Refraction (*i.e.* Bending) of Sound Waves ("Dispersion")

Refraction of sound waves arises from temperature/pressure/density gradient(s) in air.

Listen to the phase shift/flanging effect of jet airplane engine's when jet is in the air. This sound effect arises from interference effect from mixing (*i.e.* superposition) of sound amplitudes from same sound source, but due to (slightly) different paths taken by sound from the sound source (jet) to observer/listener, resulting in (slightly) different path lengths of the sound in air, thus having (slightly) different propagation times from sound source to observer!

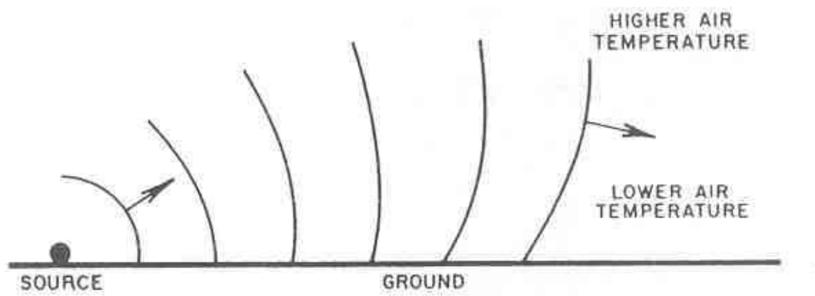

FIG. 17. Refraction of sound waves.

Refraction (bending) of sound "rays" in air arises due to density dependence of the speed of sound. From the Ideal Gas Law $PV = NRT$, the speed of sound propagation in air also depends on the temperature/pressure of air.

Interference of Sound (& Light) Waves:

Many individual sound (& light) waves propagating in a medium can exist simultaneously at the same point, x and at the same time, t in that medium.

Linear Superposition (*i.e.* Addition) of Sound Waves:

When two (or more) sound waves spatially/temporally overlap each other, in general they will ***interfere*** with each other. We must then add *e.g.* individual over-pressure (or displacement) amplitudes together to obtain the total over-pressure (or displacement) amplitude:

e.g. 2 waves: $p_{tot}(z,t) = p_1(z,t) + p_2(z,t)$

e.g. N waves: $p_{tot}(z,t) = p_1(z,t) + p_2(z,t) + ... + p_N(z,t) = \sum_{i=1}^{N} p_i(z,t)$

Sound (& light) waves can interfere $\left\{\begin{matrix}\text{constructively}\\ \text{destructively}\end{matrix}\right\}$ or somewhere in-between these two!

2-wave ***constructive*** interference: $p_{tot}(z,t) \cong 2p_1(z,t)$.

2-wave ***destructive*** interference: $p_{tot}(z,t) \cong 0 \qquad \{p_2(z,t) \cong -p_1(z,t)\}$

The mathematical addition of individual amplitudes must be done carefully, in order to preserve (relative) phase information. We discuss in detail how this is accomplished, below.