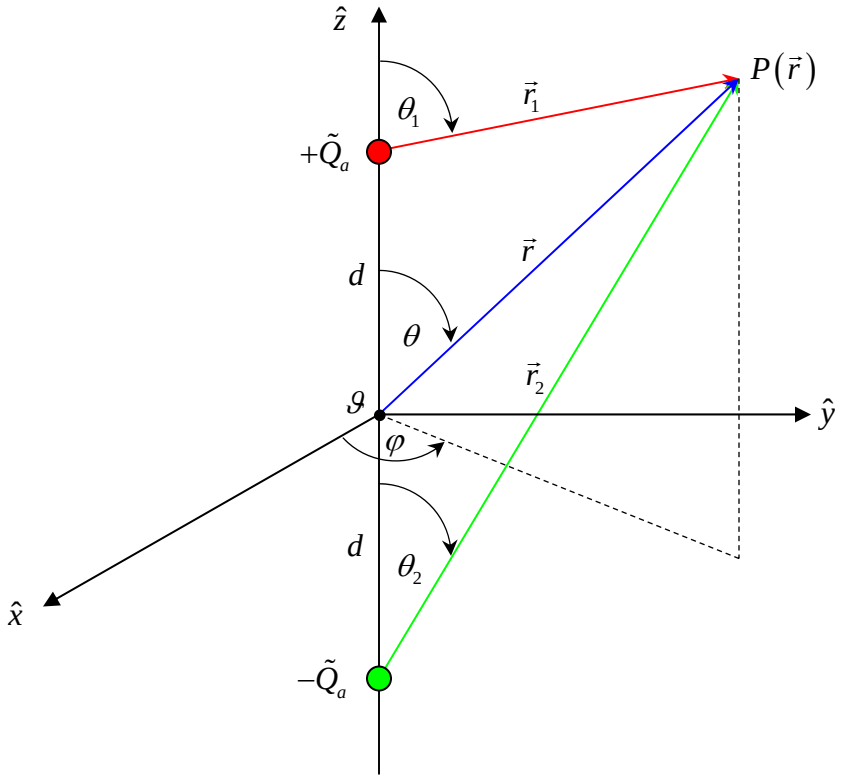
Example # 5: The Compact *Physical* Dipole Sound Source:

By the ***principle of linear superposition*** {for $SPL's \ll 134\,dB$}, we can create a so-called compact/physical ***dipole*** sound source using two ***out-of-phase*** physical monopole sources, of source strength/volume velocity $\pm\tilde{Q}_a$, and separated from each other by a distance $2d$, and subject to the requirement that $kd \ll 1$ (i.e. $f \ll c/2\pi d$ or $d \ll c/2\pi f$), as shown in the figure below:



The ***time-domain*** and the ***frequency-domain*** total/resultant complex over-pressure amplitudes at the observer/listener's point $P(\vec{r})$ in the above figure is the linear sum of the individual complex over-pressures associated with each monopole source:

$$\tilde{p}_{tot}(\vec{r},t) = \tilde{p}_1(\vec{r},t) + \tilde{p}_2(\vec{r},t) = \tilde{B}\left[\frac{1}{r_1}e^{-ikr_1} - \frac{1}{r_2}e^{-ikr_2}\right]e^{i\omega t} = i\frac{\rho_o\omega\tilde{Q}_a}{4\pi}\left[\frac{1}{r_1}e^{-ikr_1} - \frac{1}{r_2}e^{-ikr_2}\right]e^{i\omega t} = \tilde{p}_{tot}(\vec{r},\omega)e^{i\omega t}$$

The ***time-domain*** and ***frequency-domain*** total/resultant complex particle velocity at the observation/listener's point $P(\vec{r})$ in the above figure is the ***vector*** sum of the individual complex particle velocities associated with each monopole source:

$$\vec{\tilde{u}}_{tot}(\vec{r},t) = \vec{\tilde{u}}_1(\vec{r},t) + \vec{\tilde{u}}_2(\vec{r},t) = \tilde{u}_1(\vec{r},t)\hat{r}_1 + \tilde{u}_2(\vec{r},t)\hat{r}_2$$