Phys 110B 28Oct20

Distinguishing properties of radiation

fall-off like $\frac{1}{R}$

transport "to ∞" energy, momentum, angular momentum, information

Retardation/propagation delay

Geometric transversality

Functional transversality (divergence free)

representability by "Null fields" $\vec{E}\cdot\vec{B}$ $E^2 - c^2B^2$
(in superposition)

Acceleration-dependence

Non-unipolarity  vs 

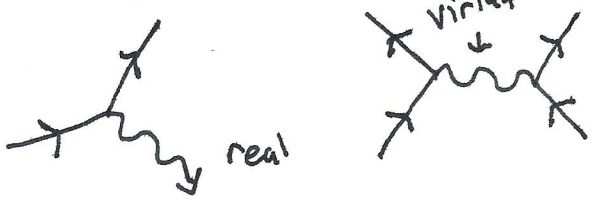
zero average

non zero average
0 frequency component

Source-free dynamics away from sources
radiation fields that are "shaken loose" from the charges and take on an independent existance.

Irreversibility/resistance vs reactive fields
radiations sloshing of energy back and forth

Real vs "Virtual" photons



real photon $\omega = c|\vec{k}|$
$E = c|\vec{p}|$

virtual photon $\omega \neq c|\vec{k}|$

Any measured photon is virtual but we can approximate a real photon with large distances

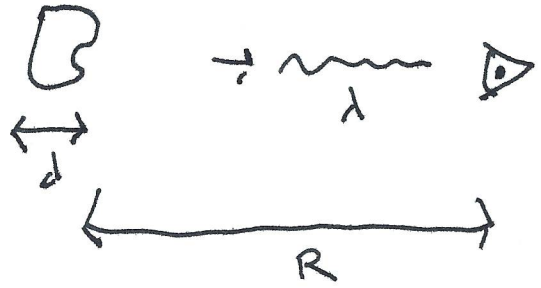
Lorentz covariant

Spatial Regimes "near-field" "far-field" "intermediate field"

Important length-scales

$\lambda = \frac{2\pi}{k}$ wavelength

$d =$ size / support of the sources

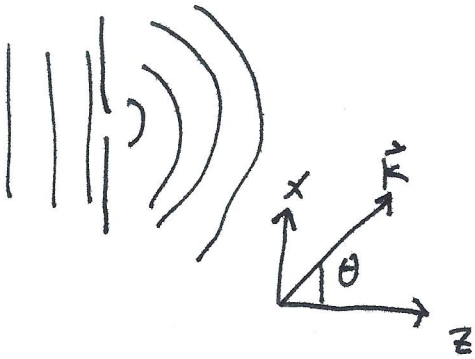


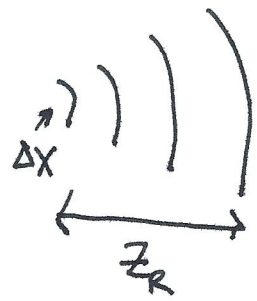
R distance from the source to the observer

k_s^{-1} length-scale(s) for features or structures in the source

Rayleigh range (Fraunhofer distance)

$Z_R \sim \frac{d^2}{\lambda}$ propagation distance associated with appreciable diffraction





$Z_R \tan\Delta\theta \sim \Delta x$

$\Delta\theta \lesssim \sin\Delta\theta$

$Z_R \sim \frac{\Delta x}{\sin\Delta\theta} \sim 4\pi\frac{d^2}{\lambda}$

Fourier-Heisenberg uncertainty principle

$$\frac{\Delta k_x \Delta x}{k} \geq \frac{1}{2}\frac{1}{k} = \frac{1}{2}\frac{\lambda}{2\pi} = \frac{\lambda}{4\pi}$$

$$\sin\Delta\theta\,\Delta x \geq \frac{\lambda}{4\pi}$$

length scales: $\lambda, d, R, k_s^{-1}, Z_R \sim \frac{d^2}{\lambda}$

Hertzian Regime $d \ll \lambda$

Kirchoff Regime $d \gg \lambda$

Mie Scattering $d \sim \lambda$

Hertz Regime:

near-zone $d < R \ll \lambda$
quasi-static

intermediate zone $d \ll \lambda \sim R$
induction zone

far zone $d \ll \lambda \ll R$
radiation zone