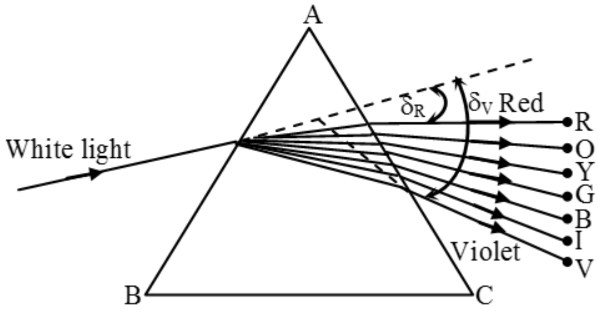
Refraction of light through a prism

Prism is a homogeneous transparent refracting medium bounded by at least two non-parallel surfaces inclined at some angle.

Dispersion of white light by a Glass prism

When white light passes through a glass prism, we get a band of seven colours on a white screen as shown in figure. The colours obtained on the screen are Violet, indigo, blue, green, yellow, orange and red .These colours can be remembered as VIBGYOR.

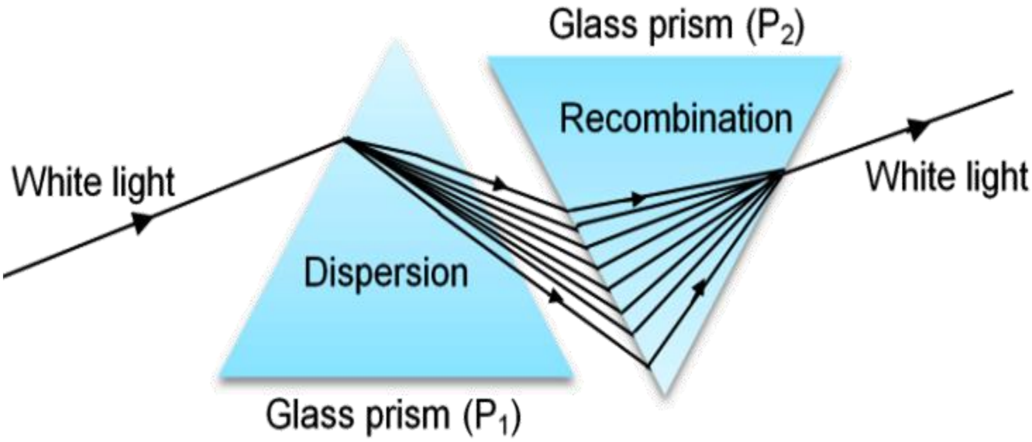


Dispersion of white light by a glass prism

Cause of dispersion

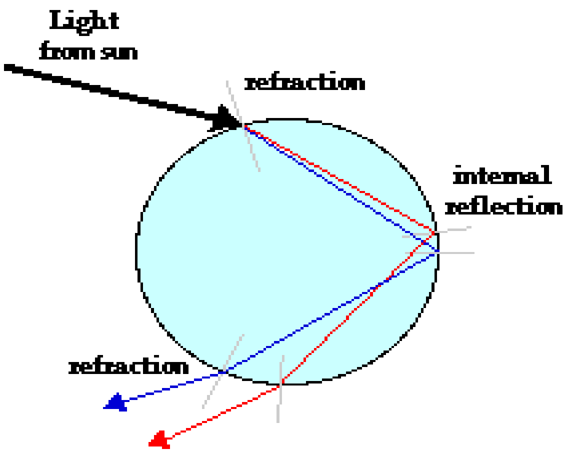
White light consists of seven colours: red, orange , yellow , green , blue , indigo and violet . Each colour has its own wavelength. The wavelength of red colour is the longest and the wavelength of violet colour is the shortest. The speed of light depends upon the wavelength or colour of light. If wavelength of a colour is large, the speed of the colour is also large. Thus, each colour of light travels with different speeds in a given medium. Red will have more speed and violet will have least speed. Hence, all colours of white light are refracted by different amounts while passing through the glass prism. Therefore, when a white light passes through a glass prism, different constituent colours come out of the prism at different angles. This gives to the dispersion of white light.

White light spitted by a glass prism can be recombined to get white light by another glass prism



Dispersion of white light in nature

When sunlight falls on the water drops suspended in the atmosphere after rainfall, rainbow formed due to the dispersion of sun light. The water drops suspended in air acts as prism.



When sunlight falls on a water drops suspended in air, the sunlight refracted. The refracted sunlight splits (or dispersed) into its constituent colours (i.e. seven colours) Thus, water drop suspended in air behaves as a glass prism. The red colour deviates the least and the violet colour deviates the most. Different colours of refracted sunlight fall on the opposite face of the water drop. Now , each colour suffers internal reflection. The reflected colours on reaching the lower surface of water drop are refracted again into the air. Thus, we get a spectrum of seven colours, which is known as Rainbow.

Conditions for observing a rainbow

Rainbow is observed during a rainfall or after rainfall or when we look at a water fountain provided the sun is at the back of the observer.

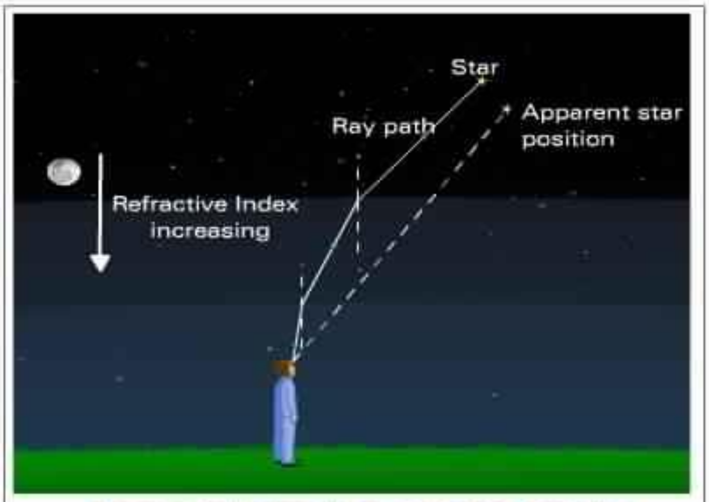
Atmospheric refraction

When sun light enters the earth's atmosphere , it continuously goes from rarer to the denser medium and hence refraction of light takes place. The refraction of light taking place in the atmosphere is known as atmosphere refraction.

Atmospheric refraction gives rise to many optical phenomena

(A) Twinkling of stars

Light emitted by distant stars (acts as point sources of light) passes through the atmosphere of the earth before reaching our eyes. The atmosphere of the earth is not uniform but consists of many layers of different densities. The layers close to the surface of the earth are optically denser. As we go higher and higher, the density of layers and refractive index decreases progressively. As the light from a star enters the upper most layer of the atmosphere, it bends towards the normal as it enters the next layer. This process continues till the light enters our eyes.so due to refraction of light , the apparent position of the star is different from the actual position of the star.



Apparent Star Position due to Atmospheric Refraction

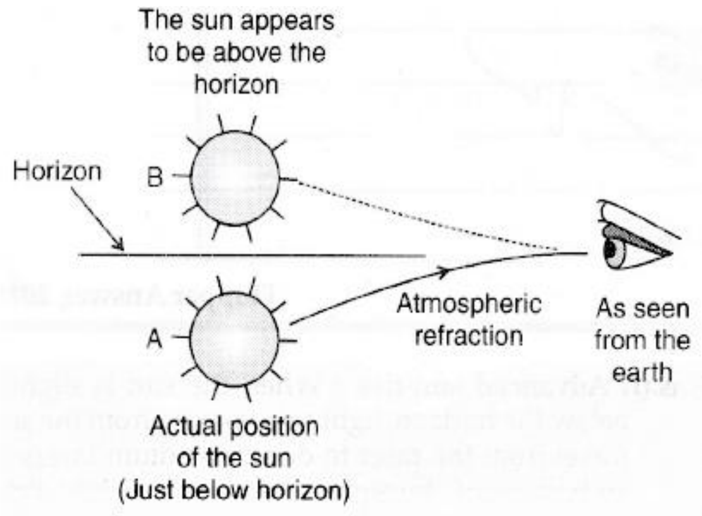
Moreover , the different layers of the atmosphere are mobile and the temperature and the density of layers of atmosphere changes continuously. Hence , the apparent position of the star changes continuously. The change in the apparent position of the star continuously leads to the twinkling of a star.

(b) Why planets do not twinkle?

Planets are very close to the earth as compared to the stars. The planets act as extended sources of light. So the intensity of light we receive from the planets is very large, Therefore, the variation in the brightness of the planets is not directed. Hence, planets do not twinkle.

(C) We can see the sun for few minutes even after it has actually set.

Actual sun set when it is below the horizon in the evening. The rays of light from the sun below the horizon reach our eyes because of refraction of light. These rays appear to come from the apparent position of the sun, which is above the horizon as in figure. Hence, we can see the sun for few minutes (about 2 minutes) even after it has actually set. Similarly, the sun can be seen about 2 minutes before it actually rises. Thus, we gain about 4 minutes of additional daylight each day.



<u>**Scattering of light.**</u>

When sun light enters the atmosphere of the earth, the atoms and molecules of different gases present in the atmosphere absorb this light. Then these atoms and molecules of the gases re-emit light in all directions. This process is known as Scattering of light. The atoms or particles scattering the light are known as scatterers.

The intensity of scattered light is inversely proportional to the fourth power of the wavelength of incident light. If the size of the particles (say atoms or molecules) scattering the light is less than the wavelength of the incident light.

That is , intensity of scattered light . I $\alpha \frac{1}{\lambda^4}$, we know wavelength of the red light is greater than the wavelength of blue or violet light. Therefore, the intensity of scattered light is less than the intensity of the scattered blue light or violet light.

<u>**Applications of scattering phenomena in daily life**</u>

(a) <u>**Sky would appear black in daytime if earth had no atmosphere**</u>

If earth had no atmosphere, then there would be no gas present in the atmosphere. Since there is no scatterer in the atmosphere of the earth, so there will be no scattering of light. Hence, the sky would appear dark. For astronauts far from the atmosphere of the earth, the sky appears dark, as there is no scattering of light.

When the earth had no atmosphere, sunlight would be visible only if we look directly at the sun. Even stars will be seen in daytime in the absence of the earth's atmosphere.

(b) Why is the colour of clear sky blue?

When sunlight enters the earth's atmosphere, the atoms or molecules of the gases present in the atmosphere scatter this light. Since wavelength of red colour is larger than the wavelengths of other colours in sunlight, so red colour is scattered least. Violet colour is scattered the most followed by blue, green, yellow, orange and red colours respectively . Our eye is more sensitive to the blue light than the violet light. Therefore, scattered light in the sky contains blue colour in plenty and hence the clear sky appears blue.

Note : Sky appears greyish over cities having industries units. The smoke and dust particles in the atmosphere over such cities scatter red, orange and yellow colours more than other colours of small wavelength. Hence, sky appears greyish.

(**c) Why Sunset and sun =rise are red?**

At the time of sunrise or sunset , the position of the sun is very far away from us. The sunlight travels longer distance through the atmosphere of the earth before reaching our eyes. Scattering of blue light is more than the scattering of red light. As a result of this, more red light reaches our eyes than the other colour. Hence, sunset and sunrise appear red.

(d) Why clouds are white?

Clouds are made of water droplets of different sizes. These different sized droplets scatter different colours. For examples, the tiniest droplets scatter more blue light than other colours. Droplets of size greater than the tiniest droplets scatter more green colour and largest droplets scatter more red light. As all the colours are scattered by the droplets in the clouds, so the resultant light is white. Hence, clouds appear white.

(e) Danger Signals are of red colour.

When light falls on the signal, all colours are scattered much more than that of red colour. So the red colour suffering least scattering confined around the signal, which in turn illuminates the signal significantly. Thus, the danger signals can be seen from far off distances. Moreover, among all colours, red is scattered least by smoke or fog. Hence, red signals are visible even through the smoke or fog.

(f) Tyndall effect

The phenomenon of scattering of light by dust, smoke and water droplets suspended in air is known as Tyndall effect.

Tyndall effect is seen (a) From dust particles in air when sun light comes through a window or a slit in a window. (b) When sun light comes down through the clouds (c) When head light beams comes through for or mist.