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Scattering of light; Blue colour of sky and reddish colour of sun at sun set and sun rise

XII- SCIENCE

SUBJECT : PHYSICS
CHAPTER NUMBER: 9
CHAPTER NAME : RAY OPTICS

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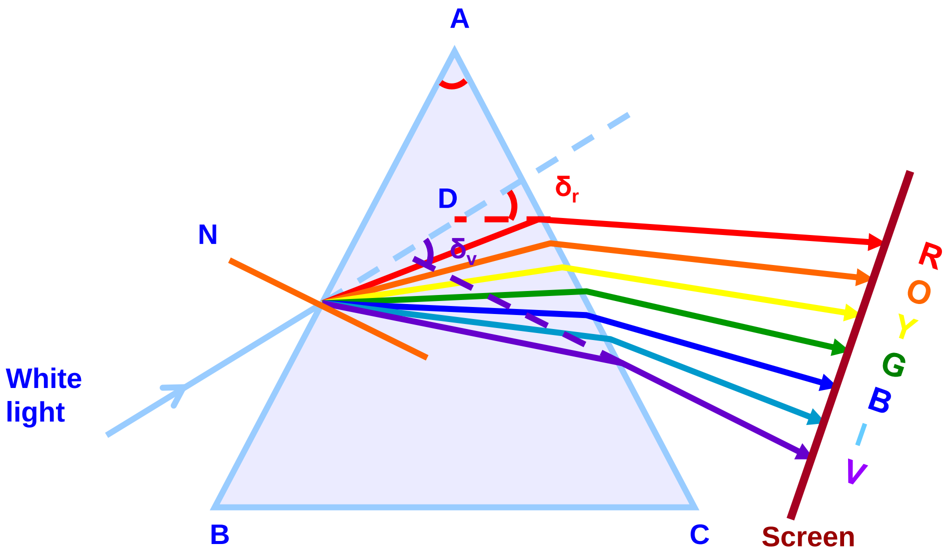
Dispersion of White Light through Prism:

The phenomenon of splitting a ray of white light into its constituent colours (wavelengths) is called dispersion and the band of colours from violet to red is called spectrum (VIBGYOR).



Cause of Dispersion:

$$\mu_v = \frac{\sin i}{\sin r_v} \quad \text{and} \quad \mu_r = \frac{\sin i}{\sin r_r}$$

Since $\mu_v > \mu_r$, $r_r > r_v$

So, the colours are refracted at different angles and hence get separated.

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Dispersion can also be explained on the basis of Cauchy's equation.

$$\mu = a + \frac{b}{\lambda^2} + \frac{c}{\lambda^4}$$ (where a, b and c are constants for the material)

Since $\lambda_v < \lambda_r$, $\mu_v > \mu_r$

But $\delta = A(\mu - 1)$

Therefore, $\delta_v > \delta_r$

So, the colours get separated with different angles of deviation.
Violet is most deviated and Red is least deviated.

Angular Dispersion:

1. The difference in the deviations suffered by two colours in passing through a prism gives the angular dispersion for those colours.
2. The angle between the emergent rays of any two colours is called angular dispersion between those colours.
3. It is the rate of change of angle of deviation with wavelength. ($\Phi = d\delta / d\lambda$)

$\Phi = \delta_v - \delta_r$ or $\boxed{\Phi = (\mu_v - \mu_r) A}$

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Dispersive Power:

The dispersive power of the material of a prism for any two colours is defined as the ratio of the angular dispersion for those two colours to the mean deviation produced by the prism.

It may also be defined as dispersion per unit deviation.

$$\omega = \frac{\Phi}{\delta} \quad \text{where } \delta \text{ is the mean deviation and } \quad \delta = \frac{\delta_v + \delta_r}{2}$$

$$\text{Also} \quad \omega = \frac{\delta_v - \delta_r}{\delta} \qquad \text{or} \quad \omega = \frac{(\mu_v - \mu_r)\,A}{(\mu_y - 1)\,A} \qquad \text{or} \quad \omega = \frac{(\mu_v - \mu_r)}{(\mu_y - 1)}$$

Dispersive Power:

Scattering of Light – Blue colour of the sky and Reddish appearance of the Sun at Sun-rise and Sun-set:

The molecules of the atmosphere and other particles that are smaller than the longest wavelength of visible light are more effective in scattering light of shorter wavelengths than light of longer wavelengths. The amount of scattering is inversely proportional to the fourth power of the wavelength. (Rayleigh Effect)

Light from the Sun near the horizon passes through a greater distance in the Earth's atmosphere than does the light received when the Sun is overhead. The correspondingly greater scattering of short wavelengths accounts for the reddish appearance of the Sun at rising and at setting.

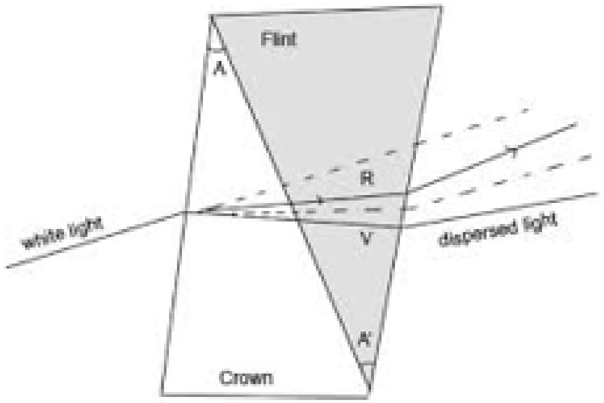
When looking at the sky in a direction away from the Sun, we receive scattered sunlight in which short wavelengths predominate giving the sky its characteristic bluish colour.

2. **Dispersion without deviation:**

i.e. $D + D^1 = 0$

$$\Rightarrow (\mu - 1)A + (\mu^1 - 1)A^1 = 0$$

$$\Rightarrow A^1 = -\frac{(\mu - 1)A}{(\mu^1 - 1)}$$



This is the relation between angles of prisms of the prisms combined to produce dispersion without deviation . –ve sign is there because the prisms are to be arranged in opposite sense .

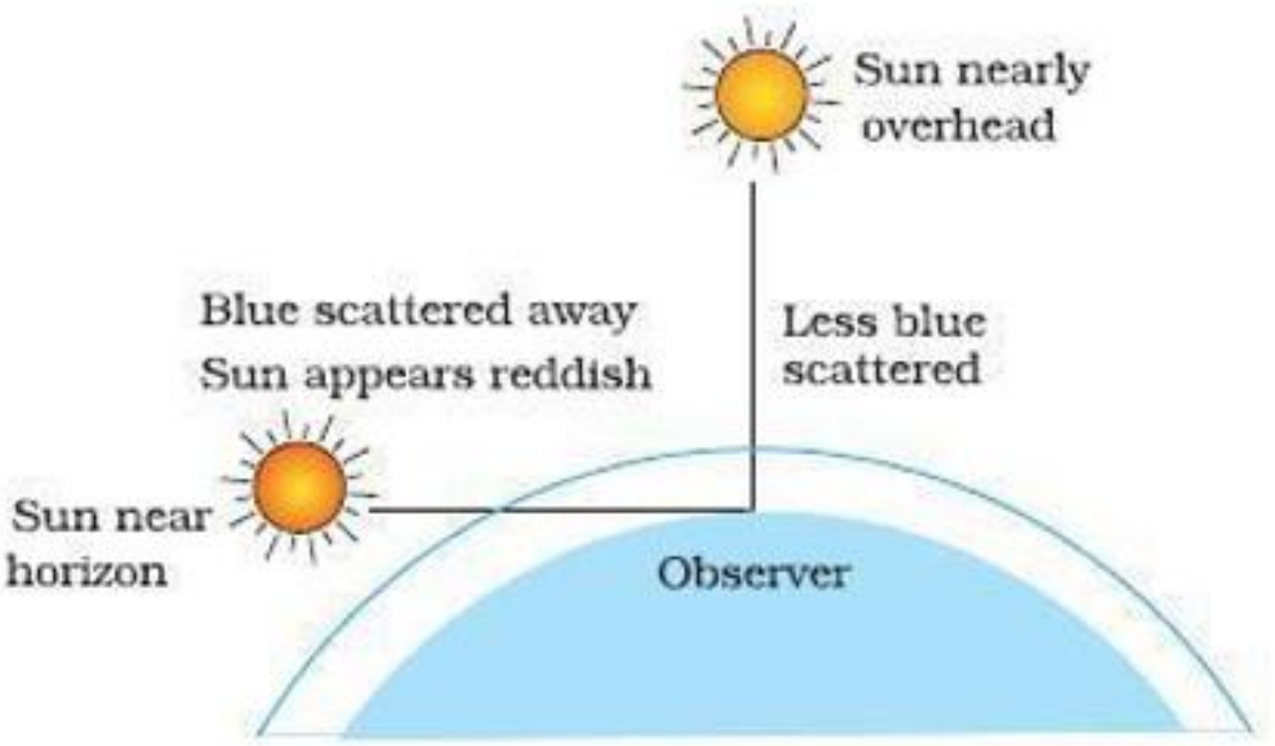
Scattering of light :

- When light strikes very small particles of size comparable to the wavelength of light then its direction is changed . This phenomenon is called as scattering of light .The particle that scatters the light is called as ***scatterer*** .
- **Rayleigh's scattering :** The amount of scattering or the intensity of scattered light is inversely proportional to the fourth power of wave length .

  i.e. $I \propto 1/\lambda^4$.
- ***Blue colour of sky :*** The small particles of atmospheres of size comparable to wave length scatters the light . As according to Rayleigh scattering $I \propto 1/\lambda^4$, then blue colour is scattered more strongly than red , green because of smaller wavelength . Although violet is scattered more strongly than blue , but our eyes are more sensitive towards blue than violet . So sky is blue.

- ***White colours of clouds :*** Large particles like dust and water droplets in cloud have very large size (a >> λ) . So they don't scatter light and hence appear white .
- ***Appearance sun at different times in a day :*** (i) During sunrise and sun set sun remains near the horizon . So sun rays have to travel through a larger distance in the tmosphere at this time . Most of the blue and other shorter wavelengths are removed by scattering . The ***least scattered*** light reaching our eyes , **therefore sun looks reddish** .

  (ii) But at the noon time , sun is over head . So light rays from sun does not travel through a larger distance . So all colours reach in equal amount in our eye . So sun appear white during noon time .


Sun nearly overhead
Blue scattered away
Sun appears reddish
Less blue scattered
Sun near horizon
Observer

THANKING YOU

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