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Noninertial Freely Falling Frames Affected by Gravitational Tidal Forces

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Abstract

It is a major misconception that freely falling reference frames are inertial in a gravitational field. This is one outcome when employing Einstein's principle of equivalence between a dynamical acceleration and a homogeneous gravity, which does not exist technically in nature, because gravity is radial from all mass centers, even at nearly infinite distances between masses. Even though floating objects within a space station orbiting Earth appear to move with constant inertial velocities, tidal forces exist to accelerate all such objects. The four oceanic tides of Earth prove that the Moon and Sun are the two external gravitational bodies pulling on Earth, even if an earthbound observer cannot physically feel the tidal forces. Theoretical experiments demonstrate how to observe tidal effects internally to determine the external gravitational forces. Tidal forces make dumbbell-shaped artificial satellites rotate around a heavenly body once per orbit. A liquid in free fall like mercury becomes prolate in shape and aligns with the external gravitational force if the liquid's surface tension can be minimized. Today's technology is very precise and can detect most subtle forces, so that local experiments can distinguish between a reference frame in free fall versus a truly inertial frame placed far away from gravitational bodies. Tidal forces always exist in any neighborhood of a test mass due to the radial gravitational force from any external mass, so the mathematical limit of a shrinking local reference frame always contains tidal forces within its domain. Thus, Einstein's equivalence principle is an approximation and is technically applicable for only point masses.