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The relativistic geoid: redshift and acceleration potential

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We construct a relativistic geoid based on a time-independent redshift potential, which foliates the spacetime into isochronometric surfaces. This relativistic potential coincides with the acceleration potential for isometric congruences. We show that the a- and u- geoid, defined in a post-Newtonian framework, coincide also in a more general setup. Known Newtonian and post-Newtonian results are recovered in the respective limits. Our approach offers a relativistic definition of the Earth's geoid as well as a description of the Earth itself (or observers on its surface) in terms of an isometric congruence. Being fully relativistic, this notion of a geoid can also be applied to other compact objects such as neutron stars.

By definition, this relativistic geoid can be determined by a congruence of Killing observers equipped with standard clocks by comparing their frequencies as well as by measuring accelerations of objects that follow the congruence. The redshift potential gives the correct result also for frequency comparison through optical fiber links as long as the fiber is at rest w.r.t. the congruence.

We give explicit expressions for the relativistic geoid in the Kerr spacetime and the Weyl class of spacetimes. To investigate the influence of higher order mass multipole moments we compare the results for the Schwarzschild case to those obtained for the Erez-Rosen and q-metric spacetimes.