<u>Complex Sound Fields</u> $\tilde{S}(\vec{r},t)$**:**

The acoustical physics properties associated with an <u>arbitrary</u> "everyday" audio complex sound field $\tilde{S}(\vec{r},t)$ can be ***<u>completely</u>*****/*****<u>uniquely</u>*** ***<u>determined</u>*** at the space-time point $(\vec{r},t)$ by measuring ***<u>two</u>*** physical quantities associated with the complex sound field:

(*a*.) the complex over-pressure $\tilde{p}(\vec{r},t)$ at the space-time point $(\vec{r},t)$ - a ***<u>scalar</u>*** quantity,

.and.

(*b*.) the complex particle velocity $\vec{\tilde{u}}(\vec{r},t)$ at the space-time point $(\vec{r},t)$ - a 3-D ***<u>vector</u>*** quantity with: $\lim_{r\to\infty} \vec{\tilde{u}}(\vec{r}) \to 0$, $\vec{\nabla}\bullet\vec{\tilde{u}}(\vec{r},t) \simeq -\frac{1}{\rho_o}\left(\partial\tilde{\rho}(\vec{r},t)/\partial t\right)$ and: $\vec{\nabla}\times\vec{\tilde{u}}(\vec{r},t)=0$ {or = constant}.

<u>Complex Sound Field Quantities: Working in the *Time-Domain vs*. the *Frequency-Domain*</u>

It is extremely important whenever working with any/all complex sound field quantities to understand/distinguish as to whether one is working with such quantities in the ***time-domain*** *vs*. working with such quantities in the ***frequency-domain*** – they are ***<u>not</u>*** the same/indentical…

Complex quantities in the ***time-domain*** *vs*. their ***frequency-domain*** counterparts are related by ***Fourier transforms*** of each other – because time *t* (units = seconds) and frequency $f=\omega/2\pi$ (units = 1/sec = *Hz*) are so-called ***Fourier conjugate variables*** of each other. We thus use the notation $\tilde{S}(\vec{r},t)$ *vs*. $\tilde{S}(\vec{r},\omega)$ to indicate a ***time-domain*** complex sound field *vs*. ***frequency-domain*** complex sound field at the space-point $\vec{r}$, respectively.

How do we know whether we are working in the ***time-domain*** *vs*. the ***frequency domain***?

A time-dependent ***instantaneous*** voltage signal $V_{p\text{-}mic}(\vec{r},t)=V_o^{p\text{-}mic}(\omega_o)\cos\left(\omega_o t+\varphi_p(\vec{r},\omega_o)\right)$, *e.g*. output from a pressure sensitive microphone placed at the point $\vec{r}=(x\hat{x},y\hat{y},z\hat{z})$ in the sound field of a loudspeaker {located at the origin $(0,0,0)$} and driven by a sine-wave function generator (of angular frequency $\omega_o=2\pi f_o$) + power amplifier is a typical example of a ***time-domain*** signal – it is observable *e.g*. on an oscilloscope, which displays the ***instantaneous*** voltage signal $V_{p\text{-}mic}(\vec{r},t)=V_o^{p\text{-}mic}(\vec{r},\omega_o)\cos\left(\omega_o t+\varphi_p(\vec{r},\omega_o)\right)$ output from the microphone as a function of time, *t*.

We specify, for clarity/definiteness′ sake that the oscilloscope trace of the display of the *p*-mic signal $V_{p\text{-}mic}(\vec{r},t)=V_o^{p\text{-}mic}(\vec{r},\omega_o)\cos\left(\omega_o t+\varphi_p(\vec{r},\omega_o)\right)$ is triggered ***externally*** by the ***sync signal*** output from the sine-wave generator – which serves as the ***reference*** signal and thus gives physical meaning to the (overall) phase $\varphi_p(\vec{r},\omega_o)$ of the *p*-mic signal, which is defined ***<u>relative</u>*** to the ***time-domain*** sine-wave voltage signal $V_{FG}(t)=V_o^{FG}\cos\omega_o t$ output from the sine-wave generator, since (by industry standard, the positive-going edge of) the TTL-level ***sync signal*** output from the sine-wave generator is used to ***in-phase*** trigger the start of the oscilloscope trace displaying the microphone signal $V_{p\text{-}mic}(\vec{r},t)=V_o^{p\text{-}mic}(\vec{r},\omega_o)\cos\left(\omega_o t+\varphi_p(\vec{r},\omega_o)\right)$.