The Experimental Verdict on Spacetime from Gravity Probe B

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The ancient Stoics are said to have held that space and time in themselves are unreal, since they can neither act upon nor be acted upon by matter. The Pythagoreans and Greek Atomists are credited with originating the opposite view, that empty space in itself is real. Philosophers and physicists have oscillated ever since between this absolutist view of space and time (as epitomized above all by Newton) and the relational one (as associated most famously with Mach). Einstein's special relativity made space and time observer-dependent (or relative, as distinct from relational). Minkowski fused Einstein's space and time into a single fabric, albeit one that still existed absolutely. With Einstein's general relativity the pendulum began to swing back toward the relational view. Curved spacetime still exists absolutely, but it behaves relationally; as seen most clearly in the geodetic (or de Sitter) effect and the frame-dragging (or Lense-Thirring) effect. If Einstein was right, then spacetime does act on matter in the form of a gyroscope (geodetic effect) and matter in the form of the spinning Earth acts back on spacetime (frame-dragging effect) -- thus answering the objection of the ancient Stoics. Both of these effects have now been directly measured for the first time by Gravity Probe B, which makes use of superconducting quantum interference devices (SQUIDs) to monitor the spin-axis directions of four ultra-precise orbiting gyroscopes as they follow the warping and twisting of spacetime around the earth relative to a distant guide star (whose position is in turn monitored with respect to even more distant quasars). Preliminary results from this experiment will be discussed along with some of their implications.