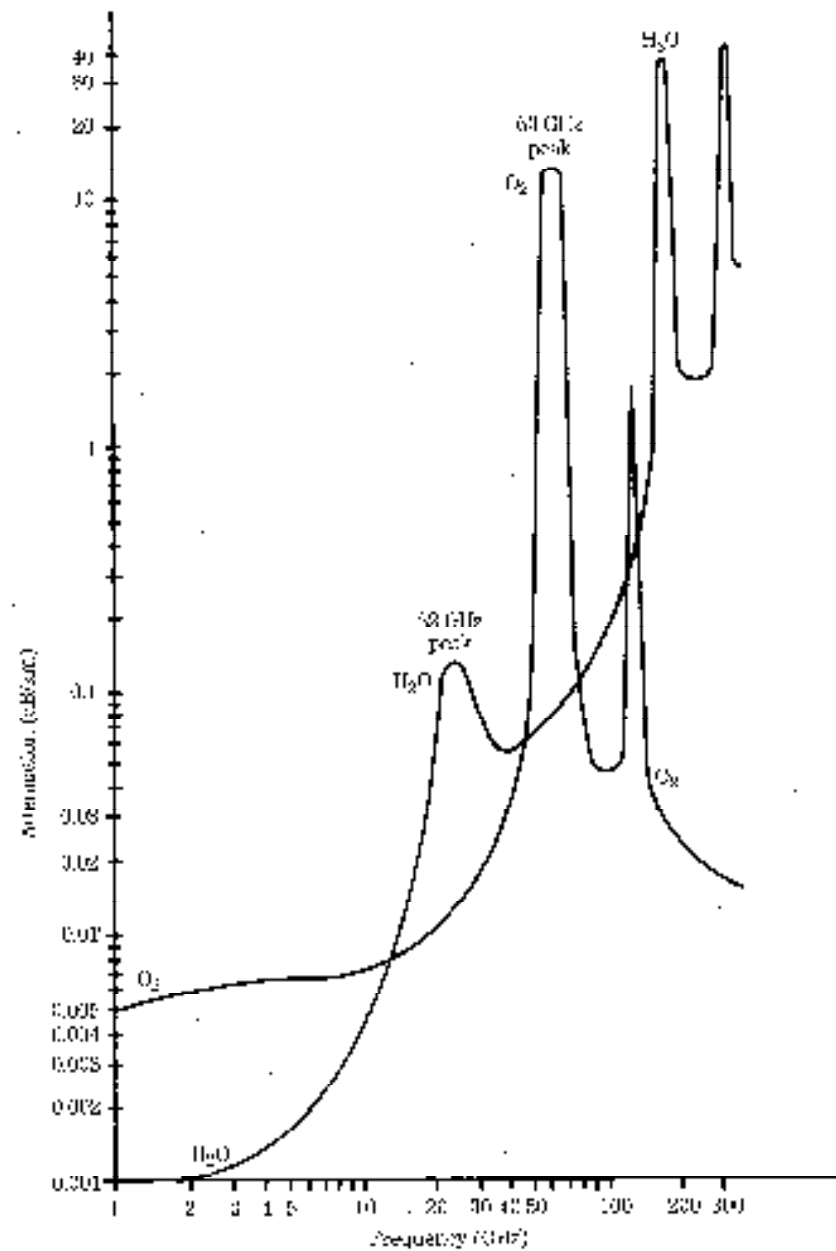


Propagation conclusion

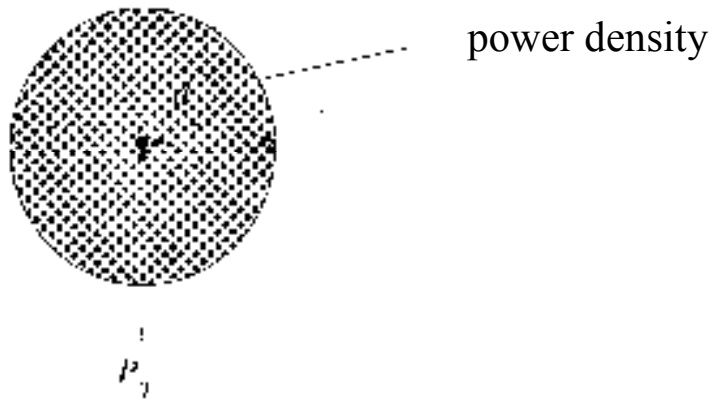
# Atmospheric absorption

- Microwave communication above 10 GHz suffers from severe attenuation.
- Caused by water vapor and oxygen in the atmosphere.
- There are several strong attenuation peaks and these are resonance frequencies for molecules and atoms.

# Attenuation



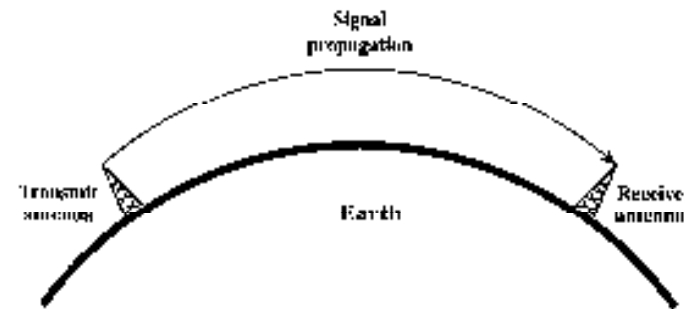
# Free space attenuation



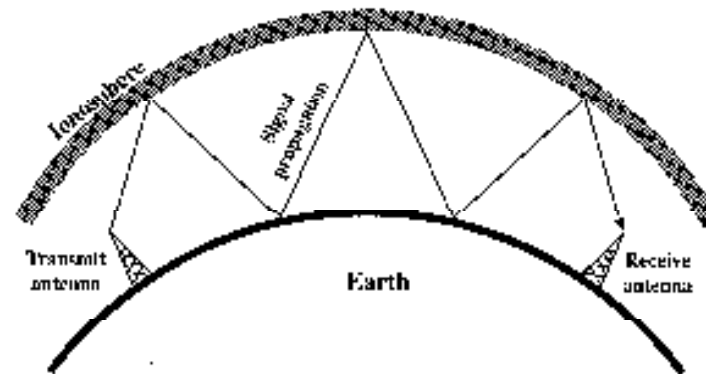
$$S_r = \frac{P_t}{4\pi r^2}$$

Isotropic radiation

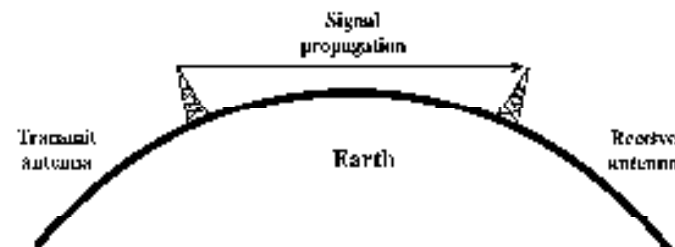
# Propagation modes



(a) Ground wave propagation (below 2 MHz)

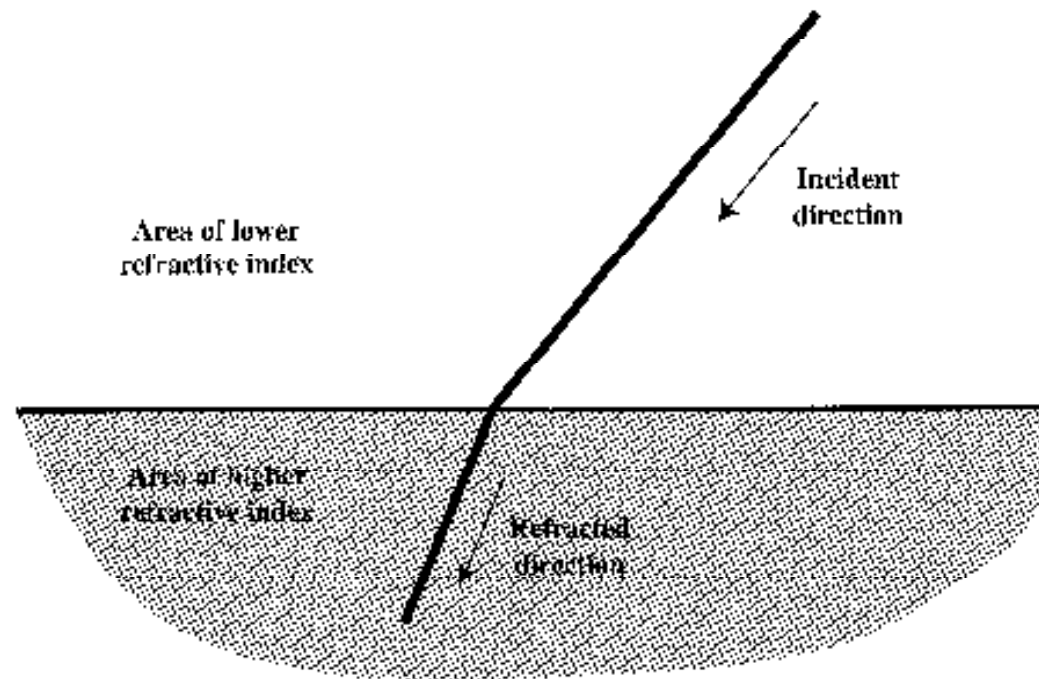


(b) Sky wave propagation (2 to 30 MHz)



(c) Line-of-sight (LOS) propagation (above 30 MHz)

# Refraction

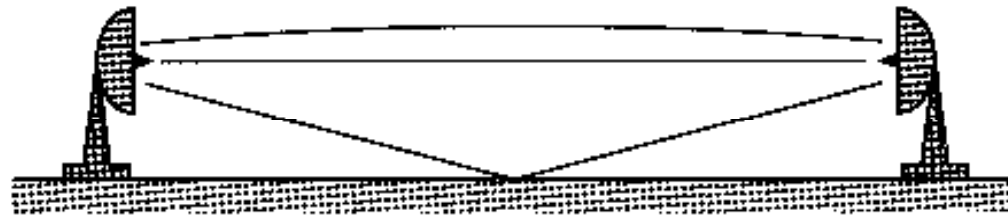


**Figure 5.6** Refraction of an Electromagnetic Wave [POOL98]

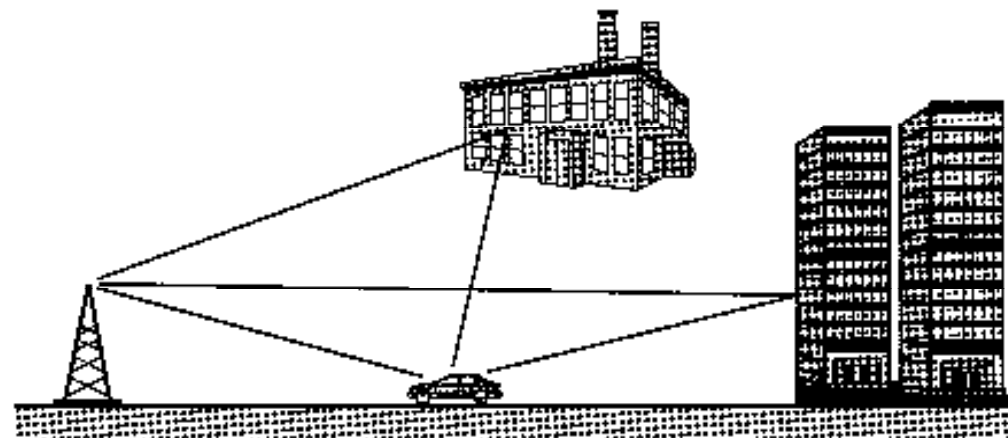
# Radio Horizon



# multipath



(a) Microwave line of sight

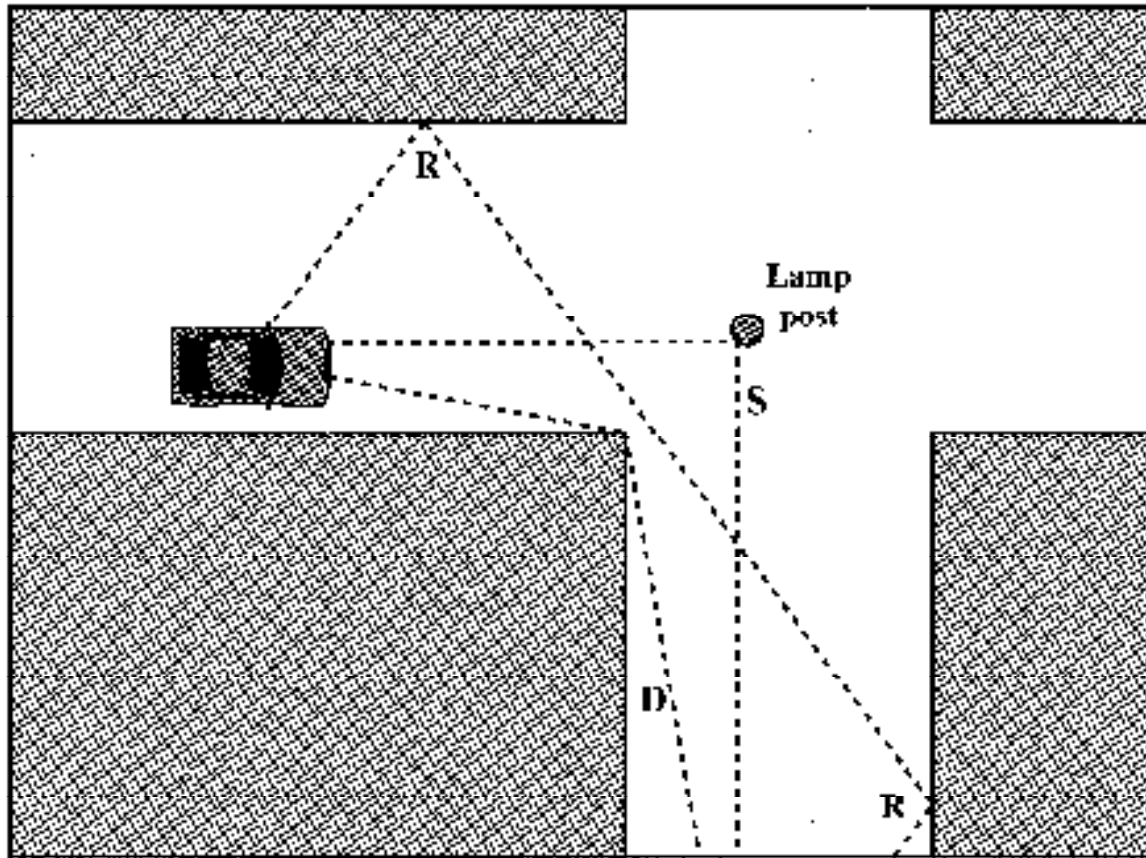


(b) Mobile radio

**Figure 5.9** Examples of Multipath Interference

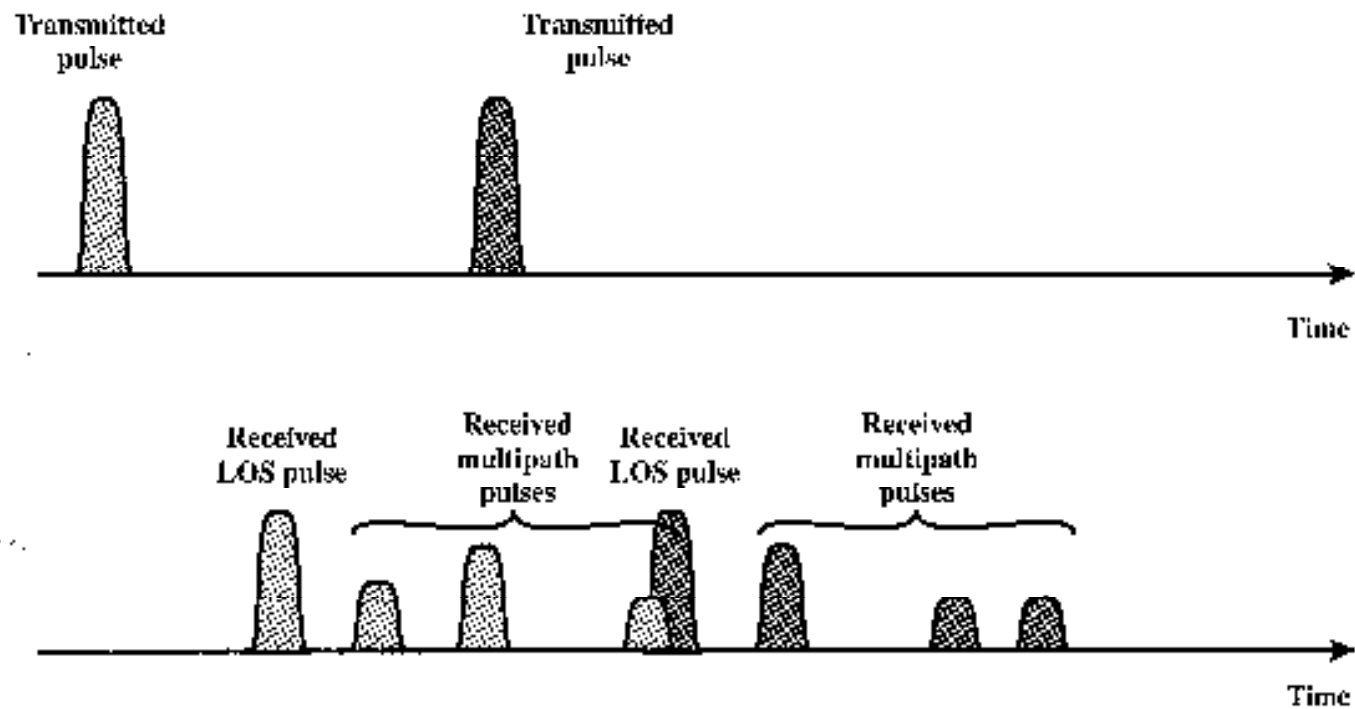


# Propagation Phenomena's



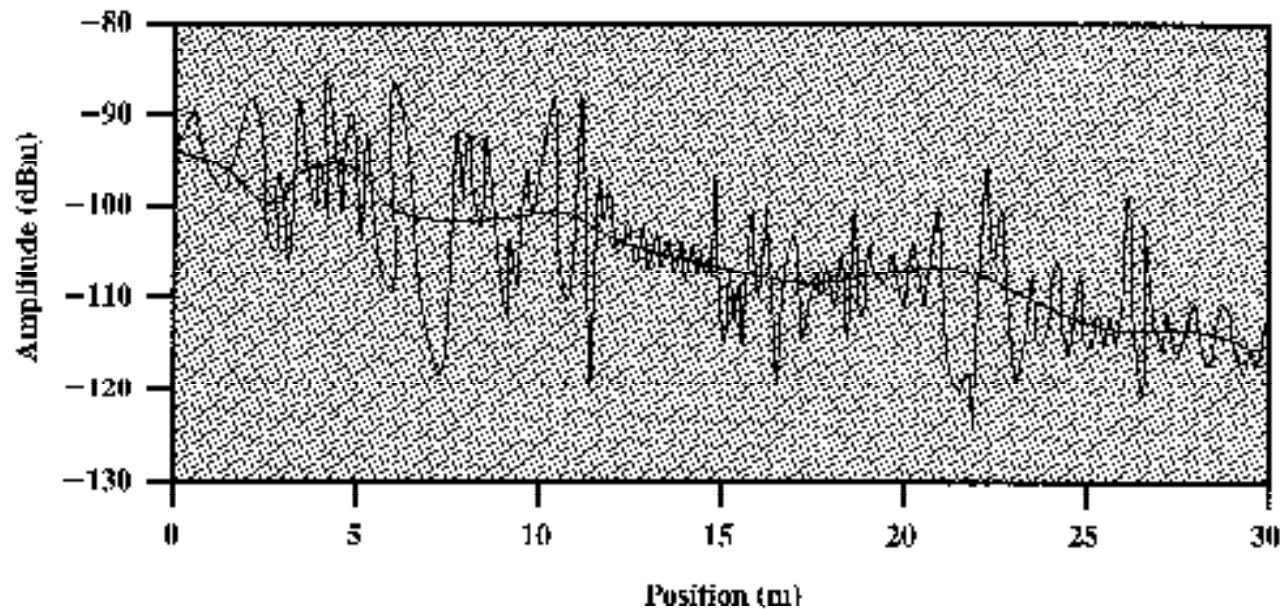
**Figure 5.10** Sketch of Three Important Propagation Mechanisms: Reflection (R), Scattering (S), Diffraction (D) [ANDE95]

# Multipath



**Figure 5.11** Two Pulses in Time-Variant Multipath

# Typical fading in urban environment.



**Figure 5.12** Typical Slow and Fast Fading in an Urban Mobile Environment