

### Abstract

I would like to propose a new explanation for the Michelson-Morley experiment that allows relativistic physics to be embedded in absolute 3-dimensional Euclidean space with absolute time. The explanation consists of augmenting the gravitational potential  $V_G$  with two others: a momentum potential  $\mathbf{V}_P$  and a force potential  $\mathbf{V}_F$ . The  $V_G$ ,  $\mathbf{V}_P$ , and  $\mathbf{V}_F$  potentials create a 3-dimensional planetary coordinate system around a massive rotating sphere. The potentials provide sufficient information for a photon to be able to determine the rotational and gravitational properties of the sphere, and also to determine its position relative to the sphere. Thus, a photon can use  $V_G$ ,  $\mathbf{V}_P$ , and  $\mathbf{V}_F$  to define a local inertial reference frame. I think that this result may be important both practically and theoretically.

# A New Explanation for the Michelson-Morley Experiment

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## 1 Introduction

I would like to propose a new explanation for the Michelson-Morley experiment that allows relativistic physics to be embedded in absolute 3-dimensional Euclidean space with absolute time. The explanation consists of augmenting the gravitational potential  $V_G$  with two others: a momentum potential  $\mathbf{V}_P$  and a force potential  $\mathbf{V}_F$ .

Imagine that the universe has an absolute 3-dimensional Euclidean coordinate system and an absolute time that proceeds at the same rate everywhere. Imagine a physicist on the surface of the Earth. Imagine a photon near the physicist, and imagine that the photon wants to modify its speed in absolute space so that its speed relative to the physicist is  $c$  in all directions (which will also have the effect of modifying the physicist's clocks to measure local time instead of absolute time).

The gravitational potential  $V_G$  does not provide enough information for the photon to adjust its speed relative to the rotating Earth. For example, the photon cannot determine how fast the Earth is rotating. Adding the momentum and force potentials  $\mathbf{V}_P$  and  $\mathbf{V}_F$  provides the missing information that the photon needs so that the photon can calculate a local inertial reference frame for itself in terms of  $V_G$ ,  $\mathbf{V}_P$ , and  $\mathbf{V}_F$ .

## 2 The Momentum and Force Potentials Around a Massive Rotating Sphere

The gravitational potential  $V_G$  is a scalar potential, and the momentum potential  $\mathbf{V}_P$  and force potential  $\mathbf{V}_F$  are vector potentials.  $\mathbf{V}_P$  and  $\mathbf{V}_F$  are calculated in the same way as  $V_G$ :

$$\begin{aligned} V_G(\mathbf{s}) &= \int_V \frac{\sigma_G(\mathbf{s}')}{|\mathbf{s} - \mathbf{s}'|} dV \\ \mathbf{V}_P(\mathbf{s}) &= \int_V \frac{\boldsymbol{\sigma}_P(\mathbf{s}')}{|\mathbf{s} - \mathbf{s}'|} dV \\ \mathbf{V}_F(\mathbf{s}) &= \int_V \frac{\boldsymbol{\sigma}_F(\mathbf{s}')}{|\mathbf{s} - \mathbf{s}'|} dV \end{aligned}$$

where  $\sigma_G$  is the scalar mass density,  $\boldsymbol{\sigma}_P$  is the vector momentum density (e.g. mass density times velocity),  $\boldsymbol{\sigma}_F$  is the vector force density (e.g. mass density times acceleration),  $\mathbf{s}$  is the point where we are calculating the potential,  $\mathbf{s}'$  is a point in the volume of integration, and  $V$  is the volume of integration.

In this paper we will use  $(\rho, \theta, \phi)$  as spherical coordinates and  $(r, \theta, z)$  as cylindrical coordinates. The  $\theta$  coordinate is the same in both cases.

The potentials  $V_G$ ,  $\mathbf{V}_P$ , and  $\mathbf{V}_F$  at a point  $(\rho, \theta, \phi)$  outside of a uniformly-dense massive rotating sphere are:

$$\begin{aligned} V_G(\rho, \theta, \phi) &= \frac{M}{\rho} \\ \mathbf{V}_P(\rho, \theta, \phi) &= \frac{\omega \sin \phi MR^2}{5\rho^2} \hat{\boldsymbol{\theta}} \\ \mathbf{V}_F(\rho, \theta, \phi) &= \frac{-\omega^2 \sin \phi MR^2}{5\rho^2} \hat{\mathbf{r}} \end{aligned}$$

where  $M$  is the mass of the sphere,  $R$  is the radius of the sphere, and  $\omega = d\theta/dt$  is the angular rotation speed of the sphere around the  $z$  axis

The potentials  $V_G$ ,  $\mathbf{V}_P$ , and  $\mathbf{V}_F$  form a nonorthogonal 3-dimensional planetary coordinate system around a massive rotating sphere. The gradient of  $V_G$  points toward the center of the sphere,  $\mathbf{V}_P$  circulates around the sphere, and  $\mathbf{V}_F$  points toward the axis of rotation. The planetary coordinate system is a hybrid of spherical and cylindrical coordinates. For example, the magnitude of  $\mathbf{V}_F$  is easiest to express in spherical coordinates, while its direction is easiest to express in terms of the cylindrical unit vector  $\hat{\mathbf{r}} = \sin \phi \hat{\boldsymbol{\rho}} + \cos \phi \hat{\boldsymbol{\phi}}$ .

The photon near the physicist can now use  $V_G$ ,  $\mathbf{V}_P$ , and  $\mathbf{V}_F$  to calculate an explicit inertial reference frame for itself in absolute space. The information needed for the inertial reference frame is a set of unit vectors (which for convenience we will pick to be the spherical unit vectors  $\hat{\boldsymbol{\rho}}$ ,  $\hat{\boldsymbol{\theta}}$ , and  $\hat{\boldsymbol{\phi}}$ ), the photon's distance  $\rho$  from the center of the Earth, the photon's angle  $\phi$  from the  $z$  axis (i.e. its latitude), and the inertial reference frame's angular speed  $d\theta/dt$  around the  $z$  axis:

$$\begin{aligned} \hat{\boldsymbol{\rho}} &= \frac{-\nabla V_G}{|\nabla V_G|}, \quad \hat{\boldsymbol{\theta}} = \frac{\mathbf{V}_P}{|\mathbf{V}_P|}, \quad \hat{\boldsymbol{\phi}} = \hat{\boldsymbol{\theta}} \times \hat{\boldsymbol{\rho}} \\ \rho &= \frac{V_G}{|\nabla V_G|}, \quad \frac{d\theta}{dt} = \frac{|\mathbf{V}_F|}{|\mathbf{V}_P|}, \quad \phi = \tan^{-1} \left( \frac{\mathbf{V}_F \cdot \hat{\boldsymbol{\rho}}}{\mathbf{V}_F \cdot \hat{\boldsymbol{\phi}}} \right) \end{aligned}$$

where the gradient of  $V_G$ ,  $\nabla V_G$ , is:

$$\nabla V_G(\rho, \theta, \phi) = \frac{-M}{\rho^2} \hat{\boldsymbol{\rho}}$$

### 3 Technical Details

A technical difficulty with calculating  $\mathbf{V}_{\mathbf{P}}$  and  $\mathbf{V}_{\mathbf{F}}$  around a massive rotating sphere is that the definite integrals are elliptical. None of the symbolic math packages I tried could do them. This section shows a way to do them by hand, by rotating the problem to remove the elliptical integrals.

We will demonstrate the technique using  $\mathbf{V}_{\mathbf{P}}$ . The same method works for  $\mathbf{V}_{\mathbf{F}}$ . We will start with the formula for  $\mathbf{V}_{\mathbf{P}}$ :

$$\mathbf{V}_{\mathbf{P}}(\mathbf{s}) = \int_V \frac{\boldsymbol{\sigma}_{\mathbf{P}}(\mathbf{s}')}{|\mathbf{s} - \mathbf{s}'|} dV$$

A natural way to set up the calculation of  $\mathbf{V}_{\mathbf{P}}$  around a massive rotating sphere is in cylindrical coordinates. To keep the calculations as simple as possible we will assume that the sphere has a uniform mass density  $\sigma_{\mathbf{G}} = 3M/(4\pi R^3)$ . The velocity at a point  $(r, \theta, z)$  inside a sphere rotating with an angular speed  $\omega$  around the  $z$  axis is  $\omega r \hat{\boldsymbol{\theta}}$ . Letting the momentum density  $\boldsymbol{\sigma}_{\mathbf{P}}$  be the mass density times the velocity gives:

$$\boldsymbol{\sigma}_{\mathbf{P}}(r, \theta, z) = \sigma_{\mathbf{G}} \omega r \hat{\boldsymbol{\theta}}$$

The unit vector  $\hat{\boldsymbol{\theta}}$  is the same in spherical coordinates as in cylindrical, so we can convert the momentum density to spherical coordinates by making the substitution  $r = \rho \sin \phi$ :

$$\boldsymbol{\sigma}_{\mathbf{P}}(\rho, \theta, \phi) = \sigma_{\mathbf{G}} \omega \rho \sin \phi \hat{\boldsymbol{\theta}}$$

We will let the initial point of integration  $\mathbf{s}$  be  $(\rho_0, \theta_0, \phi_0)$ :

$$\mathbf{V}_{\mathbf{P}}(\mathbf{s}) = \mathbf{V}_{\mathbf{P}}(\rho_0, \theta_0, \phi_0)$$

To eliminate the elliptical integrals we are now going to rotate the problem by  $-\theta_0$  around the  $z$  axis and then by  $-\phi_0$  around the  $y$  axis. That will tilt the sphere's axis of rotation off of the  $z$  axis and put the point of integration on the  $z$  axis. The rotated point of integration is:

$$\mathbf{V}_{\mathbf{P}}(\mathbf{s}) = \mathbf{V}_{\mathbf{P}}(\rho_0, 0, 0)$$

To rotate  $\boldsymbol{\sigma}_{\mathbf{P}}$  we will first convert it from spherical to cartesian coordinates using the substitutions:

$$\begin{aligned} \rho &= \sqrt{x^2 + y^2 + z^2}, & \theta &= \tan^{-1}(y, x), & \phi &= \cos^{-1}(z/\rho) \\ \hat{\boldsymbol{\rho}} &= \cos \theta \sin \phi \hat{\mathbf{x}} + \sin \theta \sin \phi \hat{\mathbf{y}} + \cos \phi \hat{\mathbf{z}} \\ \hat{\boldsymbol{\theta}} &= -\sin \theta \hat{\mathbf{x}} + \cos \theta \hat{\mathbf{y}} \\ \hat{\boldsymbol{\phi}} &= \cos \theta \cos \phi \hat{\mathbf{x}} + \sin \theta \cos \phi \hat{\mathbf{y}} - \sin \phi \hat{\mathbf{z}} \end{aligned}$$

where  $\theta$  goes from 0 to  $2\pi$ ,  $\phi$  goes from 0 to  $\pi$ ,  $\sin \phi = \sqrt{x^2 + y^2}/\rho$ , and where the two-argument form of  $\tan^{-1}$  indicates that the quadrant of  $x$  and  $y$  determines the value of  $\theta$  so that  $\sin \theta = y/\sqrt{x^2 + y^2}$  and  $\cos \theta = x/\sqrt{x^2 + y^2}$ .

After substituting,  $\sigma_{\mathbf{P}}$  in cartesian coordinates simplifies to:

$$\sigma_{\mathbf{P}}(x, y, z) = \sigma_{\mathbf{G}} \omega(-y \hat{\mathbf{x}} + x \hat{\mathbf{y}})$$

The matrix  $\mathbf{R}$  that rotates points by  $-\theta_0$  around the  $z$  axis and then by  $-\phi_0$  around the  $y$  axis is the product of the two rotation matrices  $\mathbf{R} = \mathbf{R}(-\phi_0)\mathbf{R}(-\theta_0)$ . We need the inverse of that matrix,  $\mathbf{R}^{-1} = \mathbf{R}(\theta_0)\mathbf{R}(\phi_0)$ , in order to find substitutions for the unrotated coordinates in terms of the rotated coordinates:

$$\begin{aligned} \mathbf{R}^{-1} &= \begin{bmatrix} \cos \theta_0 & -\sin \theta_0 & 0 \\ \sin \theta_0 & \cos \theta_0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos \phi_0 & 0 & \sin \phi_0 \\ 0 & 1 & 0 \\ -\sin \phi_0 & 0 & \cos \phi_0 \end{bmatrix} \\ &= \begin{bmatrix} \cos \theta_0 \cos \phi_0 & -\sin \theta_0 & \cos \theta_0 \sin \phi_0 \\ \sin \theta_0 \cos \phi_0 & \cos \theta_0 & \sin \theta_0 \sin \phi_0 \\ -\sin \phi_0 & 0 & \cos \phi_0 \end{bmatrix} \end{aligned}$$

The values to substitute for  $x, y, z, \hat{\mathbf{x}}, \hat{\mathbf{y}}$ , and  $\hat{\mathbf{z}}$  are then:

$$\begin{aligned} \begin{bmatrix} x \\ y \\ z \end{bmatrix} &= \mathbf{R}^{-1} \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} \cos \theta_0 \cos \phi_0 x' - \sin \theta_0 y' + \cos \theta_0 \sin \phi_0 z' \\ \sin \theta_0 \cos \phi_0 x' + \cos \theta_0 y' + \sin \theta_0 \sin \phi_0 z' \\ -\sin \phi_0 x' + \cos \phi_0 z' \end{bmatrix} \\ \begin{bmatrix} \hat{\mathbf{x}} \\ \hat{\mathbf{y}} \\ \hat{\mathbf{z}} \end{bmatrix} &= \mathbf{R}^{-1} \begin{bmatrix} \hat{\mathbf{x}}' \\ \hat{\mathbf{y}}' \\ \hat{\mathbf{z}}' \end{bmatrix} = \begin{bmatrix} \cos \theta_0 \cos \phi_0 \hat{\mathbf{x}}' - \sin \theta_0 \hat{\mathbf{y}}' + \cos \theta_0 \sin \phi_0 \hat{\mathbf{z}}' \\ \sin \theta_0 \cos \phi_0 \hat{\mathbf{x}}' + \cos \theta_0 \hat{\mathbf{y}}' + \sin \theta_0 \sin \phi_0 \hat{\mathbf{z}}' \\ -\sin \phi_0 \hat{\mathbf{x}}' + \cos \phi_0 \hat{\mathbf{z}}' \end{bmatrix} \end{aligned}$$

Substituting and simplifying, the rotated  $\sigma_{\mathbf{P}}$  in cartesian coordinates is:

$$\sigma_{\mathbf{P}}(x', y', z') = \sigma_{\mathbf{G}} \omega(-\cos \phi_0 y' \hat{\mathbf{x}}' + (\cos \phi_0 x' + \sin \phi_0 z') \hat{\mathbf{y}}' - \sin \phi_0 y' \hat{\mathbf{z}}')$$

Notice that there are no terms in  $\theta_0$ . We could have invoked rotational symmetry earlier in order to ignore the rotation by  $-\theta_0$ , but including the rotation by  $-\theta_0$  did not add greatly to the calculations.

The integrals will be easier to evaluate if we now convert the problem back to spherical coordinates using the substitutions:

$$\begin{aligned} x' &= \rho' \cos \theta' \sin \phi', & y' &= \rho' \sin \theta' \sin \phi', & z' &= \rho' \cos \phi' \\ \hat{\mathbf{x}}' &= \cos \theta' \sin \phi' \hat{\boldsymbol{\rho}}' - \sin \theta' \hat{\boldsymbol{\theta}}' + \cos \theta' \cos \phi' \hat{\boldsymbol{\phi}}' \\ \hat{\mathbf{y}}' &= \sin \theta' \sin \phi' \hat{\boldsymbol{\rho}}' + \cos \theta' \hat{\boldsymbol{\theta}}' + \sin \theta' \cos \phi' \hat{\boldsymbol{\phi}}' \\ \hat{\mathbf{z}}' &= \cos \phi' \hat{\boldsymbol{\rho}}' - \sin \phi' \hat{\boldsymbol{\phi}}' \end{aligned}$$

Substituting and simplifying, the rotated  $\sigma_{\mathbf{P}}$  in spherical coordinates is:

$$\sigma_{\mathbf{P}}(\rho', \theta', \phi') = \sigma_{\mathbf{G}} \omega \rho' ( (\cos \phi_0 \sin \phi' + \sin \phi_0 \cos \theta' \cos \phi') \hat{\boldsymbol{\theta}}' + \sin \phi_0 \sin \theta' \hat{\boldsymbol{\phi}}' )$$

We will also need the distance  $|\mathbf{s} - \mathbf{s}'|$  from the point  $\mathbf{s}$  at  $(\rho_0, 0, 0)$  to the point  $\mathbf{s}'$  at  $(\rho', \theta', \phi')$ :

$$|\mathbf{s} - \mathbf{s}'| = \sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}$$

The problem is now non-elliptical. Substituting for  $\sigma_{\mathbf{P}}$  and  $|\mathbf{s} - \mathbf{s}'|$  in the equation for  $\mathbf{V}_{\mathbf{P}}$ , then separating the integrals involving  $\hat{\boldsymbol{\theta}}'$  and  $\hat{\boldsymbol{\phi}}'$  gives:

$$\begin{aligned} \mathbf{V}_{\mathbf{P}}(\rho_0, 0, 0) &= \sigma_{\mathbf{G}} \omega \int_V \frac{\rho' (\cos \phi_0 \sin \phi' + \sin \phi_0 \cos \theta' \cos \phi')}{\sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}} \hat{\boldsymbol{\theta}}' dV \\ &+ \sigma_{\mathbf{G}} \omega \int_V \frac{\rho' \sin \theta' \sin \phi_0}{\sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}} \hat{\boldsymbol{\phi}}' dV \end{aligned}$$

The unit vectors  $\hat{\boldsymbol{\rho}}'$ ,  $\hat{\boldsymbol{\theta}}'$ , and  $\hat{\boldsymbol{\phi}}'$  at  $(\rho', \theta', \phi')$  in terms of the unit vectors  $\hat{\boldsymbol{\rho}}$ ,  $\hat{\boldsymbol{\theta}}$ , and  $\hat{\boldsymbol{\phi}}$  at  $(\rho_0, 0, 0)$  are:

$$\begin{aligned} \hat{\boldsymbol{\rho}}' &= \cos \phi' \hat{\boldsymbol{\rho}} + \sin \theta' \sin \phi' \hat{\boldsymbol{\theta}} + \cos \theta' \sin \phi' \hat{\boldsymbol{\phi}} \\ \hat{\boldsymbol{\theta}}' &= \cos \theta' \hat{\boldsymbol{\theta}} - \sin \theta' \hat{\boldsymbol{\phi}} \\ \hat{\boldsymbol{\phi}}' &= -\sin \phi' \hat{\boldsymbol{\rho}} + \sin \theta' \cos \phi' \hat{\boldsymbol{\theta}} + \cos \theta' \cos \phi' \hat{\boldsymbol{\phi}} \end{aligned}$$

Substituting for  $\hat{\boldsymbol{\theta}}'$  and  $\hat{\boldsymbol{\phi}}'$ , and then removing  $\hat{\boldsymbol{\rho}}$ ,  $\hat{\boldsymbol{\theta}}$ , and  $\hat{\boldsymbol{\phi}}$  from inside the integrals gives:

$$\begin{aligned} \mathbf{V}_{\mathbf{P}}(\rho_0, 0, 0) &= -\sigma_{\mathbf{G}} \omega \sin \theta_0 \hat{\boldsymbol{\rho}} \int_V \frac{\rho' \sin \theta' \sin \phi'}{\sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}} dV \\ &+ \sigma_{\mathbf{G}} \omega \cos \phi_0 \hat{\boldsymbol{\theta}} \int_V \frac{\rho' \cos \theta' \sin \phi'}{\sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}} dV \\ &+ \sigma_{\mathbf{G}} \omega \sin \phi_0 \hat{\boldsymbol{\theta}} \int_V \frac{\rho' \cos \phi'}{\sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}} dV \\ &- \sigma_{\mathbf{G}} \omega \cos \theta_0 \hat{\boldsymbol{\phi}} \int_V \frac{\rho' \sin \theta' \sin \phi'}{\sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}} dV \end{aligned}$$

When we substitute  $dV = \rho'^2 \sin \phi' d\theta' d\phi' d\rho'$  and integrate over the sphere, the integrals involving  $\sin \theta'$  or  $\cos \theta'$  go to 0 when  $\theta'$  goes from 0 to  $2\pi$ , leaving only the integral:

$$\mathbf{V}_{\mathbf{P}}(\rho_0, 0, 0) = \sigma_{\mathbf{G}} \omega \sin \phi_0 \hat{\boldsymbol{\theta}} \int_{\rho'=0}^R \int_{\phi'=0}^{\pi} \int_{\theta'=0}^{2\pi} \frac{\rho'^3 \cos \phi' \sin \phi' d\theta' d\phi' d\rho'}{\sqrt{\rho_0^2 + \rho'^2 - 2\rho_0\rho' \cos \phi'}}$$

Performing the integration gives:

$$\mathbf{V}_{\mathbf{P}}(\rho_0, 0, 0) = \sigma_{\mathbf{G}} \omega \sin \phi_0 \hat{\boldsymbol{\theta}} \frac{4\pi R^5}{15\rho_0^2}$$

Finally, substituting  $\sigma_{\mathbf{G}} = 3M/(4\pi R^3)$  gives:

$$\mathbf{V}_{\mathbf{P}}(\rho_0, 0, 0) = \frac{\omega \sin \phi_0 MR^2}{5\rho_0^2} \hat{\boldsymbol{\theta}}$$

Rotating the problem back to its original orientation changes only the position and orientation of  $\hat{\boldsymbol{\theta}}$ , leaving the equation for the result unchanged.

To calculate the force potential  $\mathbf{V}_{\mathbf{F}}$ , it is natural to begin as for the momentum potential  $\mathbf{V}_{\mathbf{P}}$  and set up the problem in cylindrical coordinates. The acceleration at a point  $(r, \theta, z)$  inside a sphere rotating with an angular speed  $\omega$  around the  $z$  axis is  $-\omega^2 r \hat{\mathbf{r}}$ . Letting the force density  $\boldsymbol{\sigma}_{\mathbf{F}}$  be the uniform mass density  $\sigma_{\mathbf{G}}$  times the acceleration gives:

$$\boldsymbol{\sigma}_{\mathbf{F}}(r, \theta, z) = -\sigma_{\mathbf{G}} \omega^2 r \hat{\mathbf{r}}$$

Converting  $\boldsymbol{\sigma}_{\mathbf{F}}$  to spherical coordinates using the substitutions  $r = \rho \sin \phi$  and  $\hat{\mathbf{r}} = \sin \phi \hat{\boldsymbol{\rho}} + \cos \phi \hat{\boldsymbol{\phi}}$  gives:

$$\boldsymbol{\sigma}_{\mathbf{F}}(\rho, \theta, \phi) = -\sigma_{\mathbf{G}} \omega^2 \rho \sin \phi (\sin \phi \hat{\boldsymbol{\rho}} + \cos \phi \hat{\boldsymbol{\phi}})$$

The calculation of  $\mathbf{V}_{\mathbf{F}}$  then proceeds along the same lines as the calculation for  $\mathbf{V}_{\mathbf{P}}$ .

## 4 Historical Notes

The idea that there might exist a momentum potential based on mass times velocity, analogous to the magnetic potential based on charge times velocity, seems to be an old one that has occurred to many people. I think that Stokes and Lorentz[2] may have investigated something similar to a momentum potential in an attempt to resolve surface velocity problems in the aether theories. However, any such attempt would have failed because the momentum potential is insufficient without the force potential.

I cannot find any prior reference to the force potential, much less any reference to the idea of using the trio of potentials  $V_G$ ,  $\mathbf{V}_{\mathbf{P}}$ , and  $\mathbf{V}_{\mathbf{F}}$  to define inertial reference frames.

I first calculated that  $V_G$ ,  $\mathbf{V}_{\mathbf{P}}$ , and  $\mathbf{V}_{\mathbf{F}}$  could define inertial reference frames after reading Feynman[1] in about 1980 when I worked at the Stanford Linear Accelerator Center. I set the idea aside, until just recently, in



order to work on artificial neural networks, computer languages, and 3D graphics.

## 5 Discussion

The momentum and force potentials may be important both practically and theoretically.

In practical terms, decoupling space and time may lead to simulations that are easier to create, faster to execute, and more accurate.

Theoretically, the decoupling of space and time may make it easier to quantize gravitation. Other theoretical work that remains to be done is to see if the theory conforms to existing experiments, and if not, if it can be modified to make it conform. Some possibilities for further research include whether the momentum and force potentials have any bearing on inertia, or on the strong and weak forces.

In the past, the discovery of a new potential (or of a new force associated with it) has explained a previous parity violation. For example, Newton's discovery of the laws of gravitation explained an up-down parity violation: objects prefer to fall down. The discovery of the laws of magnetism explained a directional parity violation: lodestones floating on corks align themselves north-south.

The fact that we currently observe a left-right parity violation makes me immediately think of the cross product of two vectors, and the momentum and force potentials provide two new vectors to cross. So perhaps the magnitude of left-right parity violation that we measure on Earth is an astronomical or cosmological phenomenon due to the momentum and force potentials generated by the motions of the Earth, Moon, Sun, or galaxies.

## References

- [1] R. P. Feynman, R. B. Leighton, and M. Sands. *The Feynman Lectures on Physics*. Addison-Wesley, Reading, Massachusetts, 1963.
- [2] E. T. Whittaker. *A History of the Theories of Aether and Electricity*. Longmans, Green, and Co., Dublin, 1910.