Waves I:

Introduction to Waves - Traveling Waves

In these lecture notes on waves, our goal is to understand the physical behavior of waves - waves on guitar strings, sound waves in air, and also in dense media - such as vibrating guitar bodies, guitar necks, *etc*. Here we provide a brief review of the mathematics necessary to describe the behavior of such waves.

In general, a *traveling* wave is a *disturbance* that propagates in a medium (*e.g.* air, water, a guitar string, *etc*.) as a function of time, carrying with it energy, E and momentum p. As the traveling wave propagates, say along the x-axis, if the nature of the local disturbance - the displacement of atoms or molecules from their equilibrium positions - associated with the traveling wave at a given point, x at a given time, t is *transverse* (*i.e.* perpendicular) to the direction of propagation (say in the y-direction), as in the case of traveling waves on a string, we call such waves *transverse traveling waves*. In contrast to this, sound waves propagating *e.g.* in air or water (a fluid) are *longitudinal traveling waves* - the local disturbance (*i.e.* displacement from equilibrium position of air or water molecules) at a given point, x at a given time, t is *longitudinal* (*i.e.* parallel) to the direction of propagation.

In the figure shown below, we show a time sequence of the propagation of a transverse traveling wave, plotting the transverse displacement, $y(x,t) = y_o \exp\{-(x-v_x t)^2\}$ for a gaussian-shaped transverse traveling wave, for $t = -5$ seconds, $t = 0$ and $t = +5$ seconds. Here, we have chosen the amplitude, y_o (= transverse *displacement* from the equilibrium, $y = 0$ position) of this transverse wave, in *SI* (*i.e. mksa* {*meters-kilograms-seconds-ampere* units}) to be $y_o = 1.0$ *m*, the *longitudinal* propagation velocity of the transverse traveling wave (the x-velocity of the wave as it propagates along the x-axis) to be $v_x = +1$ *m*/*sec*. Note that this wave propagates in the $+x$ direction as time increases.