

Einstein's equivalence principle

According to Einstein's equivalence principle, the effects of acceleration are indistinguishable from those of a uniform gravitational field that causes the same acceleration. This is sometimes illustrated by considering two identically accelerating rockets, one in front of the other, that have synchronized clocks.

Signals are emitted from the leading rocket every second - as measured by the first rocket's clock - and the signals' times of arrival at the trailing rocket are measured using its own clock. As the trailing rocket travels at increasing speeds toward the signals they have progressively less distance to travel before they arrive. So they arrive more frequently than once a second. From this it is concluded that the trailing rocket has a slower time rate than the one in front. For a given rocket spacing the difference in time rates is the same as between two clocks at the same vertical spacing in a gravitational field producing the same acceleration. This is said to confirm the equivalence principle.

This though assumes the rockets' clocks have the same time rate. The signals arrive sooner simply because they arrive sooner not because of different time rates. The time rates must be the same if the rockets' thrusts and masses are the same. So the clocks would show equal elapsed times if the acceleration ended - the clocks then being in the same inertial frame again. Hence the different time rates are a temporary illusion. In contrast, after spending a while at different heights in a gravitational field two clocks would exhibit a permanent inequality in elapsed times.

Suppose many rockets are placed symmetrically in a large circle and they accelerate identically and tangentially. The time rate of each rocket cannot be slower than that of the rocket in front as their accelerations are the same. They would all have the same energy - unlike objects at different heights in a gravitational field. A rocket at rest near a massive body has lost energy compared with a stationary rocket that is far away from massive bodies.