Define a set of 80 wave numbers with units of 1/Angstroms:

\[ m = 80 \quad dk = 0.005 \quad j = 1..m \quad k_j = 0.8 + (j - 1) \cdot dk \]

Define amplitudes for the wave numbers according to a gaussian shape:

\[
A(u) := \frac{1}{\sqrt{2 \cdot \pi \cdot \sigma_k}} \cdot e^{-\frac{(u - k_0)^2}{4 \cdot \sigma_k^2}}
\]

Absolute value of A squared is a gaussian of rms width sigma-k and area unity (normalized).

This is a plot of the squared of each amplitude from the set of 80.

\[
\sum_{n=1}^{m} A(k_n)^2 \cdot dk = 1
\]

Now define frequencies, as for a free electron. Units are 1/fs (fs=1.0E-15 s).

\[
\omega_j = \frac{1970 \cdot (k_j)^2}{2 \cdot 511000 \cdot 3 \cdot 10^3}
\]

Define the wave packet as a sum of the 80 plane waves, each with a different frequency. Check that the result has the proper normalization.

\[
f(x, t) := \sum_{n=1}^{m} A(k_n) \cdot e^{i \cdot (k_n \cdot x - \omega_n \cdot t)} \cdot \frac{dk}{\sqrt{2 \cdot \pi}} \quad \int_{-60}^{60} (|f(x, 0)|^2 \, dx = 1
\]
Evaluate the wave packet at $t=0$.
Add together the 80 waves and plot the real part: $x := -100, -99, \ldots, 100$

And plot the imaginary part:

And plot the probability distribution:

Note: $\sigma_x = \frac{1}{2 \cdot \sigma_k}$
Plot the magnitude as a function of time. The pulse will move with speed 11.6 Angstroms per femtosecond (fs) and will broaden.