Interference Effects from Multiple Sound Sources – Phased Arrays:

Obviously, the phasor diagram can be extended to multiple (*i.e.* N) identical sound sources, each with sound intensity I_o arranged in a line (*e.g.* the x-axis), each separated by a lateral distance d from each other, and interfering with each other – analogous to multiple, or N-slit interference in optics!

The intensity distribution for N-slit interference on a transverse screen is given by:

$$I_{tot}(x) = I_o \left\{ \frac{\sin^2\left(\frac{N\delta}{2}\right)}{\sin^2\left(\frac{\delta}{2}\right)} \right\}$$

Minima – *i.e.* intensity zeroes (complete destructive interference) occur when the numerator factor $N\delta/2 = \pm\pi, \pm 2\pi, \pm 3\pi, \ldots = n\pi$, $n = \pm 1, \pm 2, \pm 3, \ldots$ ***except*** when the denominator factor simultaneously has $\delta/2 = \pm\pi, \pm 2\pi, \pm 3\pi, \ldots = n\pi$, $n = \pm 1, \pm 2, \pm 3, \ldots$ then we have a ***global maximum*** of the intensity, where $I_{tot} = N^2 I_o$.

The limiting case is where the number of sources/slits, $N \to \infty$ – *i.e.* a ***continuum*** of closely-spaced/immediately adjacent/contiguous, infinitesimally small sound sources, all in phase with each other, as in the 2-sound source case described immediately above. This limiting case describes the phenomena of ***diffraction*** of sound waves (or light waves) *e.g.* through a constricting aperture!

The phasor method can also be used for obtaining the intensity distribution associated *e.g.* with a 2-dimensional phased array of sound sources since, as in the case for light/EM waves, sound interference effects along one axis (*e.g.* x) do ***not*** interfere with those along a different axis (*e.g.* y). For example, the overall intensity distribution for a 2-dimensional rectangular array of N_x and N_y sound sources in the far-field limit is given by the product expression:

$$I_{tot}(x,y) = I_o \left\{ \frac{\sin^2\left(\frac{N_x\delta_x}{2}\right)}{\sin^2\left(\frac{\delta_x}{2}\right)} \right\} \left\{ \frac{\sin^2\left(\frac{N_y\delta_y}{2}\right)}{\sin^2\left(\frac{\delta_y}{2}\right)} \right\}$$

where in the far-field limit: $\delta_x = 2\pi d_x \sin\theta_x/\lambda$ and $\delta_y = 2\pi d_y \sin\theta_y/\lambda$ (in radians).

Additional info & plots on 1-D and 2-D N-slit "far-field" interference is available on the Physics 406 Software webpage at the following URL:

http://courses.physics.illinois.edu/phys406/406pom_sw.html