Twin Paradox

No consequence of Einstein's relativity has perhaps spilled more ink than the so-called "twin paradox," which Paul Langevin, in a slightly different form, proposed as early as 1912. Consider, in an indefinite future, two twins: Victor, an inveterate traveler, and Stéphane, an incorrigible homebody. The first interstellar mission being organized toward Alpha Centauri, 4 light-years away, Victor hastens to enlist. The rocket quickly reaches its cruising speed, say 80% of the speed of light, which allows the expedition to complete its round trip in 10 years (neglecting the time spent at the destination). According to the theory of relativity, when Victor returns to Earth after having lived a decade of travel, he finds a Stéphane who, for his part, has aged about 17 years. If our technical means hardly allow us yet to realize the above scenario, its unfolding is beyond doubt. Similar experiments are carried out daily on a microscopic scale in large accelerators, where unstable particles traveling at speeds close to the limit speed show average lifetimes far superior to those of their immobile twins. On a macroscopic scale, a delicate experiment was conducted several years ago by taking very precise atomic clocks on a world tour while twin instruments remained at home. The time difference, which was measured in microseconds for a journey of a few days, was quite measurable and in line with theoretical predictions. It is therefore useless to try to get rid of what is a paradox only in the etymological sense (contrary to common sense), without any logical contradiction. The argument usually used to reject the Langevin effect claims to invoke the very relativity from which it originates. From Victor's point of view, it is said, it is Stéphane who is traveling and who therefore should be younger when they reunite. But the viewpoints of Victor and Stéphane are not equivalent, because Victor does not have uniform motion (as required by the theory), due to the very fact that he turns back; he is necessarily subjected to detectable accelerations that are sufficient to break the symmetry. Above all, the Langevin effect should not be interpreted as a differential aging of the two twins due to motion. Victor's clocks, whether mechanical or biological, behave on board as normally as Stéphane's on Earth. Viewed within the framework of relativity's space-time, the Langevin effect is simply the analog of a banal property of ordinary space: the distance separating two points depends on the path followed to connect them—the shortest being that of the straight line; similarly, the duration separating two events depends on the space-time trajectory that connects them—the longest elapsing when the two events occur at the same place. One can indeed travel through time—but in only one direction, toward the future.

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