Direction of Time Encyclopedia Article

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BOOKRAGS

Contents

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The directionality of **time** is a fundamental and unexplained characteristic of the **universe**. Unlike the three dimensions of **space**, which have no obvious preferred direction, time is unequivocally separated into the past, from which we may receive information, the present, and the future, which is influenced by the present. There exists an **arrow of time** that separates cause from effect.

Curiously, reversal of time has no effect on nearly all microscopic physical processes. The laws of **electromagnetism**, for example, are invariant (do not change form) when time is reversed: every possible electromagnetic process, if observed to "run backwards," obeys the same laws. Thus, no electromagnetic phenomenon can define a direction of time. For electromagnetic systems the distinction between forward and reverse **motion** is not well-defined. Similarly, classical and quantum **mechanics**, and Einstein's theory of gravitation are all time-reversal invariant. Yet some physical phenomena must violate the laws of physics when time is simply reversed--otherwise the experimentally obvious distinction between the past and future would not exist.

Strong empirical evidence does exist that the distinction between past and future is not simply an artifact of human perception. The second law of **thermodynamics** states that **entropy** (disorder) of the universe will not decrease with the (forward) advance of time for all physical processes. That is, the universe moves toward increasing disorder. Thus the "arrow of time" can be defined as the direction of increasing entropy. The unyielding increase of entropy as expressed in the **second law of thermodynamics**, having been observed in countless systems, can be explained by the use of probability theory. Probability inherently requires a notion of past and future, however, and a satisfactory explanation of the connection between fundamental, microscopic physical laws and the source of the universal arrow of time has not been found.

Violation of time-reversal invariance (also called time-reversal symmetry breaking) is exhibited by nuclear processes, namely those that involve the weak nuclear **force** (weak interactions) as opposed to electromagnetic interactions. In 1964 J. W. Cronin and V. L. Fitch indirectly observed time-reversal symmetry breaking in the decay of neutral **K mesons**. In 1997 investigators reported observations of violation of time-reversal invariance in the behavior of tunnel junctions in a superconductor.