

LEDs and astronomy — a chance for restoration of the dark night sky — or for further loss

Richard Wainscoat
University of Hawaii
Institute for Astronomy

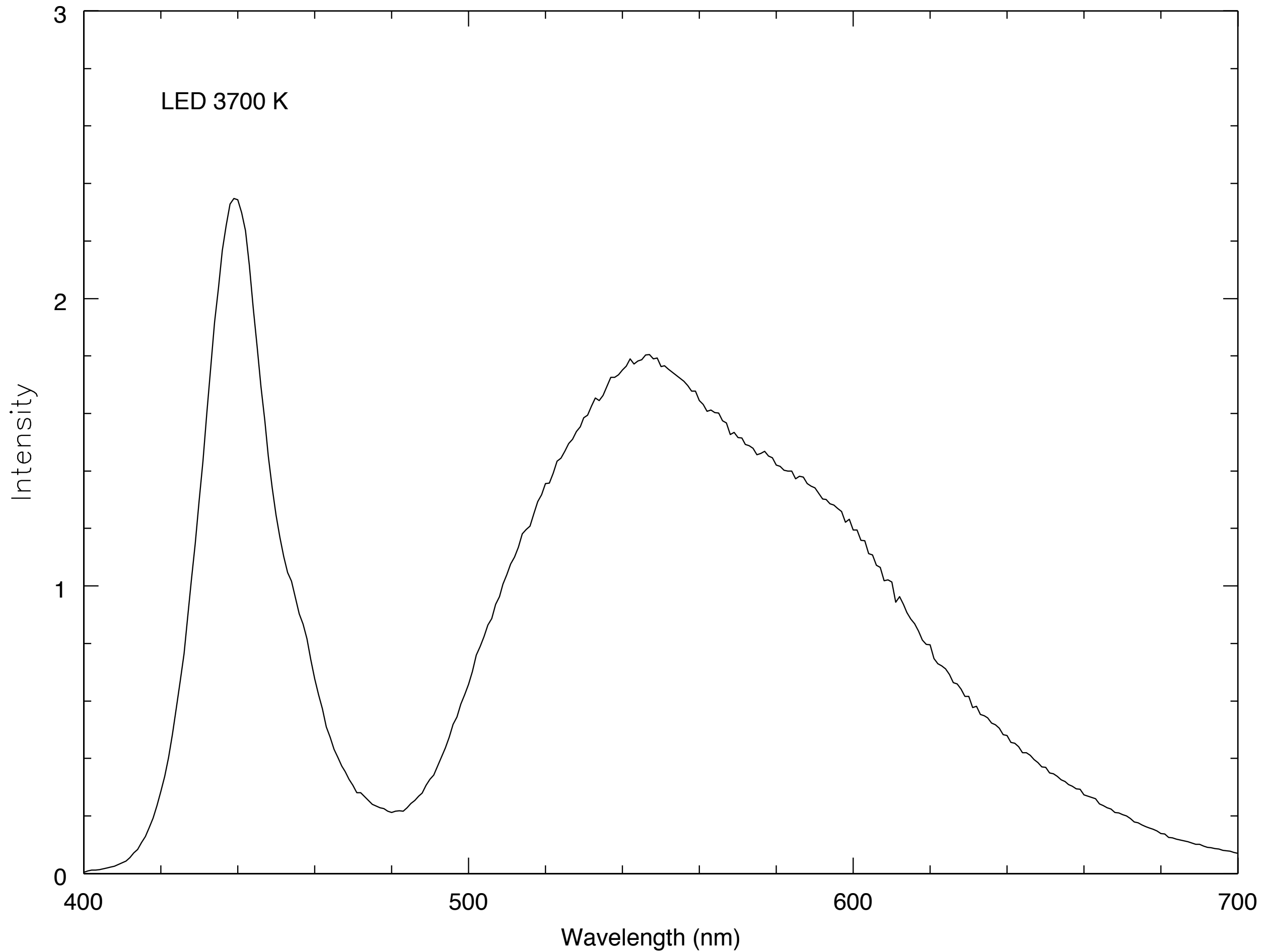


Dark sites are critically important for astronomy

- ✧ Astronomers are severely affected by light pollution
- ✧ Every 10% brighter the sky becomes from artificial light makes the telescope's effective aperture 10% smaller
- ✧ Spectral emission lines from high intensity discharge lamps are very damaging — particularly the bluer lines
- ✧ LEDs pose a new threat

2014 Nobel prize in physics

- ✦ Awarded to Isamu Akasaki, Hiroshi Amano, and Shuji Nakamura “for the invention of efficient blue light emitting diodes which has enabled bright and energy saving white light sources”



LEDs are likely to replace all other forms of lighting

- ✦ Most street lighting is presently sodium based
 - ✦ High pressure sodium yields as much as 100 lumens per Watt
 - ✦ Low pressure sodium yields as much as 200 lumens per Watt
- ✦ LEDs are widely promoted for their energy efficiency
 - ✦ LEDs with over 100 lumens per Watt have only recently become available

LEDs are likely to replace all other forms of lighting

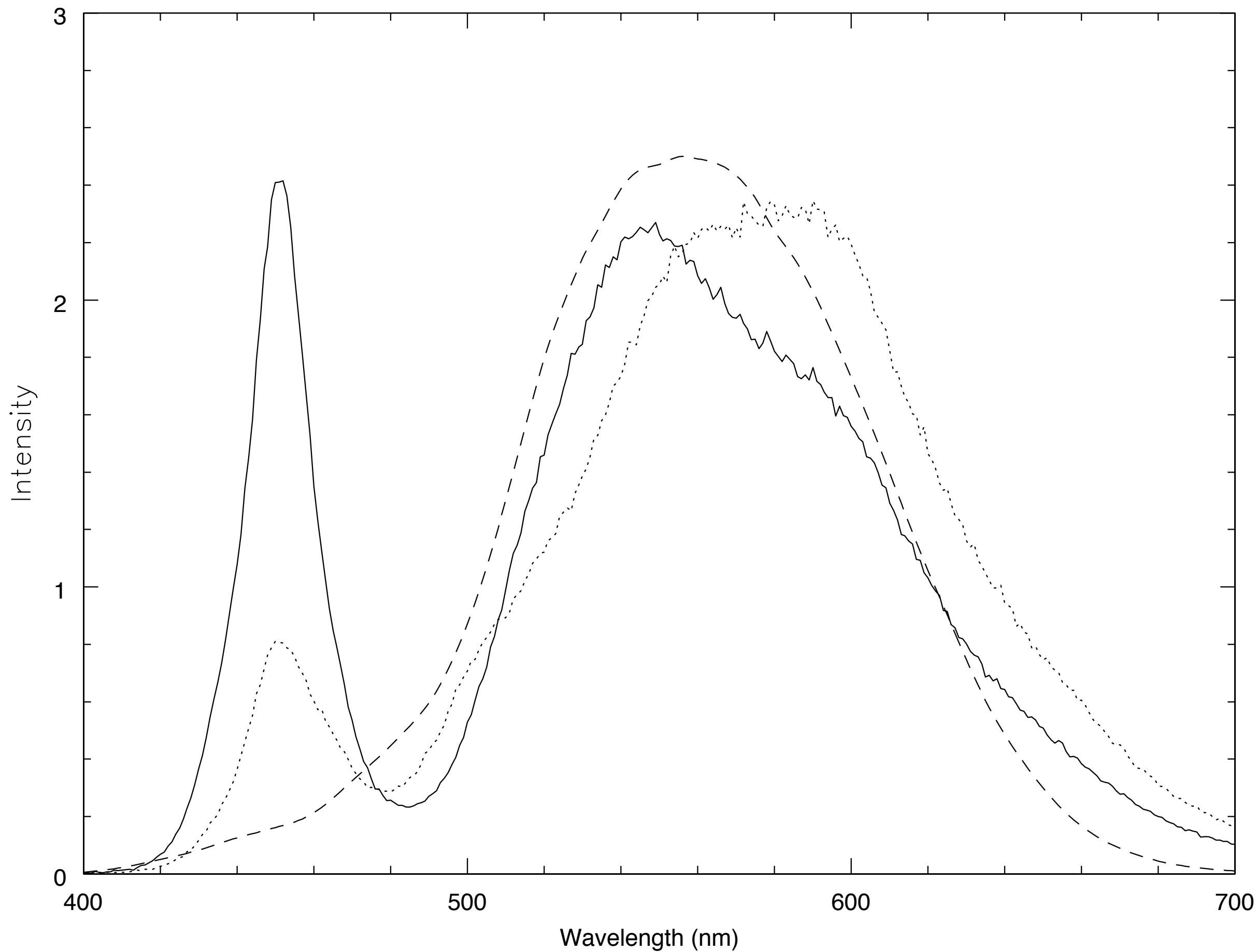
- ✦ The huge advantage that LEDs offer is that the light from an LED is much easier to direct
 - ✦ A lighting task, such as a roadway, can therefore be lit with many less lumens (and therefore less Watts)
 - ✦ This is how energy is saved — there is much less spill or wasted light
 - ✦ This is very good for astronomy and for dark skies

The blue light problem(s)

- ✦ White LEDs have a lot of blue light; sodium lighting has very little blue light
- ✦ Blue light is much more easily scattered by air molecules via Rayleigh scattering, which scales as wavelength to the power of -4

The blue light problem(s)

- ✦ The high correlated color temperature LEDs (cool white) produce more lumens per Watt than lower color temperature LEDs (warm white)
- ✦ Sales people promote cool white LEDs because higher energy savings are possible, making it easier to sell their product



The blue light problem(s)

- ✦ Fortunately, there has been good improvement in efficiency of warm white LEDs, and there is only a 5–7% difference in energy efficiency between 3000 K and 5000 K white LEDs
- ✦ And fortunately, few people like cool white LEDs, describing them as prison lights or zombie lights
 - ✦ Davis, CA and Cambridge, MA are examples of cities that had to change to warmer LEDs after residents complained

The blue light problem(s)

- ✦ And blue light appears to be undesirable to many other species, such as endangered turtles
 - ✦ The National Park Service is replacing its lights with LEDs that have low amounts of blue light

The blue light problem(s)

- ✦ The human eye isn't very sensitive at 450 nm, so we don't perceive how much blue light is being emitted
 - ✦ But telescopes and their cameras are extremely sensitive at 450nm
 - ✦ And the natural night sky is extremely dark at 450 nm
- ✦ The dark adapted human eye (scotopic) is more sensitive at 450 nm, so casual star gazing will be profoundly affected by scattered blue light from LEDs



The solutions

- ✦ It is absolutely essential that when LEDs replace sodium or other HID lamps, that the new fixtures are fully shielded, emitting no light directly upwards
 - ✦ There is no longer any excuse for unshielded lights
 - ✦ This is a once in a generation opportunity to replace unshielded lights with fully shielded lights

Part of Honolulu at night



- ✦ 30 million lumens upwards
- ✦ \$300,000 per year wasted

The solutions

- ✦ Reduce the amount of blue light. This can be done by:
 - ✦ Restricting the color temperature: 2700K and 3000K LED lights have much less blue than 4000K and 5000K LED lights
 - ✦ Filtering out the blue light (or converting it to redder colors)
 - ✦ Use of LEDs that intrinsically have little blue light, such as amber LEDs

The solutions

- ✦ Adaptive lighting should be used in new lighting installations when practical
 - ✦ The Illuminating Society of North America RP8 - 2014 outlines how to do it
 - ✦ Huge energy savings are possible

The solutions

- ✦ All cities and towns urgently need lighting ordinances that control upward light and the spectrum of light at night
- ✦ Installation of horizontally aimed cool white LEDs is occurring at an alarming pace
 - ✦ These are extremely damaging to the night sky and produce terrible glare
 - ✦ This must be stopped

This doesn't just affect astronomers

- ✧ At the CIE meeting in Manchester in July 2015, I talked to officials from China and Taiwan
- ✧ They are seeking help from CIE regarding
 - ✧ Light trespass
 - ✧ Distracting light
 - ✧ LED billboards

Light trespass

- ✦ Lighting levels at bedroom windows in China and Taiwan have become so high that people are having trouble sleeping at night
 - ✦ One of the best ways to address light trespass is by use of proper shielding; blue light should also be limited
- ✦ In Hawaii, we like to use the trade winds as a natural air conditioner
 - ✦ This doesn't work if you have to use black out curtains to block outside light





Distracting lights

- ✦ Businesses in Taiwan attach many LED lights to the exterior, often flashing, and often blue, to attract attention
 - ✦ This is very distracting to drivers
 - ✦ It makes a lot of unnecessary light pollution

LED billboards

- ✧ LED billboards are a growing problem both in the United States, China and Taiwan
 - ✧ These are so new that CIE has not yet discussed them
 - ✧ LED billboards are a big problem for observatories in Arizona

CIE and IESNA

- ✧ The IAU has a formal relationship with CIE, and this should be continued and hopefully will flourish
- ✧ Although help from CIE will take time, CIE is very influential at the international level, and it is an important development that China and Taiwan have problems with light trespass and LED billboards
 - ✧ Astronomers will benefit from efforts to limit light trespass and billboards
- ✧ Can AAS develop a similar relationship with IESNA?



Night sky seen from Mauna Kea