Uncertainty Principle Encyclopedia Article

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Uncertainty Principle

The Uncertainty principle (also known as the Heisenburg uncertainty principle or Indeterminacy principle) is a fundamental postulate of **quantum theory** used to describe the behavior of **energy** and **matter** on atomic and subatomic scale that states that two complementary properties of a system (i.e., the position and **momentum** of an **electron**) can never both be measured exactly. In this regard the Uncertainty principle established a limit to the accuracy of measurement. Moreover, the Uncertainty principle specifies that the measurement of a system alters the system.

Using matrix mathematics, German physicist **Werner Heisenberg** formulated the first complete and self-consistent theory of quantum **mechanics**. In 1926, Heisenberg put forward his uncertainty principle and the concept quickly became a cornerstone of quantum theory that helped explain the wave-particle nature of **subatomic particles**. The Uncertainty principle mathematically specifies that the position and the momentum of an object cannot both be measured exactly. Moreover, at the quantum level, the concepts of position and momentum have no specified values until a system is measured. For example, Heisenburg asserted that in any measurement of the position or the momentum of an electron, there would be an uncertainty in the measurement due to the fact that the measurement of one of the quantities would necessarily disturb the measurement of the second quantity. For example, the position of an electron can be determined using short **wavelength radiation** which consists of high-energy photons. However, the use of high-energy photons to determine the position of an electron changes the momentum of the electron.

The development of quantum theory, especially the delineation of Plancküs constant and the articulation of the Heisenburg uncertainty principle carried profound philosophical implications regarding limits on knowledge. Because the product of the uncertainty in the measurement of position and momentum must always be greater than or equal to Planck's constant (*h*) divided by 2*pi*, infinite precision in measurement is not possible.

The uncertainty principle also applies to energy and **time** and explains the broadening of **spectral lines**: if the lifetime of a molecule promoted to an excited state is short, the uncertainty in time will be small and the uncertainty in energy will be large, resulting in a wide range of energy values for the transition and in spectral broadening of the line.