Optical Depth and Applications

Just the Basics

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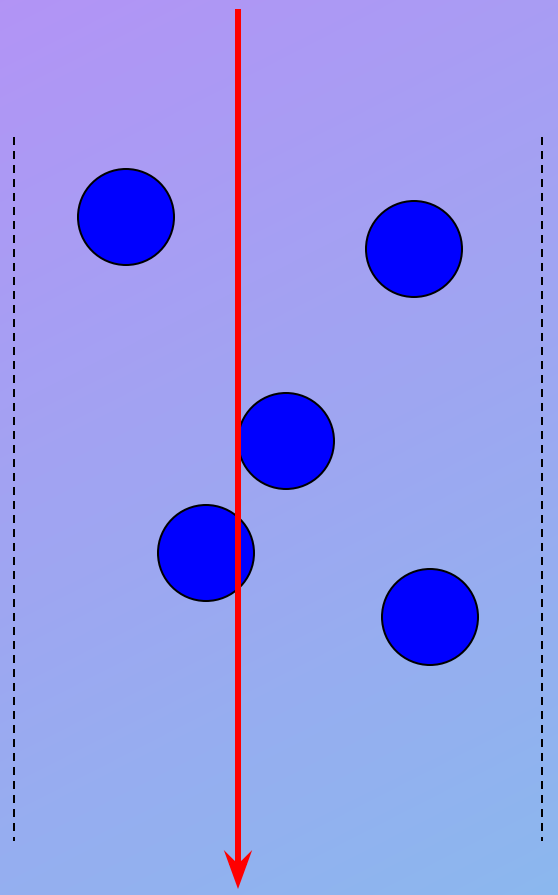
Interpreting optical depth



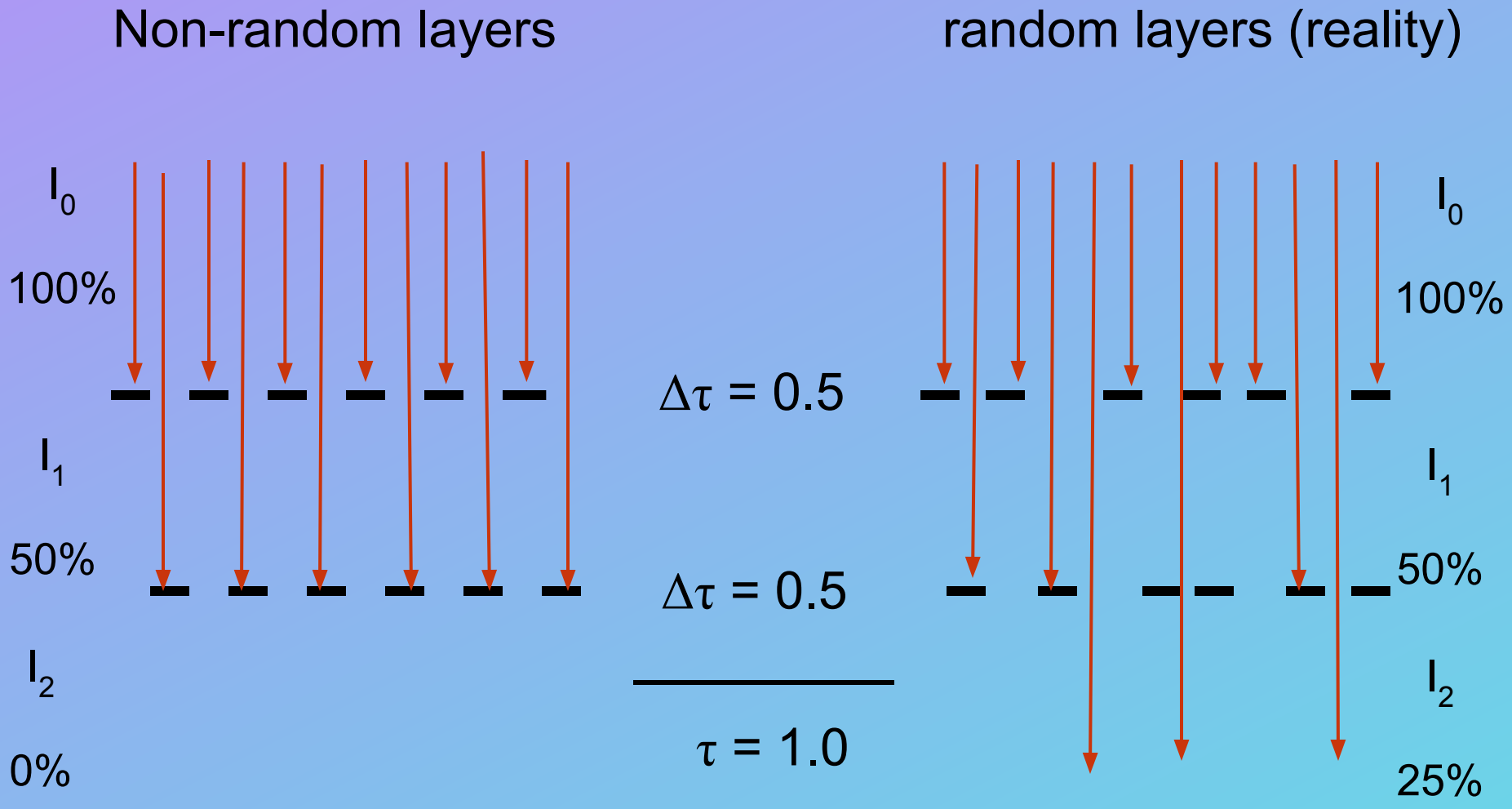
Due to wave effects, the optical cross section may be larger or even smaller than the geometrical cross section.

Optical Depth: number of times on average that a photon path will interact with particles.
= total effective cross sectional area
= scattering + absorption

Key Concept: Optical Depth

- Tells you what fraction of light will be affected. When small, the fraction IS the optical depth. More complex as optical depth increases.
- Can be thought of as the average number of times a photon will strike the material it passes through.
- The optical depth of a material changes with wavelength because absorption and scattering changes with wavelength - even though the material stays the same.

Optical Depth and Probability



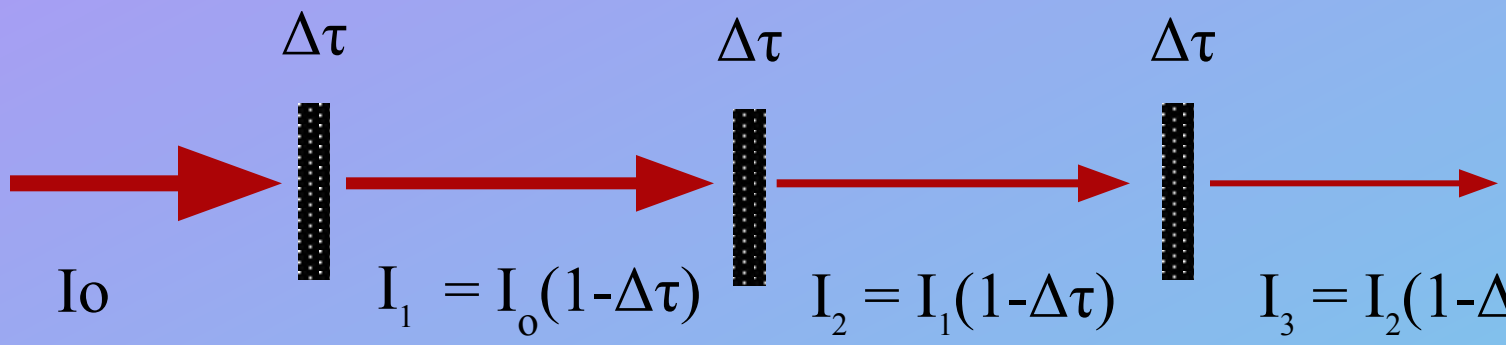
So as Optical Depth Increases…

Transmission:	decreases
Scattering:	increases
Absorption:	increases

Purely Absorbing Material: Exponential Decay

The symbol for optical depth is τ

$$\Delta I = I_1 - I_o = -I_o \Delta\tau \quad \Rightarrow \quad I_1 = I_o (1-\Delta\tau)$$



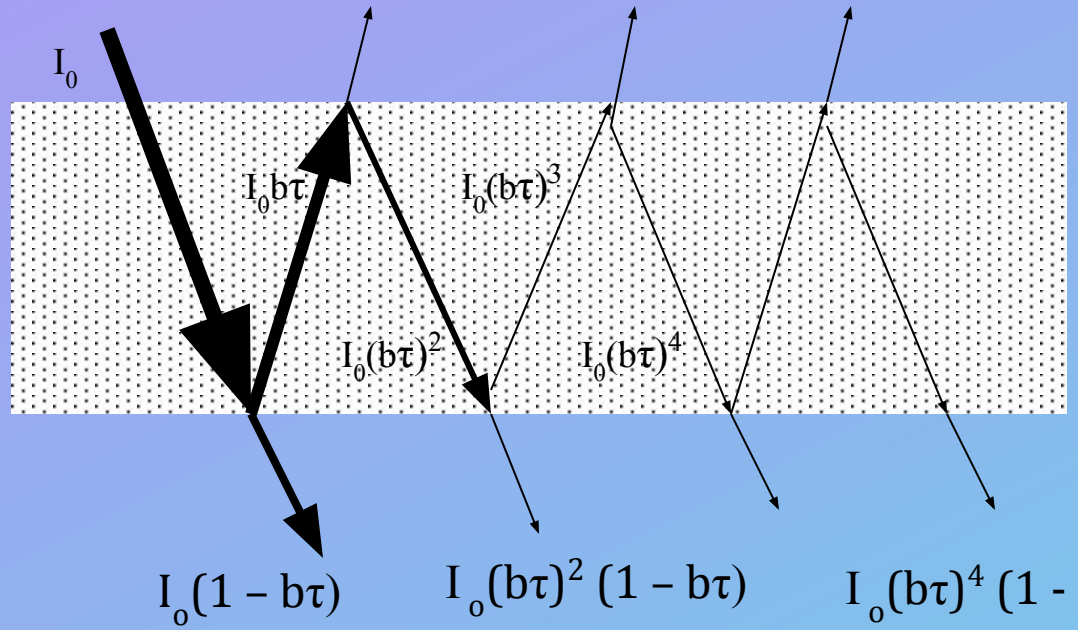
But $\tau = n\Delta\tau$ so $I_n = I(\tau) = I_o(1-\Delta\tau)^n = I_o(1-\tau/n)^n$

$$I(\tau) = I_o(1-\tau/n)^n = I_o e^{-\tau}$$

$\lim n \to \infty$

Purely Scattering Transmission

b = backscatter fraction



$$\text{total I} = I_o(1 - b\tau + (b\tau)^2 - (b\tau)^3 + (b\tau)^4 ...) = \frac{I_o}{1 + b\tau}$$

or $\dfrac{I_T}{I_0} = \dfrac{1}{1 + b\tau}$

What about the reflected light?

Optical Depth Practice:

Above a black tent the sunlight has an intensity of 1200 W/m^2. If the optical depth is 1, what is the intensity inside the tent? What if it's 2?

If 75% of light gets through an absorbing medium, what is the optical depth?

50% of light gets through a scattering medium. What is the optical depth if backscatter = 0.5?