

- (a) Consider the ray path with only one internal reflection. Show that the scattering angle ϕ between the incident ray and the exit ray is $2(2\theta_2 - \theta_1)$, where θ_1 is the incident angle and θ_2 is the refracted angle.
- (b) For a sphere with a radius a where $ka \gg 1$, the direction where the scattering angle is stationary ($\frac{d\phi}{d\theta_1} = 0$) corresponds to the least cancellation between different rays and hence a large scattering amplitude. Show that the maximum scattering angle (ϕ_{\max}) occurs at $\theta_1 = \sin^{-1} \sqrt{(4 - n^2)/3}$ and $\phi_{\max} \approx 42^\circ$ for $n = 4/3$, with the scattering angle between the incident ray and scattered ray $\theta_s = 138^\circ$.
- (c) The refractive index for a raindrop is $n = 1.330$ for red light ($\lambda = 0.7\mu\text{m}$), $n = 4/3 = 1.333$ for orange light, and $n = 1.342$ for violet light ($\lambda = 0.4\mu\text{m}$). Determine the scattering angles for the red and violet light rays. What are the relative positions of the different color bands in a rainbow?