The Research Programme

Blue light in the wavelength range 460-480mm is effective in maintaining the human circadian clock. The penetration of daylight may not provide sufficient luminance that maintain healthily synchronized biorhythms. Luminescent devices with appropriate spectral shifting can provide lighting conditions that maintain biorhythmic health. Without incurring the energy use associated with artificial lighting. Natural variations in solar illuminance directly produce the output illuminance. These three PhD studentships will research different aspects of bringing such devices to realty.

Exposure to daylight has many positive attributes, from aiding visual performance to production of vitamin D and the mood-enhancing neurotransmitter serotonin. Daylight also has much broader and more complex longer-term impacts on well-being, such as enabling proper eye development and, as the ultraviolet part of daylight can kill germs, is important for hygiene. These are only a small selection of the complex outcomes of the harnessing and alteration of daylight by people, buildings and the wider environment to give interlinked, and often unconscious, physiological, psychological and cultural outcomes.

Bringing daylight into buildings to provide sufficient illumination for many activities for most of the day, even with overcast skies, has been a critical part of building design. Strategies include elongating buildings at higher latitudes along an east–west axis, allowing daylight to enter high into rooms, admitting daylight from multiple sides of rooms, mitigating direct sunlight from producing glare and using light-coloured interior surfaces. Deeper daylighting of rooms combined with controls that switch-off artificial lighting reduces electricity use as does locating highly visual tasks near to daylit building perimeters. However, since the advent of electric lighting, buildings not only became larger and taller but also often have deeper plans with limited, or no, daylight penetration. In many artificially lit offices and shopping malls, the temporal cues provided by changes in daylight are absent. This can have consequences for occupant health as daylight is a powerful cue for the maintenance the human circadian pacemaker that follows the cycle of night and day. Being crucial to the healthy regulation of hormonal rhythms that impact cognitive performance. Properly maintaining daylight-driven circadian rhythms requires a complex combination of light intensity, duration and timing of exposure to daylight, the amount of blue wavelengths in the received spectrum and that daylights' spatial distribution. Enhancing quantity of blue light in received daylight by luminescent spectral shifting and concentration Blue light in the wavelength range 460-480mm is more effective compared to monochromatic light of wavelength 555 nm in maintaining the human circadian clock. Particularly when overcast prevail, for spaces away from windows within deeper-plan buildings, the penetration of daylight may not provide the luminance level required to maintain healthily synchronized biorhythms. Extension of exposure time to sufficient luminance from light in the wavelength range 460-480mm therefore becomes necessary. This could be achieved by use of blue light-emitting diode (LED) artificial lighting together with controls that appropriately vary the luminance to mimic the diurnal variation of daylight. However, as it is driven by a day-to-night cycle, circadian entrainment only requires light during daylight hours. The use of blue LEDs to maintain circadian health thus incurs electrical energy use that could be avoided if the intensity and spectrum of incident daylight could be increased and modified respectively for provision to insufficiently day-lit parts of a building. This work will investigate luminescence devices to concentrate solar energy, spectrally-shift the incident spectrum to have a greater proportion of blue light and transport higher-than-external blue-enhanced daylight deeper into the building extending, as shown in figure 2, of exposure time to sufficient luminance in the wavelength range 460-480mm.

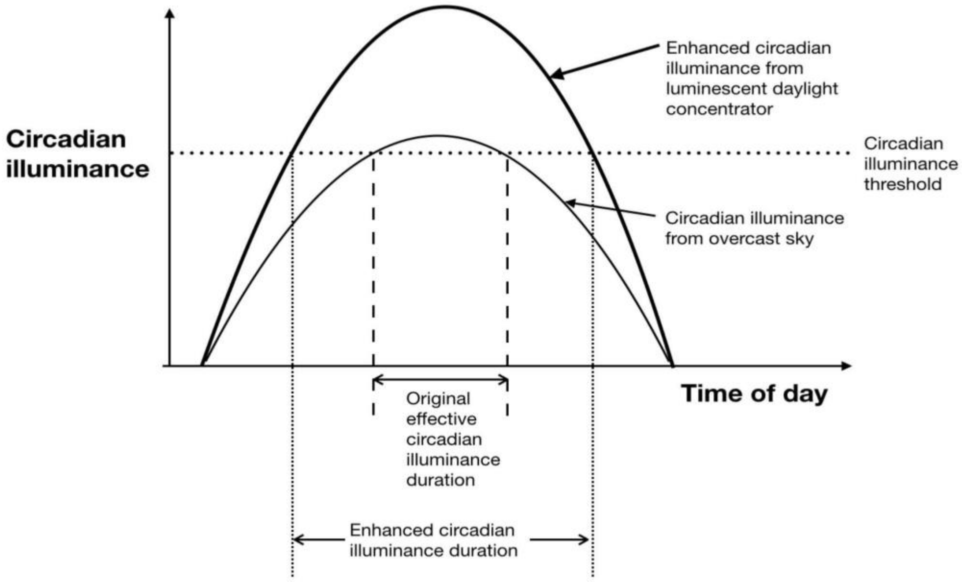

Figure 1. Schematic illustration of the enhanced duration of circadian illuminance that could be provided by a suitable luminescent concentrator of daylight with appropriate spectral shifting.

One possible configuration of a luminescent concentrator is shown in figure 2.

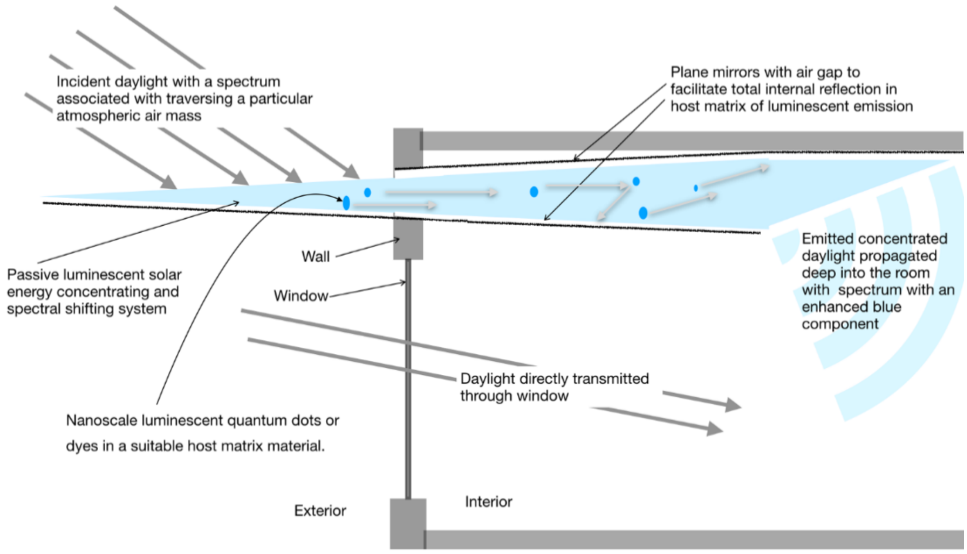

Figure 3. Schematic concept of a luminescent lightshelf

Luminescent devices with appropriate spectral shifting can potentially provide lighting conditions that maintain biorhythmic health. They do so without incurring the energy use associated with artificial lighting. Natural variations in solar illuminance directly produce the output illuminance. This obviates a need for the controls required when artificial lighting is used. The main objectives of this research are: (i) improved understanding of fundamental mechanisms, (ii) development of an analytical framework for device optimisation, (iii) development of suitable fabrication techniques with a particular focus on integration into a building and (iv) realization and evaluation of a proof-of-concept device.

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PhD Studentship on “Systems modeling of luminescent lightshelves in buildings”