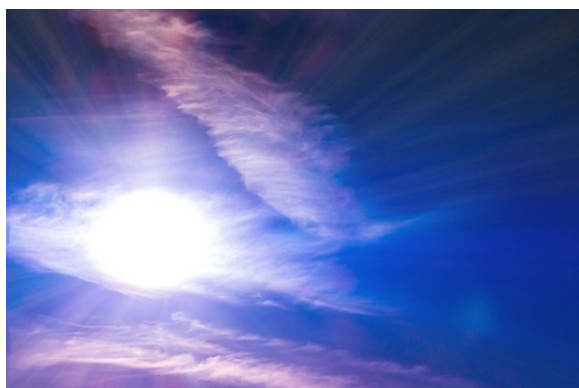


Optical Phenomena



Optical phenomena occur when light interacts with clouds, water, dust, gases, or gradients.

What are optical phenomena?

Optical phenomena are the visible result of light's interaction with clouds, water, dust, gases, or gradients (e.g. temperature, humidity). The interactions responsible for optical phenomena are **reflection**, **refraction**, and **diffraction**. **Reflection** is the process by which light rays contact a smooth surface and come back at the same angle. **Refraction**, on the other hand, occurs when light bends as it passes through two transparent media (e.g. air and water). **Diffraction** is the passage of light rays near or around an object, much like water bends when it passes around a rock in a stream. While light appears white to our eyes, it is composed of a spectrum of colors. We are most familiar with this spectrum as the colors of the rainbow. Reflection, refraction, and diffraction can cause light to separate into this spectrum. Though generally observed in the sky, one notable optical phenomenon occurs due to the refraction of light through the surface of a body of water. The optical phenomena detailed here are **apparent depth**, **coronas**, **displacement**, **glories**, **green flash**, **halos**, **mirages**, **the northern lights (Aurora Borealis)**, **rainbows**, **scattered light**, **sundogs**, **sun pillars**, and **twinkling stars**.

Apparent Depth

Apparent depth refers to the effect of light refracting at the surface of a body of water. This refraction makes swimming pools and ponds look shallower than they are. The apparent depth is not the true depth. This causes objects beneath the surface to appear nearer to the surface than they truly are. It is also responsible for sticks placed partially in the water appearing bent. If light strikes



Apparent depth is an optical phenomenon in which water bodies appear shallower than they are.

the water's surface at an angle of 0° , however, this phenomenon doesn't occur. The **refractive index**, or how much light bends when passing between media, determines the apparent depth. In fact, it is the ratio between the real and apparent depths.

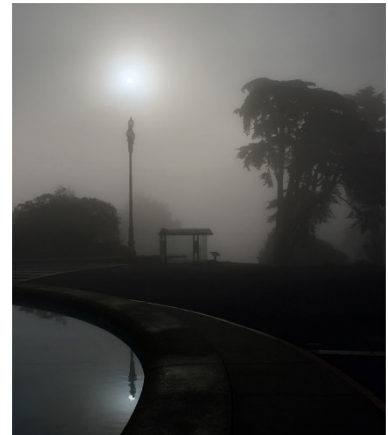
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Displacement

Displacement, also called **parallax**, is similar to the effect of apparent depth: things appear in a place where they are not. In this case, those things are stars, including our sun. As the sun nears the horizon, its light passes through our atmosphere at an angle. This angle causes it to refract. When we view this light, we are seeing it bent, so the sun appears higher than it truly is. The closer it is to the horizon, the greater the displacement.



The sun appears displaced above its true position, as evidenced by the reflection in the pond. Credit: TheBrockenInaGlory



A glory around what appears to be the shadow of a large rock.

Glories

Glories, like coronas, are caused by diffraction. In this case, however, light rays pass around an object in the sky

and onto water droplets in a cloud on the other side of the object. This causes concentric, colored rings around the shadow of that object. In order to see it, one must be between the sun and the cloud. As such, this phenomenon is usually only seen from an airplane.

Green Flash

Green flashes are due to refraction, are very rare, and only occur in the moment after sunrise or sunset. After all other wavelengths of light have disappeared (red, orange, yellow), the shorter-wavelength green light remains for less than a second. This causes a flash of green light to appear on the top edge of the sun.



Green flashes are very rare. Credit: TheBrokenInaGlory

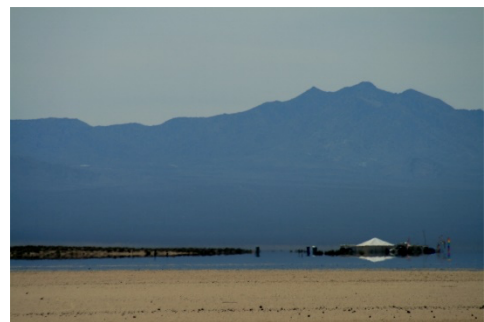
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Mirages

Mirages are very common refractive phenomena. They are caused by strong temperature gradients near the surface of the planet. The two types of mirages are **inferior** and **superior**. **Inferior mirages** occur when air near the ground is hotter than the air above it (e.g. hot asphalt). Light is refracted as it passes through



Inferior mirages look like bodies of water.

two types of media – the hot, less dense air and the cooler, denser air. This refraction

causes it to look like there is a puddle on the ground in which you can see objects reflected. This apparent puddle is actually the sky projected onto the ground. **Superior mirages** occur in the opposite condition: when air near the ground is cooler than the air above it (e.g. in polar areas). This causes light from an object to refract, making it look as though it's floating above where it truly is. It can also lead to objects appearing distorted, larger, smaller, stretched, or compressed.

The Northern Lights (Aurora Borealis)

The **northern lights** are due to Earth's magnetic field pulling particles from the sun into the atmosphere. These particles react with the gases in the atmosphere, causing the appearance of colors in the sky.



The northern lights are a result of particles from the sun interacting with gases in the atmosphere.

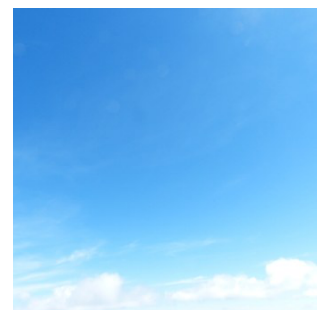
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Scattered Light

When light is **scattered** by bouncing off many small molecules in the air, some wavelengths are scattered more than others, namely the shorter wavelengths (blue, green, indigo, and violet), making them more visible. This phenomenon causes the sky to appear blue.



The sky appears blue because of scattered light.

Sundogs

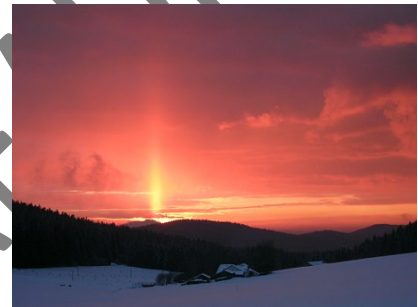


Sundogs are reflections of the sun that appear on either side of it.

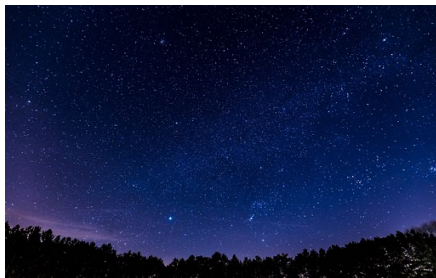
Sundogs, also called mock suns or parahelia, are formed similarly to halos. They are the result of light refracted through ice crystals in cirrus clouds at an angle of 22° . Crystals that create sundogs are larger than those that result in haloes. Sundogs appear as two bright spots, reflections of the sun, located on either side of the sun, usually near the horizon.

Sun pillars

Sun pillars are columns of light extending from the top or bottom of the sun. They are caused by reflection of light off ice crystals in cirrus clouds and generally occur when the sun is near the horizon.



Sun pillars usually extend up from the sun rather than down.



The twinkling of stars is an optical phenomenon.

Twinkling Stars

Stars appear to **twinkle** in the night sky. Interestingly, planets don't. Because stars are so far away from the Earth, their light is only a very narrow beam when it reaches us. This beam refracts through the atmosphere.

The light scatters when it hits particles in the air. Because it is so narrow, however, it also passes through the air without striking anything on its path to our eyes. The light is deflected and unobstructed several times a second. We see this alternating pattern as a twinkle. Because planets are closer to the Earth, their beam is wider and can't be deflected as easily as a narrower beam. This is why planets don't appear to twinkle.

Reading Comprehension Questions:

1. What
2. What are the three light interactions responsible for optical phenomena and what do each of them do?
3. What
4. What are the three phenomena caused by light passing through ice crystals?
5. What is
6. What are the two types of mirages and what is the difference between them?
7. Why

Extension Questions:

8. Research optical phenomena. List
9. What is the “Fata Morgana”? Give an example of an instance of this that made the news.

Reading Comprehension Questions:

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