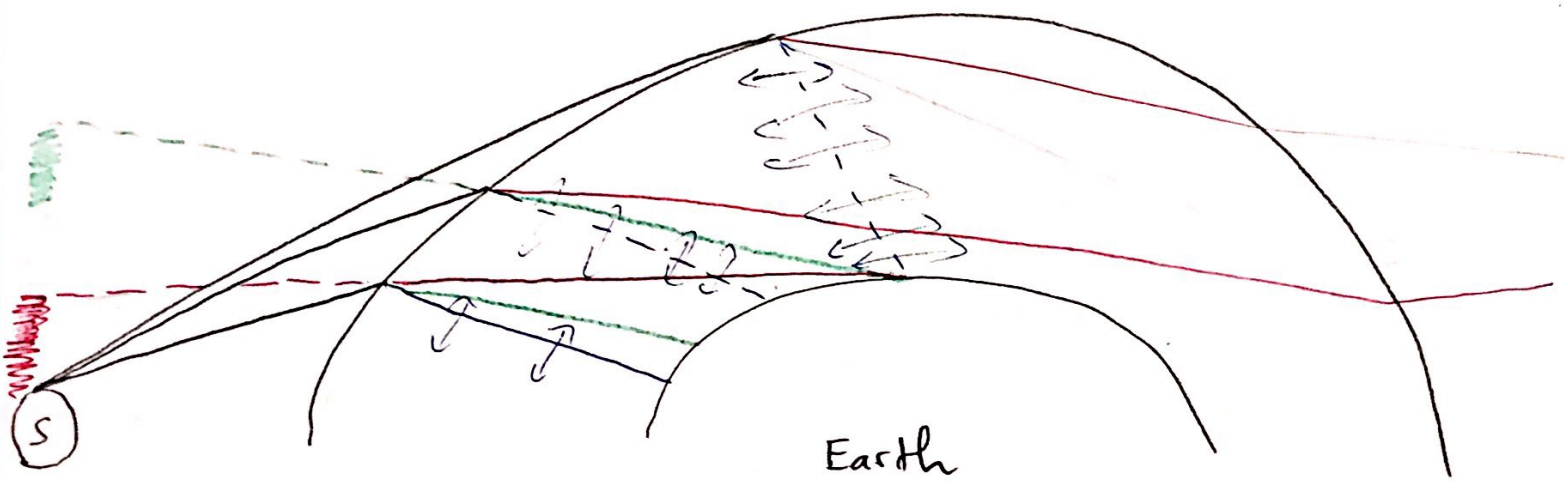
Name:

1C Discussion- Week 7

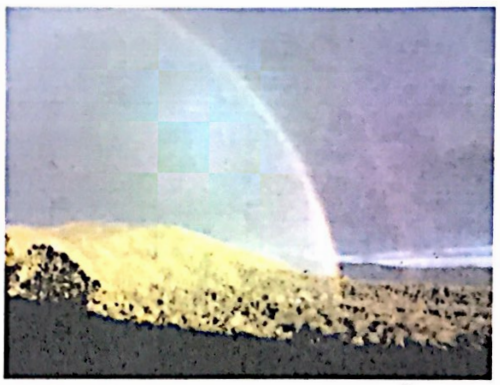
1. **Green Flash.** Green flashes are sometimes observed as the sun sets over the ocean with little turbulence in the air mass. They usually last between a few seconds and half a minute. Explain the occurence of the green flash in these ideal sunsets.

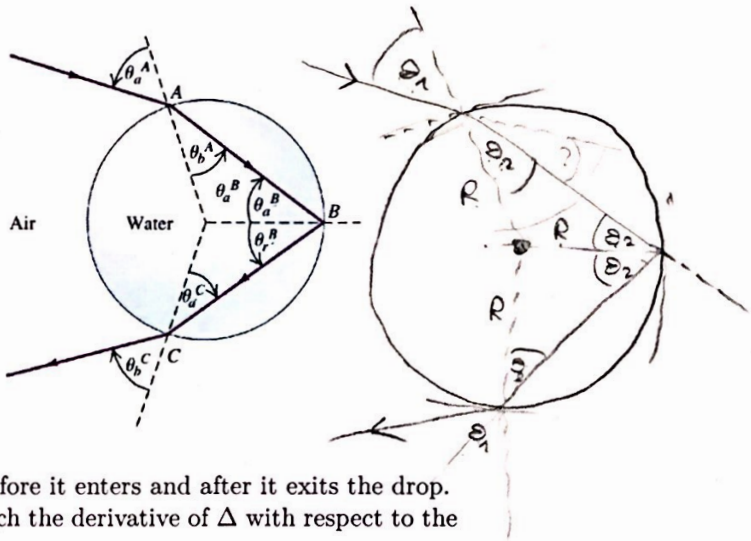


(1) Refraction at space-atmosphere boundary

(2) Scattering of blue light at probability $\propto \frac{1}{\lambda^4}$ $\gg$ red, green.

2. **Double rainbow all the way.** What does it mean? It means that light undergoes internal reflection *twice*.





(a) Find the angle Δ between the ray before it enters and after it exits the drop.
(b) What is the incident angle θ_a^A for which the derivative of Δ with respect to the incident angle θ_a^A is zero?
(c) The indexes of refraction for red and violet light in water are $n_v = 1.342$ and $n_r = 1.330$. Find θ_2 and Δ for violet and red light. When you view a secondary rainbow, is red or violet higher above the horizon?

a) $\Delta_{primary} = \theta_1 - \theta_2 + (\pi - 2\theta_2) + \theta_1 - \theta_2$

$\Delta_{secondary} = \theta_1 - \theta_2 + 2(\pi - 2\theta_2) + \theta_1 - \theta_2 = 2\theta_1 + 2\pi - 6\theta_2$

$n_a \sin\theta_1 = n_w \sin\theta_2 \Rightarrow \theta_2 = \arcsin\left(\frac{\sin\theta_1}{n}\right)$

b) $\frac{d\Delta(\theta_1)}{d\theta_1} = 0$, where small $d\theta_1$ give same Δ ⇒ reinforced rainbow

$\Rightarrow 0 = 2 - \frac{6\,\frac{\cos\theta_1}{n}}{\sqrt{1 - \frac{\sin^2\theta_1}{n^2}}} \Rightarrow \cos^2\theta_1 = \frac{1}{8}(n^2 - 1)$

$\Rightarrow \theta_1 = \arccos\left(\sqrt{\frac{n^2-1}{8}}\right)$

c) $\theta_{1,v} = 71.55°$ $\quad \theta_{1,r} = 71.94$

$\Delta_v = 233.2$ $\quad \Delta_r = 230.1$

$\delta_v = 53.2$ $\quad \delta_r = 50.1$