A Michelson-Morley Type Experiment Should be Performed in Low Earth Orbit and Interplanetary Space

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This paper supports those who have proposed that a Michelson-Morley type experiment (MMX) be performed in outer space. It predicts results that will falsify the foundational postulates of Einstein's relativity and it explains why these these unexpected results are predicted. The prediction is that a Michelson-Morley type experiment performed in low Earth orbit will show an unambiguous non-null result with a fringe or frequency variation proportional to the square of its orbital velocity ($7.6km/sec$ for a 500 km orbital altitude). If performed in interplanetary space, the result will be equivalent to the spacecraft's orbital velocity around the Sun ($\sim 30km/sec$). These predictions are based on an alternative ether concept proposed by the late Prof. Petr Beckmann in 1986 and independently developed by late Prof. Ching-Chuan Su in 2000. Prof. Su called it the local-ether model. It explains that the reason terrestrial MMX type experiments have reported null results is not because there is no "ether-wind" to detect; it is because the actual value of the "ether-wind" is due only to the velocity of Earth's rotation at the latitude of the laboratory ($464cos\theta$ meters/sec). This is too small for even the most sensitive recent versions of the MMX to unambiguously detect. Finally we will discuss accomplishing the experiment with private funding.

1 Introduction

This paper presents a case for conducting Michelson-Morley type experiments in low earth orbit and (better) in interplanetary space. We predict that for low Earth orbit there will be a phase/frequency shift proportional to v^2/c^2 where v is the spacecraft's velocity with respect to the Earth Centered Inertial reference frame (the ECI) (essentially its orbital velocity). For a 500 km altitude v = 7.6 km/sec. If performed in interplanetary space, the phase/frequency shift will be the spacecraft's velocity with respect to the Sun centered inertial reference frame ($\sim 30,000m/s$). This is the minimum velocity that all Michelson-Morley type experiments have expected to detect with terrestrial based interferometers.

This proposal is not new. Many have suggested it before. But the physics community is so certain of the validity of Einstein's Relativity that they believe it would produce the same null results that terrestrial implementations have reported. It would be a waste of time and money.

We will demonstrate that there are good reasons to expect a positive result:

1. Phenomena that involve the one-way point-to-point propagation of EM waves (including light) have shown that a terrestrial laboratory moves at the velocity of the Earth's rotation rate with respect to the ECI. This means that the actual velocity of the "ether wind" is less than 460 meters/second.

2. Only recently conducted MMX type experiments have been sensitive enough to detect this much lower velocity. They may well have detected it but it was barely above the noise threshold and since they weren't looking for it they identified as "spurious". If conducted in low Earth orbit the effective "ether-wind would be the velocity of the spacecraft with respect to the ECI and the signal would be 500 times stronger.

2 A crucial experiment to falsify Einstein's Relativity and a viable alternative to replace it

The two postulates of Special Relativity imply that the speed of electromagnetic waves (including light) are independent of the motion of the receiver with respect to any reference frame. These postulates depend on the null results of MMX type experiments. are accepted as true physical reality, Special Relativity follows as an internally self-consistent representation of true physical reality (that many think is irrefutable). Since General Relativity is founded on Special Relativity, it follows as well. Therefore the most effective (and probably only) way to refute Special Relativity is to decisively demonstrate that its postulates are contradicted by experimental facts. It is also very important to provide an alternative physical model that is consistent with the physical facts. Hopefully this alternative model is simple and restores the classical concepts of absolute time and three dimensional space. Such an alternative model exists. And it suggests an experimental test that would convincingly contradict the postulates of Special Relativity.

The test is simple in concept: perform a Michelson-

Morley type experiment with an interferometer on a spacecraft in low Earth orbit. Or better, launch the spacecraft into interplanetary space orbiting the Sun. It is predicted that there will be a positive result equivalent to the spacecraft's orbital velocity: $\sim 7.6 km/sec$ for a 500 km altitude Earth orbit and $\sim 30 km/sec$ for orbiting the Sun in interplanetary space. Special Relativity would (of course) predict null results for both. So positive results would directly contradict the reason Special Relativity was originally proposed. And since the null results of Michelson-Morley experiments done on Earth is so often cited as the fundamental proof of Special Relativity, a positive result should lead to a reevaluation of the concept of Special Relativity.

There are two arguments in favor of performing this experiment:

1. There is clear experimental evidence that the velocity rotation of the Earth is the actual velocity that terrestrial experiments should have been looking for.

2. This velocity indicates that the Earth's gravitational potential generated by the Earth's mass and is carried in it's orbit around the Sun is equivalent to a preferred reference frame. It has been detected by modern versions of the MMX but has been ignored by the experimenters as a systematic.

3 Why this experiment is worth performing

An alternative concept to Einstein's Relativity was proposed by the late Prof. Petr Beckmann in 1986 in his book, *Einstein Plus Two* [1] and independently by the late Prof. Ching-Chuan Su in 2000 [2]. They postulate that electromagnetic (EM) waves (including light) propagate classically via a material medium that is different than what is commonly imagined for the ether. It is not universally uniform and at rest with the Universe. They postulate that it has a variable density that is proportional to the gravitational potential/field generated by the mass of a celestial body. Like the gravitational potential, it is carried with the celestial body. It can be pictured as a "halo" surrounding the celestial body. A key difference with previous entrained ether concepts is that it doesn't rotate with the celestial body. Its direction is fixed with respect to the fixed stars and a celestial body rotates within its own halo. The halo extends out to where the gravitational field of another celestial body becomes dominant. For the Earth it is where the Sun's gravitational field becomes dominant ($\sim 10^6$ km). The outer boundary for the local-ether of the Sun and Solar System is ~ 2 light years from the Sun. An additional postulate is that the speed of light is a function of the magnitude of the local gravitational potential. Prof. Su calls this halo the local-ether.

A local-ether defines the unique preferred reference frame for the classical propagation of EM waves within its halo. "Classical" is meant in the Newtonian sense: Time is absolute (no time dilation) and space is Euclidean (no length contraction). For the Earth, this reference frame is called the Earth Centered Inertial frame (the ECI).

The Sun's local-ether is stationary with respect to the heliocentric inertial frame. There is a local-ether for the Milky Way Galaxy and one for the Local Group. A hierarchy of local-ethers of ever greater extent must exist. These local-ethers form preferred reference frames for the propagation of electromagnetic waves within their boundaries. Prof. Su further postulates that the speed of electromagnetic radiation is a function of the local gravitational potential. This is shown to account for the phenomena of General Relativity.

Based on the local-ether model, all experiments done on the Earth's surface are within the Earth's local-ether and are shielded from the Earth's orbital velocity around the Sun. The **only** motion of the laboratory with respect to the Earth's local-ether is due to the Earth's diurnal rotation within its local-ether halo ($464 cos\theta$ meters/sec) where θ is the latitude. Also note that the direction of this velocity is always due west. This is too small to be detected by Michelson-Morley experiments that have been done before 1979. In low Earth orbit, the interferometer would also be within the Earth's local-ether and therefore also shielded from the Earth's orbital velocity around the Sun. However, the experiment would be moving within the Earth's local-ether with respect to the ECI as it orbits the Earth at $7600 meters/sec$ for a 500 km altitude orbit and it should be able to unambiguously detect that motion. It is $7600/360 = 22$ times faster than the "ether-wind" for a terrestrial lab which would produce a $22^2 = 500$ times greater fringe shift/frequency variation.

Based on the local-ether model the "a function of the latitude of the laboratory (355 m/s) and that its direction is always due west. This velocity has been clearly detected by many experiments that involve the one-way propagation of EM waves. These phenomena include the pseudorange correction formula used to calculate the latitude and longitude of a GPS receiver [9] and the longer propagation times for intercontinental microwave signals sent transmitted east compared to when they transmitted west to east between the same locations [6] [8]. This velocity is easier to detect than for MMX type experiments because the effect is proportional to v/c (i.e. first order).

Note that none of these phenomena show any influence from the Earth's motion with respect to the Sun, the Milky Way Galaxy, or the CMBR Dipole. Also note, one should be highly skeptical of any terrestrial experiment that reports an "ether wind" that is not equivalent

to the Earth's rotation.

A Michelson-Morley type experiment involves the two-way propagation (reflection) of a light source. This cancels out any effect proportional to v/c (first order). However a signal proportional to v^2/c^2 (i.e. second order) remains.

This explains why MMX type experiments have come up empty - at least until the Brillet and Hall experiment in 1979 [4]: they were not sensitive enough to detect the velocity of the Earth's rotation. The signal for a second order experiment at 40° latitude is $(355/30000)^2 = .00014$ times smaller then a signal due to the Earth's orbital velocity would be.

When Michelson-Morley type experiments failed to detect a 30000 m/s "ether wind", 19th and early 20th century mainstream physics jumped to the conclusion that it meant there was no "ether wind" to be detected. This led inexorably to Einstein's Relativity.

But the physics of the propagation of electromagnetic waves and light **must** be the same whether the experiment is first order in v/c or second order in v^2/c^2.

The 1979 Brillet and Hall experiment detected a signal consistent with the Earth's rotation velocity that varied at twice the rotation rate of the base of the interferometer ($2\omega R$) but it was dismissed as "spurious" and was averaged out of the results. The goal of the experiment was to detect an anisotropy due to the Earth's motion relative to the CMBR dipole and this would only be detectable over a month or more.

More recent MMX type interferometers use cavity resonators for even greater sensitivity. Their goal has been to test for Lorentz invariance violations predicted by some recent theories. At least some of them also mention a $2\omega R$ signal (for ones that rotate the base of the device).

They also dismiss this signal as a systematic and average it out of their results. They are also expecting a signal that varies over the course of days or months. I assert that the $2\omega R$ signal is actually the long sought "ether wind". However the experimenters appear to be so certain of the correctness of Einstein's Relativity that they assume the $2\omega R$ signal must be spurious.

According to mainstream physics, all first order experiments involve rotation and are therefore examples of the Sagnac Effect. And since the mainstream claims that the Sagnac effect does not violate Einstein's Relativity they dismiss any first order experiment as not a disproof of Einstein's Relativity.

This is why an MMX type experiment in low earth orbit or interplanetary space experiment is necessary. It is necessary to show a positive result for the same experiment that led to Einstein's Relativity. If done in low earth orbit, the "ether wind" would be equal to the spacecraft's velocity with respect to the ECI: 7600 m/s. This would be much easier to unambiguously detect and therefore could not be dismissed. If done in interplanetary space, the spacecraft would be moving with respect to the Sun's local-ether so the full orbital velocity would be measured. According to Einstein's Relativity, the results would be null so this would be a falsification of the fundamental postulates of Special Relativity that could not be denied. If they expected non-null results, it would have been tried already. This makes it much more difficult to try to make an after-the-fact claim that positive results were consistent with Einstein's Relativity.

4 Analysis of Michelson-Morley type experiments based on the local-ether model

Prof. Su specifically discusses Michelson-Morley type experiments in §6.2 of "A local-ether model of propagation of EM wave" [2]:

> From physical reasoning, it is expected that the propagation mechanism in the Michēlson-Morley experiment in no way can be different from that in GPS and earthbound microwave link experiments, from the standpoint of any plausible propagation model. The null effect of earth's orbital motion in the Michelson-Morley experiment reflects no Sagnac correction due to this motion in the GPS pseudorange. On the other hand, the Sagnac effect due to earth's rotation in the high-precision GPS and intercontinental microwave link should reflect a non-null effect of earth's rotation in the Michelson-Morley experiment. The difficulty in the Michelson-Morley experiment is that this effect becomes a term of the second order of the normalized speed, owing to the round-trip path and the lack of relative motion between transceiver and target.

And:

> According to the classical propagation model, the resonance frequency of a cylindrical cavity resonator is inversely proportional to the round-trip propagation time over the propagation path along the cylinder axis. Thus the motion of the cavity with respect to the unique propagation frame tends to affect the round-trip propagation time and hence the resonance frequency. The shift in propagation time can manifest itself as a corresponding variation in beat frequency between two waves from two perpendicular cylindrical cavities [28] or between a wave from a single cavity and a reference wave from a stable source [29,30].

> Then, based on the local-ether model, the second-order round-trip Sagnac effect due to earth's rotation results in a quadrupole anisotropy in the resonance frequency of a cylindrical cavity, as the direction of cavity is changing.
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> That is, the resonance frequency is the lowest when the axis of the cavity points in the east-west direction; it is the highest when it is in the north-south direction. As the cavity is rotating slowly with respect to the ground in a horizontal plane, the beat frequency is expected to vary sinusoidally at twice the turntable rotation rate.
>
> Moreover, the peak-to-peak amplitude Δf_{max} for the case of a single cavity can be found from the round-trip propagation time given in (13) as
>
> $$\Delta f_{max}/f = v_E^2/2c^2 \simeq 1.2cos^2\theta_l \times 10^{-12}, \quad (14)$$
>
> where $v_E = \omega_E R_E cos(\theta_l)$ is the linear speed due to earth's rotation with respect to an ECI frame, R_E is earth's radius, and θ_l is the latitude.
>
> Such a heterodyne system using a stable He-Ne laser at 3.39 μm (f = 0.88 $\times 10^{14}$ Hz) and a stable Fabry-Perot resonator has been developed [29]. According to the local-ether model, the amplitude Δf_{max} is expected to be 62 Hz, as the cavity heterodyne experiment is supposed to be conducted at a latitude of 40°. In the measured data, a term varying at the expected rate has been reported. However, the peak-to-peak amplitude of this term is merely about 17 × Hz and was attributed to a persistent spurious signal among other larger noises. It seems too early to make a decisive conclusion from this experiment. A more careful experiment is anticipated to test the second-order round-trip Sagnac effect supposed due to earth's rotation.

Reference [29] refers to the 1979 Brillet and Hall experiment [4]. This experiment was also analyzed by Prof. Howard Hayden [7] [9]. He came to the same conclusion that the experiment most likely detected an "ether-wind" equal to the Earth's rotation rate but the signal to noise ration was low enough that it could be ignored as "spurious".

I again stress that a Michelson-Morley type experiment needs to be performed in low Earth orbit or (better) in interplanetary space to unambiguously resolve the discrepancy between first order and second order EM wave propagation experiments. The physics of EM wave propagation **must** be the same whether the propagation path is one-way point-to-point (first order in v/c) (e.g. GPS pseudo-range correction) or two-way round-trip second order in v^2/c^2 (e.g. MMX type interferometers).

5 The MMX "ether-drift" has been detected but dismissed

There have been several MMX type experiments done in the past 20 years with increasing sensitivity. They were looking for violations of Lorentz Invariance assuming the CMBR forms a universal inertial reference frame. They report null results with ever higher precision. However, they appear to detect (but dismiss) a signal consistent with the Earth's rotation with respect to the Earth Centered Inertial reference frame (the ECI). This is consistent with experiments that are sensitive to the first order of v/c that clearly detect this velocity. From one of the most recent experiments by Nagel et al. in 2015 using cavity resonators on a rotating platform [5]:

> Taking error-weighted averages of relevant amplitudes from equation (1) we found a $2\omega R$ amplitude of 98±6 nHz. This value of interest, $2\omega R$, is only statistically significant, owing to the influence of systematic noise sources (see Fig. 3), the most dominant of which is the dependency of oscillator resonance frequency on external magnetic fields, arising from the presence of impurities in the sapphire crystal25 and ferrite-based microwave components. The frequency variations induced by moving the oscillators through the quasi-static magnetic field of the Earth in the laboratory **are indistinguishable from a Lorentz violating signal**.

(my emphasis).

I suggest that it could have been possible to shield the experiment from the Earth's magnetic field if they were not so confident that it must be only a systematic effect.

6 How to accomplish Low Earth Orbit MMX with private funding

So why haven't these experiments been done years ago? The probable answer is that the mainstream physics is so certain the Einstein's Relativity is correct that they believe the results would be the same null results as terrestrial based Michelson-Morley type experiments. It would be a waste of time and money. No committee would dare approve such a proposal.

Perhaps the best option would be to privately fund the experiment. The good news is that the cost of getting it done is much lower than in the past. There is now a commercial company that will launch a small satellite into a 500 km orbit for a relatively modest fee. The company is called Rocket Lab [12]. It has already had three successful launches. It supports the launch of small satellites called CubeSats [11] that use standardized off-the-shelf components that can share the ride with several other projects so the cost of the launch is only a fraction of what a dedicated launch would cost. It's also developing a capability to design and implement small satellites using a standard base called "Photon" that provides common components for control and communications. I would think they would accept the project as long as it is paid for. At one point they were quoting $100K$ dollars for a single unit CubeSat.

It might be able to accomplish the project for around 500,000 dollars. It might be feasible to raise this amount by crowd sourcing.

Interplanetary MMX would be more expensive and there aren't any commercial launch services that support it yet. But if low Earth orbit MMX is successful, it would be a powerful argument for a NASA or other government space agency to sponsor the project.

7 Conclusion

We predict that a Michelson-Morley experiment conducted in low earth orbit will produce an unambiguous positive result proportional to the square of the orbital velocity. If successful, Einstein's Relativity will be proven to be fatally flawed.

The first step is to perform the experiment in low earth orbit using private funds to be launched by a commercial company like Rocket Lab so approval by a mainstream committee would not be required.

After a successful result is achieved, NASA or another country's space agency would probably be willing to sponsor the more expensive version in interplanetary space.

Please also see Prof. Su's full thesis from 2007 *Quantum Electromagnetics* [3] for further details on how he provides alternative qualitative and quantitative explanations for a wide array of physical phenomena based on his local-ether model. And he extends his model to unify electromagnetic, quantum, and gravitational phenomena.

I also recommend *Questioning Einstein: Is Relativity Necessary?* by Thomas Bethell. He describes Beckmann's theory for non-physicists and presents the case for MMX in outer space more clearly than I can.

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