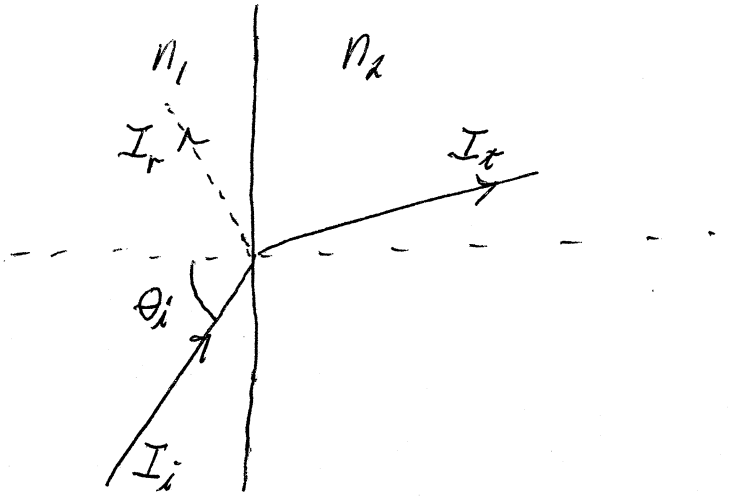
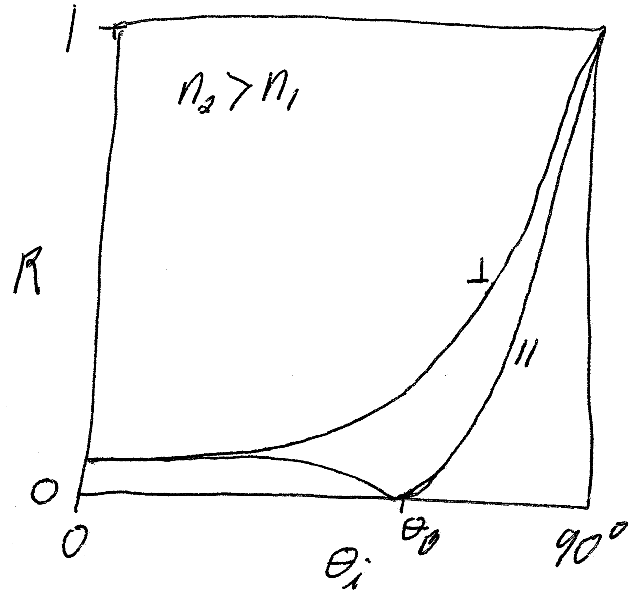
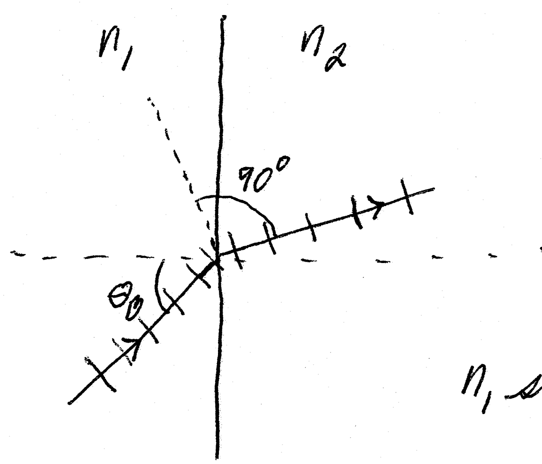
For non-normal incidence, use Fresnel Eq's --





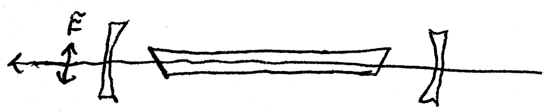
Brewster's angle θ_B : zero reflectivity for $E \parallel$ plane of incidence



oscillating dipoles do not radiate along axis

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_1 + \theta_2 = 90°$$



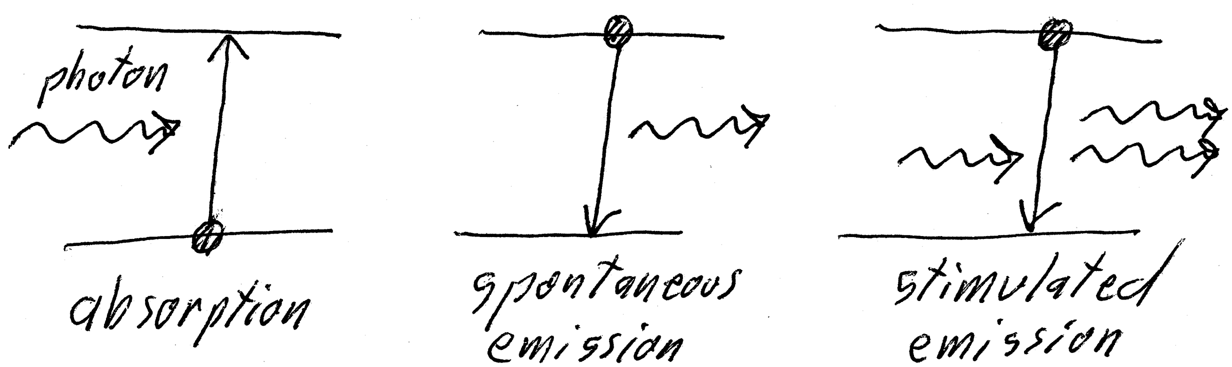
so $\sin\theta_2 = \cos\theta_1$

and $n_1 \sin\theta_1 = n_2 \cos\theta_1$

$$\boxed{\tan\theta_B = n_2/n_1}$$

Coherence of Laser Light

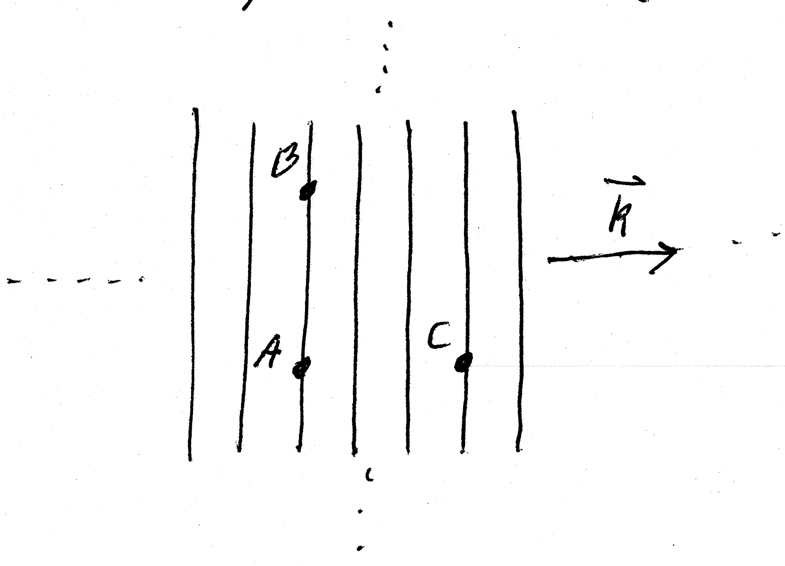
Arises from stimulated emission process:



"Optical clone" of original photon

Plane wave is perfectly coherent:

$$\vec{E}(\vec{r}, t) = \vec{E}_0 \cos(\vec{k}\cdot\vec{r} - \omega t)$$



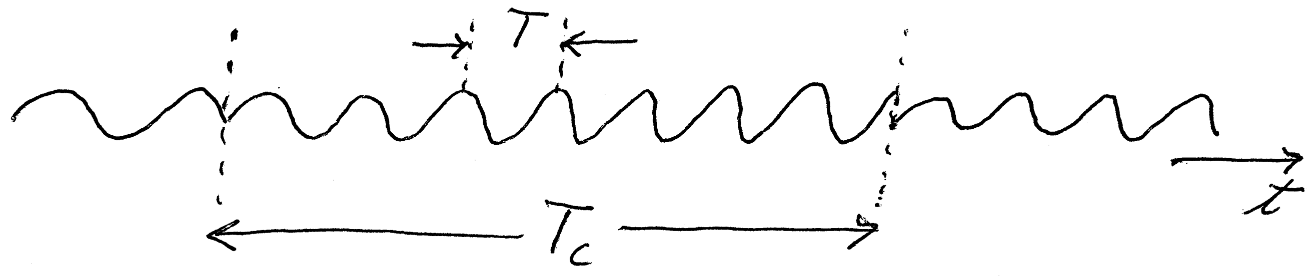
fixed points A, B, C all have same phase at all times

Temporal coherence: A & C same phase

Spatial coherence: A & B same phase

Real light has finite coherence.

1) Temporal coherence time T_c

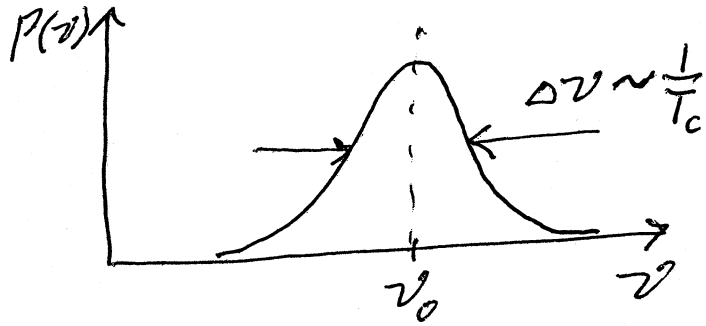


Longitudinal coherence length

$$L_c = c\, T_c$$

Power spectrum (power per frequency interval) for above, by Fourier Transform:

$\nu_0 = \frac{1}{T}$



Or can use uncertainty principle for photon energy

$$\Delta E\, \Delta t \sim h$$

$$h\, \Delta\nu\, T_c \sim h$$

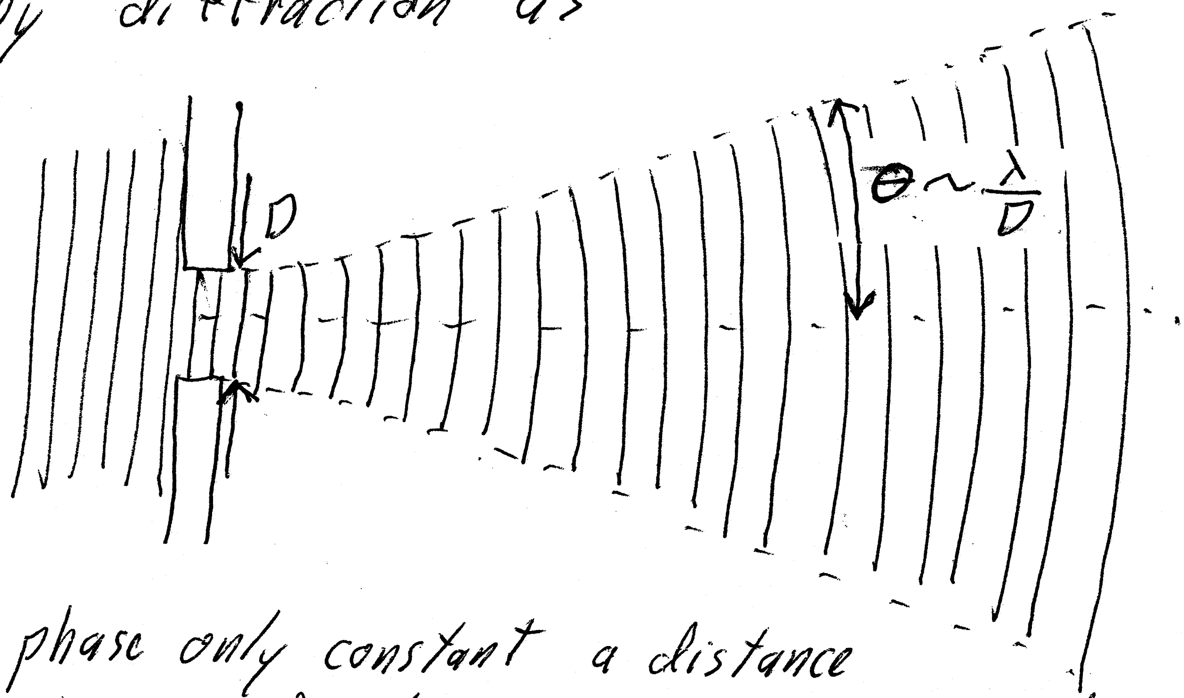
$$\Delta\nu \sim \frac{1}{T_c}$$

Light with $T_c \gg T$, or $\Delta\nu \ll \nu_0$ is spectrally "pure" (single color)(monochromatic)

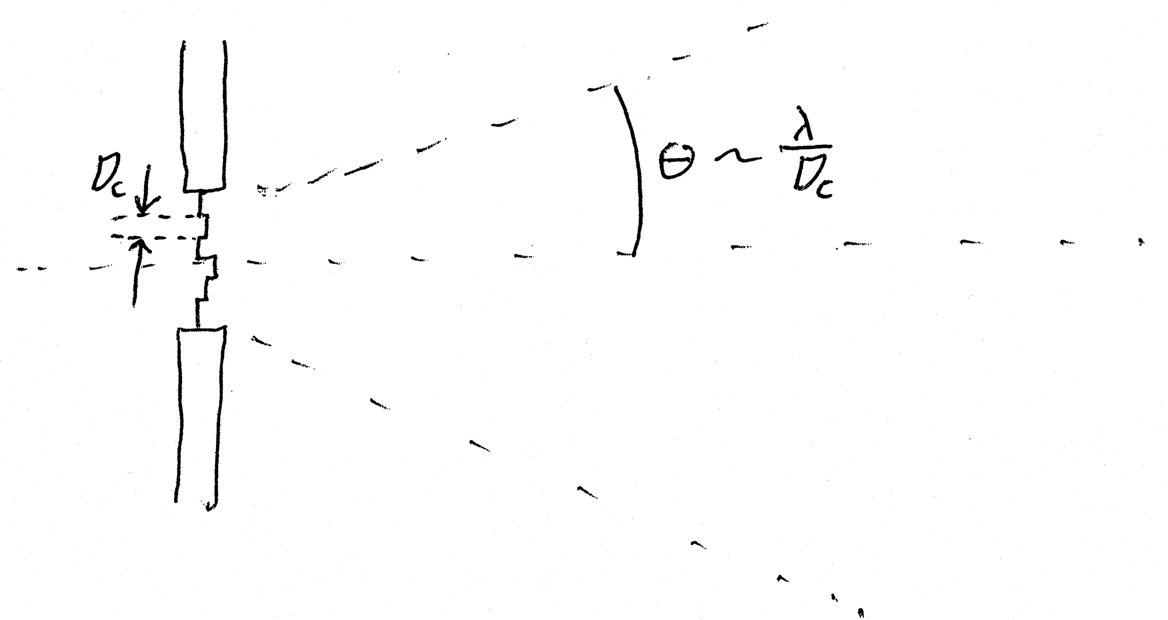
Temporal coherence important for interferometry applications such as holography.

2) Spatial coherence length D_c

Light that is perfectly coherent along the wavefronts ($\perp \vec{k}$) spreads out by diffraction as



If phase only constant a distance D_c along wavefront,



Smaller $D_c \longrightarrow$ greater θ

When $D_c > D$, have minimum θ

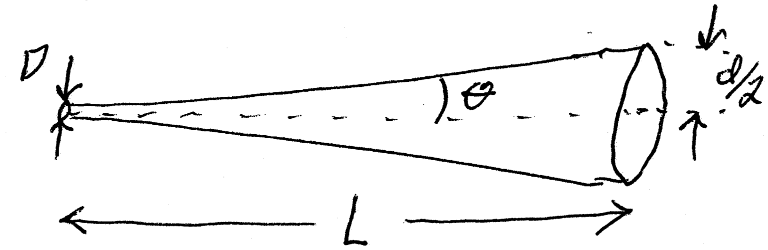
Leads to directional property of laser light.

<u>Example</u>: He-Ne laser

$$\left.\begin{array}{l} \lambda = 632.8 \text{ nm} \\ D \simeq 1 \text{ mm} \end{array}\right\} \quad \theta \sim \frac{6 \cdot 10^{-7}}{10^{-3}} = 6 \cdot 10^{-4}$$

$$\theta \sim 0.034^{\circ}$$

After propagating 100 m, beam diameter is

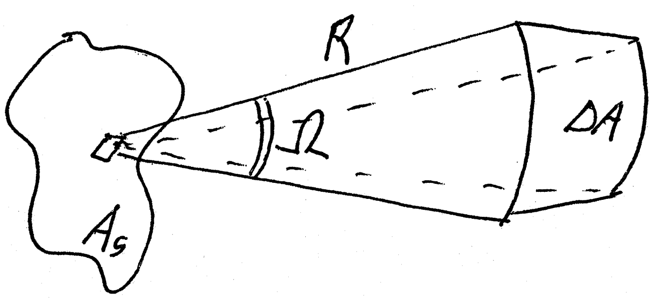


$$\frac{d}{2} = L \tan\theta \approx L\theta \sim L\,(6 \cdot 10^{-4})$$

$$d \simeq (2)(100\text{m})(6 \cdot 10^{-4}) = 0.12 \text{ m}$$

$$= 12 \text{ cm}$$

Directionality gives rise to high <u>Brightness</u>



$$B \equiv \frac{P}{A_s\,\Omega}$$

$$\Omega \equiv \frac{\Delta A}{R^2} \quad \text{solid angle}$$