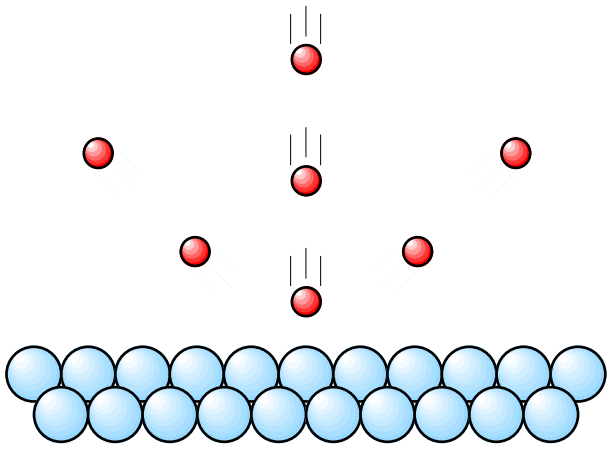
# Electron Diffraction

## Electrons as waves

In many situations, electrons can be considered as particles of essentially zero size. However, if a beam of electrons with a kinetic energy of tens or hundreds of electron-volts hits the surface of a crystalline material, then it is observed to diffract like a wave.

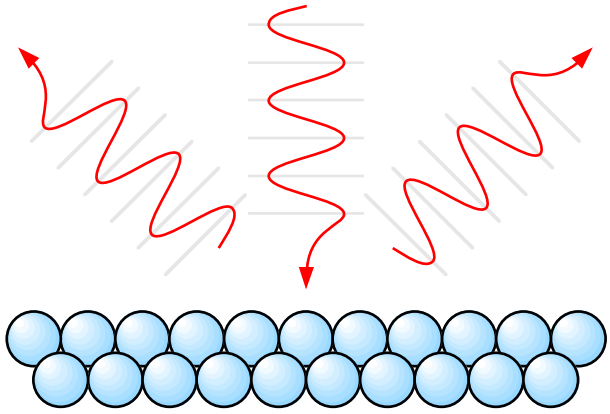


The deBroglie relationship

$$\lambda = h / p$$

for an electron with a kinetic energy of 25 eV gives a wavelength for the electron of 0.25 nm, which is comparable to the wavelength of an x-ray and to the lattice constants of many materials.

Electrons interact very strongly with the atoms in a solid material simply because they are charged. An x-ray photon may pass through a mm of material before it is scattered by an atom, but a low-energy electron is unlikely to travel more than a few nm.



As a result of this, low-energy electron diffraction (LEED) patterns are determined by the crystallographic order of atoms at the surface of a material. This means that LEED is a very useful technique to study the arrangement of atoms and molecules on surfaces.

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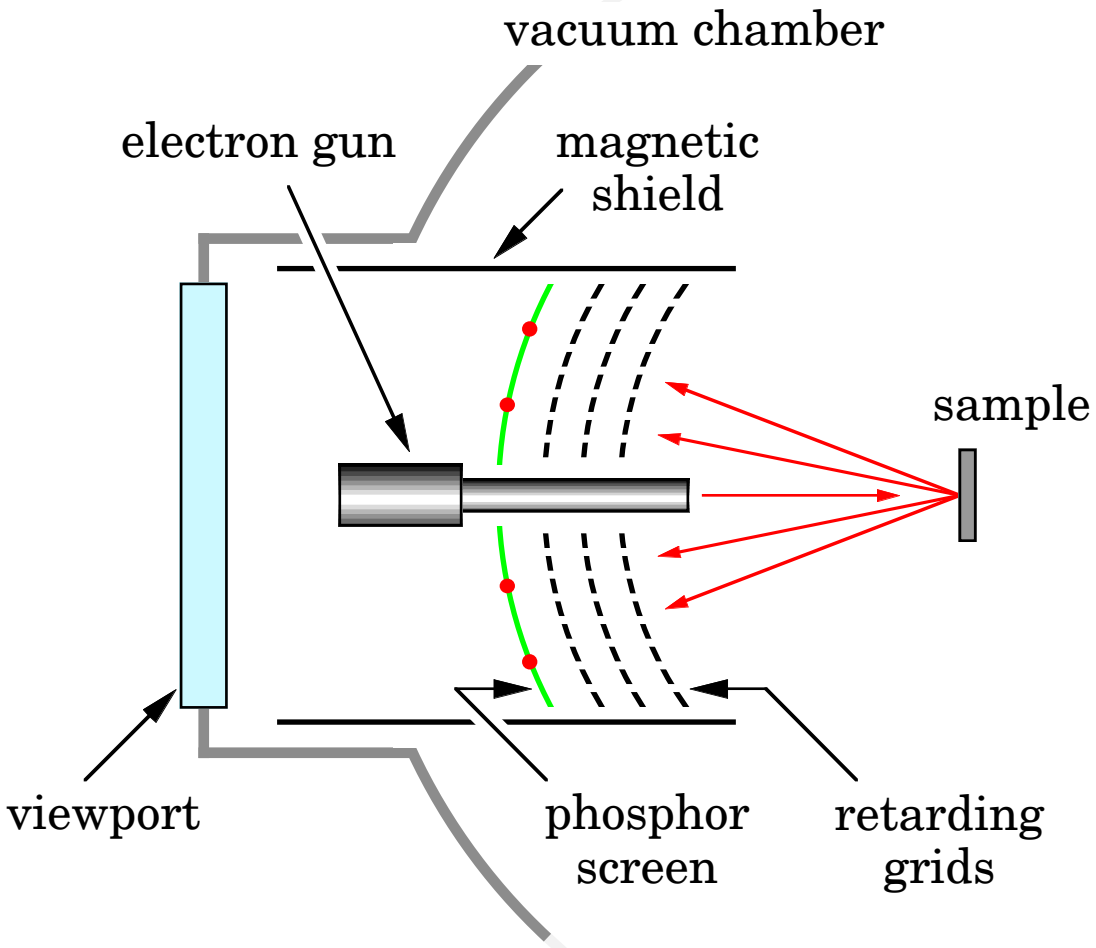
In a LEED experiment, electrons are fired from an electron gun towards the surface of a sample mounted inside a vacuum chamber. To keep the sample surface free from contamination, the vacuum has to be kept below $10^{-8}$ Pa ($10^{-10}$ mbar).




The beams diffracted from the sample pass through metal grids that are held at a negative potential to stop any electrons with energy less than that of the incident beam. Then the electrons are accelerated into a phosphor screen that is held at a high positive potential. This produces a spot on the screen that can be seen or recorded using a video camera.

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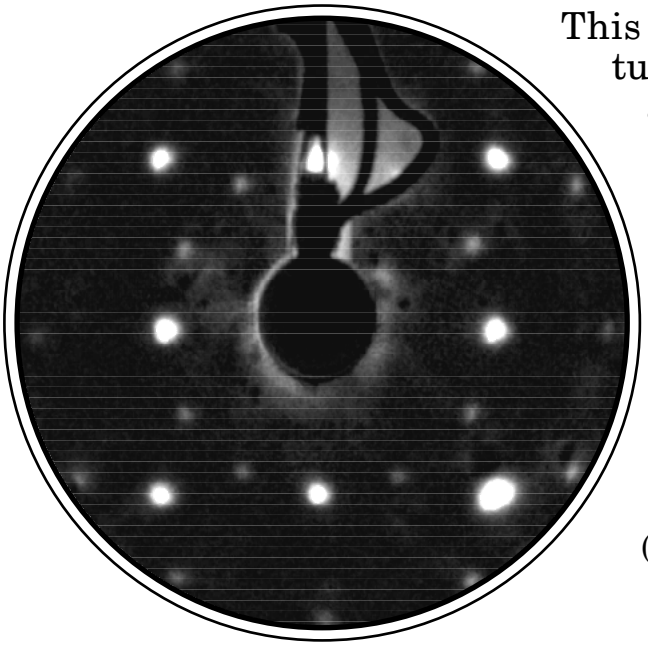
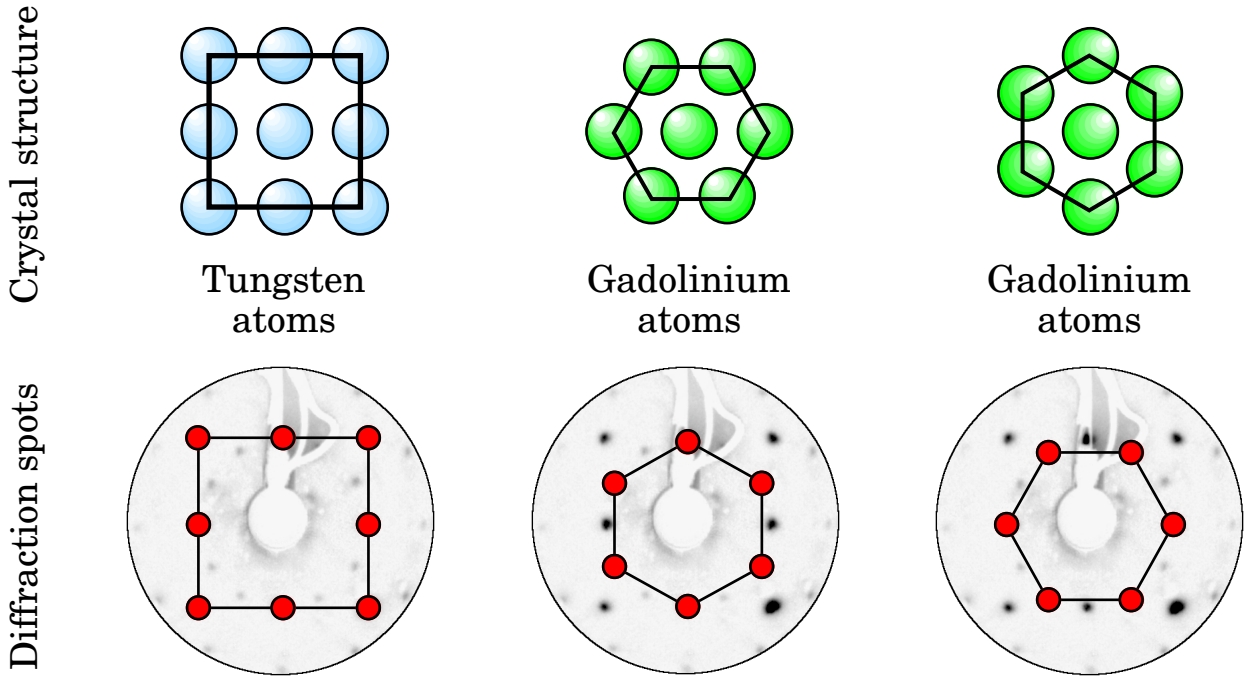


This LEED pattern was seen from a tungsten surface on top of which three atomic layers of the rare-earth metal gadolinium had been deposited. How is this LEED pattern interpreted?

From x-ray diffraction we know that the tungsten atoms are arranged in a cubic crystal structure. We also expect the gadolinium atoms in the thin film to form hexagonal structures (similar to those of bulk crystals).




Thus the thin film of gadolinium atoms comprises two domains, each oriented with respect to the tungsten surface as indicated above.

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