Minkowski Space-Time Encyclopedia Article

Minkowski Space-Time

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Minkowski Space-Time

Minkowski **space-time** is a single, four-dimensional continuum composed of the three coordinates defining position and a fourth **dimension** of time. It is a concept developed by German mathematical physicist **Hermann Minkowski** in 1907, and it provides the framework for all mathematical work in relativity, including Albert Einstein's general theory of relativity. Minkowski space-time is also often referred to as Minkowski **space** or the Minkowski universe. Although Minkowski space-time is used predominately in special relativity, it can be applied to other studies involving the coupling of time to spatial vectors. In order to be able to use Minkowski space-time in this manner, this type of coupling must show that the time **transformation** of a process is not independent of the spatial components, that the two are strictly interdependent.

In an attempt to understand work previously done by Lorentz and Einstein, Hermann Minkowski developed a four-dimensional space-time continuum in 1907. Until the development of Minkowski space-time the three-dimensional coordinate system describing position and the other dimension, time, were considered as independent entities in Newtonian physics. Minkowski realized that the preliminary work on relativity could best be understood in a non-Euclidean space that involved a combination of these two separate systems. He coupled these two systems together into a four-dimensional space-time continuum and employed it in his own treatments of a four-dimensional study of electrodynamics. He noticed that the **invariant interval** between two events has some of the properties of the **distance** in Euclidean **geometry** and formulated it as the **square** root of a sum and difference of squares of intervals of both space and time. Using this idea, events localized with regards to both space and time are the analogues of points in three-dimensional geometry. This means that in Minkowski space-time the time in the history of one particle resembles the arc length of a curve in three-dimensional space. Minkowski space-time does not add anything to the original physical concepts of relativity, but its contribution to the conceptual development of relativity is immeasurable.