In Twin Paradox Twist, the Accelerated Twin is Older

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Scientists have found that, when twins are orbiting a massive object, time dilation can cause the accelerated twin to be older if that twin is moving slower than the other twin; in this case, velocity is the deciding factor of age, and the twin with the greater velocity is younger. ©2005 Cetin Bal.

Just when you thought you were beginning to understand the twin paradox (maybe), scientists have found something new to ponder. In the original version of the famous thought experiment on time dilation, one twin stays on Earth while the other twin takes a rocket at nearly light speed into space, and returns to find that he is younger than his twin on Earth. But a new version of the story now shows that the twin who experiences an acceleration can be older than the twin who doesn't accelerate, under slightly different conditions.

Physicist Marek Abramowicz of Goteborg University in Sweden and astronomer Stanislaw Bajtlik of the Nicolaus Copernicus Astronomical Center in Warszawa, Poland, have proposed the surprising new version of the twin paradox, which at first seems to run contrary to the traditional version. However, the scientists show that the traditional version is actually a specific case of a more general concept.

"In the best known version of the twin paradox, the twin who is accelerated is younger," Abramowicz and Bajtlik told PhysOrg.com. "In the version discussed by us the accelerated twin is older. It is quite surprising. It is almost as to say that 'the older twin is younger.'"

In 1905, Einstein described the ideas behind the twin paradox to demonstrate the effects of time dilation according to special relativity. In 1911, physicist Paul Langevin turned the concept into a concrete story involving two hypothetical twins. Ever since then, scientists have offered various explanations for exactly why this aging paradox occurs, and whether it is even a true paradox at all.

As Abramowicz and Bajtlik note in their study, it is often claimed that the twin paradox can be explained by the acceleration of the traveling twin that occurs when he turns around to go back to Earth. Abramowicz and Bajtlik show, however, that it is not the acceleration that causes the age difference in most cases. By presenting a scenario in which the accelerated twin is older at the reunion, the scientists show that the final time difference between the twins often depends only on their velocities as measured with respect to an absolute standard of rest, and not on acceleration.

In the new scenario, both twins are in circular orbit at different velocities around a large body, with the velocities measured by observers rotating with zero angular momentum with respect to the sky. Abramowicz and Bajtlik considered what happens when twin A stops moving, and so has a velocity of zero, and therefore a non-zero acceleration. Twin B continues to orbit at a set velocity corresponding to Keplerian free orbit and therefore has zero acceleration. Twin A is the accelerated twin, and twin B is not accelerated. As the scientists calculate, contrary to the classical version of the paradox, twin B is younger.

The scientists then considered a situation where the large body that the twins orbit decreases in mass, while the twins' orbiting radius stays the same. Under these circumstances, twin B's orbiting velocity no longer follows Kepler's laws, and so he experiences an acceleration like twin A. However, the ratio of the twins' proper times still depends only on their velocities, not on their acceleration. Since the twins' velocities stay the same, with twin B orbiting at a larger velocity than twin A (who is not moving at all), twin B is still younger.

"According to Einstein's relativity theory, the time measured by moving clocks runs more slowly," Abramowicz and Bajtlik explained. "If two twins move relative to each other, for each of them the time measured by the other one runs more slowly. There is nothing contradictory or paradoxical about that. Note that, quite similarly, two twins who look at each other from a distance both have the impression that the brother looks smaller. For the twin paradox to occur, they should be brought to the same place. At the reunion the twins will find that they do not differ in size, but they may differ in age. What breaks the symmetry here? The standard answer is the acceleration. However, in many situations in which the absolute motion may be defined, the moving twin is younger, regardless of acceleration."

In the examples so far, the faster twin is younger, regardless of any acceleration. However, if the mass of the large body decreased to zero, the situation becomes the original twin paradox: twin A is not accelerated, and twin B is accelerated. In this special case, twin B is still younger - but not because he is moving faster. As the scientists explain, when the mass of the large body is zero, the explanation for the paradox changes: time dilation here is due to twin B's acceleration, not his velocity.

"The mass causes a non-zero curvature of the spacetime, and curvature gives the spacetime a structure that defines the absolute standard of rest," the scientists explained. "In Minkowski spacetime there are no such structures, and there is no way to tell who of the twins in moving faster in an absolute way."

This version of the twin paradox is not the first to suggest that the paradox can be explained by a difference in velocity between the twins. As in the current version, previous versions also show that the twin who moves or orbits faster is younger. As the scientists emphasize, this explanation holds true for all situations in which the absolute motion of the twins can be defined in terms of some global properties of spacetime. Possibly, the scientists suggest, the explanation might even be extended to the traditional version of the twin paradox by referring to the sky, although this would require further investigation.

More information: Marek A. Abramowicz and Stanislaw Bajtlik. "Adding to the paradox: the accelerated twin is older." arXiv:0905.2428v1.