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Tachyons

Tachyons are hypothetical subatomic particles which travel faster than the speed of light (Feinberg, 2004). Tachyons are mathematically compatible with the theory of special relativity and some versions of string theory. Although a number of attempts have been made, no experiment has been conducted which either proves or disproves the existence of the particles.

History

Early study on the possibility of tachyons was conducted by s. Tanaka and O.M.P. Bilaniuk, V.K. Deshpande, and E.C.G. Sudarshan (Good, 1960). G. Feinberg later made more contributions and gave tachyons their name, which is derived from a Greek work *tachys* meaning "swift" (Feinberg, 2004). Since the tachyon was first introduced a number of experiments have been conducted on them and a number of mathematical papers have been written about them.

Tachyons in Special Relativity

Within The Theory of Relativity, the equations show that a particle can not be accelerated to the speed of light (Milanese, n.d.). Two of the equations within relativity are $m = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}$ and $E = mc^2$; where m is the mass (from the reference frame of an external observer), m_o is the root mass, v is the velocity (as perceived from the same reference frame as that which is viewing the mass), and c is the speed of light. The first equation shows that as the velocity approaches the speed of light then the mass approaches infinity. When the mass approaches infinity, the second equation shows that the amount of energy necessary to accelerate the object approaches infinity, showing that no particle could be accelerated to the speed of light. However there are known particles which travel at the speed of light, such as the photon, tau neutrino and graviton,

however these are not accelerated to that speed, they are created at it, also all of these objects have no mass.

Tachyons however have a way of getting around this apparent problem within relativity. Like the particles traveling at the speed of light, tachyons are thought to be created at faster than light speeds and exist solely at faster than light speeds. The way that this is possible within Special Relativity can be shown through two more of its formulas the first has to do with the Lorentz four-vector and is $E^2 - c^2 p^2 = m^2 c^4$ and the second formula necessary shows velocity and is $v = \frac{cp}{E} c$ (Good, 1960). If these two formulas are combined then a third formula which is $E = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}$ can be derived and then if m^2 is said to be equal to $-\mu^2$ then the equation can be made to be $E = \frac{\mu c^2}{\sqrt{\frac{v^2}{c^2} - 1}}$. These formulas predict that tachyons will act in strange ways. Namely as a tachyon gains energy it will slow down and as it slows it will become more massive. They also show that the speed of light is the lower bound speed limit for tachyons. Yet the strangest part is the fact that because m^2 is said to be equal to $-\mu^2$ the mass of tachyons is imaginary.

Properties

As shown above tachyons would have an imaginary rest mass, however a tachyon would never be at rest so this is not a problem. When observed a tachyon would always appear to have real mass, momentum, and energy from the frame of reference of a subluminal object. There have also been some papers in which tachyons were said to have a negative mass rather than an imaginary mass (Feinberg, 2004; Wall, 2007).

Detection

One of the possible properties of tachyons which scientists have attempted to detect it by is the possibility of it emitting Cherenkov radiation (Feinberg, 2004). Any charged particle which travels faster than the local speed of light gives off Cherenkov radiation seen as a glow. If tachyons did exist and they where charged then they would be the only object capable of giving off Cherenkov radiation in a Vacuum. They have also looked for the $-m^2$ value in elementary particle interactions. It is theorized that since all other subatomic particles can be created within high energy particle collisions that this must be true for tachyons; therefore scientists have looked for tachyons within particle accelerators, to no avail.

Paradoxes

Due to the high speed of tachyons they can create some interesting effects. One is that you will never see one approach. One of the more important ones is that depending on a persons frame of reference the particle's energy can appear negative (Tachyon, n.d.). this problem can be solved by what is know as the reinterpretation principle which says that for that frame of reference the particle was absorbed, before it was emitted. This means that all frames of reference see positive energy; however they disagree on the direction of motion of the tachyon. This causes the emitter of tachyons to also be an absorber, and vice versa. Another solution to this problem is the possibility that tachyons travel in very tight orbits, moving within their orbits at speeds faster than the speed of light; however the centers of their orbits would move at slower than light speeds so the paradoxes related to their speeds would not occur, and the possibility of using tachyons for faster than light communications would not exist.

Conclusion

Tachyons are still a hypothetical particle, with multiple different definitions. Attempts will continue to make more discoveries about them both mathematically and scientifically. If

discovered they could have interesting uses as well as interesting effects. They have already become manifested within science fiction and extreme marketing uses. Whether they exist or not remains a mystery

Glossary

-Frame of Reference- Easily put; a point of view

-Lorentz Factor- A factor by which the axes of travel shrinks, time shrinks, and mass expands due to motion

-Root (rest) Mass- the mass a particle would have if it had no velocity.

String Theory- “is a theory of the fundamental forces of nature. Since the mid-1980's, physicists have developed many forms of the theory, including a group of *superstring theories.* However, the theory is still incomplete.

> The key to string theory is its description of *elementary particles,* objects that are not made up of other objects. According to conventional theories of physics, these objects—which include electrons and quarks—are pointlike. But in string theory, they are tiny strings that can vibrate in various ways. Different patterns of vibration would appear to us as different particles.
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> A successful string theory would be the first single theory to describe all four of the known fundamental forces: (1) the *electromagnetic force* that underlies electricity and magnetism; (2) the *strong nuclear force* that binds together quarks in protons, neutrons, and other objects; (3) the *weak nuclear force,* responsible for the radioactive decay of atomic nuclei; and (4) *gravitation,* the attraction between material objects. Physicists have developed successful conventional theories of the four forces, but they have not combined those theories.
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> The conventional theories of the electromagnetic, strong, and weak forces are *quantum theories*—that is, they use the principles of the theory of quantum mechanics. According to that theory, particles transmit forces to one another by means of *quanta,* or "chunks" of energy. *(Quanta* is the plural of *quantum.)* For example, a quantum called the *photon* transmits electric and magnetic forces.
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> The gravitational theory is the theory of general relativity, developed by the German-born physicist Albert Einstein. The theory of relativity is not a quantum theory. Rather, the theory says, gravitation is an effect of a distortion of space and time by the presence of matter. A successful string theory would combine aspects of general relativity and quantum mechanics.” (Dine, n. d.)

-The Speed of Light- approximately 300,000 kilometers per second. It is the speed electromagnetic radiation travels in a vacuum

-The Theory of relativity- a theory created by Einstein which is based on the fact that: (1) There is no ether, and the speed of light is the same for all observers,

whatever their relative motion. (2) The laws of nature are the same in all inertial frames

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