THE UNCERTAINTY PRINCIPLE

In classical mechanics, there is no limitation to the accuracy of our measurements in experiments. In principle, we could always make a more precise measurement using a more finely detailed meterstick or a stronger magnifier. This unlimited precision does not hold true in quantum mechanics. The absence of such precision is not due to the limitations of our instruments or to our perturbation of the system when we make measurements. It is a fundamental limitation inherent in nature due to the wave nature of particles.

Simultaneous measurements of position and momentum cannot be completely certain

In 1927, Werner Heisenberg argued that *it is fundamentally impossible to make simultaneous measurements of a particle's position and momentum with infinite accuracy.* In fact, the more we learn about a particle's momentum, the less we know of its position, and the reverse is also true. This principle is known as Heisenberg's **uncertainty principle.**

uncertainty principle

the principle that states that it is impossible to simultaneously determine a particle's position and momentum with infinite accuracy

To understand the uncertainty principle, consider the following thought experiment. Suppose you wish to measure the position and momentum of an electron as accurately as possible. You might be able to do this by viewing the electron with a powerful microscope. In order for you to see the electron and thus determine its location, at least one photon of light must bounce off the electron and pass through the microscope into your eye. This incident photon is shown moving toward the electron in **Figure 19(a).** When the photon strikes the electron as in **Figure 19(b),** it transfers some of its energy and momentum to the electron. So, in the process of attempting to locate the electron very accurately, we become less certain of its momentum. The measurement procedure limits the accuracy to which we can determine position and momentum simultaneously.

A thought experiment for viewing an electron with a powerful microscope

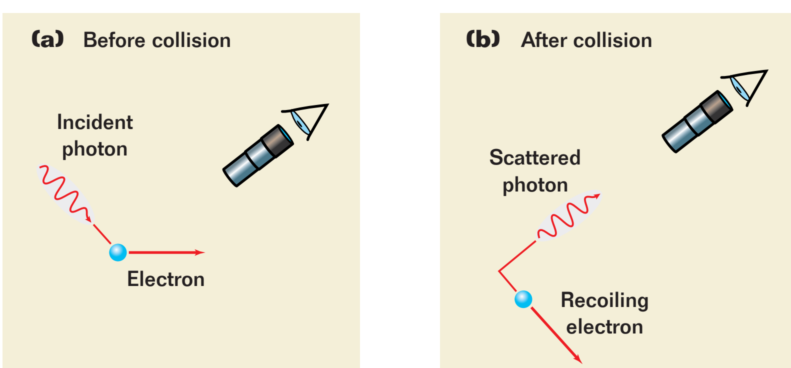

Figure 19
(a) The electron is viewed before colliding with the photon. **(b)** The electron recoils (is disturbed) as the result of the collision with the photon.