Correspondence Principle Encyclopedia Article

Correspondence Principle

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Contents

Correspondence Principle Encyclopedia Article.....1

Contents.....2

Correspondence Principle.....3

Correspondence Principle

The correspondence principle, which **Niels Bohr** proposed in 1923, asserts that a new theory of physics should also account for the predictions of an older theory when the older theory is consistent with observations. In particular, if **Planck's constant** (ħ), which sets the characteristic scale for quantum mechanical phenomena is sent to zero, then in this limit, quantum **mechanics** recovers the classical **dynamics** of **Isaac Newton** and the classical **electrodynamics** of **James Clerk Maxwell**. This dictum formed a part of the Copenhagen Interpretation of **quantum theory**.

An example illustrates how to apply the idea. **Quantum mechanics** holds that all particles exhibit wave-like properties with a **wavelength** given by the relation = 2ħ/p where p is the particle's **momentum**. Since momentum is the product of **mass** and **velocity** (p = mv), this wavelength decreases as the mass increases. Classical mechanics, on the other hand, holds that a particle has no wavelength. Sending ħ to zero in the quantum theory yields this result. The classical limit is the appropriate limit to consider when studying the trajectory of a baseball, which is massive enough that quantum considerations are negligible. The limit is not appropriate to the study of an **electron**.

Bohr introduced the correspondence principle while quantum mechanics was still in its infancy. Bohr's theory of the hydrogen **atom** was consistent with the classical picture in the limit of large **quantum numbers**, but it did not explain the properties of systems more complicated than a single atom. Newer formulations of quantum theory that sought to do more had also to explain the predictions of Bohr's model. The correspondence principle requires as much. Erwin Schrödinger's wave mechanics, which was equivalent to Werner Heisenberg's matrix mechanics, does this.

The correspondence principle serves as a useful philosophical tool in choosing a theory because it requires a model to explain more than just one particular set of phenomena. This idea also applies to theories other than quantum mechanics. For example, in the limit where speeds are much smaller than that of **light**, the predictions of the special theory of relativity match the predictions of Newtonian mechanics. The new theory, special relativity, applies to a regime where the previous theory, Newtonian mechanics, does not, and in addition, it reproduces the result of the older theory. In this way, the correspondence principle acts as a unifying thread in the development of physical theories.