Pressure vs. Intensity

Wave Amplitude: p_{rms}

$$\boxed{\text{Sound Pressure level} \Rightarrow L_p = 20\log_{10}\left(\frac{p_{rms}}{p_0}\right)\ \text{dB}}$$

Wave Amplitude Squared: $p_{rms}^2 \propto I \Rightarrow$ "intensity", or the acoustic analog of energy

$$\boxed{\text{Sound Intensity level} \Rightarrow L_I = 10\log_{10}\left(\frac{I}{I_0}\right)\ \text{dB}}$$

$\Rightarrow$ Intensity is the pressure squared $\Leftarrow$

see: Ainslie + 2022

Geometrical Spreading

Focusing now only on pressure: p (ignoring "rms" subscript)

$$\boxed{\text{SPHERICAL:} \quad p \propto \frac{1}{r}}$$ ("amplitude goes as $1/r$")

$$\therefore \left.\begin{aligned} p_1 &= \frac{p_0}{r_1} \\ p_2 &= \frac{p_0}{r_2} \end{aligned}\right\} \Rightarrow p_0 = r_1 p_1 = r_2 p_2 \Rightarrow \overset{\text{sphere}}{\boxed{p_2 = \left(\frac{r_1}{r_2}\right) p_1}}$$

$$\boxed{\text{CYLINDRICAL:} \quad p \propto \frac{1}{\sqrt{r}}}$$ ("amplitude goes as $1/\sqrt{r}$")

$$\therefore \left.\begin{aligned} p_1 &= \frac{p_0}{\sqrt{r_1}} \\ p_2 &= \frac{p_0}{\sqrt{r_2}} \end{aligned}\right\} \Rightarrow p_0 = \sqrt{r_1}\, p_1 = \sqrt{r_2}\, p_2 \Rightarrow \overset{\text{cylinder}}{\boxed{p_2 = \left(\frac{\sqrt{r_1}}{\sqrt{r_2}}\right) p_1}}$$

SPL @ Distance Given Sph. & Cyl. Spreading

Q: What's the expected sound pressure level @ r_2, L_{p2}, given a measured pressure @ r_1?

$$L_{p1} = 20\log_{10}\left(\frac{p_1}{p_0}\right) \text{ dB}$$ measured pressure @ distance r_1

$$L_{p2} = 20\log_{10}\left(\frac{p_2}{p_0}\right) \text{ dB}$$ theoretical pressure @ distance r_2

$$\boxed{\text{SPHERICAL}: \; p \propto \frac{1}{r} \Rightarrow p_2 = \left(\frac{r_1}{r_2}\right) p_1}$$

$$L_{p2} = 20\log_{10}\left(\frac{p_2}{p_0}\right) = 20\log_{10}\left(\frac{(r_1/r_2)\,p_1}{p_0}\right)^{*} = 20\log_{10}\left(\frac{r_1 p_1}{r_2 p_0}\right)$$

$$= 20\log_{10}\left(\frac{r_1}{r_2}\right) + 20\log_{10}\left(\frac{p_1}{p_0}\right)$$

$$\boxed{= L_{p1} + 20\log_{10}\left(\frac{r_1}{r_2}\right)}$$

$$\boxed{\text{CYLINDRICAL}: \; p \propto \frac{1}{\sqrt{r}} \Rightarrow p_2 = \left(\frac{\sqrt{r_1}}{\sqrt{r_2}}\right) p_1}$$

$$L_{p2} = 20\log_{10}\left(\frac{p_2}{p_0}\right) = 20\log_{10}\left(\frac{(\sqrt{r_1}/\sqrt{r_2})\,p_1}{p_0}\right)^{*} = 20\log_{10}\left(\frac{\sqrt{r_1}}{\sqrt{r_2}}\,\frac{p_1}{p_0}\right)$$

$$= 20\log_{10}\left(\frac{\sqrt{r_1}}{\sqrt{r_2}}\right) + 20\log_{10}\left(\frac{p_1}{p_0}\right)$$

$$\boxed{= L_{p1} + 20\log_{10}\left(\frac{\sqrt{r_1}}{\sqrt{r_2}}\right)}$$

---

* bc $\frac{(r_1/r_2)}{p_0} p_1 \cdot \frac{r_2}{r_2} = \frac{r_1 p_1}{p_0 r_2} = \left(\frac{r_1}{r_2}\right)\frac{p_1}{p_0}$