Physics 115 Lecture 17

Decibels part II

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The Sound Pressure Level Decibel (dB SPL)

- The sound intensity is related to the pressure amplitude, $I = p_0^2/2Z$.
- A property of logarithms: $\log x^n = n \log x$
- Sound pressure level (decibels)

$$L = 10\log_{10}\left(\frac{I}{I_r}\right) \text{ [dB IL]} = 10\log\left(\frac{p^2/2Z}{p_r^2/2Z}\right) = 10\log\left(\frac{p}{p_r}\right)^2$$

$$\boxed{L = 20\log\left(\frac{p}{p_r}\right) \text{ [dB SPL]}}$$

The Sound Pressure Level Decibel (dB SPL)

- The reference pressure amplitude is p_r = 20 μPa = 20×10^{-6} Pa = 2×10^{-5} Pa.
- A sound wave with a pressure amplitude of 20 μPa has an intensity of 1×10^{-12} W/m^2
- The sound intensity level and sound pressure level produced by the same sound are numerically identical.

Suppose a sound level increases from 82 dB to 85 dB:

	initial		final		
	value	level	value	level	ratio
pressure	0.252 Pa	82 dB SPL	0.356 Pa	85 dB SPL	$\sqrt{2}$
intensity	158 μW/m^2	82 dB IL	316 μW/m^2	85 dB IL	2.0

Increasing the pressure amplitude by $\sqrt{2}$ will double the sound intensity and increase the sound level by 3 dB

Suppose a sound level increases from 82 dB to 88 dB:

	initial		final		
	value	level	value	level	ratio
pressure	0.252 Pa	82 dB SPL	0.502 Pa	88 dB SPL	2.0
intensity	158 μW/m^2	82 dB IL	631 μW/m^2	88 dB IL	4.0

Doubling the pressure amplitude will quadruple the sound intensity and increase the sound level by 6 dB

Suppose a sound level increases from 82 dB to 92 dB:

	initial		final		
	value	level	value	level	ratio
pressure	0.252 Pa	82 dB SPL	0.796 Pa	92 dB SPL	$\sqrt{10}$
intensity	158 μW/m^2	82 dB IL	1580 μW/m^2	92 dB IL	10

Increasing the pressure amplitude by $\sqrt{10}$ will increase the sound intensity by a factor of 10 and increase the sound level by 10 dB

Adding sound waves

- When two sounds combine, their intensities add, but not their pressure amplitudes nor their sound levels in dB.

A baby cries with a sound level of 69.03 dB

$$I_1 = I_r 10^{L/10} = \left(1.0\times10^{-12}\ \text{W/m}^2\right)10^{69.03/10}$$

$$= 8.0\times10^{-6}\ \text{W/m}^2$$

Four babies cry with a sound level

$$I_4 = 4\times I_1 = 32\times10^{-6}\ \text{W/m}^2$$

$$L = 10\log\left(\frac{3.2\times10^{-5}\ \text{W/m}^2}{1.0\times10^{-12}\ \text{W/m}^2}\right)$$

$$= \boxed{75\ \text{dB IL}}$$