do not sleep enough

Reasons For Not Sleeping Enough



Some Aspects On Lighting In General

- 19% of the world electricity consumption is used for lighting
- Many governments are phasing out incandescent light bulbs
- Compact fluorescent lamps contain mercury (health risk)
- Solid-state light emitting diodes (LEDs) gain wide spread use in
  - General lighting
  - Specialized lighting
  - Televisions
  - Computer screens
  - Laptops / Tablets
  - Hand-held devices

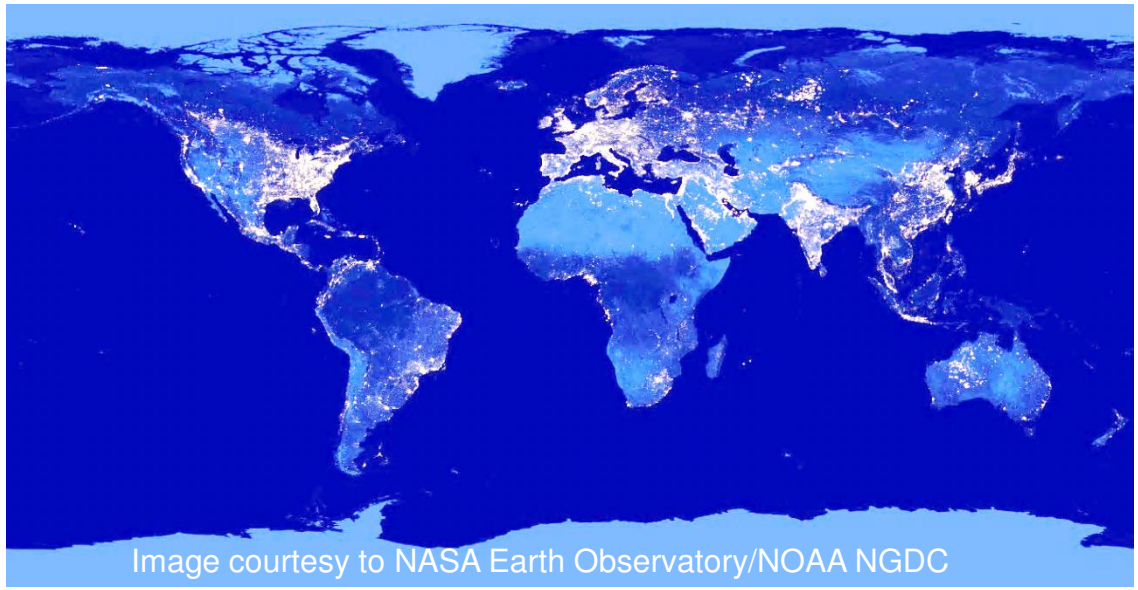
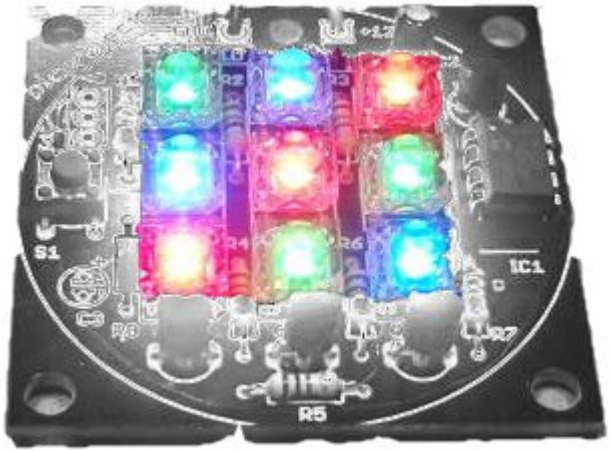


Image courtesy to NASA Earth Observatory/NOAA NGDC

- Influence on Humans ?

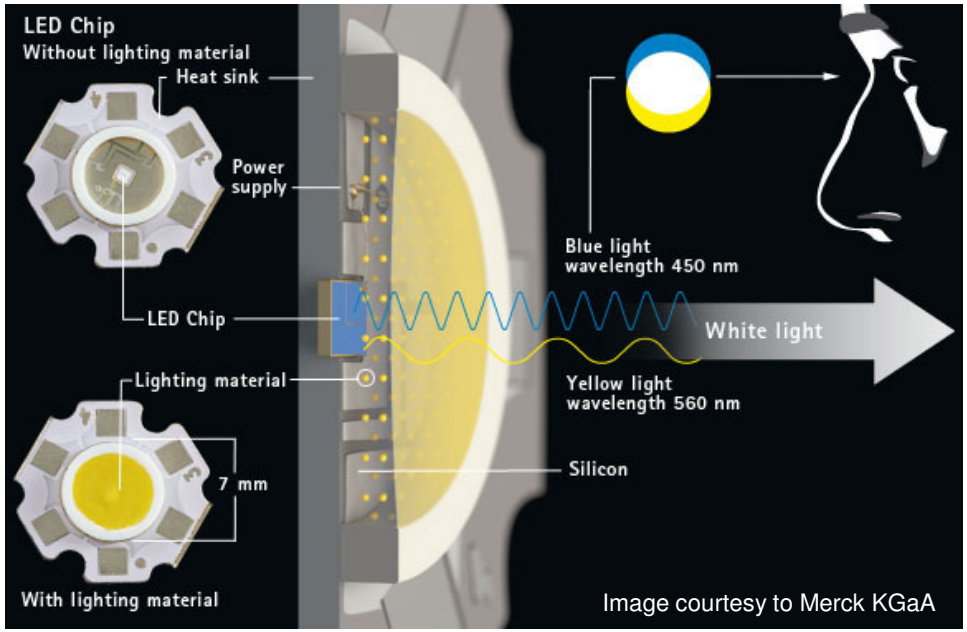
LED Technologies to Generate White Light

Color Mixing



- RGB & other individual colors
- Highest potential efficiency
  - Limited by green efficiency (green gap)
- More cost restrictive than pcLEDs

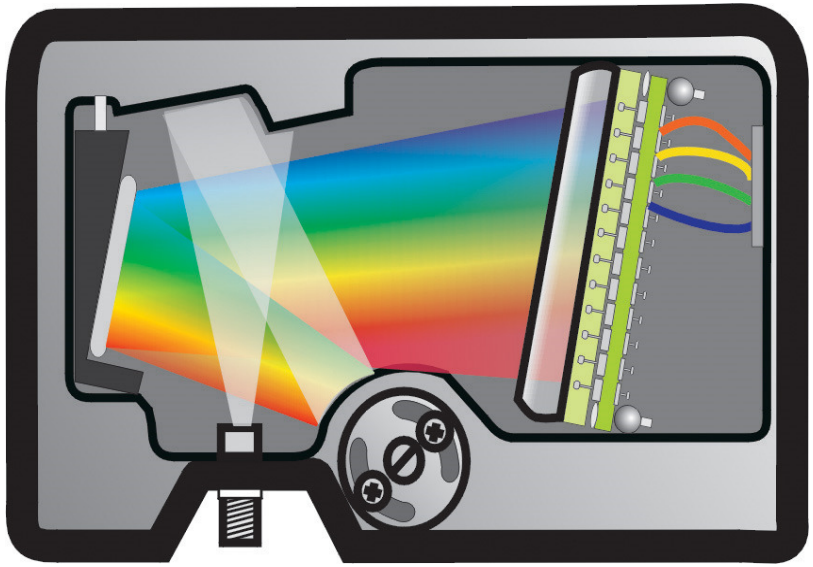
Phosphor Conversion

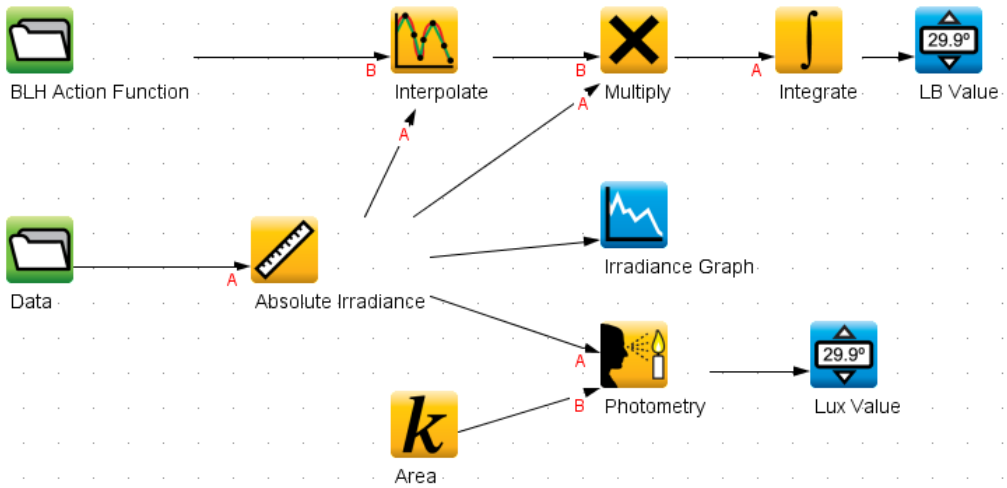


- Phosphors & quantum dots
- Relatively low cost
- Technical challenges
  - Stokes loss

Want To Measure Light – Meet The Spectrometer

- Wavelength dependent measurements are crucial in the assessment of light sources
- Absolute irradiance calibration is a requirement
  - Optimum calibration is according to EN 17025
- Rest is number-crunching in software
  - Photometry (Lux, …)
  - Blue Light Hazard
  - IR Hazard
  - …





The Eye – A Dual-Function Organ

- rods and cones enable sight (Primary Optic Tract)
- intrinsically photosensitive retinal ganglion cells (ipRGCs) enable pupillary light responses, photic resetting the circadian clock, …

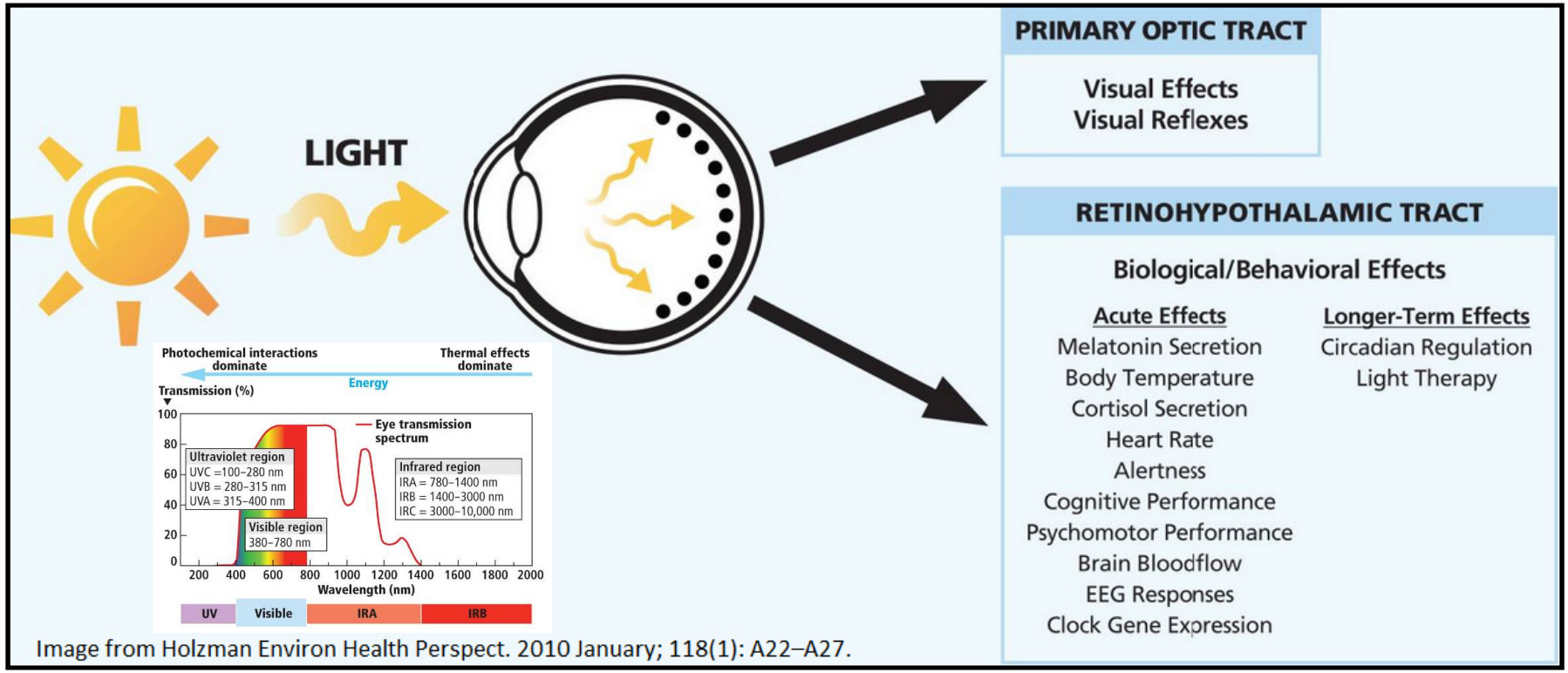
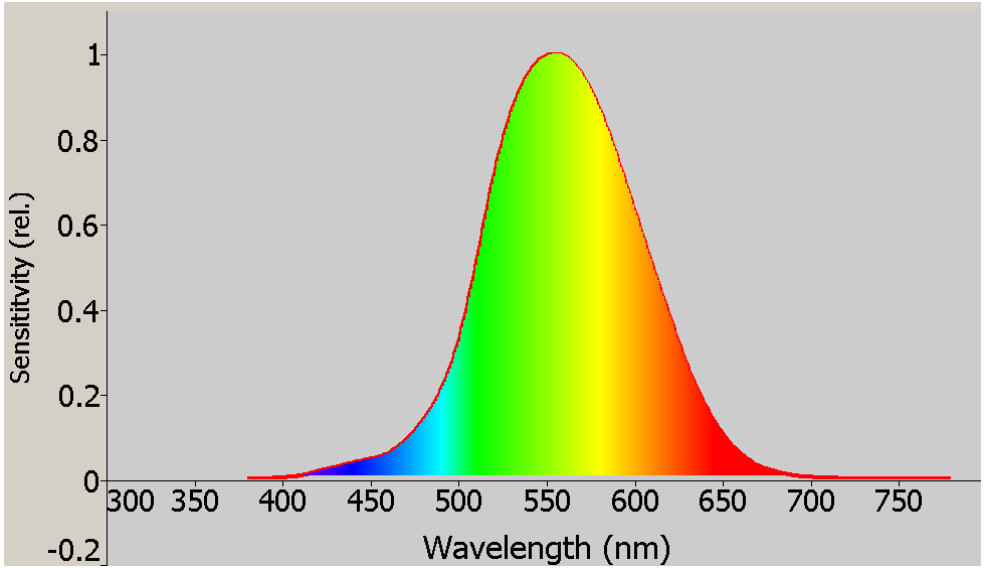
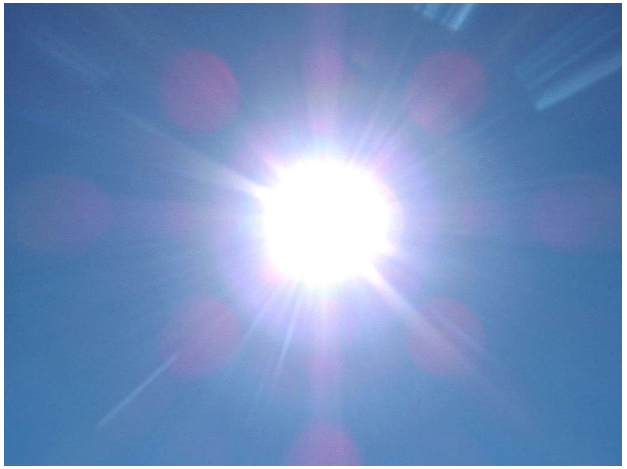


Image from Holzman Environ Health Perspect. 2010 January; 118(1): A22–A27.

Classical Photometry

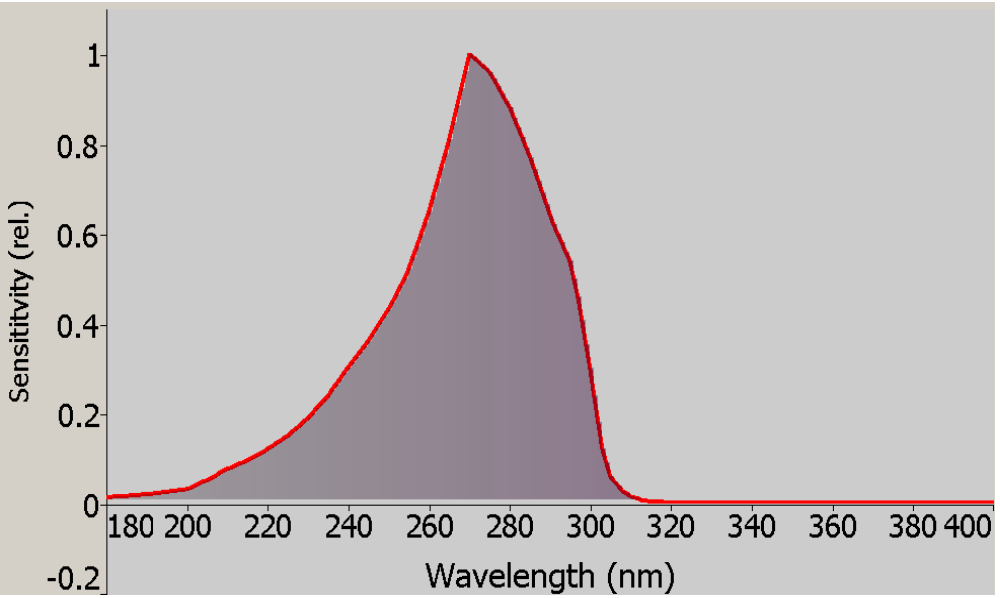
- Radiometric measurement
- Weighting with action function V(λ) (= $\bar{y}$)
- Photometric quantities
  - Irradiance
- Determine visual brightness





UV radiation hazard

- Weighting done similar to computing V(λ)-weighted values
- UV radiation hazard - S(λ)
- $$H_{eff} = \int_{180\ nm}^{400\ nm} H_{\lambda}(\lambda) \cdot S(\lambda) \cdot d\lambda$$
- Working day (8h) limit not to be exceeded: 30 J/m²
- Yearly limit: 4000 J/m²
- This guideline is also used to prevent skin damage
- Not an issue w/ LED lighting

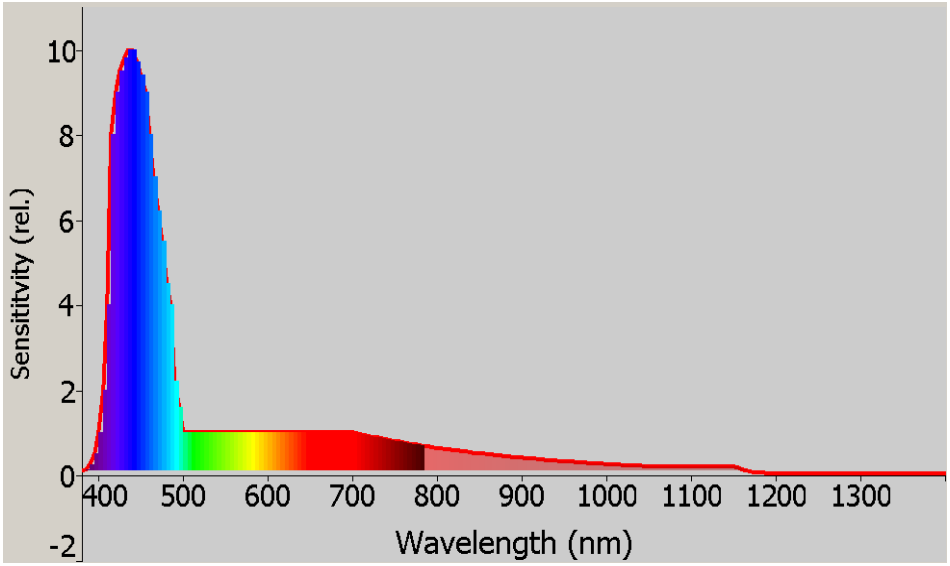


Retinal Thermal Hazard

- Action function - R(λ)
- Defined in EN 62471

$$L_R = \int_{380nm}^{1400nm} L_\lambda(\lambda) \cdot R(\lambda) d\lambda$$

- Limit: $2.8*10^4/C_\alpha$ W/cm²/sr
- Important for incandescent or FL light sources
- Not an issue with LEDs in general lighting conditions
- May apply in specialized applications (plant light)



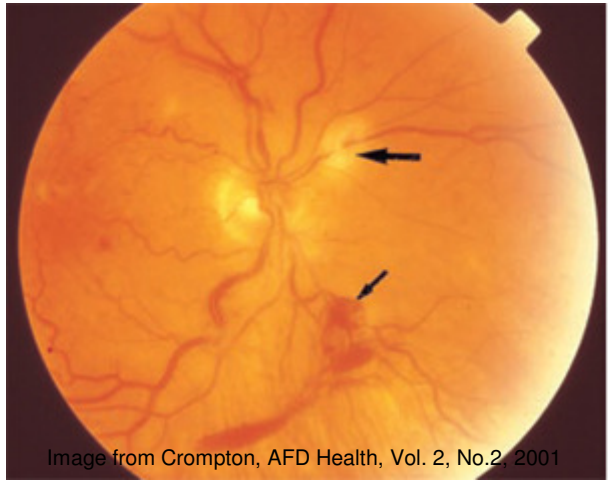
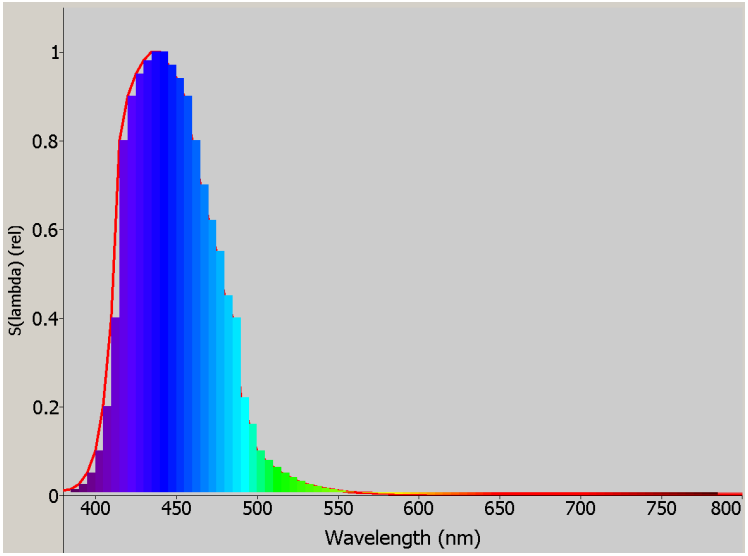


Image from Crompton, AFD Health, Vol. 2, No.2, 2001

Blue Light Hazard – 400-500nm

- Blue light photochemical hazard action function - B(λ)
- Defined in EN 62471
- $L_B = \int_{380nm}^{600nm} L_\lambda(\lambda) \cdot B(\lambda) \cdot d\lambda$
- Working day (8 h) limit:
  - $10^6/t$ W/m²/sr (α≥ 0,011 rad)
  - 100/t W/m² (α< 0,011 rad)
- Introduce L_B/Lux as index for relative blue light fraction



The Eye Evolving

- The Human Eye changes its transmission characteristic with age
- At birth: highly blue transmissive
- With aging the eye becomes more and more a “yellow” filter
- Scotopic vision reduction
  - By 33% (53 years)
  - By 75% (75 years)

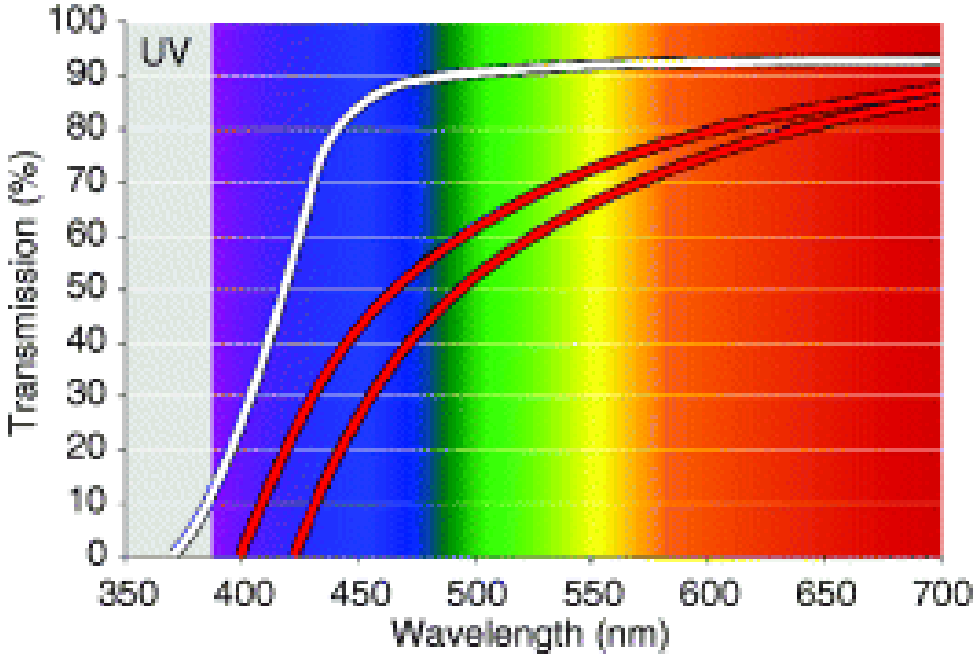
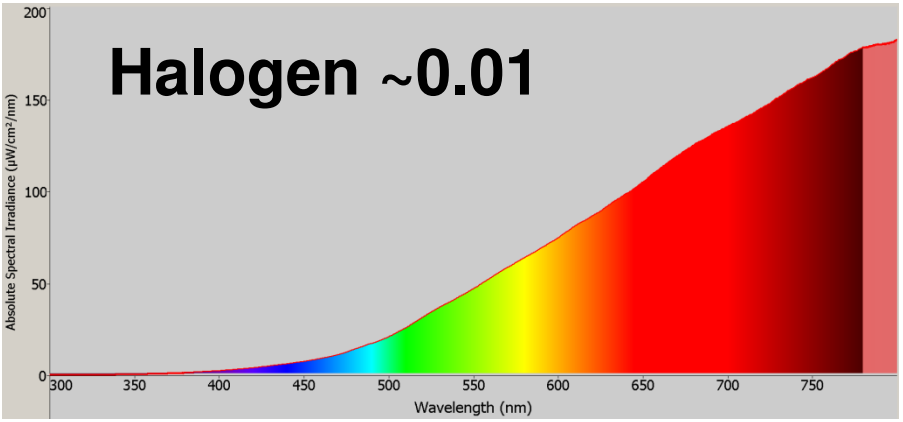
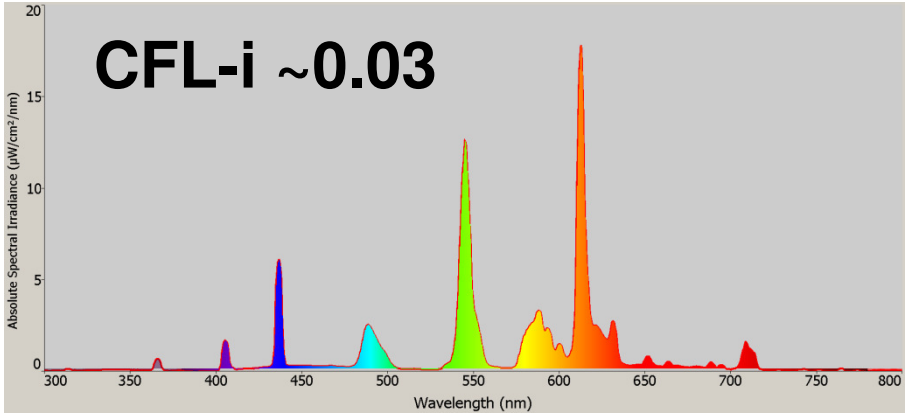


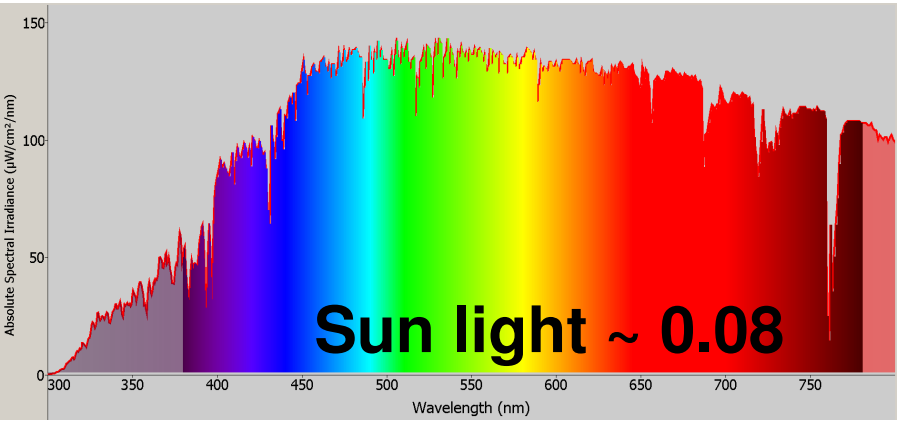
Image from Algvere et al, Acta Opth. Scan. Vol. 84, Issue1, pp 4-15,2006

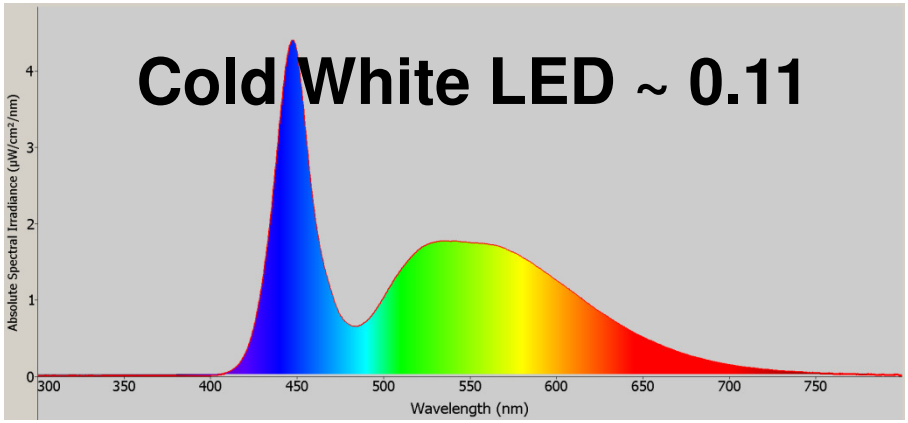
Comparison of Some Typical Light Sources

- Spectral analysis yields L_B/Lux as indicator for blue light fraction





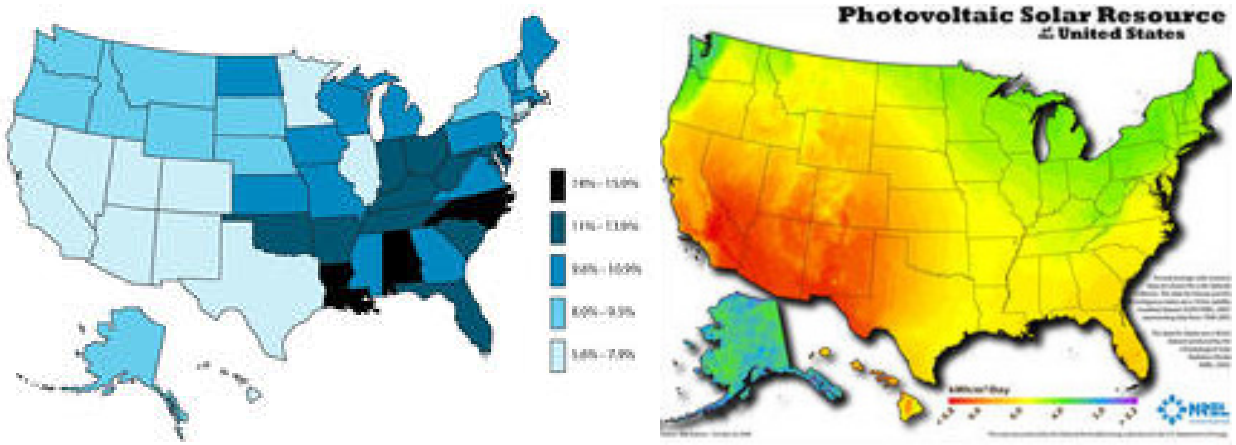




Blue Light Beneficial Uses Today

- Blue light is used to treat neonatal jaundice
  - penetrates skin better than red
  - Breaks up bilirubin into blood-dissolvable forms
- Blue light can help with stimulating the circadian clock
  - Helps with focus
  - Reduces ADHD

Image from Environ Health Perspect. 2010 January; 118(1): A22–A27.



Images from Emily Deans, Evolutionary Psychiatry, April 2013

Summary

- Given a brief introduction to lighting
- How to generate white light with LEDs
- Physiological aspects
- UV radiation & retinal thermal hazard
- Blue light and its interaction with the Human eye
  - Blue light (photochemical) retinal hazard
  - Why blue light gains attention
- Flexibility is the key → only LEDs offer that flexibility!

> "Diversity is the one true thing we all have in common. Celebrate it every day." **-Anonymous**

Feel free to visit our booth in the hall for further discussions!

Additional Slides

Blue Light Risk Group Categories

- Division into 4 Risk Groups in EN 62471

Risk Group	L_B value [W/m²/sr]	Philosophical Basis
Exempt	0-100	No photobiological hazard
RG1	100-10,000	No photobiological hazard under normal behavioral conditions
RG2	10,000-4,000,000	Does not pose a hazard due to aversion process to bright light or thermal discomfort
RG3	>4,000,000	Hazardous even for momentary exposure

- General Lighting LED sources fall mostly in Exempt or RG1

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  - TechSupport@oceanoptics.com (technical support)
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- Directions:
  - Download Driving Directions
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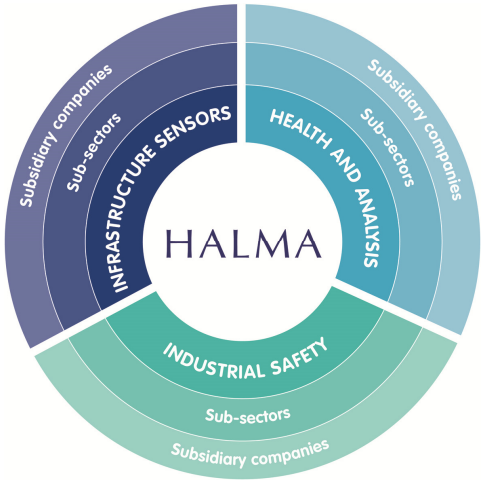
OceanOptics Company Profile



Ocean Optics is part of HALMA International (LSE:HLMA), a company dedicated to create components and products used to improve personal and public health.

As Ocean Optics we market leading technologies and products which generate, measure and condition light and analyse the interaction of light with substances. In various applications, optical sensing has proven to be a very effective and efficient way to providing unique ways of solving problems.

Ocean Optics

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Optical Sensing - New Light To Applications

- Ocean Optics provides a full set of optical tools opening new ways of analysis
- Key technology is optical spectroscopy and sensors, we sold >150.000 spectrometers
- Spectroscopy has already proven to be successful in a wide range of applications;

Markets

- ❖Pharmaceutical
- ❖Life Sciences
- ❖Homeland security
- ❖Industrial processing
- ❖Lighting industry
- ❖Bio medical
- ❖Packaging
- ❖Environmental
- ❖Biology / chemical

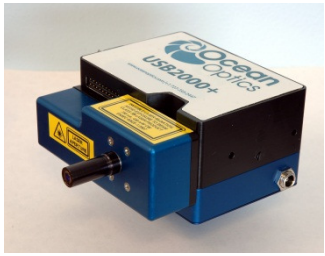
Applications

- ❖ Colour analysis
- ❖ Oxygen sensing
- ❖ Absorption
- ❖ Reflectance / transmittance
- ❖ Elemental analysis
- ❖ Raman spectroscopy
- ❖ Fluorescence detection
- ❖ Plasma monitoring
- ❖ Metrology

Optical Sensing is fast, non destructive and reliable

The Ocean Optics Product Range

- Complete range of CCD-based miniature spectrometers for the UV-VIS-NIR range
  - Supporting 150 nm – 2500 nm sensitivity
  - High dynamic range; up to 25000:1
  - Fast; up to 1000 scans/s
- Complete range of light sources
  - Tungsten halogen
  - Xenon
  - Deuterium
  - LEDs
  - Lasers



- Providing solutions for Raman spectroscopy, LIBS, Fluorescence spectroscopy, etc.
- Dedicated knowledge allows for building custom (sub) systems for OEM/end customers
- Proprietary technology in optical oxygen sensing, hyper spectral imaging etc.