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Closed Timelike Curve

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A closed timelike curve (sometimes abbreviated CTC) is a theoretical solution to the general field equations of the theory of general relativity. In a closed timelike curve, the worldline of an object through spacetime follows a curious path where it eventually returns to the exact same coordinates in space and time that it was at previously. In other words, a closed timelike curve is the mathematical result of physics equations that allows for time travel.

Normally, a closed timelike curve comes out of the equations through something called frame dragging, where a massive object or intense gravitational field moves and literally "drags" spacetime along with it. Many results that allow for a closed timelike curve involve a black hole, which allows for a singularity in the normally smooth fabric of spacetime and often results in a wormhole.

One key thing about a closed timelike curve is that it is generally thought the worldline of the object following this curve doesn't change as a result of following the curve. That is to say, the worldline is closed (it loops back on itself and becomes the original timeline), but that has "always" been the case.

Should a closed timelike curve be used to get a time traveler to travel into the past, that most common interpretation of the situation is that the time traveler would have always been part of the past, and therefore there'd be no changes to the past as a result of the time traveler suddenly showing up.

History of Closed Timelike Curves

The first closed timelike curve was predicted in 1937 by Willem Jacob van Stockum and was further elaborated by the mathematician Kurt Godel in 1949.

Criticism of Closed Timelike Curves

Though the result is technically allowed in some very highly-specialized situations, many physicists believe that time travel is not achievable in practice. One person who supported this viewpoint was Stephen Hawking, who proposed a chronological protection conjecture that the laws of the universe would ultimately be such that they prevent any possibility of time travel.

However, since a closed timelike curve doesn't result in changes to how the past unfolded, the various paradoxes that we would normally want to say are impossible don't apply in this situation. The most formal representation of this concept is known as the Novikov self-consistency principle, an idea presented by Igor Dmitriyevich Novikov in the 1980's that suggested that if CTCs are possible, then only self-consistent trips backward in time would be allowed.

Closed Timelike Curves in Popular Culture

Since closed timelike curves represent the only form of travel backward in time that is allowed under the rules of general relativity, attempts to be scientifically accurate in time travel generally try to use this approach. However, the dramatic tension involved in scientific stories often require some sort possibility, at least, that history could be altered. The number of time travel stories that really stick to the idea of closed timelike curves are pretty limited.

One classic example comes from the science fiction short story "All You Zombies," by Robert A. Heinlein. This story, which was the basis of the 2014 film ***Predestination***, involves a time traveler who repeatedly goes backward in time and interacts with various previous incarnations, but each time the traveler who comes from "later" in the timeline, the one who has "looped" back, has already experienced the encounter (albeit only for the first time).

Another good example of closed timelike curves is the time travel plotline that ran through the final seasons of the television series ***Lost***. A group of characters traveled backward in time, in the hopes of altering events, but it turned out that their actions in the past create no change in how events unfolded, but it turns out that they were always part of how those events unfolded in the first place.

Also Known As: CTC

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