Rayleigh Scattering

Luis Castaño-Justel, Nicolás Criado, Emma Delgado, Virginia Díaz, Gabriela Latorre, Irene López
Physics Fundamentals II - Group B

OBJETIVE OF THE PROJECT

The purpose of this poster is to show how Rayleigh scattering works at different moments of the day, specifically during midday and sunset.

EXPLANATION OF THE PHYSICAL PHENOMENON

Rayleigh scattering is the process by which light is dispersed in Earth's atmosphere, as the electrons that absorb light act as an antenna and re-emit part of that light. At midday, sunlight passes through less atmosphere because the Sun is overhead, therefore less scattering occurs. Because scattering depends on wavelength, and it is more effective for shorter wavelengths like blue and violet, the sky appears blue (not violet because the human eye is more sensitive to blue light). At sunrise and sunset, sunlight travels through more atmosphere because the Sun moves lower, causing increased scattering of blue and violet light while longer wavelengths, such as red, are left colouring the sky.

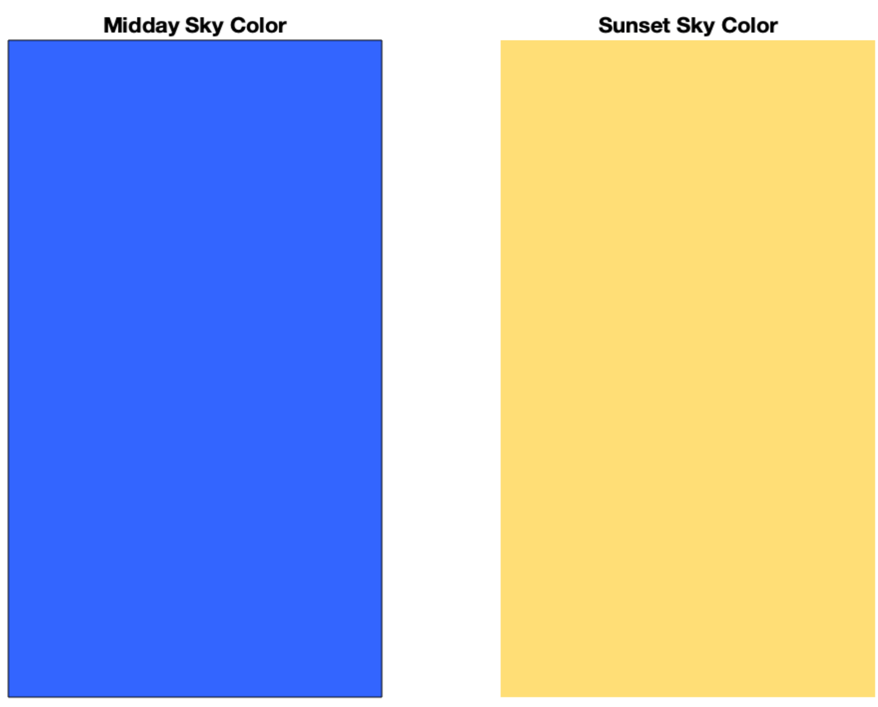

Figure 1 and 2. Coded representation of the colors seen at midday and sunset.

EXPLANATION OF COMPUTATIONAL PART

Incoming sunlight is assigned a normalised intensity of *I0 = 1*. The visible light spectrum is defined using *lambda = linspace(380e-9, 750e-9, 500)*, spanning wavelengths from 380 to 750 nanometers, covering violet to red.

The Sun's position in the sky is then defined for two conditions: **midday**, where the Sun is directly overhead (**scattering angle** *theta=π/2* rad and **solar elevation angle** *phi=π/2* rad), and **sunset**, where the Sun is low on the horizon (*theta*=0 rad, *phi=10*pi/180* rad).

Air mass quantifies how much atmosphere sunlight travels through. At midday, it's minimal (*m_midday = 1)* because sunlight comes straight down. At sunset, sunlight travels through much more atmosphere (*m_sunset = 1 / sin(10*pi/180)*), increasing scattering and absorption.

Concerning **Rayleigh scattering**, the equation *(1 / lambda.^4) * (1 + cos(theta)^2)*, indicates that light with shorter wavelengths (like blue) is scattered more than longer wavelengths. This explains why the sky appears blue during the day.

Atmospheric attenuation is modelled with a normalised scattering coefficient *k_lambda* that favours shorter wavelengths and an exponential decay function *exp(-k_lambda * m_sunset)*. As a result, at sunset, longer wavelengths like red and orange survive more than blue light.

The intensities of light that reach an observer are, for midday, the raw scattering result; for sunset, the product of scattering and attenuation. Furthermore, in the case of sunset, **gamma compression** is applied, which is a nonlinear brightness adjustment that mimics human vision.

Graphical Representation

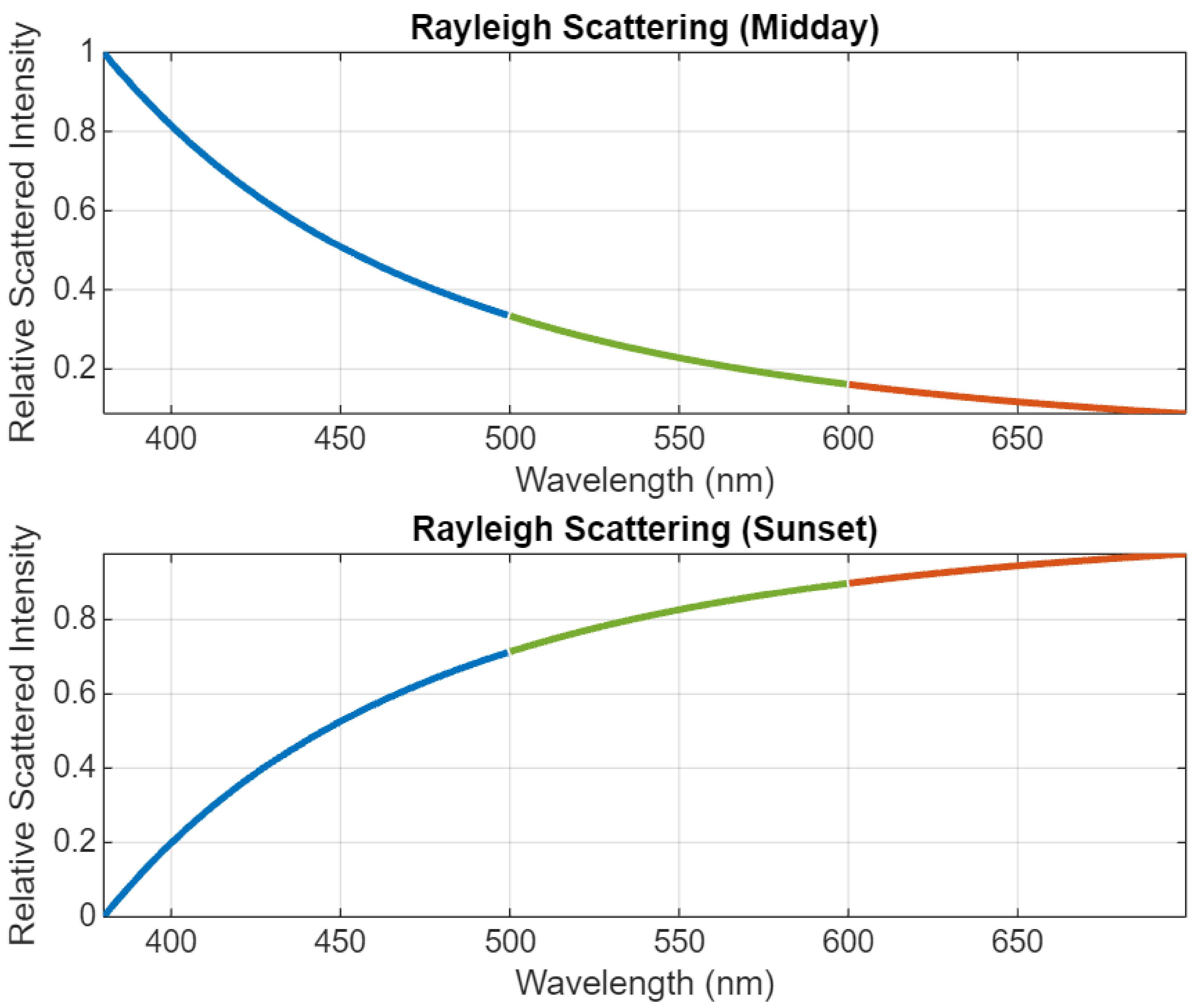

Figure 3 and 4: Relative scattered intensity in fuction of wavelength for midday and sunset

EXPLANATION OF THE FIGURES

- Both figures show the graphs corresponding to the relative scattered intensity vs different wavelengths of the visible light spectrum.
- We can see that as the scattering intensity decreases, the wavelengths are longer, which coincides with our explanation of the physical phenomena.
- For short wavelengths we receive almost 100% of its intensity, meaning that we see approximately 100% of the light sent to us.
- For red light, however, we receive close to nothing of what is sent, as visualized in the graphs.
- When receiving white light, in other words, when receiving the addition of all wavelengths, we perceive blue light because we receive a higher percentage of blue wavelengths.
- For the sunset the opposite occurs, as the relative scattered intensity increases, the wavelength increases too.
- We only receive 100% of its intensity when we have longer wavelengths.
- We receive less blue light, but almost 100% of the red light.

REFERENCES

Rayleigh scattering. (n.d.). EBSCO Information Services, Inc. | Www.ebsco.com. Retrieved May 4, 2025, from https://www.ebsco.com/research-starters/chemistry/rayleigh-scattering

ACKNOWLEDGEMENTS

This work is part of the INNOVA project "Integration of scientific computing in physics education (INCENFIS) (ref 344).