matter as thay move through the universe. The clock ticks differently from place to place and is a full-blown mathematical dimension, but no past travel destination exists within that dimension. The known universe of time is the ephemeral ticks themselves, and nothing more.

Thus, the idea that time travel is possible rests upon an incomplete understanding of relativistic law. Our cells are not simplistic mechanical clocks. They are rapidly moving particles that have altered trajectories at high relativistic speeds. At such speeds these clocks do not just slow down, they die. Accordingly, despite the closed timelike curves that pop up in various solutions of the formulas of general relativity, the prospect of traveling to the past to meet one's younger self remains the stuff of dreams.

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See also Einstein, Albert; Gödel, Kurt; Space Travel; Time, Relativity of; Time, Reversal of; Time Machine; Time Warps; Twins Paradox; Wells, H. G.; Wormholes

Further Readings

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Time Warps

Time warps have been a favorite topic in science fiction literature from H. G. Wells's *The Time Machine* (1895) to the present-day *StarTrek* series. According to these stories humans can jump throughout history to change or observe events in the past or future, and spaceships can travel quicker than the speed of light in order to travel to other galaxies, but what exactly is the scientific basis behind this phenomenon?

A time warp is defined as the slowing down or speeding up of time. This is a relatively recent concept in the history of science. In 1905 Einstein showed that space and time were relative rather than absolute, and in 1912 he showed that space and time were related ("spacetime" as it came to be known), stating that it was actually curved instead of a straight line as had previously been thought. Since the 17th century, Newtonian physics had stated that space and time were absolutes. Einstein concluded that space and time are warped by matter and energy and thereby elastic and relative. His *special theory of relativity* states that time is elastic and as a result can be stretched and shrunk.

What are the methods by which time can be warped? Speed is one tool. In order to test this theory, physicists Joe Hafele and Richard Keating put highly accurate atomic clocks into airplanes and flew them around the world in 1971. They compared the readings of these clocks with identical clocks they had left in the laboratory. The result was that time ran more slowly in the airplanes. The airborne clocks were 59 nanoseconds slower relative to the clocks that were kept in the laboratory.

This is a small difference; to get a really dramatic effect one must move very fast. Speed will distort time based on how fast an object is moving. The closer you get to the speed of light (300,000 kilometers per second) as you travel, the bigger the time warp gets. The time warp becomes infinite when the speed of light is reached.

Speed is only one method of warping time. Another method is gravity. The earth's gravitational pull causes clocks to lose one microsecond every 300 years. Because of the lack of gravity in space, it would make sense that time would run faster in space. It is not that noticeable, though; one would gain just a couple of milliseconds by spending 6 months aboard the International Space Station. Stephen Hawking, one of the modern leading experts on the relationship between space and time, has suggested that spacetime is nearly flat on Earth, so the curvature resulting from gravity makes very little difference in our everyday life, making us oblivious to the time warp phenomenon.