Регионални центар за таленте
БЕОГРАД 2

III IYNT 2015

International Young Naturalists' Tournament

4. Sunset

Serbian team

Regional Center For Talented Youth

4. Sunset

The visible Sun disk touches the horizon and after a particular time interval disappears behind the horizon. What is the duration of this time interval? Explain the optical phenomena observed during a sunset.

SUNSET

Sunset (sundown) - daily disappearance of the Sun below the western horizon, as a result of Earth's rotation

In astronomy : the time of sunset - moment when the trailing edge of the Sun's disk disappears below the horizon

ANGULAR VELOCITY OF THE SUN

- angular speed for an object spinning in space - the angle by which an object spins in a given time - its rotation rate

$$\omega = \frac{2\pi \text{ rad}}{t} \qquad t = \frac{2\pi}{\omega}$$

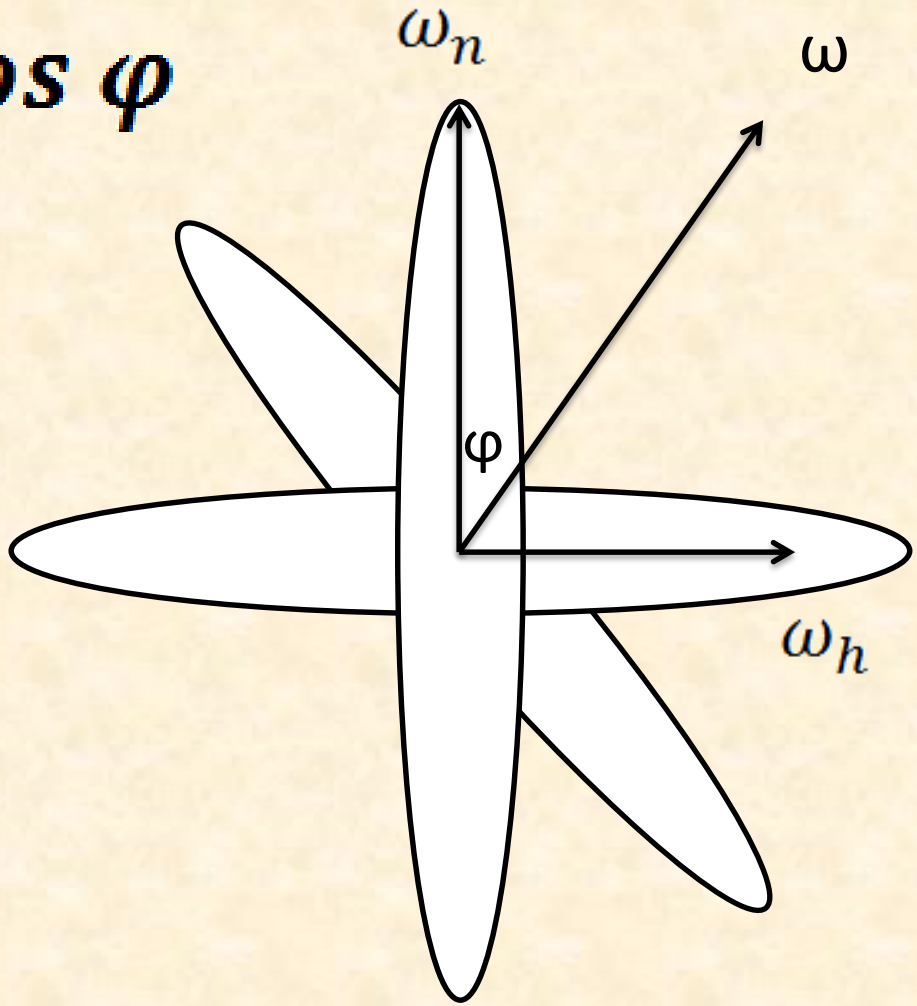
$$t = 23h\ 54\ min\ 4s$$

$$\omega \approx 7.3 \cdot 10^{-5} \frac{rad}{s} \qquad \omega \approx 15 \frac{arcsec}{s}$$

ANGULAR VELOCITY
- orthogonal component-

$$\omega_n = \omega \cdot \cos\varphi$$

$$\cos\varphi = \frac{\omega_n}{\omega}$$



DURATION OF SUNSET

- equation for the duration of sunset:

$$\tau = \frac{\theta}{\omega_n}$$

$$\tau = \frac{\theta}{\omega \cdot \cos \varphi}$$

DURATION OF SUNSET

- The fastest sunset at the time of the equinoxes (March 21 and September 23

- The slowest sunset at the time of solstice (around 21 June and 21 December)

DURATION OF SUNSET

- The fastest sunset - **2 minutes 47 sec**
- The slowest sunset - **3 min 23 sec**

- At the equator, between 128 and 142 sec

  (2 min. 8 sec and 2 min. 22 sec)

DURATION OF SUNSET

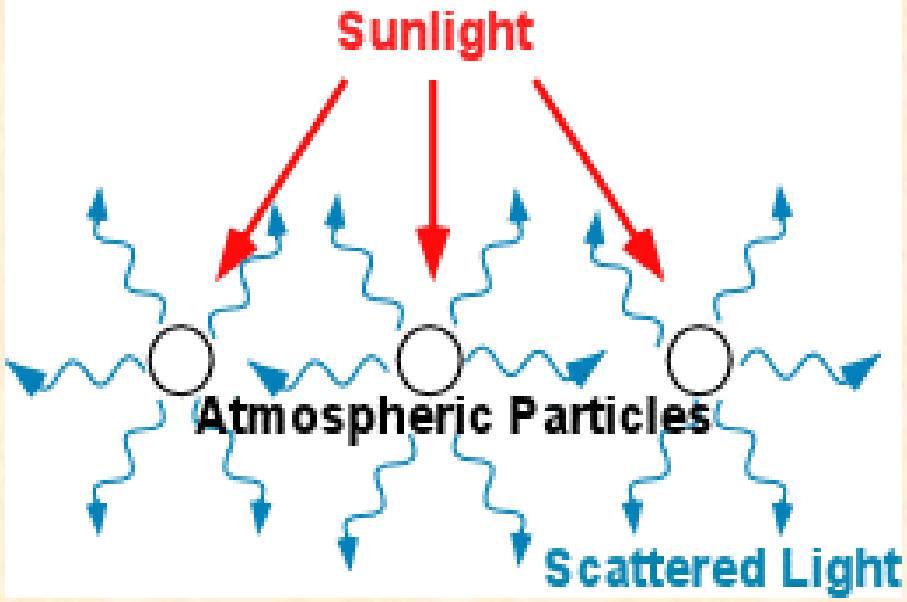
City	Duration of sunset	Latitude
Beijing	167 s	39.92°
Belgrade	183.6 s	44.82°
Paris	198 s	48.86°
London	209.3 s	51.51°
Moscow	231.5 s	55.75 °

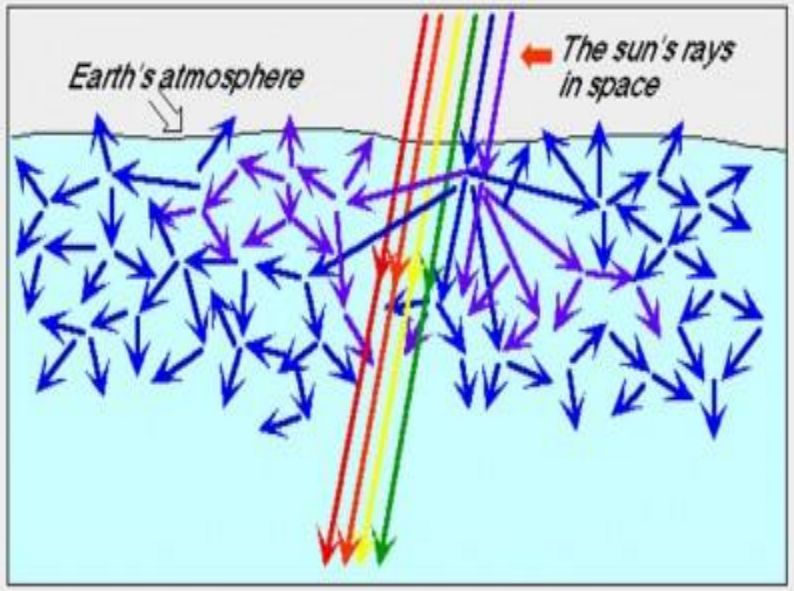
Optics Laws

Light scattering
Reflection
Refraction

LIGHT SCATTERING

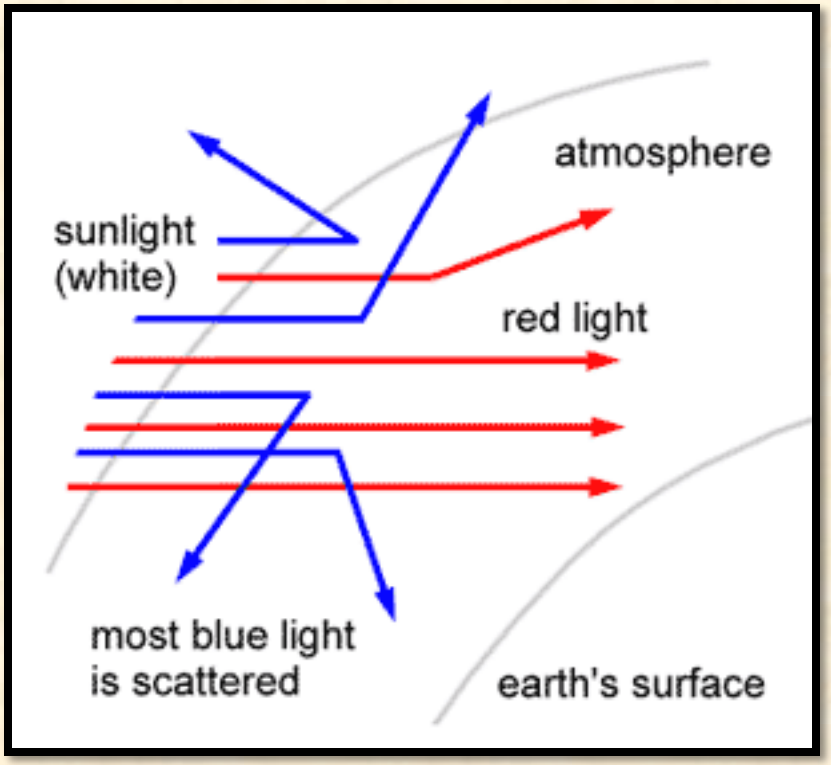
- caused by small particles and molecules in the atmosphere
- scattered rays go off in many directions

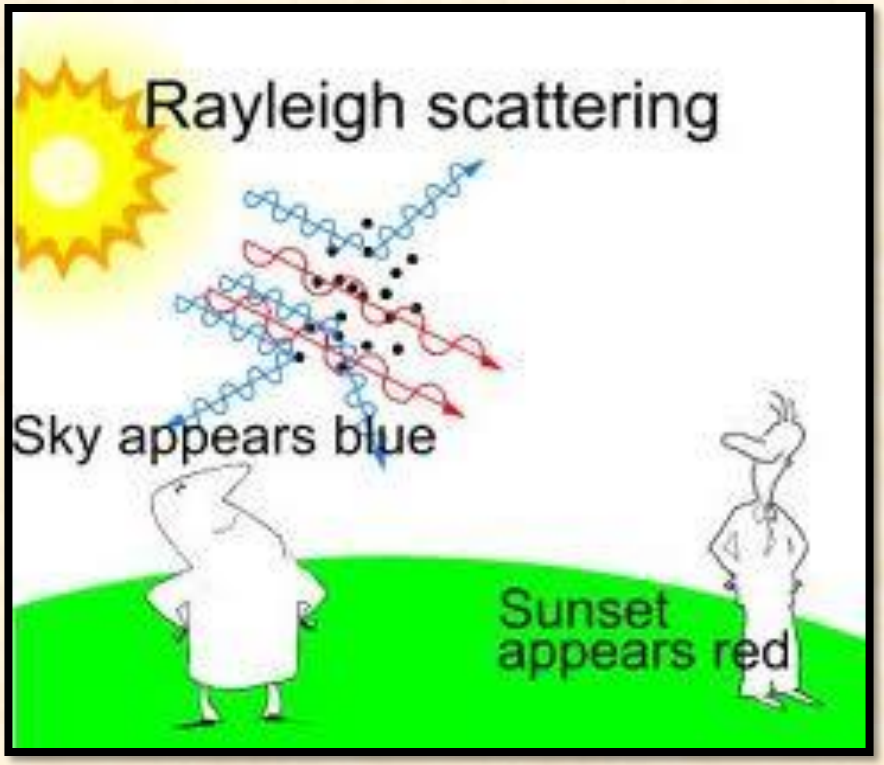




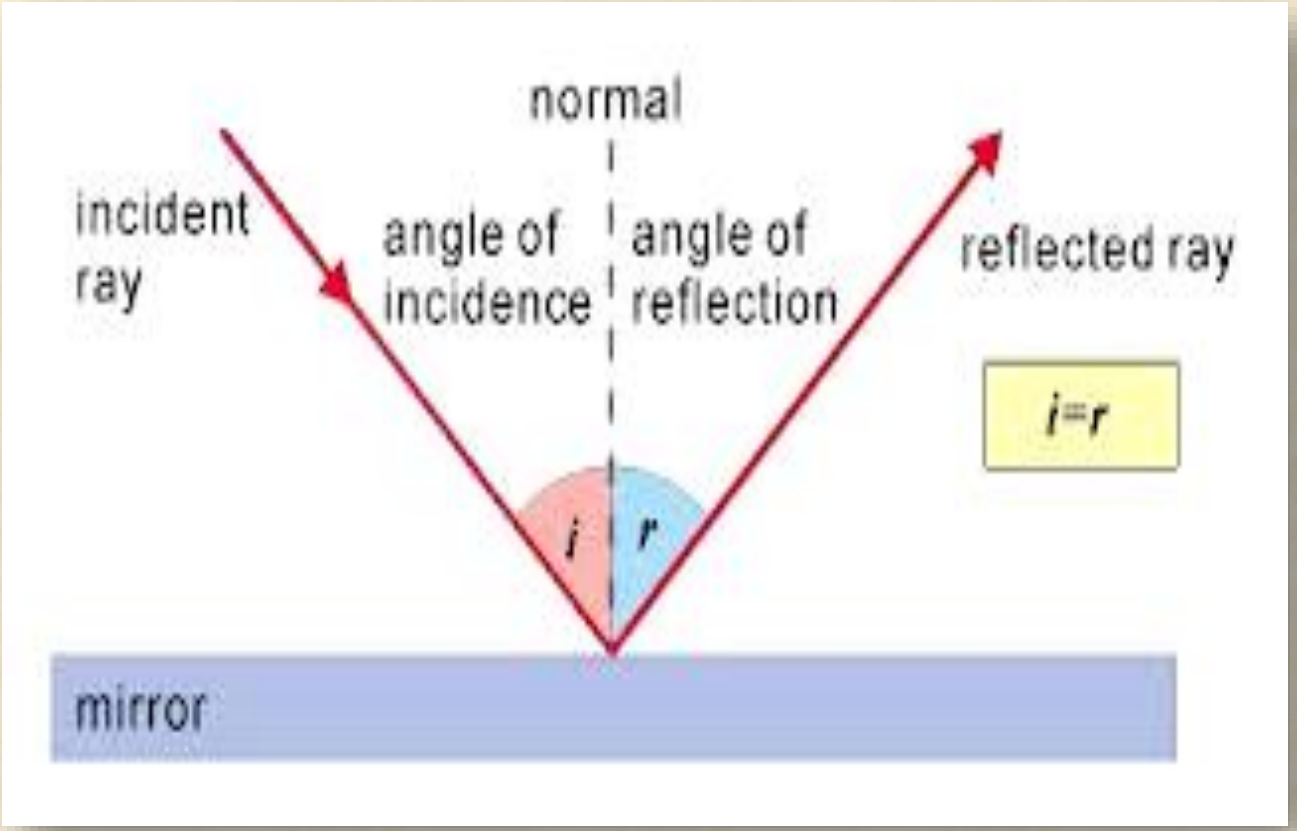
RAYLEIGH SCATTERING

- Rayleigh scattering - elastic scattering of light
- Blue light from the sun is scattered more than red



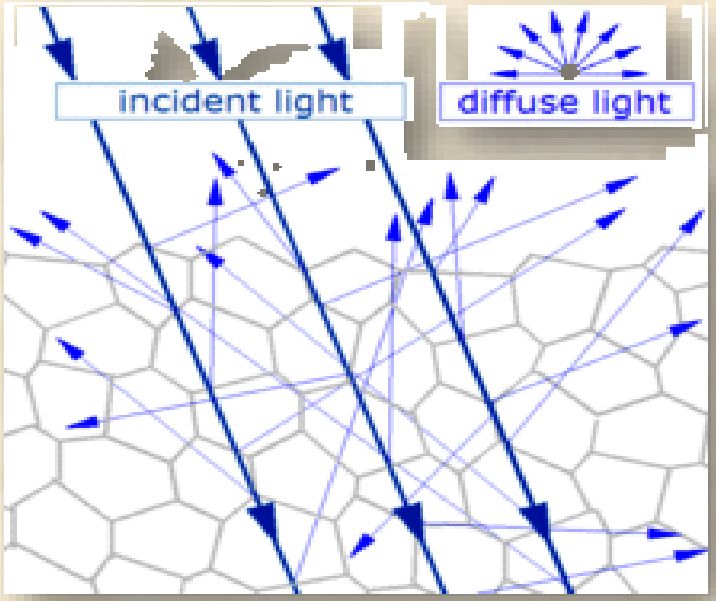


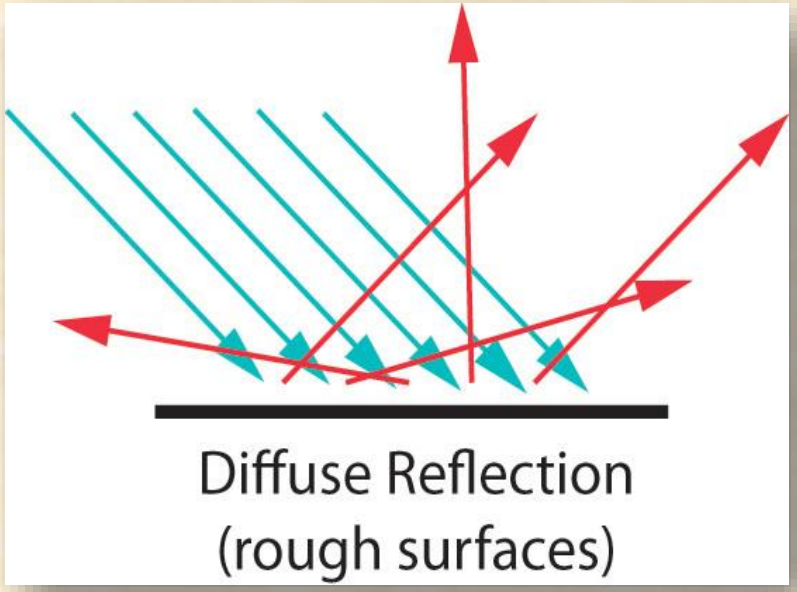
LAW OF REFLECTION



DIFFUSE REFLECTION

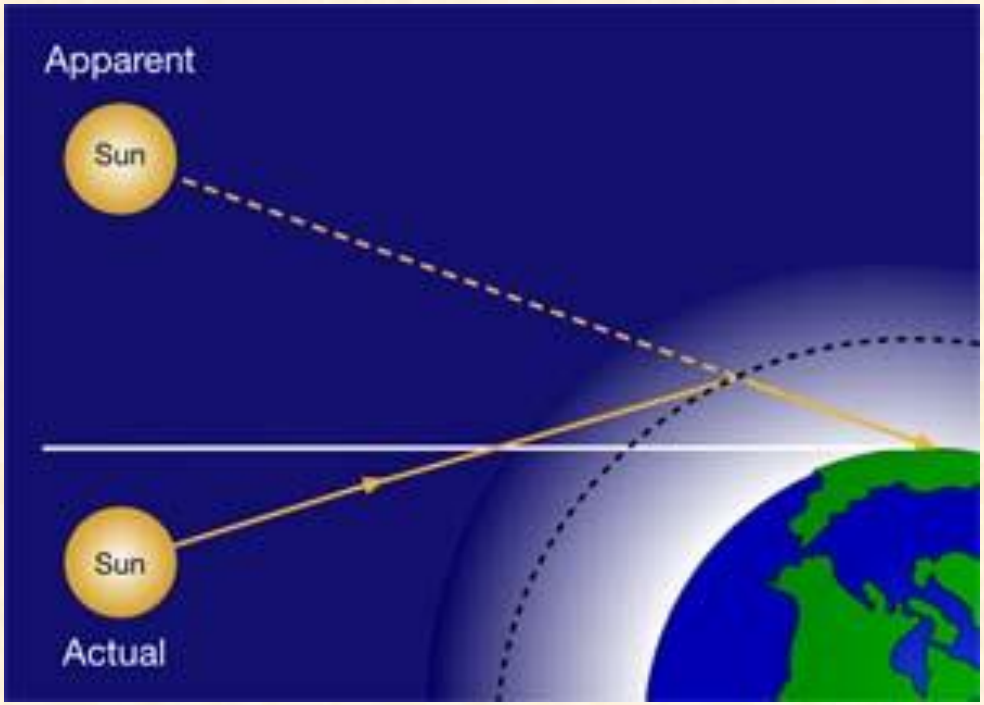
- It occurs when a rough surface causes reflected rays to travel in different directions





ATMOSPHERIC REFRACTION

- the shift in apparent direction of a celestial object caused by the refraction of light rays as they pass through Earth's atmosphere



MORE OPTICAL PHENOMENA

Twilight Wedge

Belt of Venus

Earth's shadow

Afterglow

Alpenglow

CONCLUSION

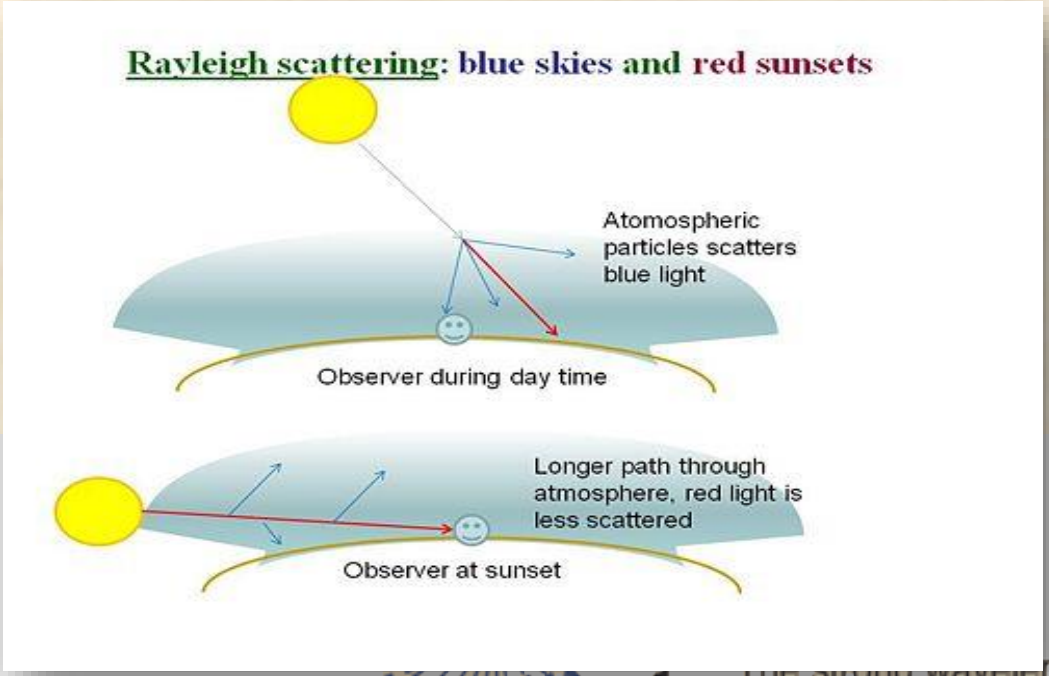
During the sunset:

1. Light scattering - Rayleigh scattering
2. Reflection - Diffuse reflection
3. Atmospheric refraction

- The fastest sunset is **2 minutes 47 sec**
- The slowest sunset is **3 minutes 23 sec**

THANK YOU FOR YOUR ATTENTION!!

- http://solar-center.stanford.edu/spin-sun/angvel.html
- https://www.itp.uni-hannover.de/~zawischa/ITP/scattering.html
- http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/opt/mch/sct.rxml
- http://www.physicsclassroom.com/class/refln/Lesson-1/Specular-vs-Diffuse-Reflection
- http://www.tutorvista.com/content/science/science-ii/human-eye-colourful-world/atmospheric-refraction.php
- http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/redsun.html
- http://www.webexhibits.org/causesofcolor/14E.html



$$I \propto \frac{1}{\lambda^4}$$

The strong wavelength dependence of Rayleigh scattering enhances the short wavelengths, giving us the blue sky.

The scattering at 400 nm is 9.4 times as great as that at 700 nm for equal incident intensity.

$$I \rightarrow \frac{I_0}{\lambda^4}$$

I_0 - intensity of light before entering the atmosphere
I - intensity of light upon arrival at the detector

SUNSET

Sunset creates unique atmospheric conditions such as the often intense orange and Sunset creates unique atmospheric conditions such as the often intense orange and red colors of the Sun and the surrounding sky

Locations north of the Arctic Circle and south of the Antarctic Circle experience no sunset or sunrise at least one day of the year, when the polar day or the polar night persists continuously for 24 hours.

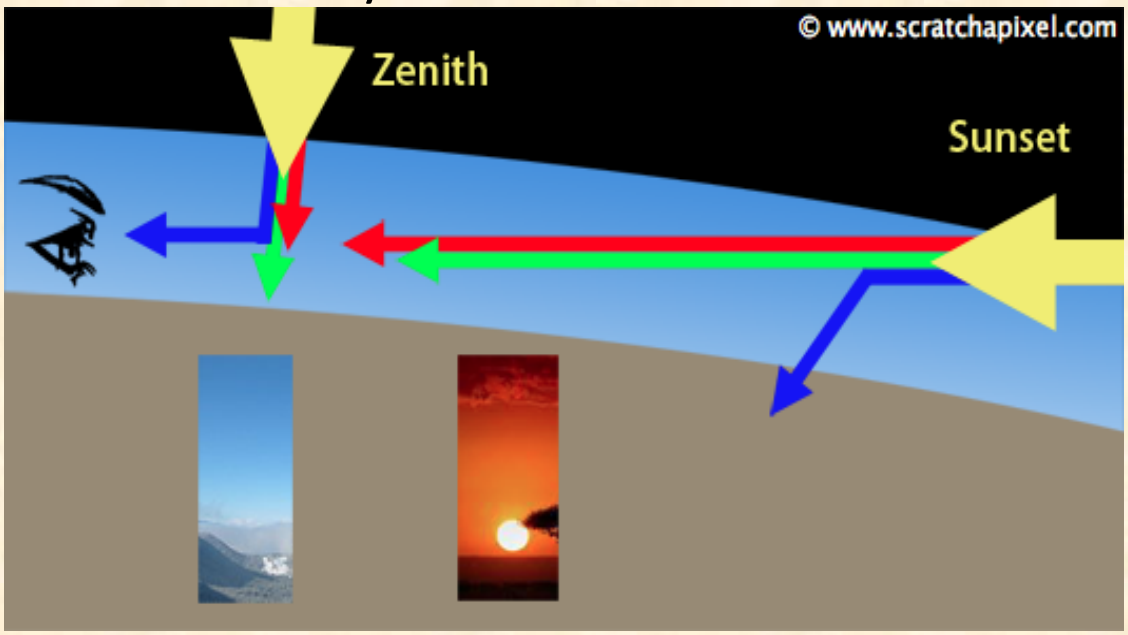
THE COLOR OF THE SKY

Sunlight - mixture of light of all colors which is usually seen as white

The ray path of light from the setting Sun is highly distorted near the horizon because of atmospheric refraction, making the sunset appear to occur when the Sun's disk is already about one diameter below the horizon.

When the sun is at the zenith, sunlight travels a short distance before it reaches the eye.
At sunset (or sunrise) sunlight travels a much bigger distance before it reaches the observer's eyes.
In the first case blue light is scattered towards the eye and the sky appears blue.
In the second case, most of the blue light has been scattered away before it can have a chance to reach the eye

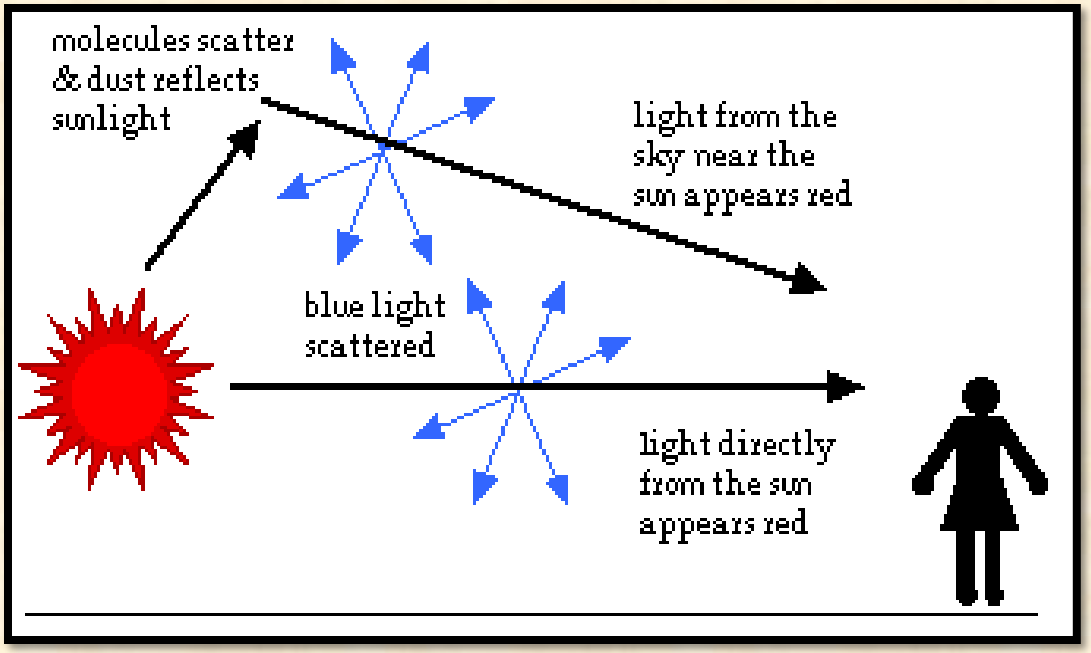
Only red-green light reaches the observer's position which explain why the sky looks red-orange when the sun is at the horizon.



WHY IS THE SUNSET RED?

As the sun begins to set, the light must travel farther through the atmosphere before it gets to you. More of the light is reflected and scattered. As less reaches you directly, the sun appears less bright. The color of the sun itself appears to change, first to orange and then to red.

This is because even more of the short wavelength blues and greens are now scattered.
Only the longer wavelengths are left in the direct beam that reaches your eyes.



$$1 \text{ arcsec} = 4.84813681 * 10^{-6} \text{ rad}$$