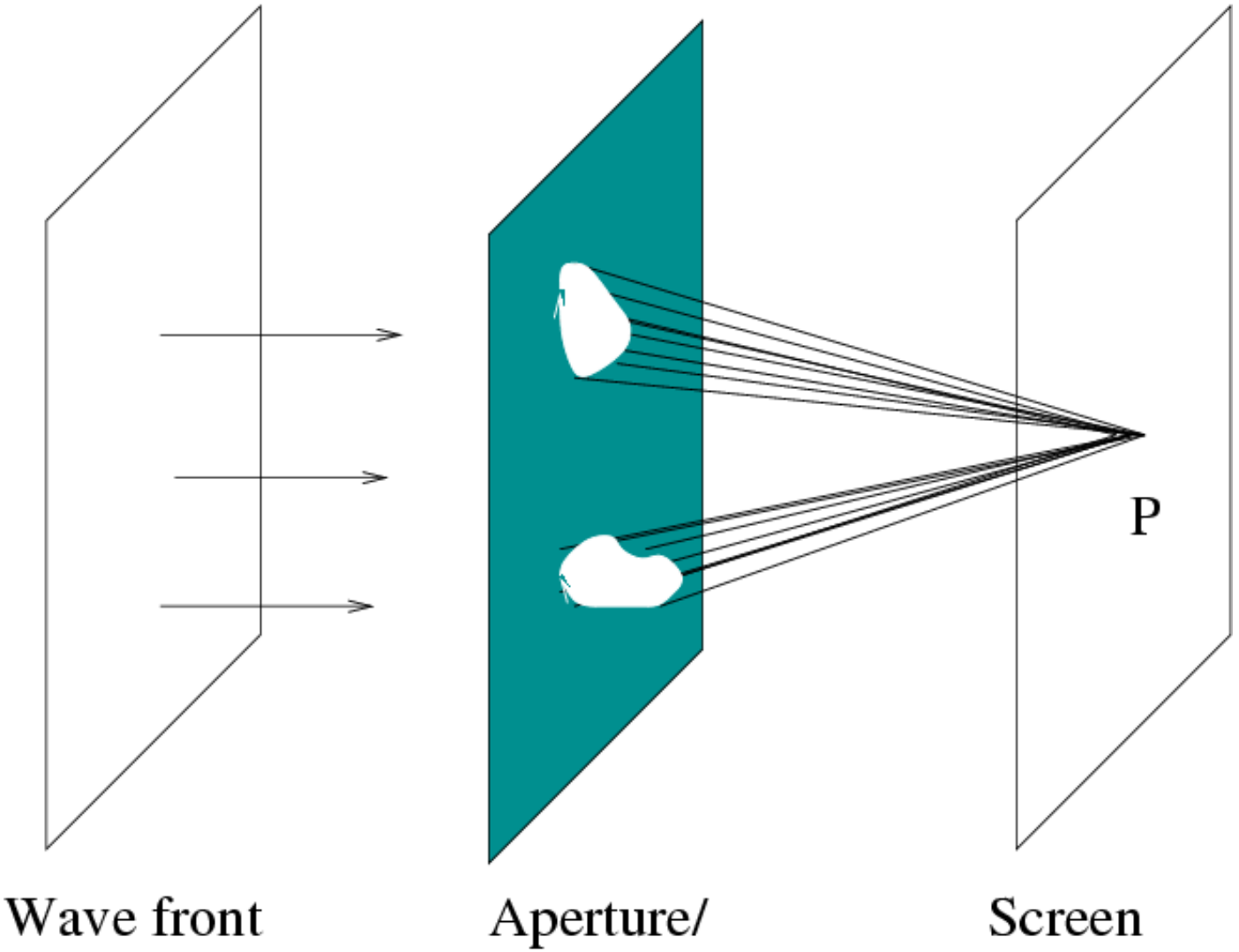
Diffraction

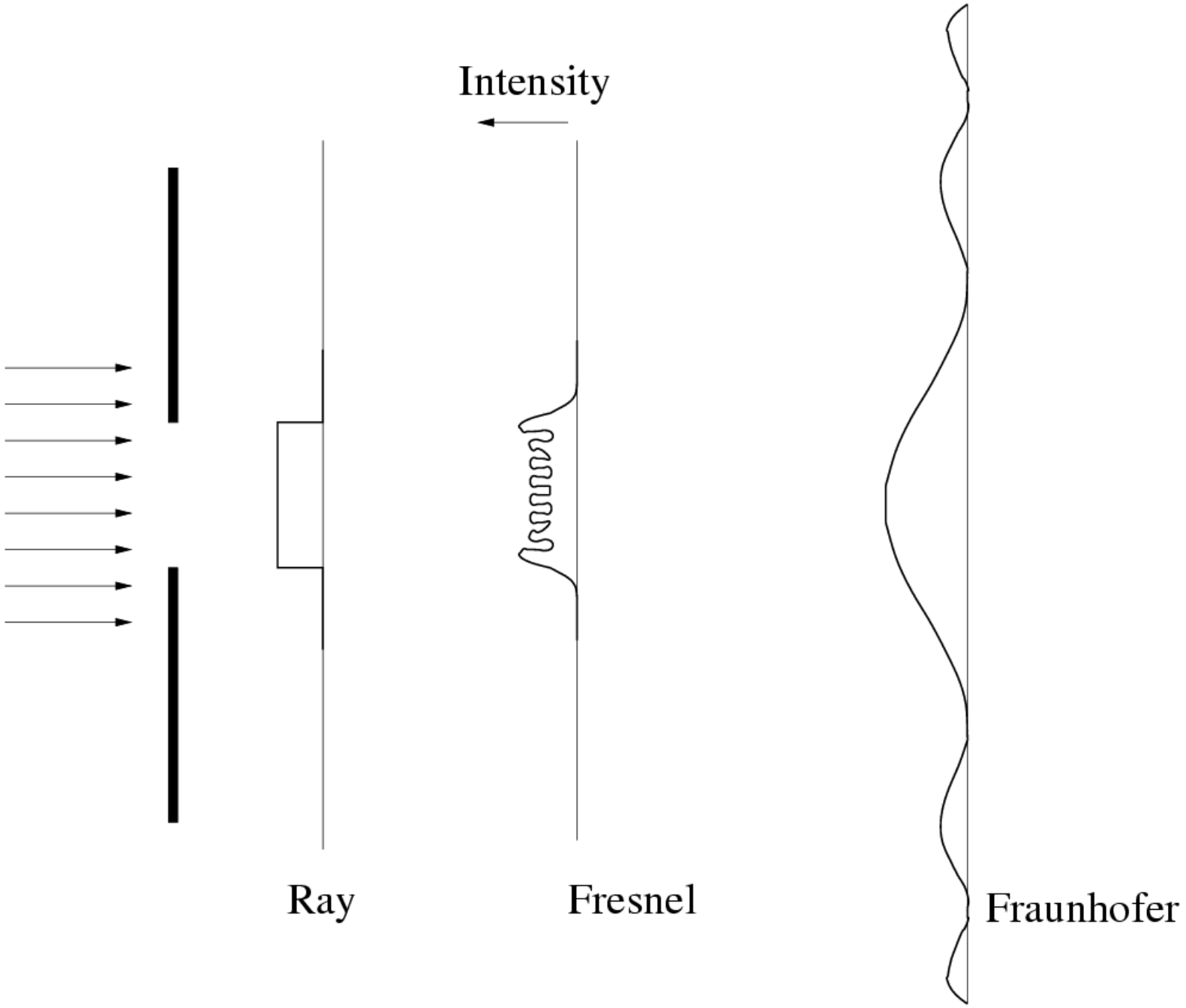
``Any deviation of light rays from rectilinear path which is neither reflection nor refraction known as diffraction.'' (Sommerfeld)

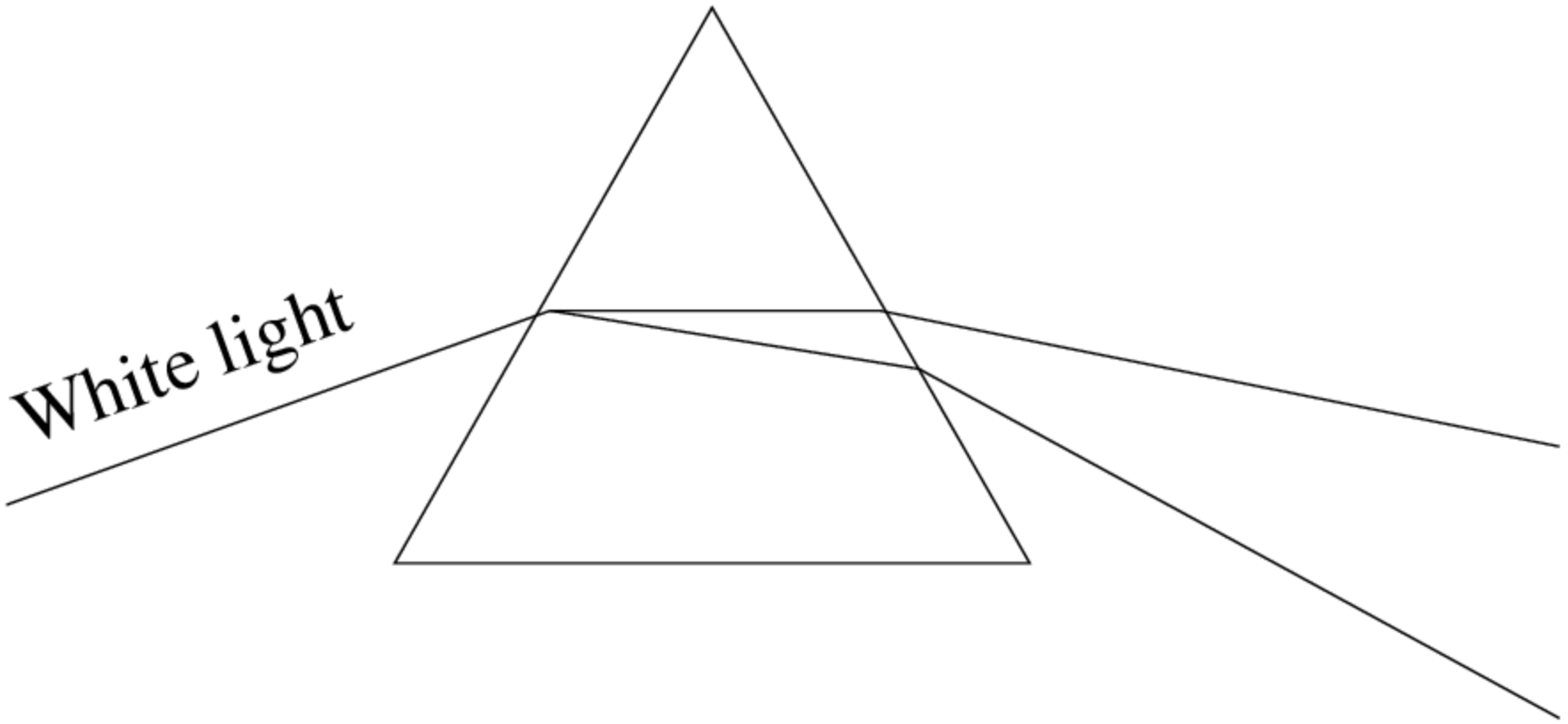
Types or kinds of diffraction:

1. Fraunhofer (1787-1826)

2. Fresnel (1788-1827)

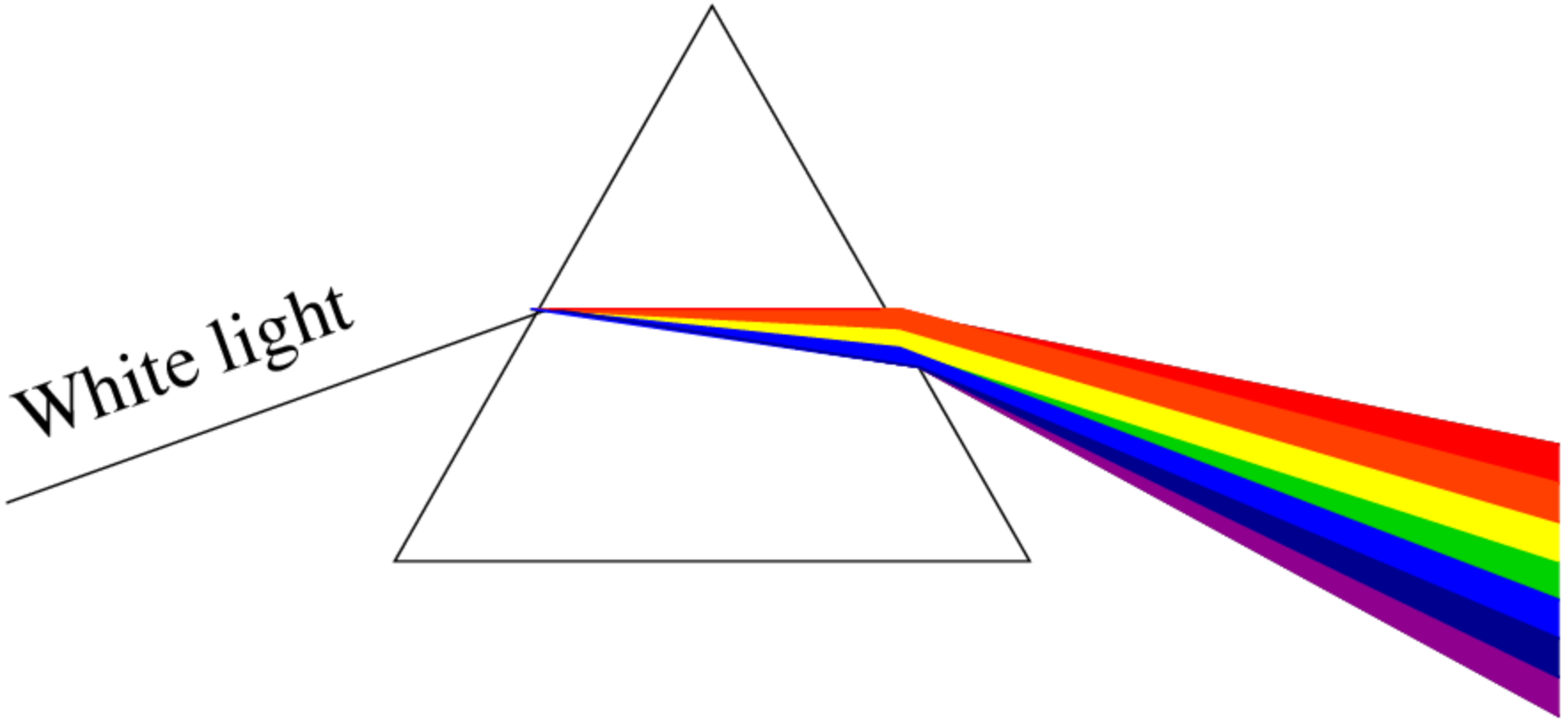

P
Wave front
Aperture/
Obstacle
Screen


Intensity
Ray
Fresnel
Fraunhofer


White light

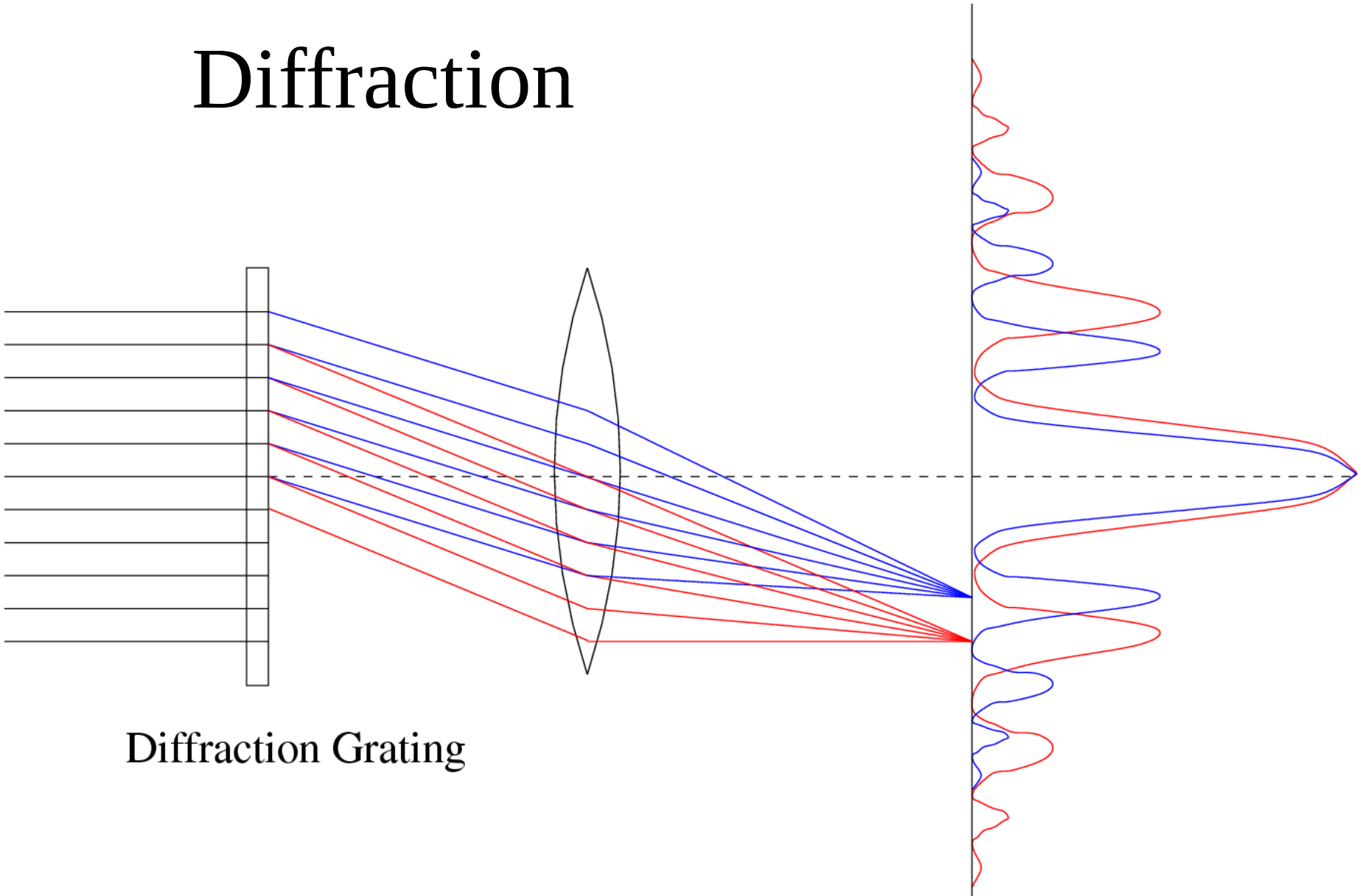
Refraction

$\mu_V > \mu_R$

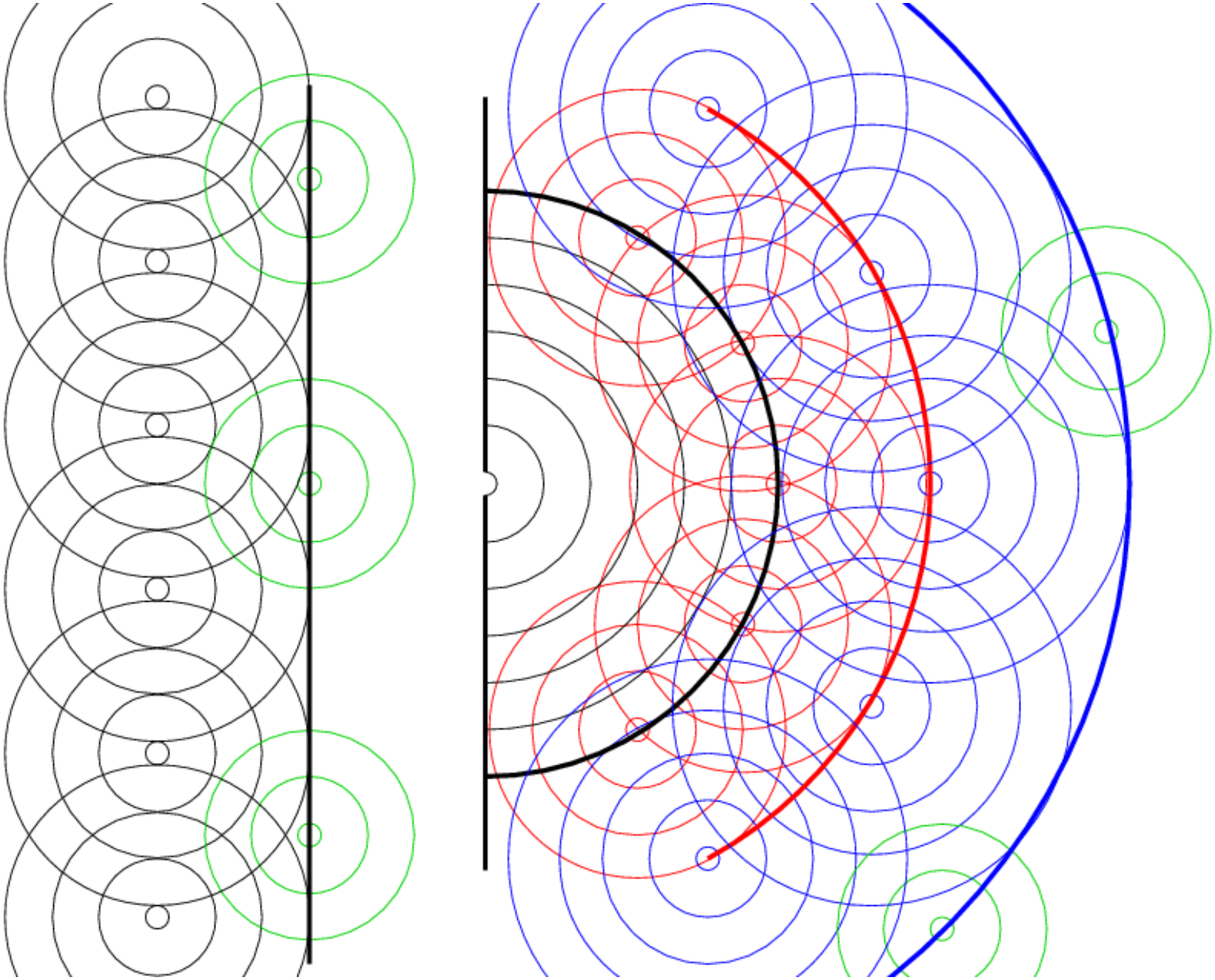


Deviation for blue is larger than that for red

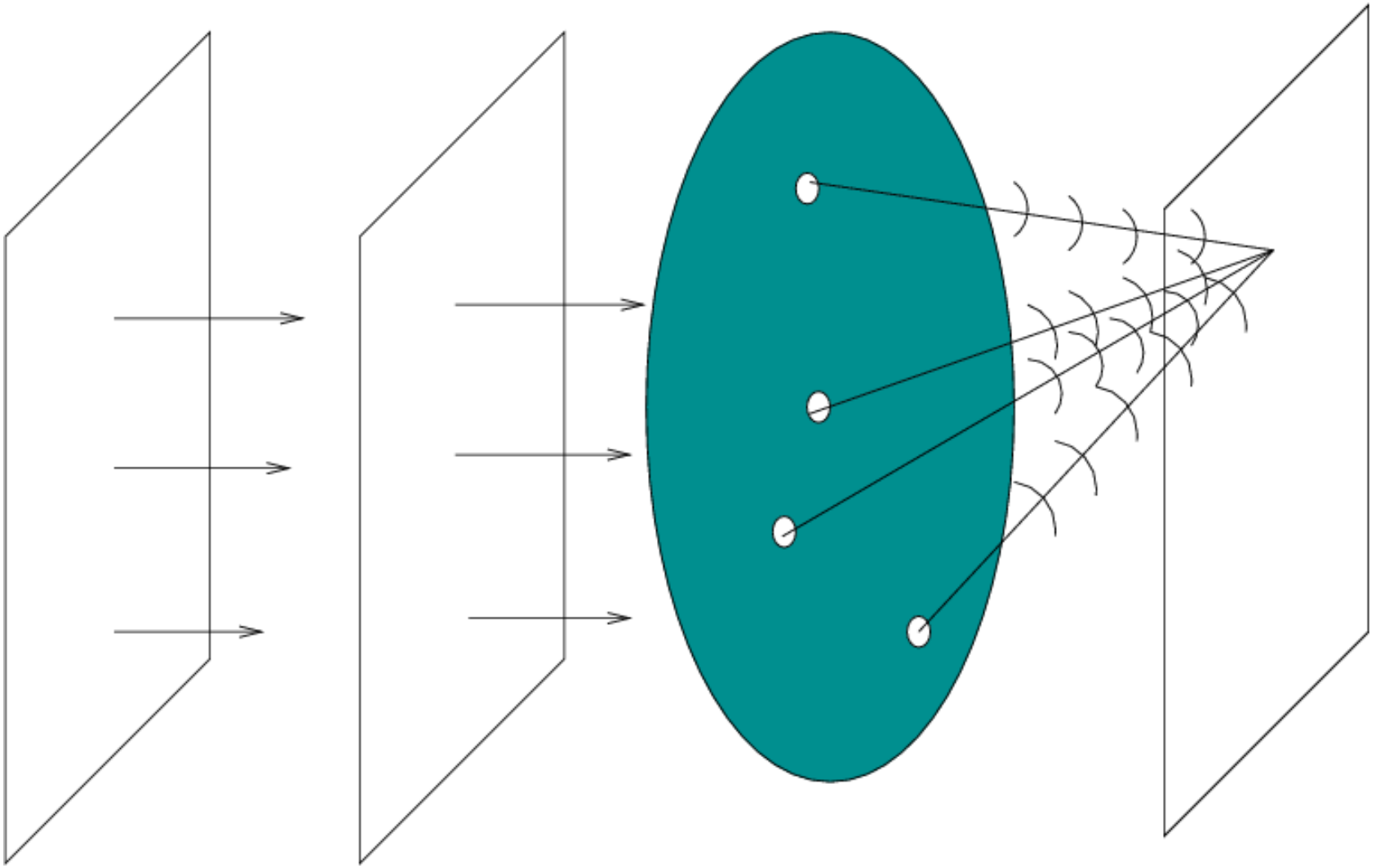
Diffraction



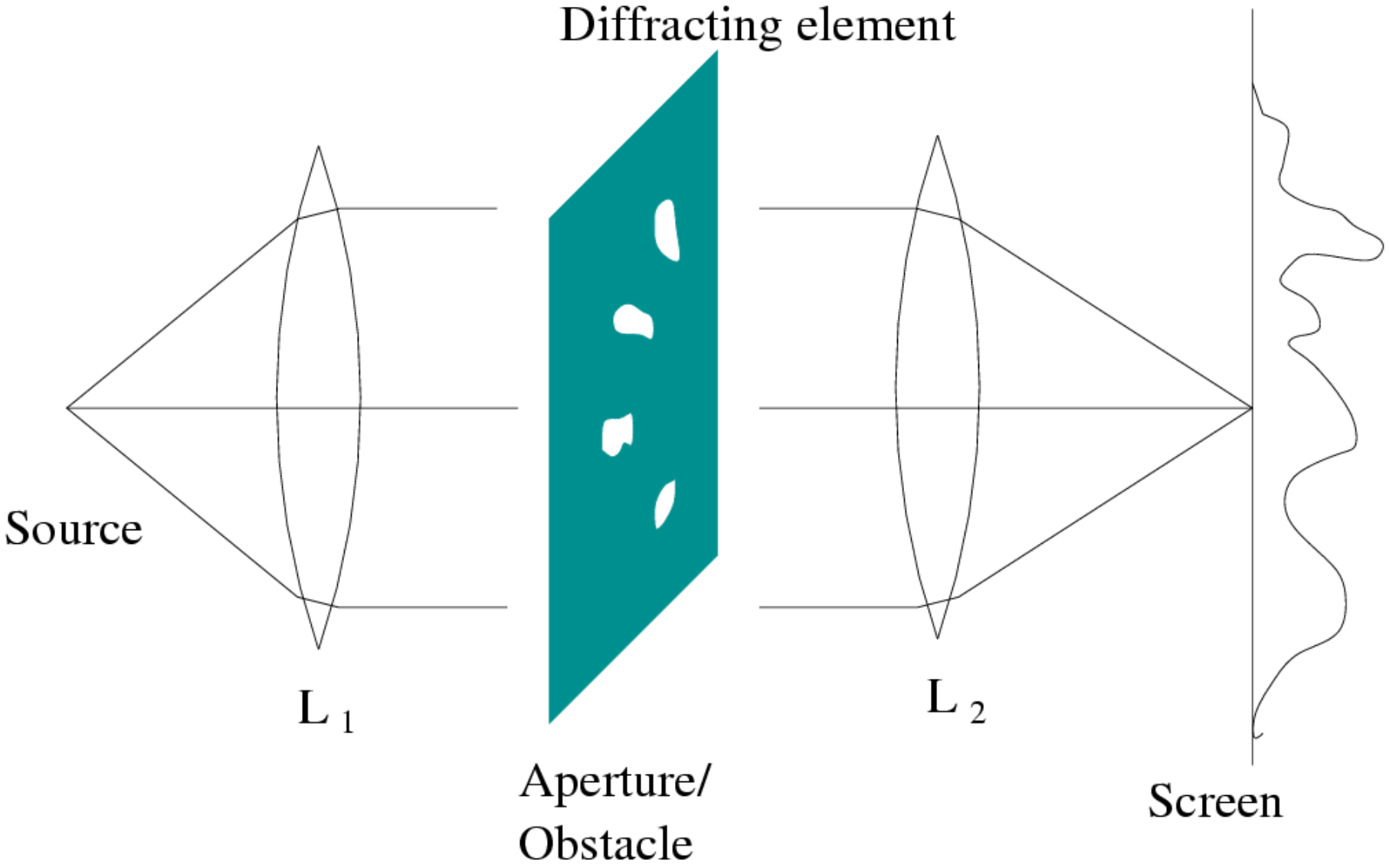
Deviation for red is larger than that for blue



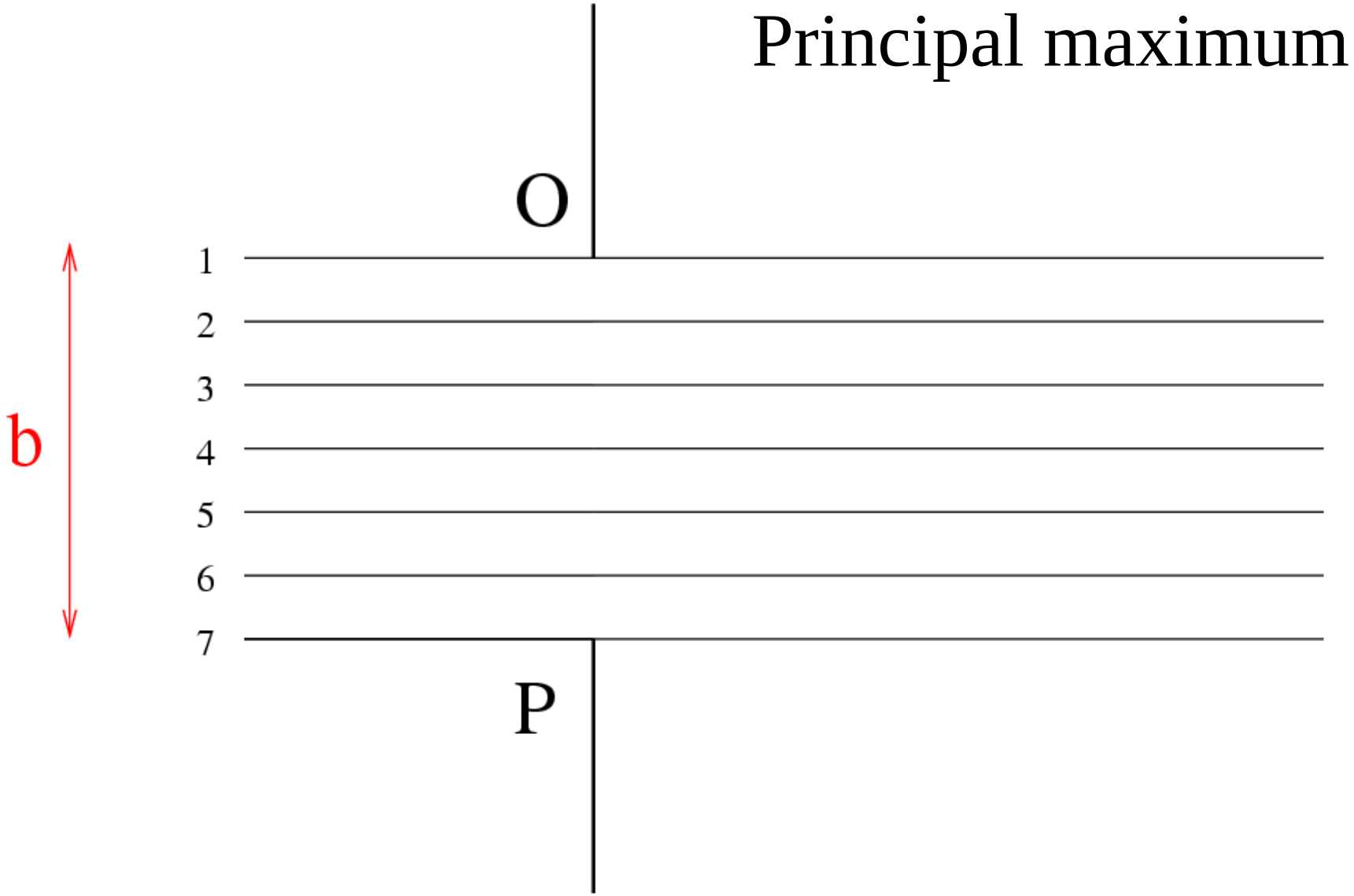
Secondary wavelets from apertures



Fraunhofer diffraction

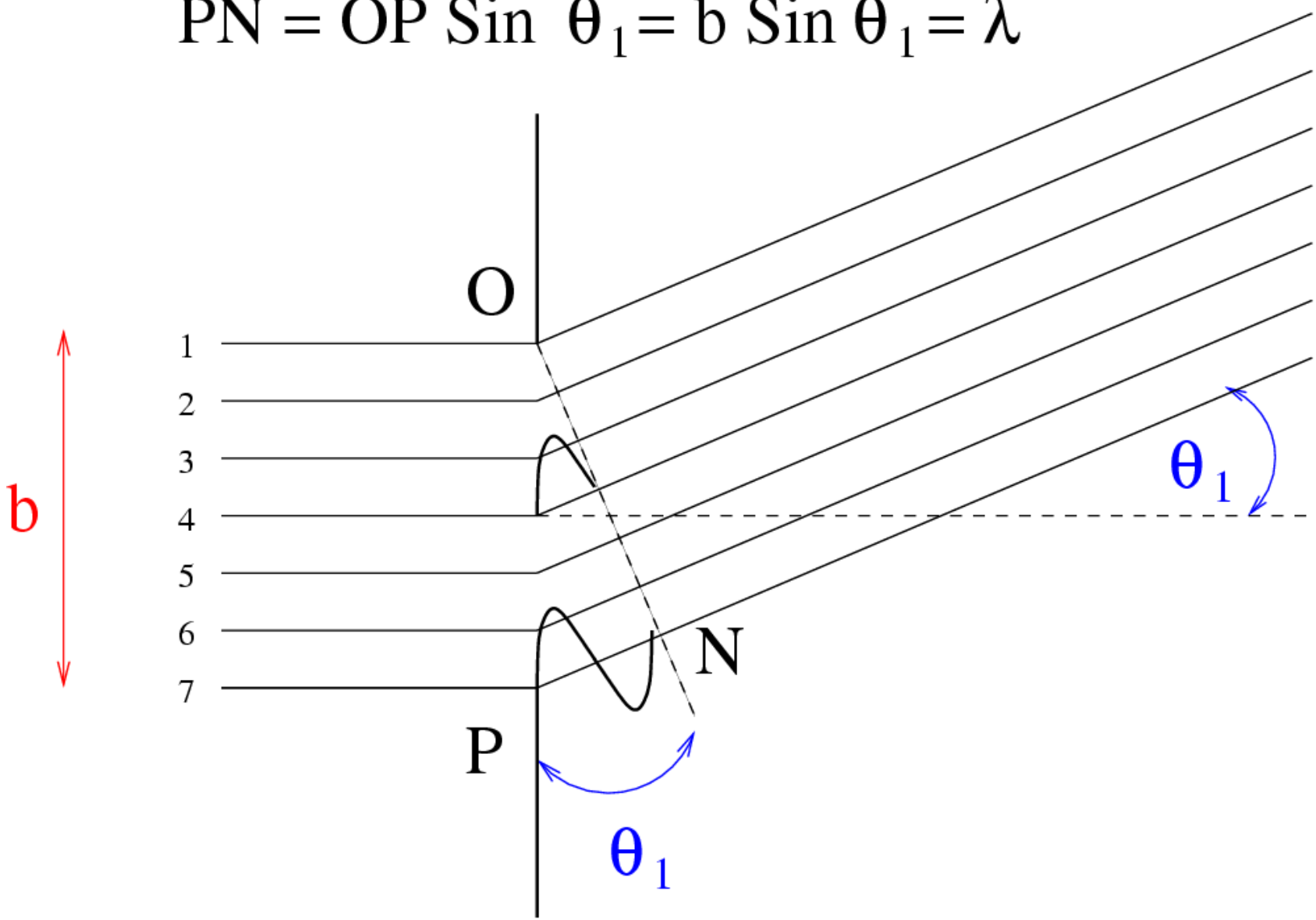


Single slit diffraction



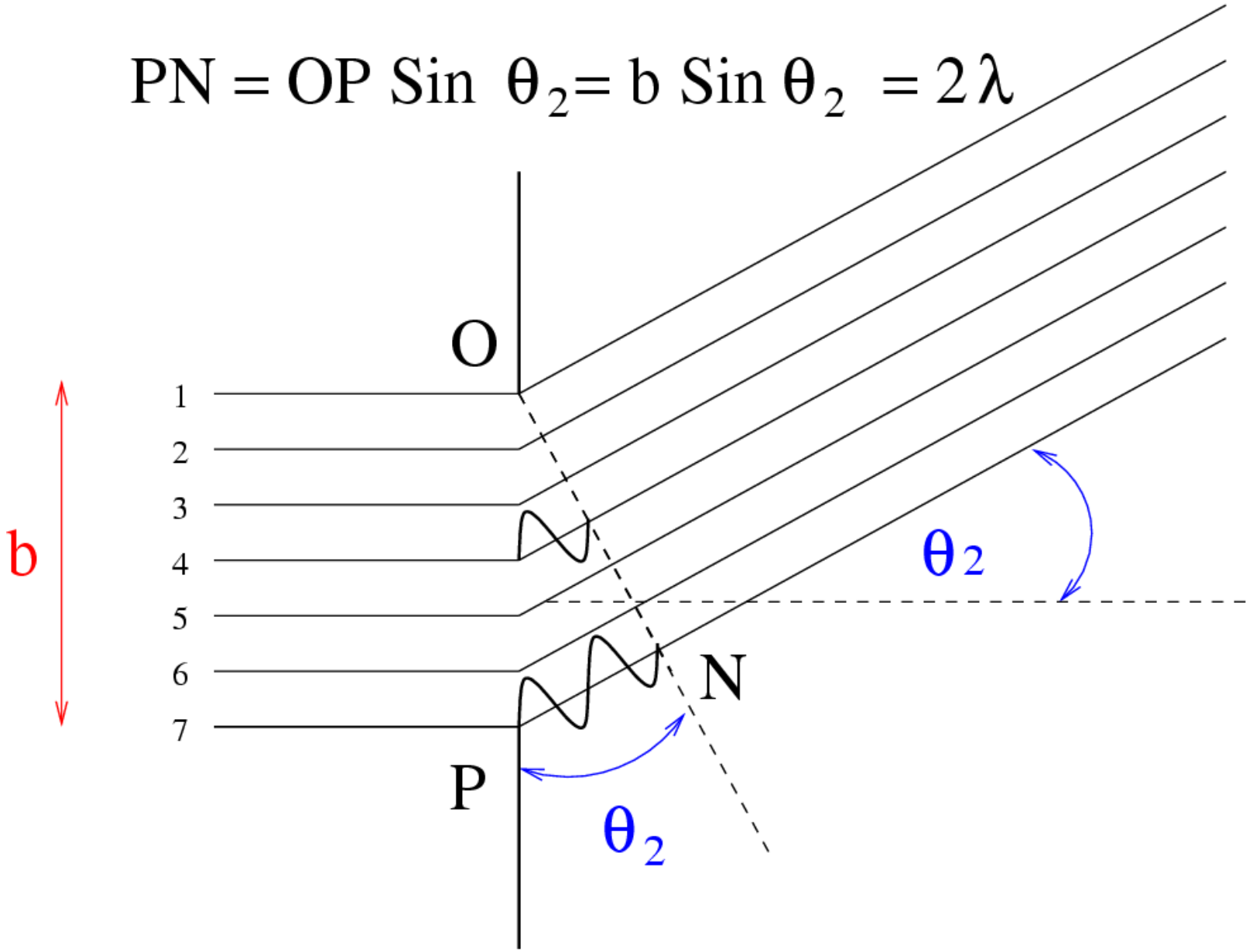
First minimum

$$PN = OP \sin \theta_1 = b \sin \theta_1 = \lambda$$



Second minimum

$$PN = OP \sin\theta_2 = b \sin\theta_2 = 2\lambda$$



Superposition of large number of phasors of equal amplitude *a* and equal successive phase difference δ. Find the resultant phasor.

$$A = |A| \exp(i\phi) = a + a\exp(i\delta) + a\exp(i2\delta)$$
$$+ a\exp(i3\delta) + \cdots a\exp(i(n-1)\delta)$$

$$A = a[1 - \exp(in\delta)]/[1 - \exp(i\delta)]$$

$$= a\frac{\sin(n\delta/2)}{\sin(\delta/2)}\exp(i(n-1)\delta/2)$$

$$|A| = a\frac{\sin(n\delta/2)}{\sin(\delta/2)}$$

$$\phi = (n-1)\delta/2$$

When n is large and δ and a are small such that

$$n\delta/2 = \beta$$
$$na = A_0$$

$$A = (A_0 \sin\beta/\beta)\exp(i\beta)$$
$$I = AA^* = I_0 \sin^2\beta/\beta^2$$

For single slit path difference between the two ends of the slit

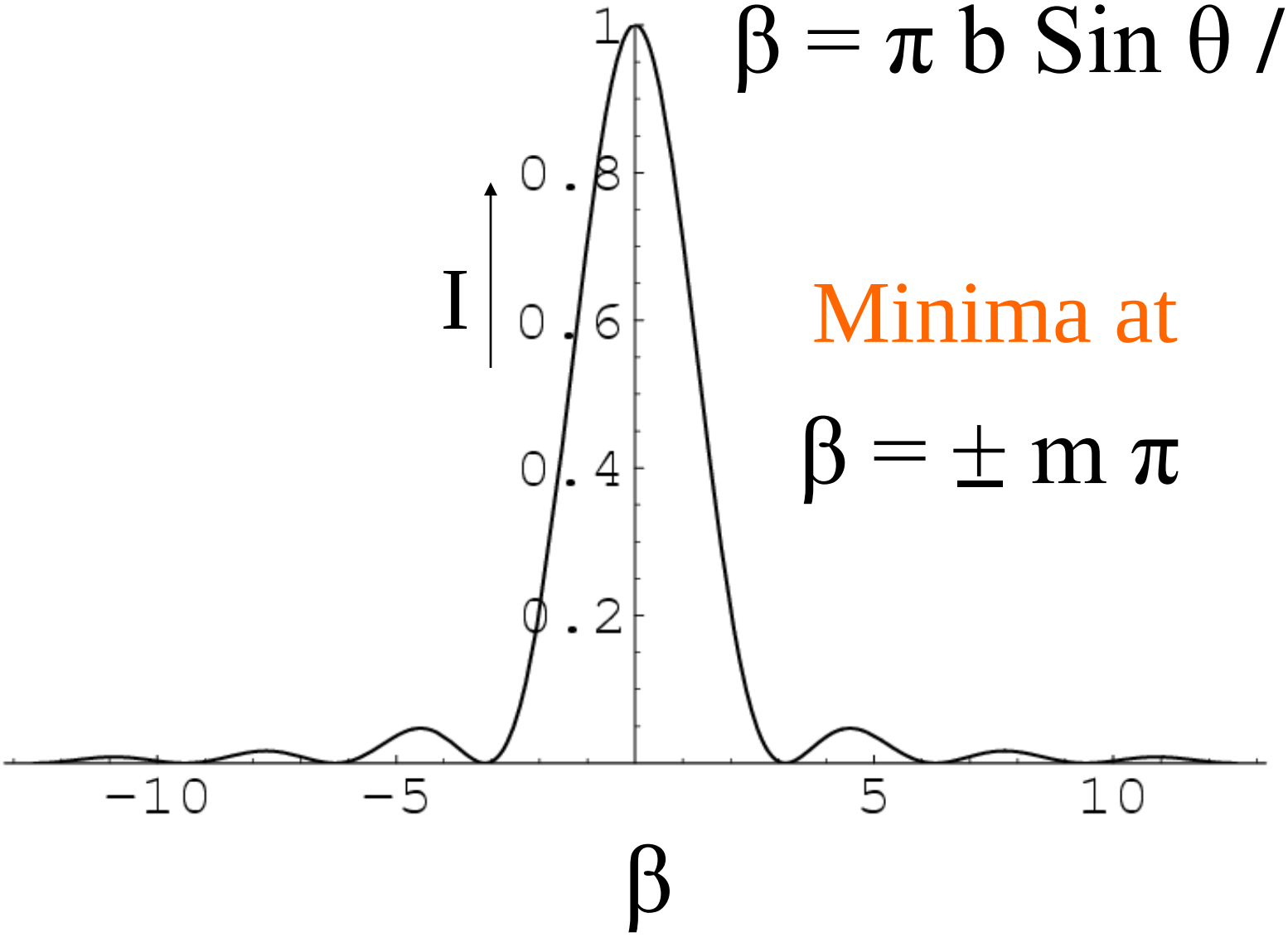
$$\Delta = b \sin\theta$$

Phase difference $= 2\pi\Delta/\lambda = n\delta$

$$\beta = n\delta/2 = \pi b \sin\theta/\lambda$$

Intensity for single slit

$$\beta = \pi \, b \, \mathrm{Sin}\, \theta \, / \, \lambda$$



Minima at

$$\beta = \pm \, m \, \pi$$