Let's come back to dispersion now.

\[ v = \text{Group velocity} \]

How can we find it? We need to answer what is \( \frac{\partial \phi}{\partial n} \).

Attained group velocity is the maximum speed we can transport the signal. At the same time, what is \( \frac{\partial \phi}{\partial n} \)?

It is both above, which is not calculated. However, we know that if the space is infinite, it is not a wave. Then Fourier transform is a superposition of many elementary components.

But since there is dispersion in the medium, each component will have its own speed. How is the question.

What do we call the speed of each signal source?

We can say that the whole packet of waves (group of waves) is moving with some speed in the medium. We call this speed group speed. For example, here is a signal:

\[ \text{This can look at the group speed of this signal and determine how it moves in space.} \]

In other words, we can look at the behavior of group velocity. To determine the speed of group phase, one must have been physically moving for some period.

For simplicity, we will take a group packet that consists of two waves:

\[ E_x = E_x \text{cos}(\omega t - k_x x) \]

\[ E_y = E_y \text{cos}(\omega t - k_y y) \]

\[ \omega > \frac{k^2}{2} \Rightarrow \text{this one will always lead.} \]

We can call freely changing component as amplitude:

\[ a = 2E \text{cos}(\frac{\omega}{2} t - \frac{k}{2} x) \]

The surface of each amplitude is:

\[ \frac{\partial \phi}{\partial n} = \frac{\partial \phi}{\partial \text{group speed}} \]

If we abbreviate:

\[ a = \text{ud} \]

\[ \text{where} \]

\[ u = \frac{\text{ud}}{2} \]

\[ d = \frac{\text{ud}}{2} \]

\[ k = \frac{\text{ud}}{2} \]

\[ \frac{\partial \phi}{\partial n} = \frac{\partial \phi}{\partial \text{group speed}} \]

\[ \frac{\partial \phi}{\partial n} = \frac{\partial \phi}{\partial \text{group speed}} \]

The formula actually explains the previous paradox.

\[ \text{Amplitude} \]

\[ \text{Phase} \]

\[ \theta = 0 \]