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Truth and Reality in Science: Defining What Is and Is Not Science

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Abstract

This paper defines what is and what is not science. These novel science definitions demonstrate that illustrations, like mathematics, can be scaler, real, not real, valid, and invalid. These definitions identify non-inertial reference frame logic inconsistencies, emphasizing the continued search for relative movement definitions. This search leads to Aristotle's primary circular and secondary rectilinear movement concepts defining the at-rest reference frame, motion, and relative movement. These three novel movement definitions are confirmed using Ptolemy's dropped ball observation, Michelson-Morley's null result, a dropped ball on a rotating platform Coriolis effect, and light's Doppler shift. The novel relative movement definitions demonstrate Ptolemy's dropped ball and Michel-son-Morley's reflected light represent motion in an at-rest reference frame. The novel relative movement definition reveals the Coriolis effect and light's Doppler shift describe the same physical process. Two future experiments are suggested to confirm the novel movement definitions. Developing the novel relative movement concepts will require applying mathematics to circular movement velocity concepts, such as rotational inertia and angular velocity.

Keywords

Definition of Science, Circular Movement, Rectilinear Movement, At-Rest Reference Frame, Motion, Relative Movement

1. Introduction

Many scientists share a recurrent question, "What is science?" A standard definition found in the Merriam-Webster Dictionary (2023) states science is "knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method." This

works well for the Periodic Table, taxonomy, and scientific experiments. But how can this be applied to other common challenges without general truths or laws?

Since the 1600s, it's been known that rhubarb stems are safe, but the leaves are toxic (Wikipedia, 2023a; Healthline.com, 2013) to eat. Does this observation qualify as science? And what is the scientific status of Ptolemy's (1998: circa 150 AD) geocentric theory? As it was scientifically discredited by Copernicus (1543/1995), it is not considered a real of the Universe. Is the geocentric concept science or not science? How do we know if the many discredited scientific theories are science or not?

Language is not considered science, yet here we are discussing science using English. As Galilei (1623/1957) observed, "This grand book, the Universe… cannot be understood unless one first learns to comprehend the language in which it is composed. It is written in the language of mathematics."

But science has a different logic than mathematics. Science's definition compels confirmation of theories; those with repeated confirmation are accepted as real, and those repeatedly discredited are accepted as not real. For example, Copernicus (1543/1995) and later Galilei (1962/1632) were the first of many to confirm heliocentrism, validating this theory as real and as science. Both scientists discredited Ptolemy's (1998: circa 150 AD) geocentric theory, making geocentric theory not real.

On the other hand, mathematics' deductive logic considers one completed derivation proof of its validity (Wikipedia, 2023b). That which is not mathematically proven is considered solvable. Mathematical definitions include scaler, real, non-real, imaginary, fictitious, valid, and invalid concepts.

Are imaginary and non-real concepts science or not science? And are fictitious forces (D'Alembert, 1743/1990), which do not exist, science or not science? Is it science or not science to use that which we know does not exist, fictitious forces, to derive and explain the non-inertial reference frame (Kleppner & Kolenkow, 2014; Chandra et al., 2014), that which we cannot otherwise mathematically solve or explain, specifically circular movement?

To truthfully answer these questions requires more than a definition of what is science. These questions need a definition of what is not science. To understand truth, we turn the page in *Aristotle's Metaphysics* (Aristotle, 1999: circa 330 BC); "To say of what is that it is not, or of what is not that it is, is false, while to say of what is that it is, and of what is not that it is not, is true."

Truthfully, science is the realistic description of the Universe, and that which is not real is not science. When the scientific method discredits a previously accepted theory, the discredited theory is not real and not science. That which is not real, even before applying the scientific method, is not science. To use that which is not real as science is false.

This study's purpose is to use Aristotle's definition of truth and reality to define what is and what is not science and apply these novel definitions to current

science. Understanding what is not science allows scientists to identify that which is not real and not science. As presented later, these novel science definitions open the door for finding novel at-rest reference frame, motion, and relative movement definitions.

Section 2 applies novel science definitions to classify observations, predictions, science fiction, and discredited scientific theories. Section 3 applies novel science definitions to illustrations. Section 4 uses circular and rectilinear movements to define the at-rest reference frame, motion, and relative movement concepts. Section 5 confirms the novel movement definitions, and 6 is the conclusion.

2. Applying the Science Definitions

The observation that rhubarb stems are safe to eat but their leaves are toxic is old (Wikipedia, 2023a). To understand if this observation is science, we look for how the scientific method has been applied. Pucher et al. (1938) measured 43 mEq/kg of oxalic acid in the stalks and 120 mEq/kg in the leaves. Potential problems of oxalic acid include headache, vomiting, and hypocalcemia (Pure Chems, 2022), as well as kidney stones (Noonan & Savage, 1999). The lethal dose, LD50, for anhydrous oxalic acid in rats is 7500 mg/kg (Pure Chems, 2022), demonstrating toxicity in mammals. Applying our definitions of science, we find the old rhubarb observation realistic and represents a scientific observation.

During WWII, rapeseed oil was extensively used as a mechanical lubricant and diesel fuel but not for animal consumption (Wikipedia, 2023c). With the widespread scientific acceptance that longer chained poly-unsaturated fatty acids (LC-PUFA) are healthy (Gladyshev & Sushchik, 2019), rapeseed oil derivatives were introduced as beneficial. Rapeseed oil derivatives were introduced as a food in the United States in 1985 and represent one of the world's most widely consumed oils (CanolaInfo, 2023).

Studies show erucic acid, an ingredient of the rapeseed derivative, is associated with animal disease (Krogdahl et al., 2022; ScienceDirect, 2023; Food Standards Australia New Zeeland, 2003). Although erucic acid comprised only 0.2% of canola oil in 2018 (Dunford, 2018), animal longevity and human safety studies still need to be completed (Food Standards Australia New Zeeland, 2003). Until further scientific studies are conducted, we will not know the extent of the accuracy of scientific observations found in the old knowledge limiting rapeseed oil derivatives to a mechanical lubricant (Wikipedia, 2023c) or the prediction of Dupont et al. (1989) that although erucic acid is not safe, its concentration in canola oil is generally acceptable if the oil consumption is limited to the anticipated and predicted quantities (Food Standards Australia New Zeeland, 2003). As such, the scientific investigation of canola oil remains incomplete, and its long-term safety is controversial.

The idea that a vessel can travel light-warp speeds greater than the speed of light, as found on Star Trek (Wikipedia, 2023d), is a popular science fiction

thought. Today, there are no known objects that exceed the velocity of light (Phalen, 2022). As we have no way of knowing what the future holds, we cannot say with certainty that there will or will not be science that allows a vessel to travel at light-warp velocities. As there is no science to determine if vessels can travel at light-warp velocity, this concept is classified as science fiction.

Ptolemy (1998: circa 150) used the Coriolis effect to argue for and justify his geocentric theory. He argued that if the Earth was rotating, producing days and nights, a dropped ball would strike the ground beyond sight, an early description of the Coriolis effect. Ptolemy observed that there was no Coriolis effect; theoretically concluded the Earth must not rotate, and this scientific rational justified his Geocentric argument for 1400 years. His conclusion, that the Earth does not rotate, was subsequently discredited by Copernicus (1543/1995), who showed the Earth rotates and orbits, but, despite this, Ptolemy's (1998: circa150 AD) dropped ball has-no-Coriolis-effect observation is valid.

Similarly, the theories of spontaneous generation, electrochemical duality, luminiferous Aether, and the Copernican system are all examples of discredited scientific theories (Wikipedia, 2023e). As they are discredited, these theories do not realistically represent the physical world. Until further evidence shows otherwise, these theories are not real and are not science. Unless the scientific evidence evolves, these theories are not real and not science.

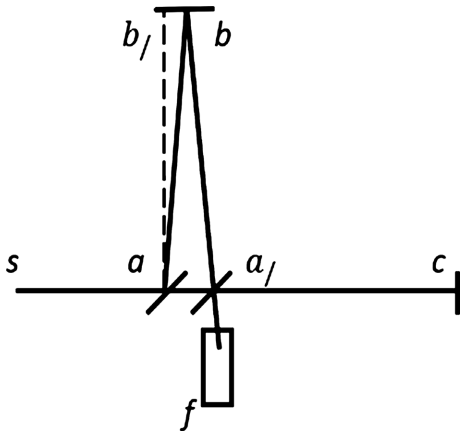
3. Scientific Illustrations

Recognizing the difference between scaler, real, not real, valid, and invalid illustrations is a critical step for successfully using mathematic and illustrative language to realistically and scientifically describe the physical world, our Universe.

Many scientific endeavors frequently begin with an illustration. The illustration serves as a starting point for defining a problem. The accuracy of the illustration impacts how the problem is conceptualized, what solutions might be possible, and the resulting mathematic and scientific derivations. To understand their importance, examples of non-real and invalid, scaler, and real and valid illustrations are presented in this paper's **Figure 1** and **Figure 2**. The scientific issues of utilizing scaler and non-real and invalid illustrations are discussed.

For instance, the understanding of the relative movement of the Earth's orbit and luminiferous Aether was represented in Michelson & Morley's (1887) figure 1, showing the at-rest perspective, and their figure 2, showing the Coriolis effect. The difference between Michelson & Morley's (1887) figure 1 and figure 2 was used to mathematically derive the difference in distance light traversed between the expected Coriolis and at-rest pathways.

In illustrating the Coriolis effect of the Earth's orbit, light reflects from the center of mirror *a* and traverses to, strikes, and reflects from mirror *b*. As the light returns to mirror *a*, mirror *a* has moved to position a_l and light strikes the center of mirror *a*. Mirror *a*'s movement is the same direction and distance magnitude as the Earth's orbital velocity. The light's pathway is illustrated with



Note. This apparatus was mounted on a round granite stone, the light source is *s*, the dotted line is light's at-rest reflected pathway, the solid line is light's reflected pathway relative to the Earth's orbit, the beam splitter is represented by *a* and $a_{/}$, two mirrors are $b_{/}$ and *b*, and mirror *c*, and the telescope is *f*.

Figure 1. A reproduction of Michelson & Morley's (1887) illustration figure 2.

the same movement as beam splitter *a* and the Earth's orbital velocity.

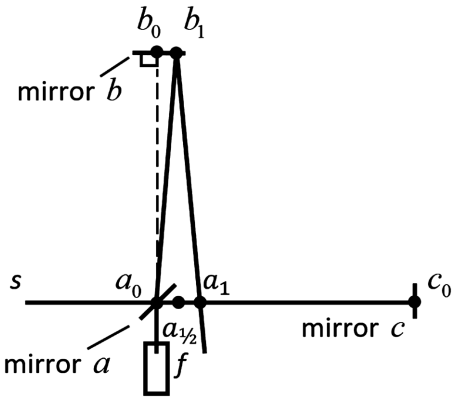
Telescope *f* is not drawn under mirror *a* to represent the at-rest reference frame. It is illustrated under mirror *a* in the $a_{/}$ position to represent movement with the same direction and distance magnitude as the Earth's orbit. **Figure 1** illustrates beam splitter *a* and telescope *f* have no Coriolis effect relative to the Earth's orbital velocity. In other words, beam splitter *a*, and telescope *f* are at-rest to the Earth's orbital velocity.

As shown in **Figure 1**, and as illustrated in Michelson & Morley's (1887) figure 2, the mirror $b_{/}$ and *b* may or may not illustrate movement. The telescope, *f*, and beam splitter, *a* and $a_{/}$, are illustrated with movement yet mirror *c* and the light source, *s*, are illustrated with no movement.

Michelson & Morley's (1887) experimental apparatus parts were all attached to the same stone base. Illustrating movement between different experimental apparatus parts is not real and invalid. This paper defines science as the realistic description of the Universe, that which is not real is not science. This definition shows Michelson & Morley's (1887) figure 2 and this paper's **Figure 1** are not real and not scientific illustrations.

Illustrating movement between different experimental apparatus parts, as shown in **Figure 1**, meets the criteria of being an invalid mathematical (Maxwell, 1959) illustration, or an illustrative mathematical fallacy (Maxwell, 1959). Although the mathematical predictions derived from this invalid illustration are not necessarily invalid, they must be confirmed with mathematical predictions derived from a valid and realistic illustration, found in **Figure 2**.

In **Figure 2**, all of the experimental apparatus parts, *s*, *a*, *b*, *c*, and *f*, are illustrated without movement are at rest to each other, and have Coriolis-like directional and distance movement to the light and Earth's orbital velocity, making this illustration both real and valid. Although the light has rectilinear movement



Note. Here, s is the light source, the dotted line represents light's pathway at-rest, the solid line represents light's pathway relative to the Earth's orbit, the beam splitter is a, light strikes the beam splitter at point a_0, light's Coriolis pathway strikes mirror b at point b_1 and mirror c at point c_0, point $a_{1/2}$ is the intersection point along segment sc_0 struck perpendicularly by a line passing through point b_1, point a_1 is the intersection point along sc_0 struck by light rays returning from mirror b, and f is the telescope.

Figure 2. Light's Coriolis pathway reflecting across a platform relative to the earth's orbit.

to the Earth's orbital velocity, the light and Earth's orbital velocity are at-rest, allowing the experimental apparatus to measure the Coriolis effect between the light and the experimental apparatus.

At rest, the distances $D = a_0b_0 = a_0c_0 = 11\,\text{m}$. In the $a_0b_1a_1$ pathway, returning light does not strike mirror a at the same location as does returning light of the $a_0c_0a_0$ pathway. Light rays reflect from mirror b along $a_0b_1a_1$ allowing the observer to measure the Gaussian wavefront fringe patterns with the telescope, f.

From Figure 2, we know distances

$$a_0a_{1/2} = a_{1/2}a_1, \quad b_1a_1 = a_0b_1 = \sqrt{D^2 + \left(a_0a_{1/2}\right)^2}, \tag{1}$$

and times

$$\frac{a_0b_1}{V} = \frac{a_0a_{1/2}}{v_o}, \tag{2}$$

where V is light's velocity and v_o is the Earth's orbital velocity. We solve for a_0b_1;

$$a_0b_1 = \frac{a_0a_{1/2}}{v_o}V = \sqrt{D^2 + \left(a_0a_{1/2}\right)^2}. \tag{3}$$

Next,

$$\frac{\left(a_0a_{1/2}\right)^2}{v_o^2}V^2 = D^2 + \left(a_0a_{1/2}\right)^2 \tag{4}$$

leads to

$$\left(a_0a_{1/2}\right)^2\left(\frac{V^2}{v_o^2} - 1\right) = D^2 \tag{5}$$

and

$$a_0a_{1/2} = \frac{D^2}{\sqrt{\frac{V^2}{v_o^2}-1}} = \pm D\frac{1}{\sqrt{\frac{V^2}{v_o^2}-1}} = \pm 1.09289 \text{ mm}, \quad (6)$$

is the magnitude of the change in direction. Thus,

$$a_0b_1 = \sqrt{D^2 + \left(a_0a_{1/2}\right)^2} = \pm 11 + 54\times 10^{-9} \text{ m} \quad (7)$$

is the change in distance.

The change in the distance light traverses between $2D$ and the vertical arms reflecting the Earth's orbit, is $2D - 2a_0b_1 = 108$ nm. By rotating the apparatus, the opposite fringe pattern produces a total fringe displacement of 216 *nm*. Using a realistic Coriolis illustration, this paper's derived distance formula reduces Michelson & Morley's (1887) predicted change in sodium light fringe pattern from 0.4 to 0.36 fringes. As Michelson & Morley's (1887) discussed, displacement of less than a twentieth of a fringe, 29 *nm*, was too small to be detected. This paper's predicted displacement outcome of 216 *nm* is 7.5 times larger than the smallest 29 *nm* measurable outcome.

Ignoring the invalid portion of Michelson & Morley's (1887) figure 2, the distance light travels from a to a_l in the at-rest illustration, figure 1, is different than the distance traversed in figure 2, yet the light strikes a and a_l at the same spot. This shows light's direction is the same in both figure 1 and figure 2. As the distance changes but the direction remains the same, this portion of Michelson & Morley's (1887) illustration is scaler.

Understanding our physical world frequently begins with an illustration. Truthfully, science is the realistic description of the Universe; that which is not real is not science. Using mathematically invalid illustrations, as found in Michelson & Morley's (1887) figure 2, is not real and not science. Using a known mathematically invalid illustration represents a mathematical fallacy (Maxwell, 1959), with the resulting scientific derivations suspect of being invalid.

4. At-Rest Reference Frames, Motion, and Relative Movement

This movement history begins with Aristotle's (1996: Circa 330 BC) primary circular movement and secondary rectilinear movement. Newton defined an absolute circular movement (Newton, 1995/1687) and absolute space and time (Newton, 1934/1713). Lange (1886) described Newton's concepts as an inertial reference frame. Recently described, the non-inertial reference frame (Chandra et al., 2014; Kleppner & Kolenkow, 2014) used fictitious concepts (D'Alembert, 1743), such as a Coriolis force (Harvard, 2023), to understand the angular velocity of a rotating body as acceleration. The inertial reference frame's primary rectilinear movement concepts describe the non-inertial reference frame's secondary circular movements.

By definition, fictitious forces do not exist and are not science. This leaves the primary rectilinear non-inertial reference frame logic incomplete, without a real force, making angular velocity a circular movement velocity concept and not acceleration. Without fictitious force, the question of how to mathematically explain the rotating platform, along with relative movement, is scientifically unanswered. By recognizing angular velocity as a primary circular velocity concept, the motion-relative movement conundrum can be cracked.

In an experiment to measure the Coriolis effect between reflected light, the Earth's orbit, and luminiferous Aether, Michelson & Morley (1887) confirmed there is no measurable Coriolis effect. Einstein (1916/1920), perplexed by Michelson et al.'s valid null result, argued that as the Earth rotates, reflected light must have a Coriolis effect. Einstein's theoretical conclusion that there must be a Coriolis effect to reflected light justified his application of FitzGerald's (1889) and Lorentz's (2023/1892) length contraction in General and Special Relativity to mathematically restore the anticipated but not measured Coriolis effect to Michelson & Morley's (1887) null result.

Michelson & Morley's (1887) reflected light experiment, finding no Coriolis effect from the Earth's orbit, confirms Ptolemy's (1998: circa 150) scientifically valid dropped ball observation of no Coriolis effect from the Earth's orbit. Both of these valid scientific observations allow us to understand that Aristotle's primary circular movements (Aristotle, 1996: circa 330 BC) for the Earth, reflected light (Michelson & Morley, 1887), and dropped ball (Ptolemy, 1998: circa 150) are the same. Aristotle's (1996: circa 330 BC) secondary rectilinear movements of the reflected light (Michelson & Morley, 1887) and dropped ball (Ptolemy, 1998: circa 150) are different from each other and the Earth, defining motion in an at-rest reference frame.

The presence of two or more objects with the same circular movements defines an at-rest reference frame. Ptolemy's dropped ball and the Earth have the same orbital and rotational circular movements, with the dropped ball having rectilinear movement. Reflected light and the Earth also have the same orbital and rotational circular movements, with the reflected light having rectilinear movement. As the dropped ball, reflected light, and Earth all have the same circular movements, they are at-rest to each other, and the rectilinear movement represents motion.

Dropping a ball from a platform demonstrates the observed path of the ball remains the same whether or not the platform rotates. The physical properties producing the path of the dropped ball are 1) the same for both the at-rest and rotating platform and 2) largely independent of the physical properties resulting in the platform's rotation.

A difference in the circular movement of the platform and the dropped ball occurs only with platform rotation. This difference in circular movement is the measurable Ptolemy/Coriolis effect relative movement. This observation shows the circular movement between two masses defines relative movement.

5. Confirming the Movement Definitions

The novel movement definitions show that the Earth, the dropped ball, and reflected light have the same circular movements, defining an at-rest reference frame, while the rectilinear movement of the dropped ball and reflected light represents motion. The difference in circular movements of two objects defines relative movement.

Restated, the novel movement definitions allow us to understand that Ptolemy's observation of no Coriolis effect for a dropped ball is valid and occurs even though the Earth has both orbital and rotational movements. Assuming physical processes equally affect a ball and light, reflected light will also show no Ptolemy/Coriolis effect on the Earth's orbit. Michelson-Morley's null result confirms the novel movement definitions and Ptolemy's dropped ball observation predictions of no Coriolis effect for reflected light to the Earth's orbit. As Michelson-Morley's null result is the predicted and measured result, no further mathematical modification of the null result is physically justified.

For further confirmation, we apply the Doppler shift. The Doppler shift results from the sum of the movements of a distant star and the Earth, using the distant star's light rectilinear movement as measured on the Earth. This movement summation is responsible for the difference in the starlight's measured and predicted wavelength.

The distant star's known movements are circular. These circular movements, contributing to the Doppler shift, include the star's rotation (S_r), the star's orbit in its galaxy (S_o), the star's galaxy rotation in the Universe (S_{Gr}), and the star's galaxy orbit in the Universe (S_{Go}). The circular movements of the Earth contributing to the Doppler shift are circular and include the Earth's rotation (E_r) and orbit (E_o) of the Earth, the Earth Sun's rotation (E_{Sunr}) and orbit (E_{Suno}) in the Milky Way Galaxy, and the Earth's Milky Way Galaxy's rotation (E_{Gr}) and orbit (E_{Go}) in the Universe. The Earth and distant star have no known rectilinear movements.

The summation of the circular movements contributing to the Doppler shift is

$$\sum_{CM} D = \sum_{CM} E + \sum_{CM} S = E_r + E_o + E_{Sunr} + E_{Suno} + E_{Gr} + E_{Go} + S_r + S_o + S_{Gr} + S_{Go}, \quad (8)$$

where CM are circular movements, E is the Earth, S is the star, and $\sum D$ is the doppler shift. Each of Equation 8 individual circular movements define a circular velocity, and the sum of the circular velocities of the Earth and the distant star represent $\sum_{CM} D$, the Doppler shift.

The distant star's light rays received and measured on the Earth demonstrate a Doppler shift unique for each distant star. Deductively, this means the light rays transmit the Doppler shift relative movements of the distant star. Restated, the distant star and its emitted light rays possess the same circular movements, that is, the distant star and its light are at-rest to each other, and the light's rectilinear movements represent motion in an at-rest reference frame. The difference in the distant starlight and Earth's circular movements produces the difference in the

starlight measured and predicted wavelength on Earth, the Doppler shift.

This confirms the Doppler shift relative movement is the difference between the distant star's light and the Earth's circular movements. The distant star and distant star's light belong to one at-rest reference frame while the Earth belongs to a different at-rest reference frame. There is relative movement between the distant star and the Earth as well as between the distant star's light and the Earth.

The Ptolemy/Coriolis relative movement is the difference between the rotating platform and Earth's circular movements. The dropped ball and the Earth belong to one at-rest reference frame, while the rotating platform belongs to a different at-rest reference frame. There is relative movement between the Earth and the rotating platform as well as between the dropped ball and the rotating platform. The novel movement definitions demonstrate the Doppler shift and the Ptolemy/Coriolis effect represent the same physical process, relative movement.

6. Conclusion

Science is the realistic description of the Universe, and that which is not real is not science. These definitions of what is and is not science can be used to determine which observations, methods, categorizations, hypotheses, statements, symbols, and illustrations are science and not science. Old rhubarb observations that the stems are safer to eat but the leaves are toxic are confirmed as realistic and, therefore, scientific. Scientific controversies occur when there is conflicting or incomplete information. Science fiction represents descriptions that cannot be confirmed as real or not real. Non-real descriptions, mathematics, illustrations, and symbols are not science.

This paper explains how Michelson & Morley's (1887) figure 2, replicated as **Figure 1** in this paper, represents a non-real illustration, an example of an invalid illustration. Ignoring the non-real and invalid parts of their illustration, Michelson *et al.*'s figure 2 also shows a change in distance but not direction between the light and mirror a_l, an example of a scaler illustration.

These illustrative examples have similar logic, concepts, and symbolism as mathematics. Michelson & Morley's (1887) calculations derived from their figure 2, a non-real and invalid illustration, differs from this paper's calculations based on **Figure 2**, a realist and valid illustration. This study's predicted change in direction, expressed by Equation (6), $\pm D\frac{1}{\sqrt{\frac{V^2}{v_o^2}-1}}$, derived the change in distance, Equation (7). This paper's realistic prediction of the difference in distance light traverses between the at-rest and Coriolis illustrations shows a different result from Michelson & Morley's (1887) invalid and scaler illustration. However, it does not significantly change their conclusions.

This paper presents examples of scaler, non-real and invalid, and real and valid illustrations. As demonstrated, the mathematical result from the non-real, with scaler components, illustration produces a different mathematical result

than does a corresponding real illustration. This example shows the importance of recognizing the difference between scaler, real, not real, valid, and invalid illustrations as a critical step for successfully using mathematical and illustrative language to realistically and scientifically describe the physical world, our Universe.

That which is not real is not science. Fictitious forces are not real and are not science. Removing fictitious force from the description of angular velocity makes the primary rectilinear movement argument for the acceleration of the rotating platform incomplete. Showing the logical inconsistencies of the non-inertial reference frame encourages the search for another explanation. Returning to the example of Ptolemy's (1998: circa 150 AD) dropped ball and Michelson & Morley's (1887) reflected light provides the basis of definitions of the at-rest reference frame, motion, and relative movement. As derived in Section 4, the presence of two or more objects with the same circular movements defines an at-rest reference frame, and the rectilinear movement of an object in an at-rest reference frame describes motion. The difference in the circular movements between two objects defines relative movement.

The Coriolis effect of a dropped ball on a rotating platform confirms the dropped ball and Earth have the same circular movements defining an at-rest reference frame, and the dropped ball represents motion in an at-rest reference frame. There is circular movement between the rotating platform and the dropped ball, as well as the Earth, confirming the relative movement definition. The Doppler shift of a distant star's light on Earth confirms the light and distant star have the same circular movements defining an at-rest reference frame, and the light's passage represents motion in an at-rest reference frame. There is circular movement between the Earth and the distant star's light as well as the distant star, confirming the relative movement definition. These examples of relative movement are analogous and show the same physical processes produce the Ptolemy/Coriolis effect and the Doppler shift. The primary physical processes resulting in relative movement include gravity and circular movement.

Rogers & Selvaggi (2012) developed a technique to measure an experimentally significant change in reflected light direction using a charge-coupled device on a rotating and non-rotating platform. Two future experiments are proposed. First, reflected light on a rotatable platform can be measured to show the change in direction relative to the Earth's rotation. The second can measure the change in reflected light direction relative to a rotating platform. Once completed, these future experimental results will confirm this paper's circular movement definition of relative movement, the physical equivalences of the Doppler shift and the Ptolemy/Coriolis effect, and recognize the roles of gravity and circular movement in relative movement.

These novel definitions begin the scientific discovery of the physical processes contributing to relative movement. Importantly, mathematical language and formulations describing the circular movement between objects must be devel-

oped. Previous concepts, such as angular velocity, once thought to be rectilinear acceleration but demonstrated in this paper to be circular movement velocity, are a starting point for developing circular movement mathematical expressions. Developing the novel relative movement definitions will require applying mathematics to circular movement velocity concepts, such as rotational inertia and angular velocity.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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