Answer on Question #60713, Physics / Electromagnetism

An electron microscope uses an electron beam of energy E=1.0 keV. Can this microscope be used to obtain the image of an individual atom? (The size of an atom ~10^{-10} m.)

Solution:

In order to resolve an object, the wavelength of the beam must be smaller than the size of the object.

Louis de Broglie showed that every particle or matter propagates like a wave. The wavelength of a particle or a matter can be calculated as follows.

$$\lambda = \frac{h}{p}$$

where λ is the wavelength of a particle, h is Planck's constant (6.626 x 10^{-34} J seconds), and p is the momentum of a particle. Since the momentum is the product of the mass and the velocity of a particle,

$$\lambda = \frac{h}{mv}$$

Beam energy is determined by velocity of electrons:

$$E = \frac{1}{2} mv^2,$$

The velocity of electrons can be calculated by

$$v = \sqrt{\frac{2E}{m}}$$

Therefore, the wavelength of propagating electrons at a given accelerating voltage can be determined by

$$\lambda = \frac{h}{\sqrt{2mE}}$$

Since the mass of an electron is 9.1 x 10^{-31} kg, the wavelength of electrons is calculated to be

$$\lambda = \frac{6.62 \cdot 10^{-34}\ \text{J s}}{\sqrt{2 \cdot 9.1 \cdot 10^{-31} kg \cdot 10^3\ eV \cdot 1.6 \cdot 10^{-19} \frac{J}{eV}}} = 3.9 \cdot 10^{-11}\ m$$

Answer:

So, we can use this microscope to obtain the image of an individual atom.