

# The Physics of Light Pollution

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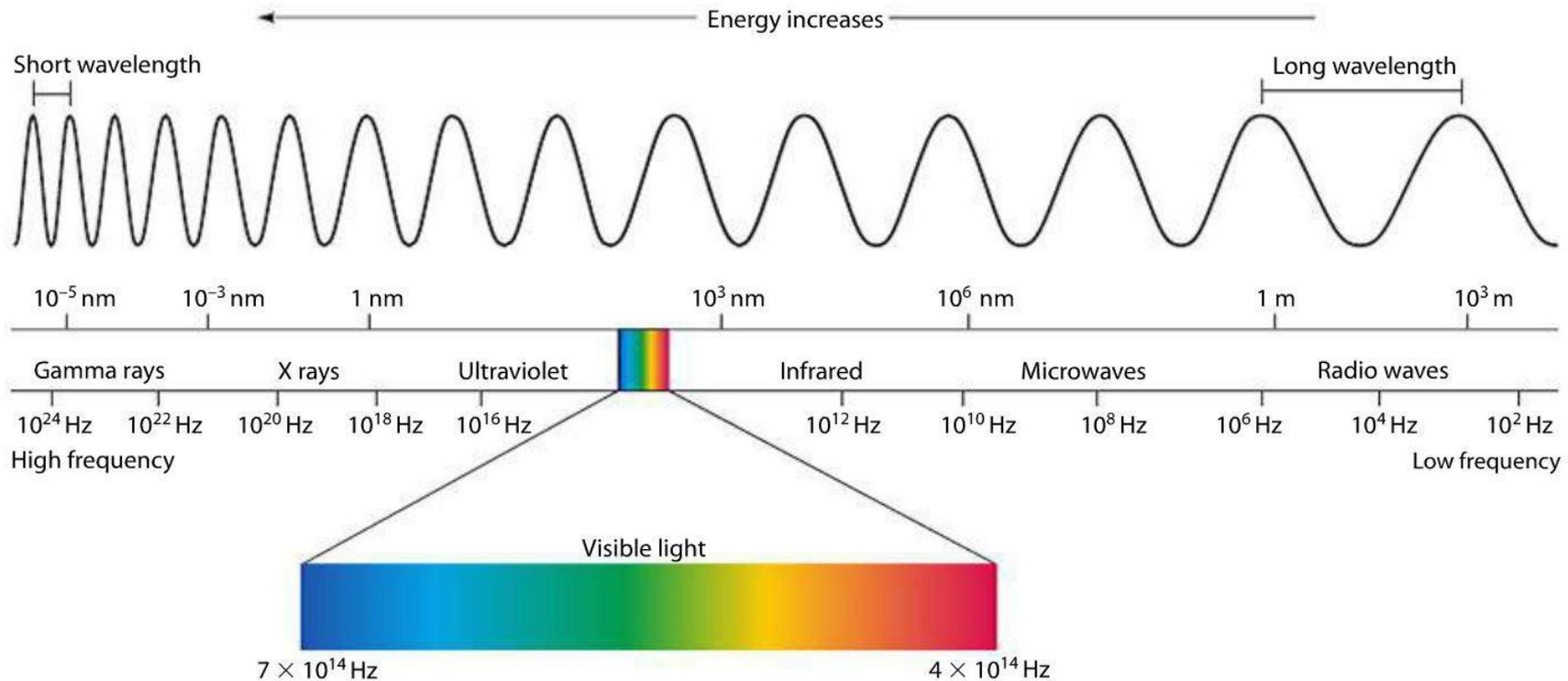
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# Light Sources Emit Energy

A light source emits energy, or a certain number of photons per second.

Each photon carries electromagnetic energy, and the amount of energy is related to the color, or wavelength or frequency of that photon.

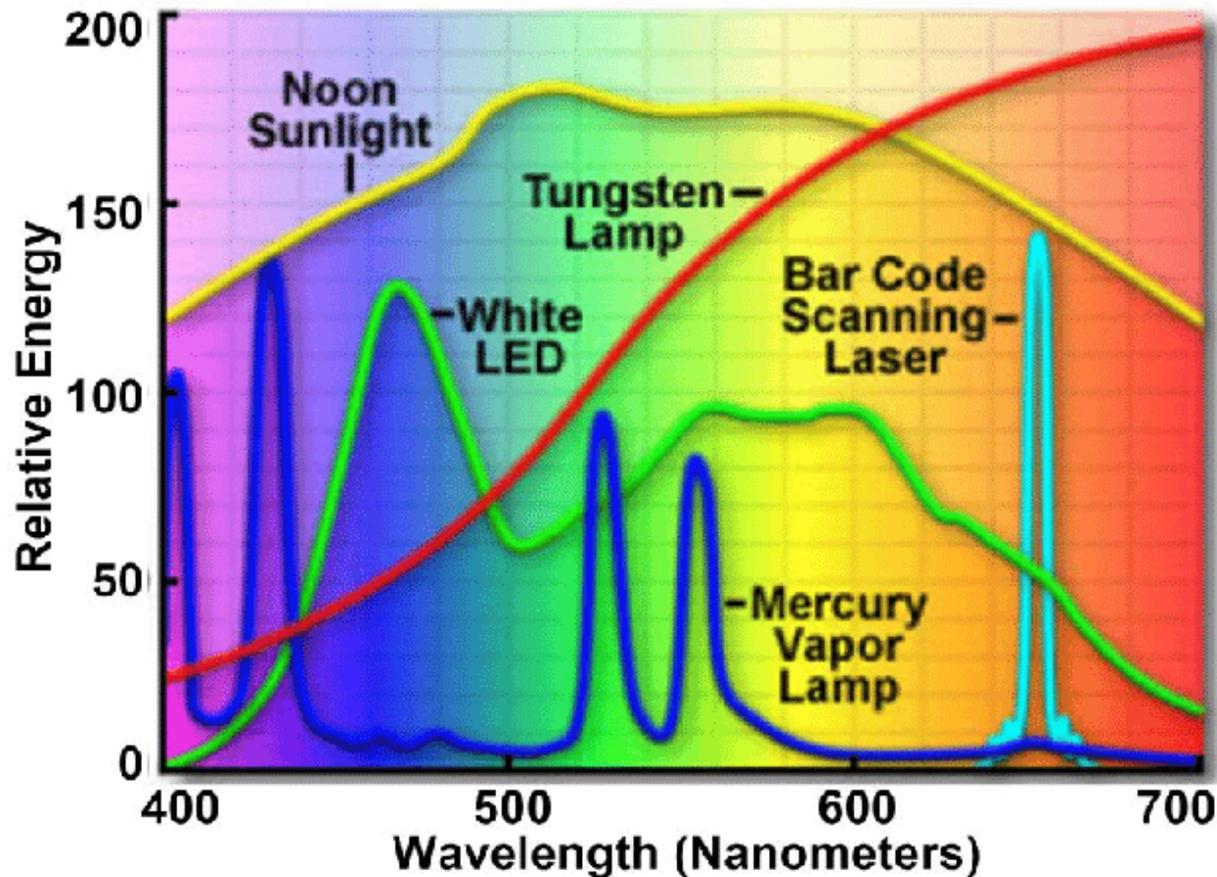
Only a small portion of the electromagnetic spectrum is visible to the human eye



# Light Sources Emit Energy

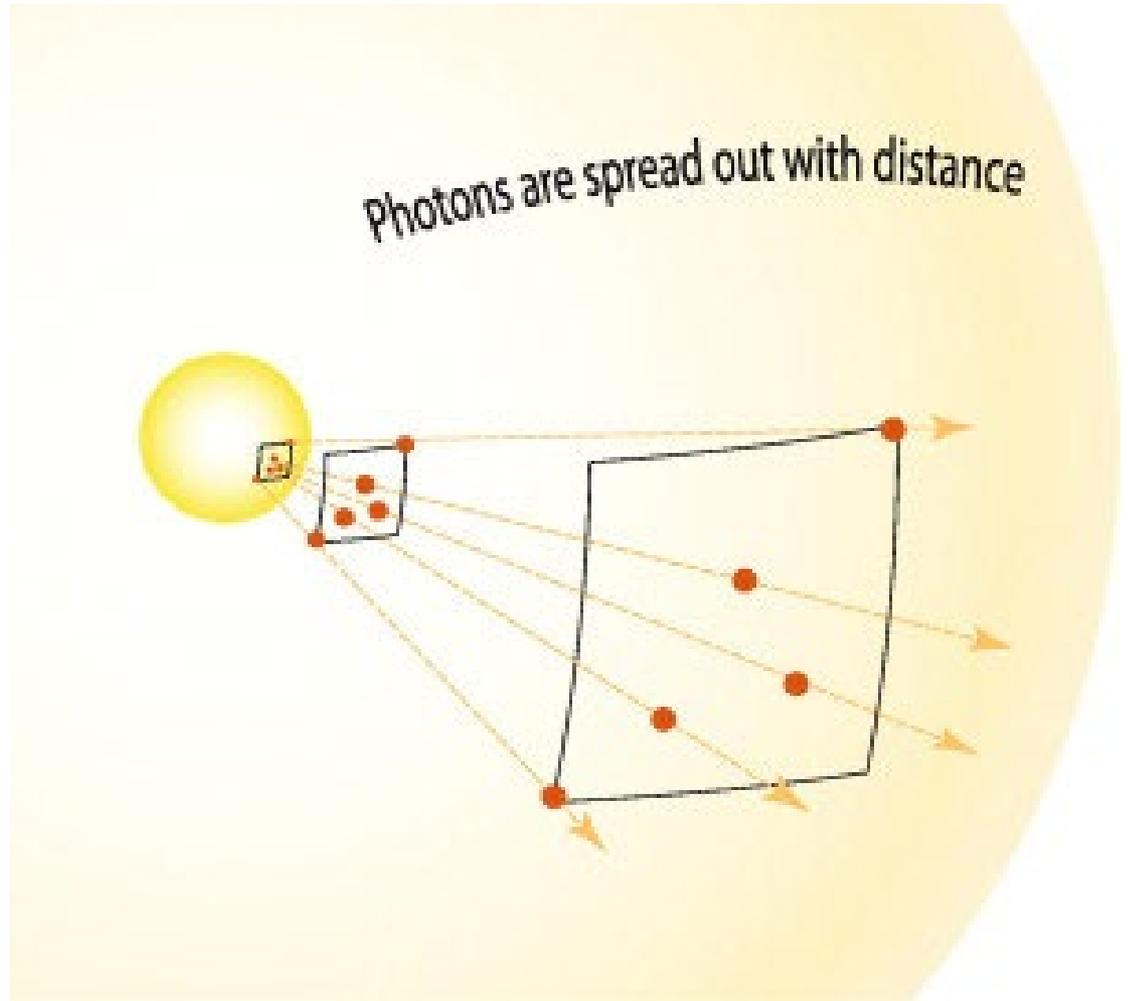
Different light sources can produce different colors of the rainbow, or spectra

Spectra From Common Sources of Visible Light



# Light spreads out

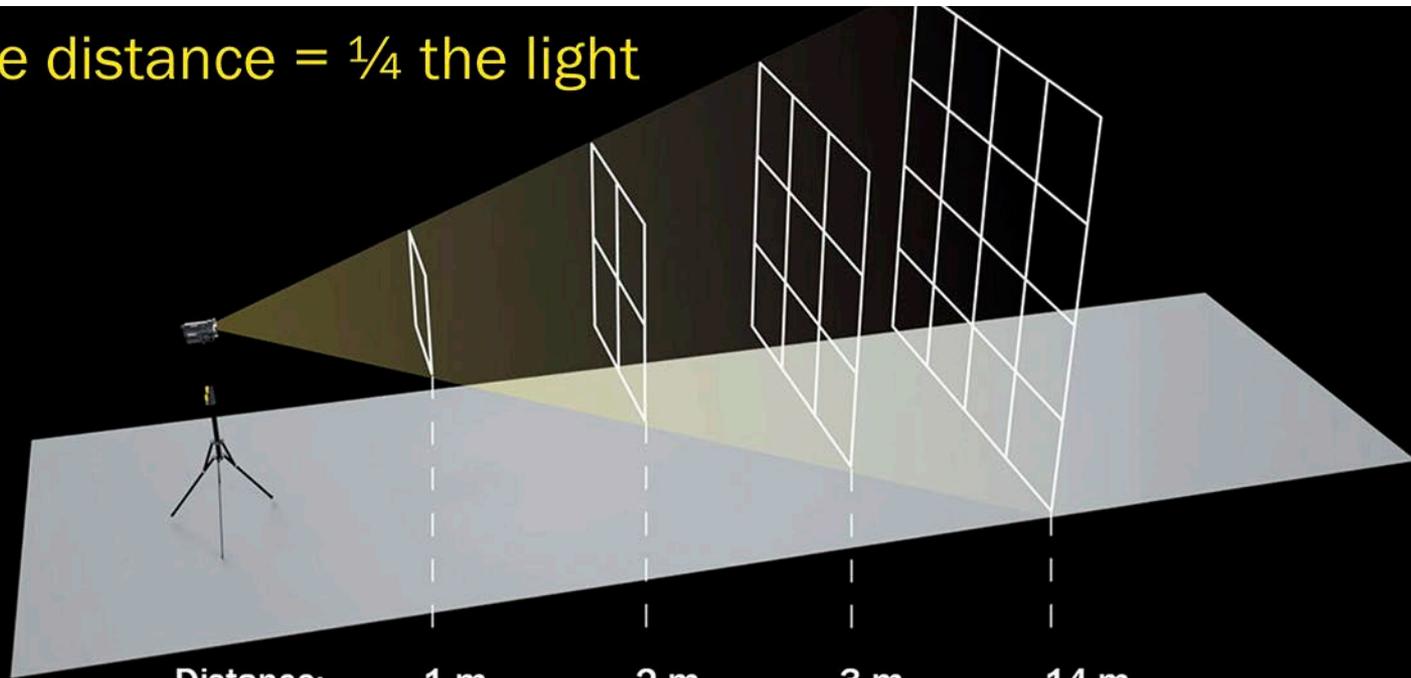
As photons travel outward from a light source in all directions in straight lines, the light spreads out with distance.



# Light spreads out

Thanks to the conservation of energy in nature, how this light spreads out in area obeys an exact mathematical formula called the inverse square law of light: intensity falls off as  $1 / \text{Distance}^2$

Twice the distance =  $\frac{1}{4}$  the light



Distance:	1 m	2 m	3 m	14 m
Lit area:	1 m <sup>2</sup>	4 m <sup>2</sup>	9 m <sup>2</sup>	16 m <sup>2</sup>
Light quantity:	1/1	1/4	1/9	1/16
	100%	25%	11,11%	6,25%

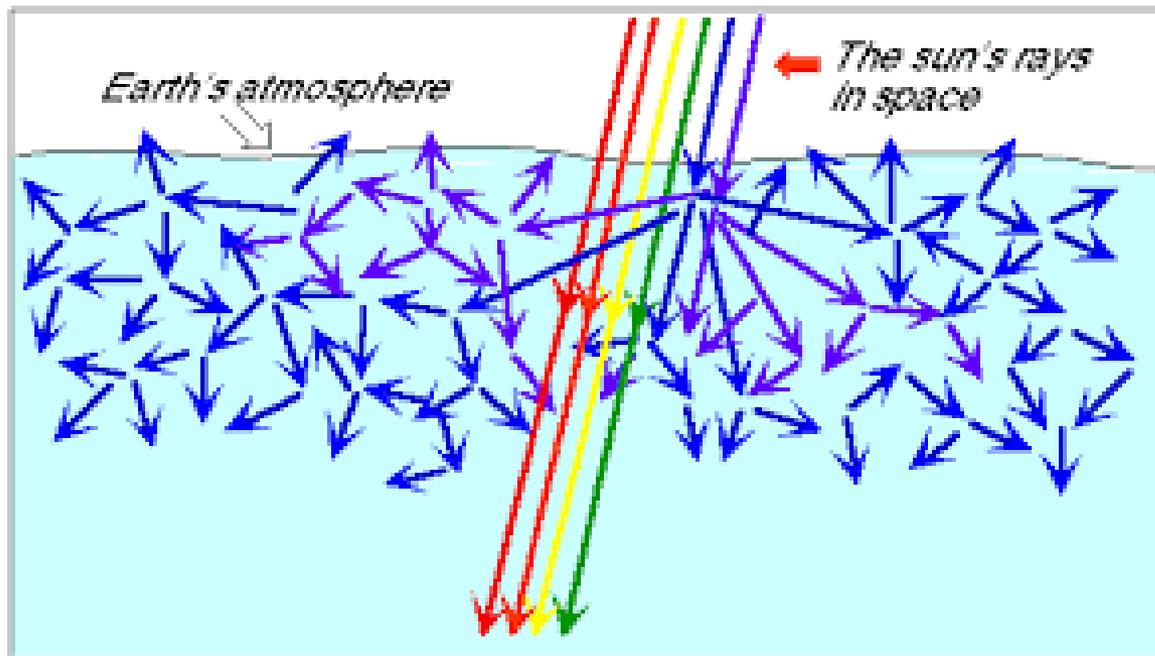
# The Sky is blue

**The sky is blue not because of the Earth's oceans, but because of an effect called "Rayleigh scattering":**



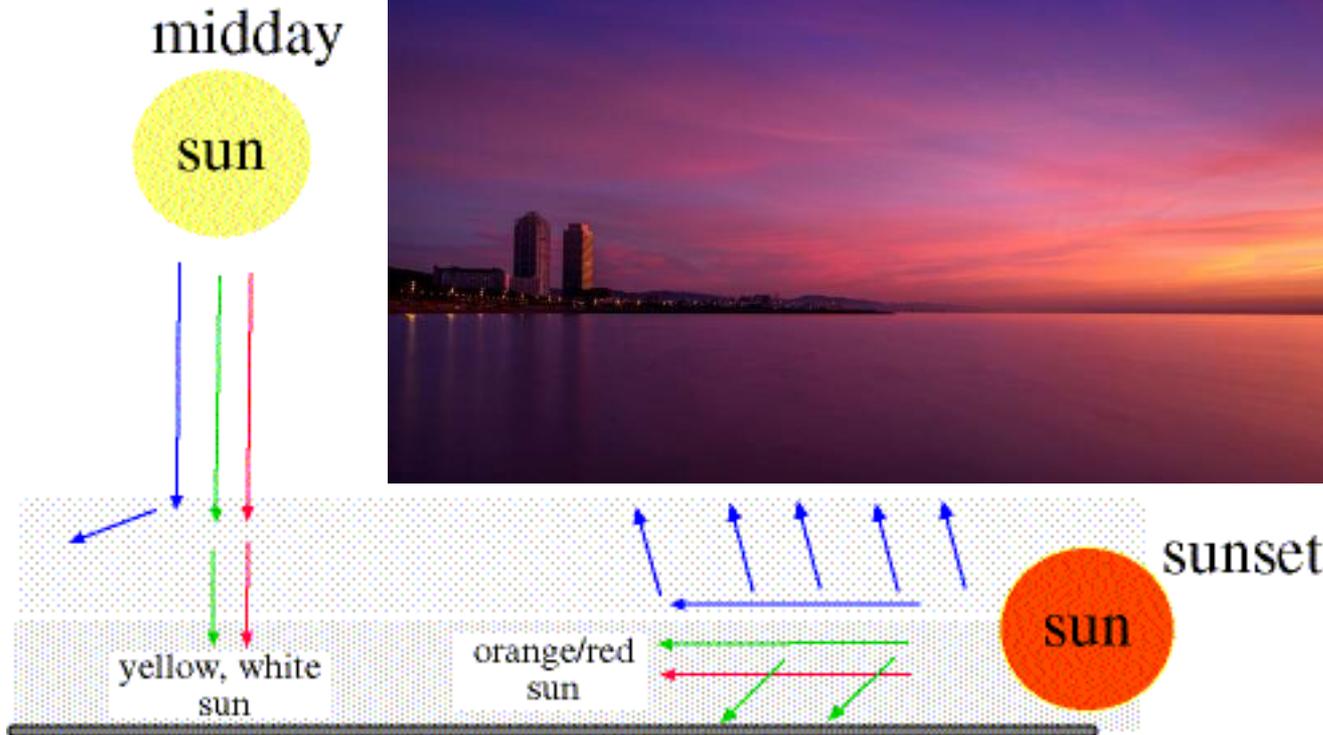
# The Sky is blue

**Rayleigh scattering is VERY color dependent.  
Violet and blue light gets scattered much more  
than red light.**



# The sun appears red at sunset

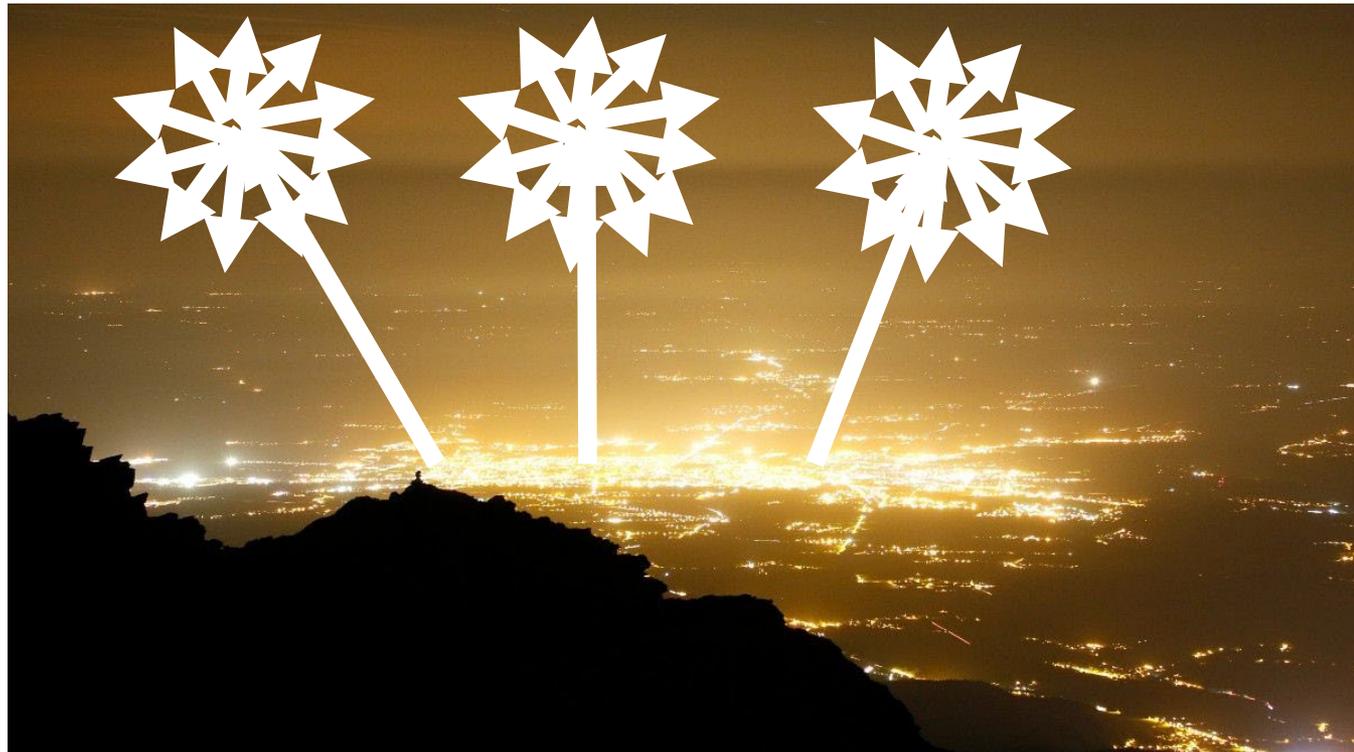
This is also why sunsets are beautiful: more green and yellow light gets scattered as it passes through more of Earth's atmosphere towards us.



# What is light pollution?

The Earth's atmosphere still scatters light at nighttime, and still preferentially bluer light. Instead of scattering sunlight, it scatters light emitted from the ground (and moon light and starlight).

Improperly shielded light fixtures, and light reflected off the ground goes up into the Earth's atmosphere, and some of that gets scattered back down like dim, continuous fireworks.

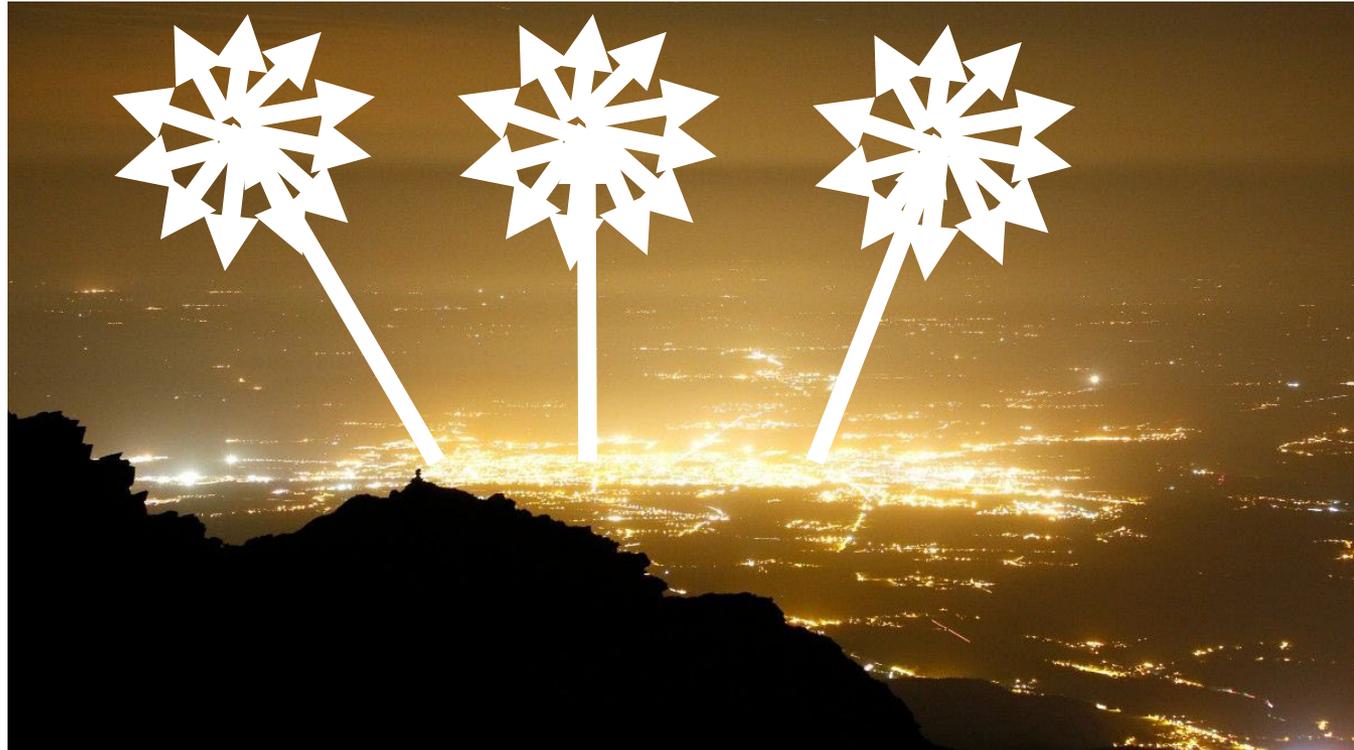


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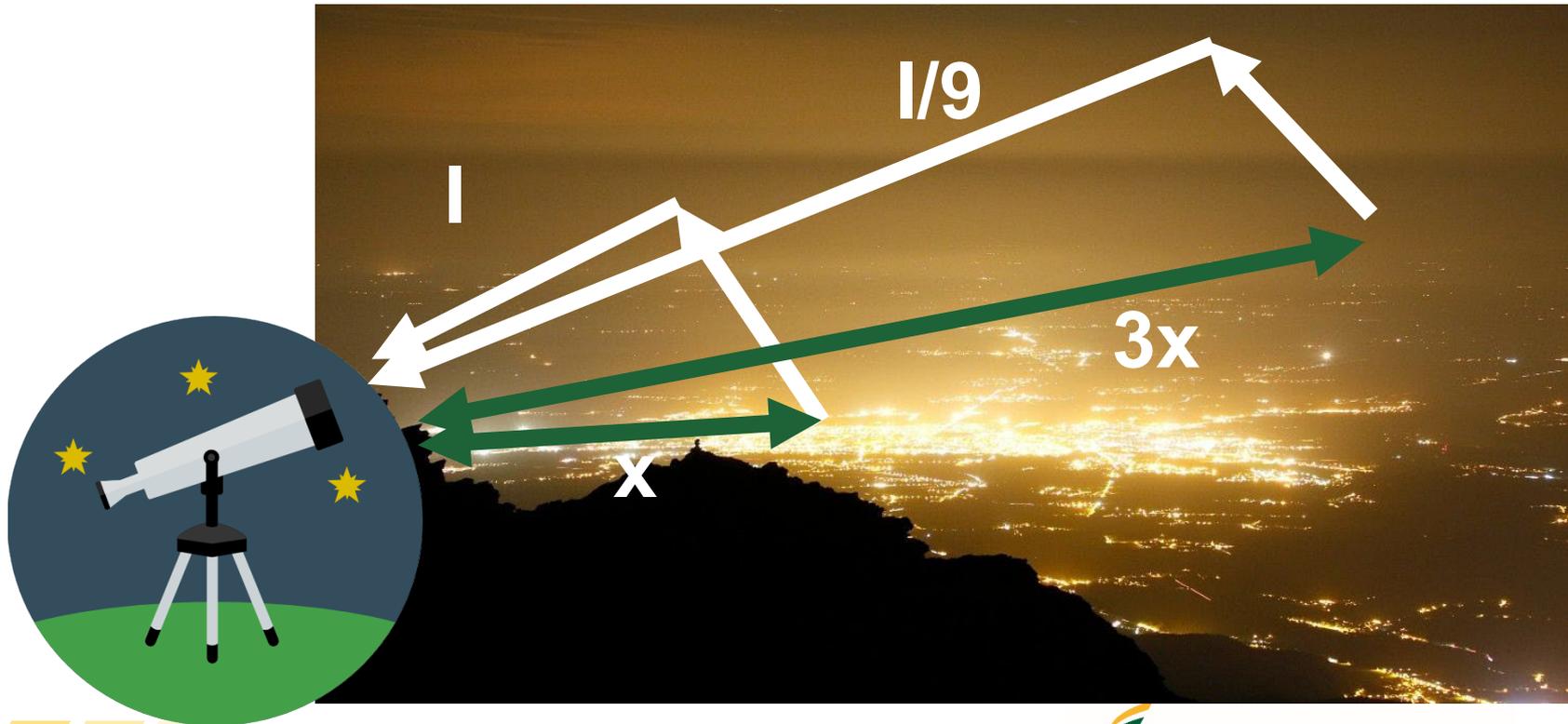
Even in the absence of light pollution and moon light, the night sky is not perfectly dark and has a brightness that the eye cannot discern.



# This means 3 things for light pollution

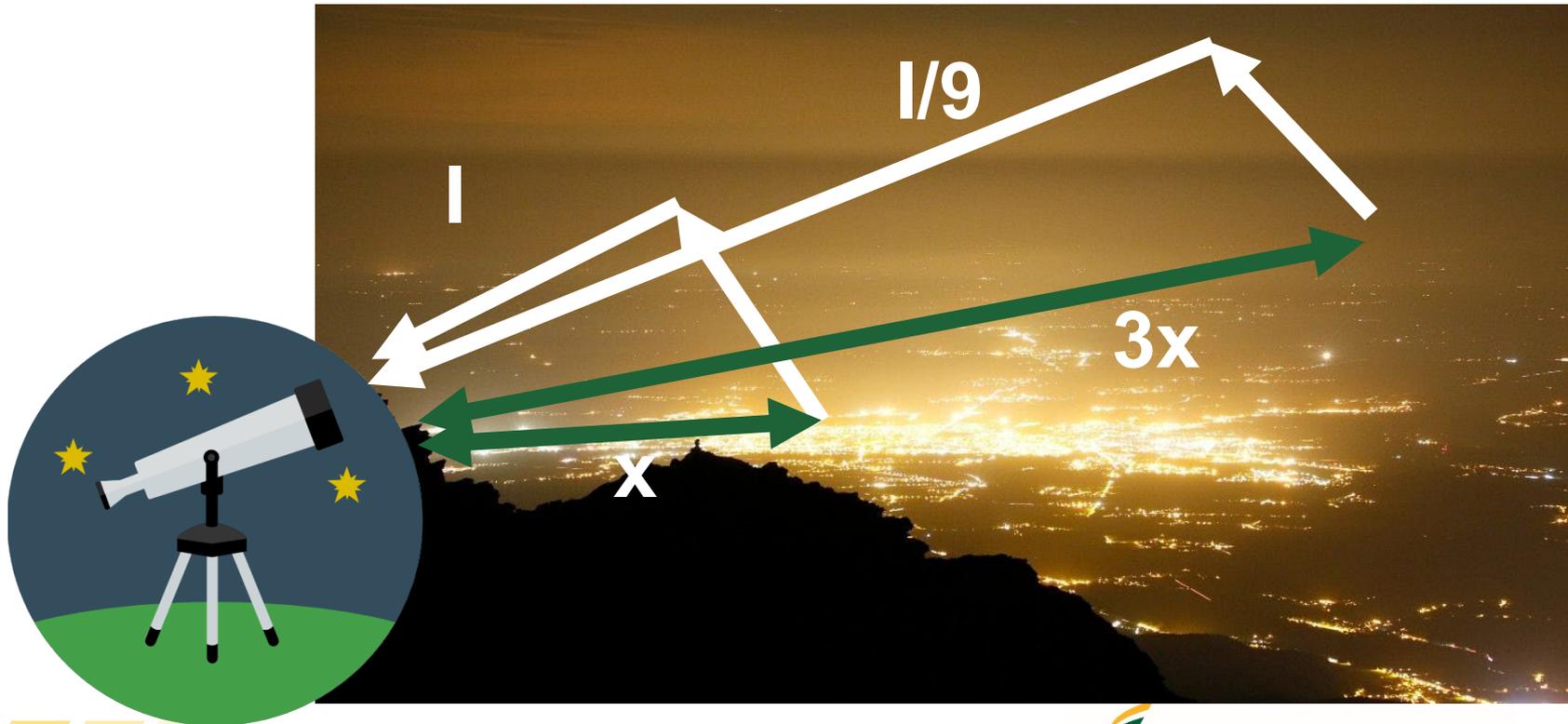
First, bluer or “hotter” bulbs are worse for light pollution; redder or “cooler” bulbs are better.

Second, light spreads out, so closer light sources at the same intensity produce more light pollution at a given location.



# This means 3 things for light pollution

A single 100 Watt bulb at 0.5 miles away produces just as much light pollution as approximately 200 identical 100 Watt light bulbs 7 miles away  $(7/0.5)^2 = 196$ .



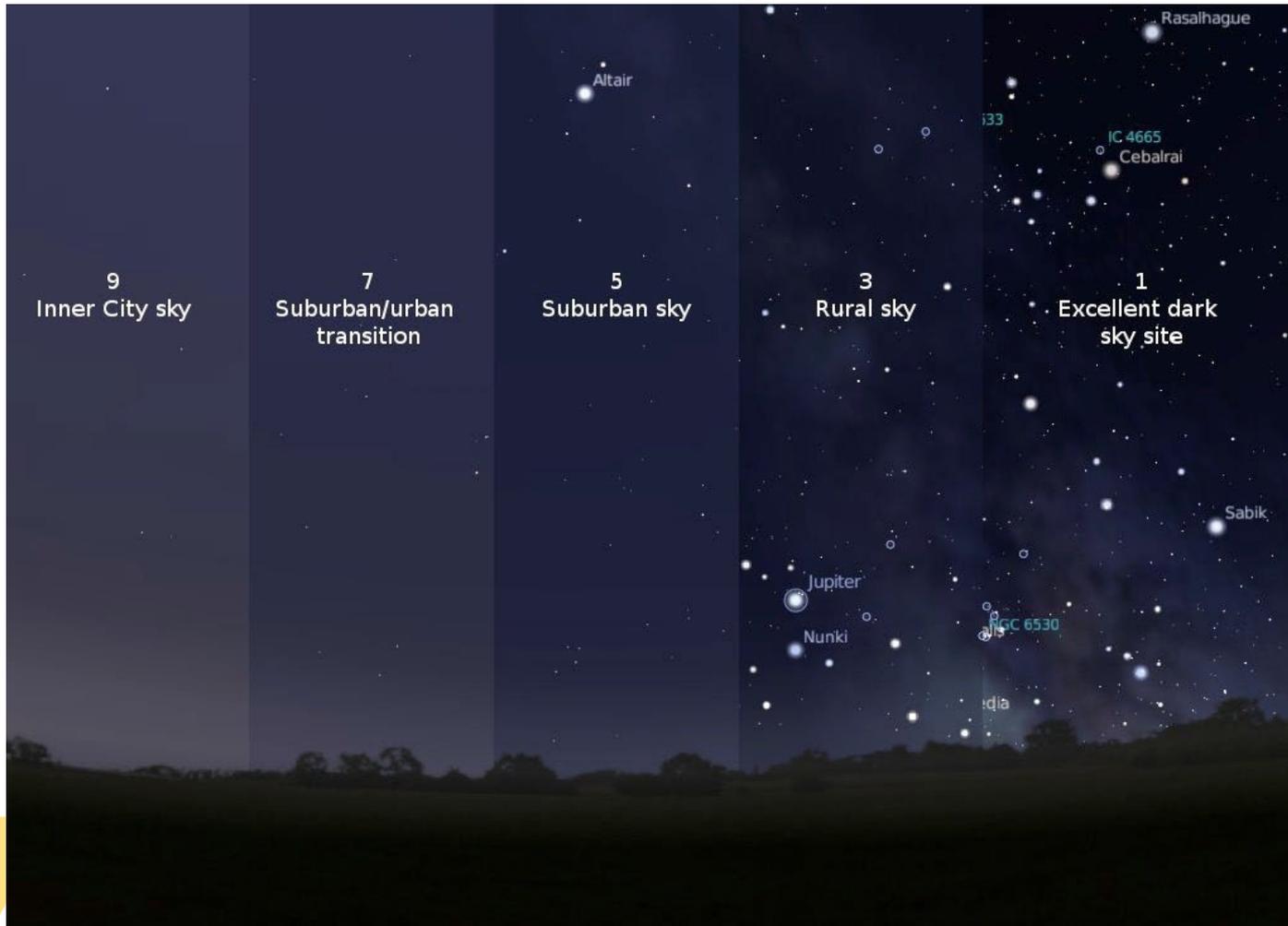
# Urban light pollution “domes”

**Third, light pollution is directional; the glow of distant cities can be seen in dark sky locations on the horizon as “domes” of scattered light:**



# Urban light pollution "domes"

Inside the dome, the light pollution is in all directions



# Urban light pollution "domes"

As a test of how light polluted your skies already are:

Did you know the number of satellites in orbit has doubled in the last two years?

You can see them after sunset and before sunrise reflecting sunlight; they will soon outnumber the stars you can see in the sky, even in dark sky locations, changing humanity's view of the sky.



# Turner Farm Observatory

While Reston, Tysons and DC are major sources of light pollution at Turner Farm, they are distant.

ONE 100W bulb shielded or eliminated within 0.5 miles of Turner Farm is worth > 100 bulbs in Reston, and > 250 bulbs in Tysons in light pollution intensity

