



## **THE IMPACT OF DIFFERENT LIGHT SOURCES, INCLUDING LEDS, ON ASTRONOMY**

Richard J. Wainscoat

*University of Hawaii, Institute for Astronomy*

Astronomy is profoundly impacted by artificial lighting of the night sky. The dark night sky has roughly equal components of starlight, zodiacal light (coming from dust in the solar system), and airglow (coming from atoms and molecules in the upper atmosphere that are releasing solar radiation that was earlier absorbed). Even small amounts of artificial light disturb this delicate balance, and overwhelm the starlight. At night, when the moon is up, the sky is blue, just like in the daytime; however, on a dark night, when the moon is set, the natural night sky is greenish-red in color. Since the natural night sky is extremely dark at blue wavelengths, this is an especially critical spectral window to preserve for astronomy research.

Professional astronomers have benefited from the use of sodium light sources. Lowpressure sodium (LPS) lamps emit almost all their light at 589 nm. This monochromatic emission can in some cases be filtered out completely. LPS is by far the best source for protection of astronomy. High-pressure sodium (HPS) lamps emit a broader spectral range centered around 589 nm, with the bulk of the emission coming at green and red wavelengths, and relatively little blue light being emitted. For many years, astronomy benefited from the fact that sodium light sources, with their high energy efficiency, were used widely for outdoor lighting.

The whiter light sources, such as metal halide, and LEDs are becoming more energy efficient and displacing the sodium lamps as the preferred light source in many applications. Some of these light sources, particularly the high color-temperature LEDs, have a very large amount of blue light. They emit light in a part of the spectrum that has previously suffered very little from light pollution.

In unpolluted air, the dominant process that leads to artificial brightening of the night sky (skyglow) is Rayleigh scattering. This is scattering of light by air molecules. It is strongly wavelength dependent, with a dependency proportional to  $\lambda^{-4}$ . This means that blue light is scattered much more easily than red light.

The blue part of the spectrum is extraordinarily important for many aspects of professional astronomy. The natural darkness in the blue has made this one of the most important windows into the distant universe. Some of the fundamental transitions of the hydrogen atom and other common elements occur in the blue, making the blue part of the spectrum critically important for studies of stars and star formation, galaxies, cosmology and the solar system.

The shift to broader spectrum bluer light sources produces new challenges to lighting professionals in limiting light pollution. The blue part of the light is much more prone to scattering by the atmosphere so it contributes even more to skyglow. It is not only astronomers who are affected more by blue light; many species of animals appear to be more affected by blue and white light compared to redder light sources. Protection of observatories and astronomy will require great care in properly shielding these new bluer lights, and careful choice in where, when, and how much of this type of light is appropriate.