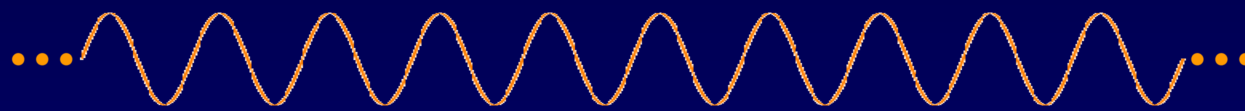
Heisenberg Uncertainty Principle

All QM objects (we think that includes everything have wave-like properties.
One mathematical property of waves is:

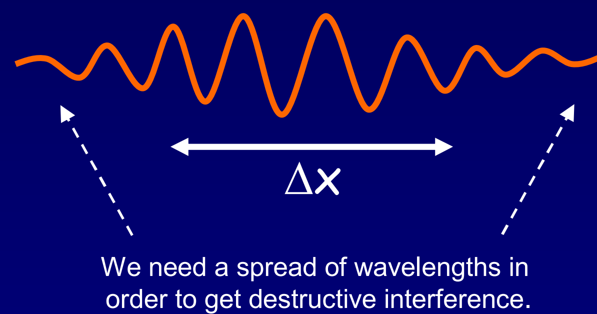
$\Delta k \cdot \Delta x \geq 1$ (See the supplementary slide for some discussion) $k = 2\pi/\lambda$

Examples:

- Infinite sine wave:
  A definite wavelength must extend forever.



- Finite wave packet:
  A wave packet requires a spread* of wavelengths.



Using $p = h/\lambda = \hbar k$, we have:

$$\hbar\,(\Delta k \cdot \Delta x \geq 1) \;\Rightarrow\; (\hbar \Delta k) \cdot \Delta x \geq \hbar \;\Rightarrow\; \boxed{\Delta p \cdot \Delta x \geq \hbar}$$

This relation is known as the Heisenberg Uncertainty Principle.
It limits the accuracy with which we can know the position and momentum of objects.

* We will not use the statistically correct definition of “spread”, which, in this context, we also call “uncertainty”.