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Introduction to Acoustics and Noise

Homework 4

Consider two spheres of radius a_0. In a frame of reference where the $\{x_1, x_2\}$ axes are horizontal and the x_3 axis is vertical, the two spheres are centered at $\{0, 0, h\}$ and $\{0, 0, -h\}$. The two spheres have a pulsating harmonic motion with a circular frequency ω and a magnitude $a_1 << a_0$ and $a_1 << \lambda$, where λ is the wavelength.

1. Write the expressions for the average pressure $\overline{p}$, intensity $\overline{I}$, and power $\overline{P}$ radiated from the two spheres in terms of the distance r from the origin and the azimuthal angle $\theta = sin^{-1}[(x_1^2 + x_2^2)^{1/2}/r]$.

2. The two spheres are pulsating with equal but opposite strength $\pm m$). Consider the cases $a_1 = a_0/50$, $h = 2a_0$, $r = 2h, 4h, 10h, 50h, 100h$ and the frequencies $\{100Hz, 1000Hz, 10,000Hz\}$. Plot the directivity of the pressure and intensity defined as

$$D_p = \frac{p'}{[|\dot{m}|/(4\pi r)]}, \tag{1}$$

$$D_I = \frac{\overline{I}}{[|\dot{m}|^2/(32\pi^2\rho_0 c_0 r^2)]}. \tag{2}$$

   Compare the results with those of a dipole at the origin. At what distance r the two spheres acoustic radiation is almost dipole-like. What is the effect of frequency?

3. If the radiation is dipole-like, it is more appropriate to use a dipole definition for the directivity

$$D_p = \frac{p'}{[|\ddot{m}|\ell/(4\pi c_0 r)]}, \tag{3}$$

$$D_I = \frac{\overline{I}}{[|\ddot{m}\ell|^2/(32\pi^2\rho_0 c_0^3 r^2)]}, \tag{4}$$

   where $\ell = 2h$.

4. The two spheres are pulsating with equal strength m. Examine their directivity as in §2.

5. Replace each sphere by a source of equal strength and examine the same issues as in the previous section.

6. Assess the source and dipole approximations.