

EINSTEIN'S TWIN PARADOX REVISITED

by

ARDESHIR MEHTA

Joe and Moe, twins born within minutes of each other, take different paths in life. Joe becomes a lawyer, and spends pretty much all his time on earth. Moe joins NASA while still in high school, and signs up for NASA's first interstellar voyage, scheduled to take about 50 years of earth time. (Joe once took a two-week holiday at the *Orbit Hilton*, just to see what it's like, and decided that the pleasures of zero-g are not for him.)

While Joe is raking in huge lawyer's fees, Moe is inside NASA's latest space ship, the *Enterprise*, launched from the International Space Station. The *Enterprise* has a nuclear-powered drive, continuously ejecting tiny amounts of extraordinarily hot plasma at enormous speeds, thereby enabling the *Enterprise* to accelerate at exactly 1g for years on end. The ship is targeted towards a nearby star about 15 light years away, around which astronomers think there could well be earth-sized planets.

NASA wants to make the trip comfortable for the astronauts: they don't want the crew suffering from the pernicious effects of microgravity. So they hit upon a neat solution: when the *Enterprise* is halfway to the target star, its engines will be briefly stopped, the ship turned round facing the earth, and the engines then restarted, now causing the *Enterprise* to decelerate at 1g, and thus in the end coming to a reasonably manageable speed when the ship gets within observable range of the star. Once observations are done, which shouldn't take too long (say, a couple weeks at the most), the ship will head back to earth, repeating the same process.

Thus the crew (which includes Moe) will pretty much always be subject to only 1g, except for the two-week period when carrying out the observations, and the two brief times when the ship is turned round to face in the opposite direction. None of the crew will undergo accelerations too great to handle, nor will they suffer from bone loss or muscle weakness, as do astronauts in prolonged weightlessness. (A couple of weeks in microgravity are okay; years on end aren't.)

Now as mentioned earlier, the target star is about 15 light years away; and if the ship accelerates for about 12 years when going halfway there and decelerates for about 12 years after that, the speed reached during a significant part of the trip will be 99.999 per cent that of light. (Since final velocity attained is equal to acceleration multiplied by time, and since the acceleration of 1g is about 10 metres per second per second, in about 3,500 days—less than 10 years—the *Enterprise* will have already attained pretty much the maximum speed it ever will achieve, namely very close to light speed.) In other words, for about 5 of the 50 years of the trip, Moe will have travelled, in Joe's frame of reference, at almost light speed, causing his ageing process to almost stop during that time.

According to Joe, then, the equations of Relativity should indicate Moe having aged slower than Joe by about 5 years or so.

But in Moe's frame of reference, it is Joe (and the earth) which has been accelerating and decelerating at 1g-plus-1g (1g due to the earth's gravity and another 1g due to the acceleration of the earth relative to Moe), and in the interim it was Joe who, in Moe's reference frame, attained close to light speed. So according to Moe, it is Joe who should have aged slower than Moe, also by about 5 years.

Well then. When Moe returns, who will actually be the older twin: Joe or Moe? (Remember, both of them have experienced only 1g, except for the two-weeks when they each experienced 0g.)

The paradox gets even more paradoxical if one assumes that Joe, too, becomes an astronaut, and is sent by NASA on a trip equivalent to Joe's in every way, except that it is carried out in the opposite direction. In that case, *there is no difference between Joe and Moe except the directions in which they were sent off by NASA, and the first letters in their names!* Yet each, according to Einstein's Theory of Relativity, must observe the other as ageing slower.

How can this be? Any comments?