

## Heisenberg Uncertainty Principle

\*\*If  $\Delta x$  is a small number (small change in position), then the position of the particle is accurately known. But then  $\Delta(mv)$  will be a large number (large change in momentum), so the movement of the particle is unknown.

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When light is shined onto a particle, some of the light waves will be scattered by the particle. This scattering pattern can be used to determine the position of the particle.

If long wavelength light is used, the position can be found. But the position cannot be known any more accurately, than within a wavelength of that light (the distance between crest and crest). If it has a long wavelength, then there is a large area that the particle could be in (large  $\Delta x$ ). The position is not known accurately, while the accuracy of the particles movement is high (small  $\Delta(mv)$ ).

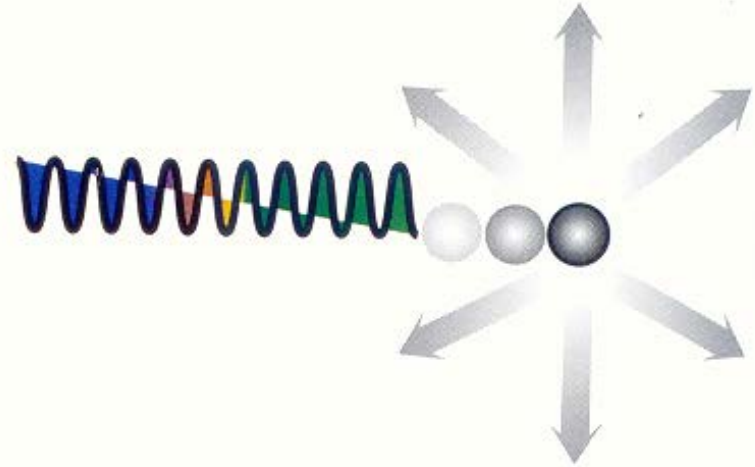
If short wavelength light is used, the position can be found more accurately due to the shorter wavelength of the light (the particle is in a smaller area). But the shorter wavelength light has more energy (higher frequency), which will adversely affect the velocity of the particle. So the accuracy of the movement is decreased (large  $\Delta(mv)$ ), while the position is known accurately (small  $\Delta x$ ).

## Long Wavelength/ Low Frequency

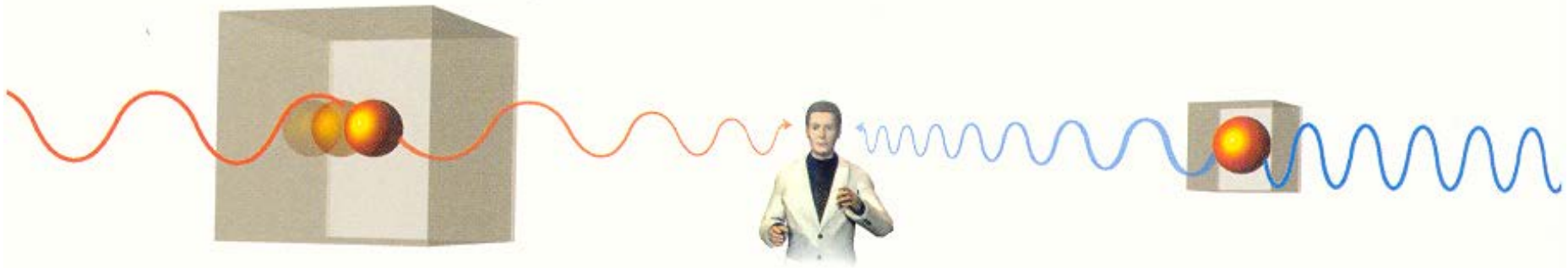


Low-frequency wavelengths disturb the velocity of the particle less.

## Short Wavelength/ High Frequency



High-frequency wavelengths disturb the velocity of the particle more.



The longer the wavelength used to observe a particle, the greater the uncertainty of its position.

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