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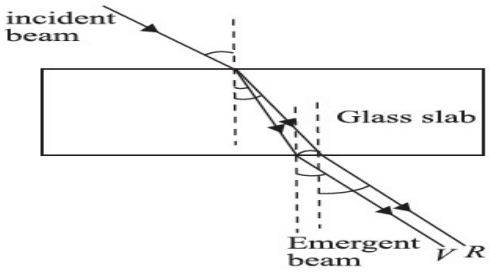
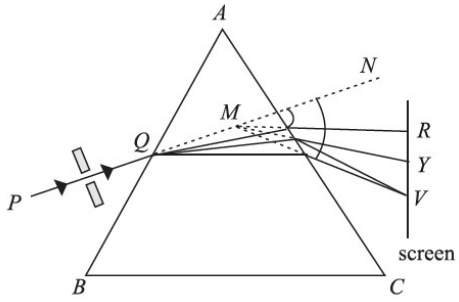
DISPERSION AND SCATTERING OF LIGHT

DISPERSION OF LIGHT

- The splitting of white light into its constituent colours or wavelengths
- by a medium is called **dispersion**
- The speed and wavelength of waves change when they travel from one medium to another.
- Variation of the refractive index of a material with wavelength is known as dispersion.
- In free space and even in air, the speeds of all waves of the visible light are the same. So, they are not separated. (Such a medium is called a **non-dispersive medium**.)
- In an optically denser medium, the component wavelengths (colours) travel with different speeds and therefore get separated. Such a medium is called **dispersive medium**

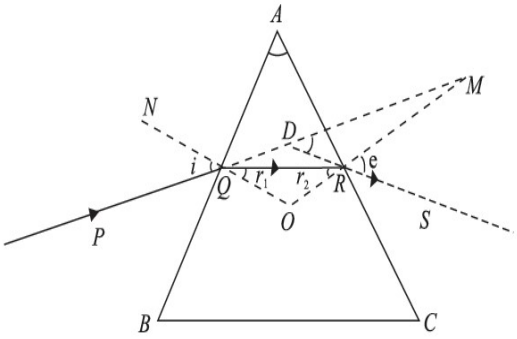
Dispersion through a Prism





- Splitting of white light into component colours is known as dispersion.
- The bending of the original beam PQN along MR and MV etc. is known as deviation.
- The angle between the emergent ray and the incident ray is known as the angle of deviation

The Angle of Deviation



- The angle between the emergent ray RS and the incident ray PQ at D is known as the angle of deviation (δ).

Angle of Minimum Deviation

- The minimum value of the angle of deviation is called angle of minimum deviation (δm).
- It depends on the material of the prism and the wavelength of light used.

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

- $$\mu \angle A = \angle A + \angle\delta$$
$$\angle\delta = (\mu - 1)\angle A$$

Angular Dispersion and Dispersive Power

Ratio of the angular dispersion to the mean deviation is taken as the dispersive power (ω) of the material of the prism :

$$\omega = \frac{\delta_V - \delta_R}{\delta_Y}$$

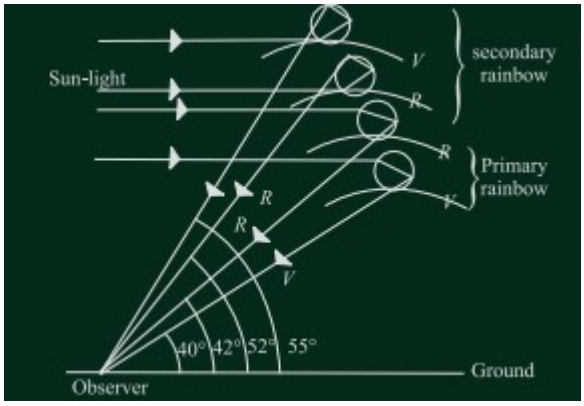
$$\omega = \frac{(\mu_V - 1)\angle A - (\mu_R - 1)\angle A}{(\mu_V - 1)\angle A}$$

$$= \frac{\mu_V - \mu_R}{\mu_Y - 1} = \frac{\Delta\mu}{\mu - 1}$$

Rainbow Formation

Dispersion of sunlight through suspanded water drops in air produces a spectracular effect in nature in the form of rainbow on a rainy day. With Sun at our back, we can see a brighter and another fainter rainbow.

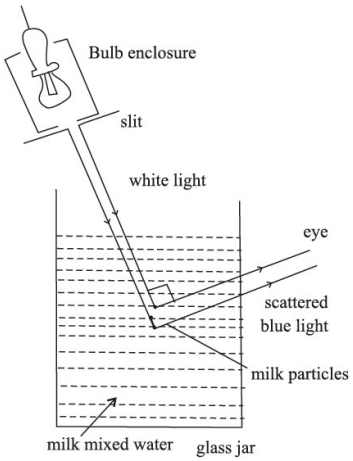
- The primary rainbow is formed by two refractions and a single internal reflection of sunlight in a water drop
- The secondary rainbow is formed by two refractions and two internal reflections of light on the water drop.



SCATTERING OF LIGHT IN ATMOSPHERE

Scattering of Light

This phenomenon involves interaction of radiation with matter



The intensity of scattered light is given by Rayleigh's law of scattering.

According to this law, the intensity of scattered light is inversely proportional to the fourth power of its wavelength:

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

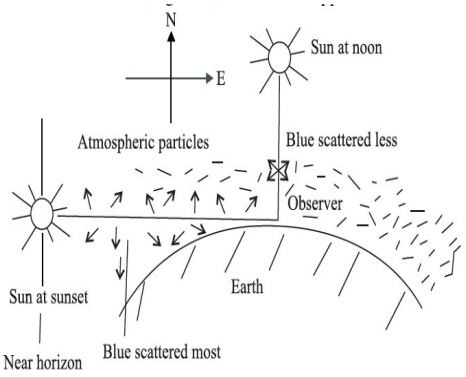
Blue Colour of the Sky

- The blue light is scattered almost six times more intensely than the red light
- The scattered light becomes rich in the shorter wavelengths of violet, blue and green colours.
- On further scattering, the violet light does not reach observe's eye as the eye iscomparatively less sensitive to violet than blue and other wavelengths in itsneighbourhood.
- So, when we look at the sky far away from the sun, it appears blue.

White colour of the clouds

The clouds are formed by the assembly of small water drops whose size becomes more than the average wavelength of the visible light (5000Å). These droplets scatter all the wavelengths with almost equal intensity. The resultant scattered light is therefore white. So, a thin layer of clouds appears white.

Red colour of the Sun at Sunrise and Sunset



In the morning and evening when the Sun is near the horizon, light has to travel a greater distance through the atmosphere. The violet and blue wavelengths are scattered by dust particles and air molecules at an angle of about 90^0 . The sunlight thus becomes devoid of shorter wavelengths and the longer wavelength of red colour reaches the observer so the Sun appears to us as red

Raman Effect

When light radiation undergoes scattering from a transparent substance (solid, liquid or gas) then the frequency of the scattered radiation may be greater or less than the frequency of the incident radiation. This phenomenon is known as Raman effect

Check Yourself

1. The colour which is scattered most in atmosphere is
   A. Red
   B. Green
   C. Yellow
   D. Blue
2. The phenomenon of scattering of light by the colloidal particle is known as
   A. Raman effect
   B. Newton's ring
   C. Spectral effect
   D. Tyndal effect
3. Colour of sky appears blue its due to
   A. Shorter wavelength of blue colour
   B. The size of fine particle in atmosphere is almost equal to wavelength of blue colour
   C. As extent of scattering of blue light is more it enters our eyes
   D. All of these
4. Which colour will be observed by a astronaut travelling in space
   A. Blue
   B. Indico
   C. Black
   D. Green
5. How many component of white light
   A. 5
   B. 6
   C. 7
   D. 8

Stretch Yourself

1. For a prism, show that $i + e = A + \delta$
2. The deviation produced for red, yellow and violet colours by a crown glass are 2.84^0 , 3.28^0 and 3.72^0 respectively. Calculate the dispersive power of the glass material.
3. A lens can be viewed as a combination of two prisms placed with their bases together. Can we observe dispersion using a lens. Justify your answer.
4. The angle of minimum deviation for a 60^0 glass prism is 39^0 . Calculate the refractive index of glass.

Hint to Check Yourself

1D 2 D 3 D 4C 5C