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Marr, James C (7030) <james.c.marr@jpl.nasa.gov> 22 de diciembre de 2009 18:43
Para: Juan Joaquín Schulz Poquet <jjschulzpoquet@gmail.com>
Cc: "Shao, Michael (3020)" <michael.shao@jpl.nasa.gov>, "Turyshev, Slava G (3267)" <slava.g.turyshev@jpl.nasa.gov>, "Unw in, Stephen C (312D)" <stephen.c.unw in@jpl.nasa.gov>

Dear Juan,

Thank you for you paper describing a possible experiment using SIM to test Einstein's second postulate.

As you may be aware, for a number of reasons SIM is unlikely to launch until 2015 at the earliest. Prior to launch, there will be opportunities to propose General Observer science experiments. You may want to watch for announcements of such opportunities.

I asked a local expert on relativity, Slava Turyshev, to review your paper. His response is enclosed below. As you can see from Slava's message, SIM will indeed test the foundations of both special and general relativity during its mission.

Again, thank you for your interest in SIM.

--Jim Marr, Project Manager, SIM Lite Astrometric Observatory
--Mike Shao, Project Scientist, SIM Lite Astrometric Observatory
SIM Lite web site: http://sim.jpl.nasa.gov

Dear Juan,

Thank you very much for your interest in the upcoming Space Interferometry Mission. As you know, the principle of local Lorentz invariance (LLI), stating the independence of physical laws from the state of motion of inertial laboratories, is one of the most fundamental facts about our physical world. An early precision measurement, demonstrating LLI for light propagation, was performed by Michelson and Morley in 1887 and its result was an essential experimental foundation for the advent of relativity. LLI is incorporated as a fundamental symmetry into the accepted theories of the fundamental forces, general relativity and the standard model. Numerous experiments have tested LLI with respect to matter and to the electromagnetic field, and have upheld its validity. For electromagnetic waves the isotropy of space has so far been verified at the level of a few parts in 10^15.

New generations of tests of LLI and of other fundamental symmetries [weak equivalence principle, local position invariance, charge-parity-time (CPT Symmetry)] are seen as important approaches in the quest for a deeper understanding of the forces of nature. They might provide useful input for the development of a theory able to describe gravity at the quantum level. In these theories, violations of fundamental symmetries are being considered. Thus, the theoretical models call for improved experiments to either validate LLI at much higher precision levels, or to uncover its limits of validity.

Violations of LLI can be interpreted using so-called test theories. A kinematic test theory commonly applied is that by Robertson, Mansouri, and Sexl (RMS). Here, light propagation is described relative to a preferred frame (“ether frame”) S_pr in which there is no preferred direction and thus the speed of light c0 is constant. Usually the frame in which the cosmic microwave background is isotropic is assumed to be this frame. Lorentz transformations between a laboratory frame S and S_pr are replaced by general linear transformations that depend on the velocity v of the lab frame with respect to S_pr and on three phenomenological parameters a, b, and d. These reduce to a=-1/2, b = 1/2 , d =0 if LLI is valid. In the moving frame S, the speed of light can be expressed to lowest order in |v| /c0 as c(f,v)/c0=1+(v/c0)^2 [b -a -1+(1/2 - b+d)(sin f)^2], where f is the angle of the direction of light propagation relative to the velocity v of the laboratory. Thus, violations of the constancy of the speed of light are described by two nonzero parameter combinations. Recently, a comprehensive test of Lorentz invariance for electromagnetic waves was performed by comparing the resonance frequencies of two optical resonators as a function of orientation in space (http://www.2physics.com/2009/11/testing-foundation-of-special.html). In terms of the Robertson-Mansouri-Sexl theory, the authors obtained (b -d -1/2)=(+1.6±1.6)x10^(-12), a significant improvement compared to the previous best results. This is currently the best test of the constancy of the speed of light. SIM will rely on this test in interpreting the astrometric data.

In addition, advances in the accuracy of astrometric observations have demonstrated importance of taking into account the relativistic effects introduced by the solar system’s gravitational environment. It is known that the reduction of the Hipparcos data has necessitated the inclusion of stellar aberration up to the terms of the second order in v/c, and the general relativistic treatment of light bending due to the gravitational field of the Sun and Earth. Even higher modeling accuracy is anticipated for SIM. The prospect of new high precision astrometric measurements from space with SIM requires inclusion of relativistic effects at the (v/c)^3 level. In fact, at the level of accuracy expected from SIM, even more subtle gravitational effects on astrometric observations from within the solar system will start to become apparent, such as the monopole and the quadrupole components of the gravitational fields of the planets and the gravito-magnetic effects caused by their motions and rotations. Thus, analysis of the SIM data will allow us to conduct extensive tests of the foundations of the spacial and general theories of relativity.

-- Slava Turyshev
turyshev@jpl.nasa.gov
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Juan Joaquín Schulz Poquet <jjschulzpoquet@gmail.com> 22 de diciembre de 2009 23:00
Para: "Marr, James C (7030)" <james.c.marr@jpl.nasa.gov>

Dear James,
Thankyou so much for your rapid and kind answ er. You'r really very polite.
I took due note of your comments and it w ill take me more time to
properly response to Prof. Turyshev, to w hich I thankful greet from
these lines.
To everybody involved in this mail my best w hishes in these fest times.
Whith my best respects
Yours sincerely

Juan J. Schulz Poquet

2009/12/22, Marr, James C (7030) <james.c.marr@jpl.nasa.gov>: