Observations of differences in electromagnetic velocity relative to anisotropy using a Lecher line and a standing electromagnetic wave

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Abstract: This paper describes an experiment designed to observe potential changes in electromagnetic propagation velocity. It has been widely demonstrated that if the frequency of an electromagnetic wave is fixed, then the associated wavelength is causally related to c. Furthermore, the logical conclusion related to this known association (of frequency, wavelength, and light speed) is that, if the generated frequency during an experiment remains the same, and there is a velocity change in c, there would be causally related expansion or reduction in the associated wavelength. With the use of a Lecher line and a standing electromagnetic wave, the experimenter can measure changes in wavelength by measuring electrical output at an assigned position on a Lecher line. Results of this experiment demonstrated an obvious and experimentally repeatable phase change associated with rotation of the Lecher line. This phase change was demonstrated by a change in electrical output measured at the assigned location on the Lecher line. This experiment was repeated using various frequencies and voltage inputs into the Lecher line with obvious results that demonstrated an anisotropic difference. Further experiments were completed attempting to find an alternative hypothesis for the phase change noted in the original experiment, but these experiments were unable to identify an alternative cause of the phase change and consequently support the hypothesis that the phase change was directly related to anisotropy secondary to a change in the measured wavelength of the electromagnetic wave. Based upon the logical conclusions associated with this experiment and the results obtained, this experiment appears to demonstrate variable speed light. Furthermore, this discovery brings into question the theory that electromagnetic propagation though space is at the constant of c. © *2024 Physics Essays Publication*. [http://dx.doi.org/10.4006/0836-1398-37.1.55]

Résumé: Cet article décrit une expérience conçue pour observer d'éventuels changements de la vitesse de propagation électromagnétique. Il a été largement démontré que si la fréquence d'une onde électromagnétique est fixe, alors la longueur d'onde associée est en relation causale avec c. De plus, la conclusion logique liée à cette association connue (fréquence, longueur d'onde et vitesse de la lumière) est que si la fréquence générée au cours d'une expérience reste la même et qu'il y a un changement de vitesse dans c, il y aurait une expansion ou une réduction causalement liée de la longueur d'onde associée. En utilisant une ligne Lecher et une onde électromagnétique stationnaire, l'expérimentateur peut mesurer les changements de longueur d'onde en mesurant la sortie électrique à une position assignée sur une ligne Lecher. Les résultats de cette expérience ont démontré un changement de phase évident et expérimentalement reproductible associé à la rotation de la ligne Lecher. Ce changement de phase a été démontré par un changement de la sortie électrique mesurée à l'emplacement assigné sur la ligne Lecher. Cette expérience a été répétée en utilisant différentes fréquences et tensions d'entrée dans la ligne Lecher avec des résultats évidents démontrant une différence anisotrope. D'autres expériences ont été menées dans le but de trouver une hypothèse alternative pour le changement de phase observé dans l'expérience initiale, mais ces expériences n'ont pas pu identifier une cause alternative du changement de phase et soutiennent donc l'hypothèse que le changement de phase était directement lié à l'anisotropie due à un changement de la longueur d'onde mesurée de l'onde électromagnétique. En se basant sur les conclusions logiques associées à cette expérience et les résultats obtenus, cette expérience semble démontrer une lumière à vitesse variable. De plus, cette découverte remet en question la théorie selon laquelle la propagation électromagnétique dans l'espace se fait à la constante c.

Key words: Light Speed; Electromagnetic Propagation; Lecher Line; Radio, Regulus; Cosmic Microwave Background; CMB; Standing Wave; Radio Wave; Superluminal; Faster Than Light; Relativity; Foundation of Physics; Michelson–Morley; Aether Theory; Varying Speed of Light; VSL.

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I. INTRODUCTION

The luminiferous aether; it is either present in the universe or it is not. It is a binary option. It has been hypothesized for more than 200 years, and in 1887, physicists Albert Michelson and Edward Morley set out to explore the nature of the aether and determine if the hypothesized substance was present in the universe. After years of research, the physicists published a "null result" suggesting that the universe was without an ever present medium upon which light traveled as a wave trough space.[1]

The Michelson–Morley experiment (MME) utilized two light beams traveling at directions 90° apart and then were returned to the instrument via mirrors to combine the two beams at a single target via an interferometer that presented a fringe display which was expected to demonstrate change as the instrument was rotated 90°.[1] The MME was designed to measure that change, and the energy change would present itself as a phase shift to the light beam on one of the beams of light.[2,3] The phase shift would result in a fringe shift. The fringe shift would result in demonstrating the presence of the aether. But it was not to be. The physicists reported a null result.

Despite the results that Michelson and Morley believed were a failure, the findings led to logical conclusions beyond what they would have imagined in their time. The consequence related to the lack of luminiferous aether was the suggestion by Albert Einstein that the speed of light must be a constant speed to all observers as described in his theory of general relativity.[4] Later experimentation and logical arguments demonstrated that the speed of light through a vacuum was 299 792 458 m/s. This constant speed has been given the variable of c.

Logical arguments have been thoroughly explored and clearly demonstrated the unusual consequences of light speed at c. It is the foundation of relativity.[5] The associated logical arguments related to relativity include parallel universes, time travel, the inability of superluminal travel, and even the logical conclusions associated with Schrödinger's cat. Over the years, many have deplored the absurdity of such consequences without the ability to find fault with the logic. For if c is constant, the logical arguments of relativity are sound.

Despite this sound logic, there are physicists who have questioned if c is actually constant.[6–9] While some of these physicists may be on the fringe of accepted science, even the highly respected physicists at CERN found themselves questioning c due to results suggesting that particles created in the lab traveled at superluminal speeds.[10] While further review of the results suggested the particles in question did not achieve superluminal speed, it is evident that respected scientists still consider the possibility of superluminal speed if research and data support such a conclusion. The experiment described in this paper provides such data.

To fully understand the experiment described in this text, the reader must have a basic understanding of four concepts:

- The aether,
- Electromagnetic propagation though space,
- The Lecher line,
- Phase change of a sine wave.

It is the combination of these elements within the experiment described that has provided the results described below.

A. The aether

The luminiferous aether is a type of matter presumed to be present in the universe. In all other materials, energy travels as a wave through a medium such as liquids, solids, or gases. Early experiments with light demonstrated the wave nature of its propagation and scientists were curious about what substance must be present for light to travel as a wave.[1]

If the aether is present, then what is it? Is the emptiness of space really filled with an unknown substance? If it is present, how would it present during an attempt to detect it? Is it dark energy? Is it connected with string theory? If the aether is present, all we really know is that it directly interacts with electromagnetic propagation as evidenced by the wave nature of electromagnetic propagation. All else is mere conjecture.

The Michelson–Morley experiment (MME) continues to remain the foundation for exploring for the aether the as they correctly deduced that any change in electrical measurement would be demonstrated via a phase change of the light source transmitted to the interferometer. If the aether is the medium in which electromagnetic energy is transmitted, and if aether is present throughout the universe, then our current technology is unlikely to demonstrate the aether without demonstrating a phase change noted by the measurement device. If the prior statement were untrue, then the foundation for the MME would be invalid as would the logical arguments for c as a constant.

B. Electromagnetic propagation

Visible light is a form of electromagnetic radiation that is propagated through the universe. Radio waves are also a form of electromagnetic propagation. It has been observed that electromagnetic radiation travels as a wave through space and its propagation is causally related to the speed of light in both frequency and in wavelength. The interrelation is described in the equations in Table I.[11]

This relationship between wavelength, frequency, and speed of light has been clearly documented for over 100 years and is the foundation for radio wave technology. While the subject of radio wave propagation can be extensive, for the purpose of this experiment, the above information is all that is required to understand the nature and results of the experiment described in this text.

C. The Lecher line

The Lecher line is a modified dipole antenna connected to a radio frequency (RF) generator. While most dipole antennas have two wires associated with the antenna that are deployed in opposite directions, the Lecher line has a two-wire antenna that runs parallel and close together. At the end

TABLE I. Wavelength formula.

Speed of light: $c = f\ \lambda$
Wavelength: $\lambda = c/f$
Frequency: $f = c/\lambda$

of the wires of the Lecher line, the antenna ends are connected which creates a complete electrical circuit and causes the creation of a standing electromagnetic wave on the antenna when a radio frequency (RF) signal is generated.

Under normal transmitting conditions using a standard dipole antenna, when the radio transmits, the antenna emits electromagnetic radiation down the antenna. For example, if the radio (or RF signal generator) transmits a 5-V signal down the antenna line, you can measure the output via an oscilloscope and see the electrical output on the display demonstrating a sine wave with a positive maximum value of 5 V and negative maximum voltage of 5 V. The measurement described can be obtained at any physical location on the antenna wire and the result will always be the same.

However, the use of a Lecher line allows the experimenter to "freeze" the electrical output by creating a standing radio wave.[12] By creating the standing radio wave, the experimenter can measure the electrical output at numerous locations on the antenna wire; however, since the radio wave is frozen, the amount of energy being radiated from the antenna wire at one location is different than at another location even though the measurement is being taken from the same piece of wire. Furthermore, by charting the results, a researcher would find that as the measurements are taken from different locations on the wire from the start of the antenna moving toward the end of the antenna, the maximum output reading would gradually increase, then decrease, then there would be a location where there is no energy transmission (a "Null Zone"), and then the polarity would change, and the electrical measurement would again climb and decrease.[12] Close measurements that are plotted would present as a sine wave. A Lecher line "freezes" a radio wave which is then described as a standing radio wave.

In Fig. 1, the sine wave (radio wave) moves across the antenna (represented by the center, horizontal line) and at each point where it crosses the antenna, there is no electrical output (Null Zone). At the crest of each wave, an observer will find the greatest electrical output measured on the oscilloscope as peak voltage.

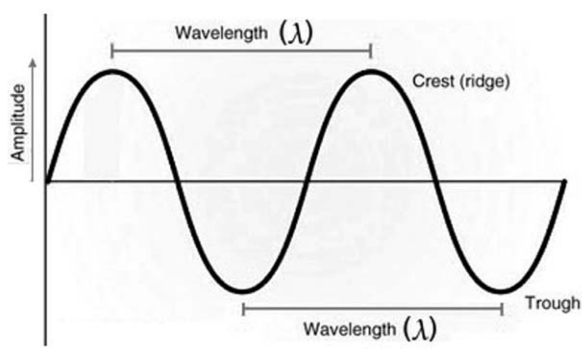


FIG. 1. A standing radio wave on an antenna.

The Lecher line freezes an electrical radio signal on an antenna and allows a researcher to make the measurements described above. This was first demonstrated in 1888 and has been demonstrated by HAM radio operators for years.[13]

The key ingredient of understanding for this experiment, in relation to the Lecher line, is that with our current understanding of radio frequency propagation, when an experimenter chooses a point in which to make an electrical measurement on the Lecher line, the point on the Lecher line will always continue to produce the exact electrical output unless there is a change in the frequency or the electrical input. Furthermore, the output measured by the experimenter at the chosen point on the Lecher line will never be the same as any other location on the Lecher line between a null point and the closest point of peak voltage on the Lecher line.

D. Phase change of a sine wave

A sine wave of the radio frequency (RF) generated on the Lecher line can be plotted on a graph. The vertical coordinates (x) chart the amplitude of the wave while the horizontal coordinates (y) describe the phase of the sine wave. Assuming there is no increase or decrease in the transmission voltage of the radio signal transmitted, the amplitude of the signal will always remain the same. When we define the phase of a radio signal, it can be described as the distance between the point of origin of any given wave and its first zero crossing. Assuming the frequency of the radio signal and the input voltage on the antenna remain the same, there will be no change in the phase of the signal.

For example, if we transmit a 6-V radio signal with a 4-m wavelength down a Lecher line that is 4 m in length, we can accurately predict some basic measurements. The first three null points will be found at the beginning of the Lecher line, at a point 2 m from the start of the Lecher line and at the end of the Lecher line. If we were then to take a measurement on the Lecher line that was at a point halfway between the first and second null points, we would find the point where the voltage is at its peak value. As such, if we were to take a reading from this wire at a point exactly 1 m on the Lecher line, we would obtain a measurement of exactly 6 V. If we were to take a measurement at a point exactly halfway between the first null point and the maximum voltage found at the 1-m point on the Lecher line, we would obtain a 3-V measurement at a point which is 0.5 m from the first null point.

Let us imagine that we have probe attached to our Lecher line and we are taking a continuous measurement of the electrical output of the Lecher line from this location. Our location is measured at exactly 0.5 m from the Lecher line input. Our signal generator is transmitting a radio frequency sine wave of 6 V at a frequency that produces a 4-m radio wave. We know from our previous measurement and our understanding of the Lecher line that the output is going to be 3 V.

Now, let us consider what will happen if we change the frequency of the radio signal. If we were to transmit a signal at a frequency with an 8-m wavelength, our reading at the 0.5-m point on the Lecher line would now decrease to an output voltage of 1.5 V. The point at which the Lecher line will output a 3-V measurement has moved from a position of 0.5 m on the Lecher line to a point at 1.0 m on the Lecher line. The transmitted voltage of 6 V never increased or decreased and, as such, there is no place where we will find an output voltage greater than 6 V. However, as the wavelength increased, the locations of the null points changed as did the locations of the maximum voltage as did the voltage output of every location on the Lecher line. This is how phase change is demonstrated and measured on a Lecher line.

E. The logical argument for the experiment

- Frequency: $f = c/\lambda$
  - It has been observed that electromagnetic radiation travels as a wave through space and its propagation is causally related to the speed of light in both frequency and in wavelength.
- $c = f\,\lambda$
  - It is widely accepted that in every case, if frequency of a radio wave is multiplied by the length of the radio wave, the result will always be the speed of electromagnetic propagation at 299 792 458 m/s.
- A logical consequence of the above equation is that if there were a change in c, there would have to be a consequential change in either the frequency or the wavelength or both.
- Further logic suggests that if there is an increase in the velocity of c, and if an experimenter can control the frequency, there would have to be a resultant change in the wavelength of the transmission.
- Thus, if an experimenter can measure an increase in wavelength, while maintaining the same frequency and without a change in the input voltage of the RF signal, then it must be a result of a change in the velocity of c.

II. METHODS AND MATERIALS

A. Experimental design

This experiment has been designed with consideration of the known travel of our planet through the universe. While the MME considered rotation of the Earth and movement of the planet in space, it did not have detailed information related to the movement of the Earth through the universe. Current understanding of this movement suggests that the Earth is moving toward the cosmic microwave background (CMB) at a speed of $631 \pm 20\,\mathrm{km\,s^{-1}}$ or 63 100 m/s.[14] The star Regulus presents itself in the sky in the constellation of Leo with the CMB behind it. For simplicity of observation, targeting this star during experimentation was expected to achieve the maximum voltage change from the Lecher line during experimentation.

Assuming the aether is similar to a gas, and our planet is an object traveling through this gas, it would present as a "wind" as we move through the aether. Looking forward into this wind would find a wind force of 63 100 m/s in our face. But if we looked backward, we would find the wind rushing away from us at the same speed. If electromagnetic propagation is not affected by the aether wind, then this wind would have no effect on the propagation. If there is no substance such as the aether, then again, the travel though the universe would have no effect on electromagnetic propagation. Our current understanding of electromagnetic propagation is that it travels at a constant speed of 299 792 458 m/s.

To conceptualize this experiment, the experimenter must ask, if the aether existed, how would it affect results in an experiment? Would such a finding result in a change in our understanding of the speed of light? Since it has already been clearly demonstrated that light speed is directly related to electromagnetic propagation, the finding of the aether will certainly affect the understanding of luminal velocity.

As such, this experiment is constructed with the possibility that the speed of light is variable. If we accept that electromagnetic propagation is moving though the aether at 299 792 458 m/s, but that it can have speeds greater than this, then we can then design an experiment where the hypothesis described can be either accepted or rejected based on data obtained.

In this experiment, I considered the speed of the Earth moving through space and then added the speed of electromagnetic propagation. As such, the speed of electromagnetic propagation from an instrument on Earth and pointed toward the same direction of the Earths travel in the universe would increase the forward electromagnetic propagation to a speed of 299 855 558 m/s. If this were to happen there must also be a change in either frequency and/or wavelength of any electromagnetic signal propagated at that speed. Since the signal generator controls the frequency, any increase in the wavelength would result in a phase shift of the RF signal on the Lecher line. That phase shift would be demonstrated by a change in the electrical output measured at the assigned location.

This stretching of the wavelength could also be physically measured by utilizing the null points on a Lecher line and measuring how far the null point stretched when the antenna is rotated. However, there are logistical issues associated with measuring from null point to null point including having to manipulate antennas that may be extremely long when using lower frequencies. If using UHF frequencies, the wavelengths are shorter, but the difference between null points is also smaller making such a measurement logistically difficult. As such, looking for phase change from a specifically assigned location on the Lecher line proves to be a more effective method of recognizing wavelength change. For this experiment, the assigned location for measuring voltage output is at a distance of 3 ft from the rear of the antenna. This spot is chosen not based upon any specific frequency or voltage but related to ease of replication of the experiment. Theoretically, any location on the Lecher line can be utilized as the "assigned location."

Once a point has been assigned as the point to obtain a reading from the Lecher line, the experimenter will always use the same assigned location for every other measurement. Assuming there is no change in the length of the wavelength or the electrical input, then there will be no change in the output. But if there is a change in the length of the wavelength, there will be an associated phase change at the site of the measurement which will also result in a change in the electrical output measured at the assigned location.

While virtually any frequency and voltage can be input into a Lecher line, the assigned frequencies and voltages utilized for this experiment were a compromise between multiple logistical complications including the capabilities of the equipment to measure output or generate input and the antenna size appropriate for this experiment. Consequently, for the experiment completed and described in this text, the Lecher line had a maximum input of 10 V (20 V peak to peak) at a frequency of 17 MHz. The frequency utilized also ensured that the sampling rate capabilities of the oscilloscope were within the parameters suggested by the Nyquist theorem.

Finally, it must be emphasized that this experiment is not measuring the speed of light. It is not based upon a one-way or two-way speed of light measurement.

The experiment described in this text is measuring the phase change of an RF signal that is associated with a change in wavelength due to anisotropy. The change in wavelength is observed by recognizing a phase change in the RF signal as evidenced by a change in the electrical output from the Lecher line. If the results of this experiment demonstrate a change in electrical output, then the logical implication is that there is a change in the phase of the RF signal due to a change in wavelength and logically suggests a change in the luminal velocity.

B. The experiment

This experiment can be conducted at any frequency and at any location on the Lecher line.

To complete an experiment, the Lecher line is placed upon a tripod using two separate tripod head mounts that are placed one on top of the other. Prior to the placement of the Lecher line, the tripod heads are leveled. Once leveled, the Lecher line is placed on top of the upper tripod head and secured in a level position.

The Lecher line is mounted on a wood base that is attached to the head of the upper tripod head. The battery pack, signal generator, laptop, and the USB oscilloscope are placed on a table about 10 ft from the tripod. The signal generator and USB oscilloscope are attached to the Lecher line via SMA coaxial cables. The battery pack provides power for the signal generator. All of these items are allowed to warm up for 30 min prior to an experiment. For the warmup procedure, the oscilloscope must be connected to the laptop which is powered on and with the software associated with the oscilloscope actively measuring an output from the Lecher line. The signal generator is also turned on and transmitting the RF signal that is to be evaluated during the experiment. For the experiment described the signal generator is transmitting a 17 MHz RF signal, as a sine wave, with a maximum voltage of 10 V.

The Lecher line is then pointed towards the star Regulus. To accomplish this, a phone application is used (SkyView Lite) to determine the exact location of the star Regulus. The lower tripod head mount is loosened so that the Lecher line can be rotated left and right and up and down. The smart phone is used as the alignment tool when the phone is placed against the back edge of the Lecher line wooden platform. When the instrument is pointed directly at Regulus, the lower head of the tripod mount is locked in position and the upper tripod mount also remains locked in position. The phone is then removed from the experimental area.

With the instrument in position and the assigned frequency set, a series of nine measurements are obtained to complete the experiment. During this time, no changes are allowed to be made to the signal generator. These measurements each last for 10 s. The first three measurements are obtained with the Lecher line pointed directly at the star Regulus. The second three measurements are obtained with the instrument pointed 90° away from regulus either to the left or to the right. After three measurements are obtained from a direction pointed 90° from Regulus, the instrument is then returned to the original direction and another three measurements are obtained. After all nine measurements have been obtained the experiment is complete.

To complete the measurement from the instrument with it pointed 90° away from Regulus, the lower tripod head remains fixed and the upper tripod head is loosened so that the instrument may be easily rotated 90°. Care should be taken to reduce shaking or hitting the instrument during this rotation as this can cause variation of the readings. Additionally, the experimenter should be well away from the instrument to reduce the chance of interfering with the measurement. This was accomplished using two SMA coaxial cables that run from the signal generator to the input of the Lecher line and from the assigned location of measurement to the USB oscilloscope.

While this experiment could easily be conducted using only two measurements (one toward Regulus and one pointing 90° away from Regulus), multiple measurements were able to ensure greater reliability. By making the measurements while pointing 90° away from regulus and then returning to the original direction (pointed toward Regulus), it allowed for the results to demonstrate that the anisotropic change identified in the experiment was not related to thermal change. Additionally, during experimentation, it was noted that while making measurements the results received had a small variation. Taking multiple measurements when pointed in a specific direction allowed the experimenter to measure baseline variability such that any anisotropic difference noted during the experiment cannot be confused with baseline variability.

The measurement from the assigned location was obtained using the USB oscilloscope VT DSO-2A20E with the following settings: single channel, A; probe setting 10×; sampling rate of 50 MHz; bit resolution setting to 16 bits (with 50 MHz sampling rate that provides an effective bit resolution of 11 bits). Measurement chosen was peak voltage.

C. Mathematical modeling of the experiment

With the association between wavelength frequency and the speed of light, modeling of the experiment starts with obtaining a ratio between the measured speed of light and the speed of the Earth through space toward the cosmic microwave background. This percentage describes the amount of predicted change in the speed of light while moving in a direction toward the CMB. With the Earth moving toward the CMB at a rate of 63 100 m/s, the percent of change becomes 0.000 210 479.

When predicting the stretch of the wavelength due to an increase in velocity of electromagnetic propagation, the known wavelength is simply multiplied by 1.000 210 47. When predicting the change in electrical output from the assigned location, the output reading (obtained while the instrument is pointed 90° away from the CMB) is also multiplied by 1.000 210 47 to determine the predicted output. The difference between the output while pointed at Regulus and the output while pointing away from regulus is described as the anisotropic difference. This difference should be considered as an absolute value as the phase change can occur to the left or to the right depending upon the location of the assigned location and its relative position in the sine wave.

D. The equipment

- Letcher line: The Lecher line can be built of anything that could be used as an antenna. For ease of building and replication of the device, the Lecher line for this experiment was built with standard 1/8-in. copper tubing. Each side of the Lecher line is made with a 5-ft-long copper pipe. The pipes are connected at one end with a 3-in.-long pipe. The two long tubes are connected to each other via the 3-in. copper tube via 90° copper pipe fittings that are braised in place on either end of the 3-in.-long copper pipe. When soldered together, they create a U-shaped device that is now the Lecher line. The RF input is attached to the end of these pipes via a small hole drilled at the end of each pipe where wires can be wrapped around and soldered in place. At each open end of the Lecher Line pipe, an 18-gauge copper wire is connected to a BNC adapter that then connects to a SMA coaxial cable; this is the input of the Lecher line. The coaxial cable is run from the input of the Lecher line to the BNC output of the signal generator. On one side of the Lecher line is the positive connection and on the other side is the negative connection. The Lecher line is then placed on top of a 6 × 1-in. wooden board and secured by being mounted by wooden spacers with holes drilled such that the instrument can be slipped into place. The point of the instrument where the two pipes are connected with a 3-in. pipe will be considered the front of the instrument when the experiment describes the instrument as being "pointed" in a particular direction. The rear of the antenna is where the signal input arrives from the signal generator. At a point 36 in. from the rear of the antenna a small hole is drilled into both sides of the instrument piping where the electrical output of the Lecher line is obtained; this is considered the assigned location for output measurement from the Lecher line. On the positive side of the Lecher line, an oscilloscope probe end is inserted into the hole previously drilled. On the negative side, an 18-gauge wire is inserted and soldered in place leaving a small "pig tail" of a wire remaining where the negative connector of the oscilloscope probe is connected during measurements. The oscilloscope probe is connected via a BNC adapter to the 20-ft SMA coaxial cable that is cable that is connected to the input of the USB oscilloscope.
- Tripod: A heavy duty tripod is required to maintain the weight of the instrument and reduce the amount of vibration that may occur during the experiment. The tripod must have a head that swivels 360° as well as have the ability to tilt upward and downward. The tripod used had a -tilt capability of −75° and +90° with the ability to pan 360°. This tripod head is used to point the instrument at the star Regulus.
- Tripod head: A second tripod head is required for the experiment. The second tripod head is mounted on the first head and is not utilized when the instrument is pointed toward regulus. When the experiment is required to point 90° away from the star Regulus, the upper tripod head is rotated 90° while the lower tripod head remains untouched.
- Battery pack: The Talentcell Rechargeable 12 V 3000 mA h lithium-ion battery pack was used to power the signal generator using the 5-V output from the battery.
- USB digital oscilloscope: The oscilloscope used was the Virtins Technology VT DSO-2A20E: PC USB 10–16 Bit 200MSPS 80 MHz. It was specifically chosen for its high bit resolution with the capability of 16-bit resolution. Standard resolution for commercial oscilloscope is 8-bit resolution and is insufficient to observe the anisotropic difference described in this experiment.
- Digital signal generator: JDS6600 DDS Signal Generator Counter. This digital signal generator has a vertical resolution of 14-bits.
- SMA coaxial cables (20 ft in length)
- Microsoft Excel: For data management.
- SkyView Lite (Phone App): Utilized for finding the location of the star Regulus.

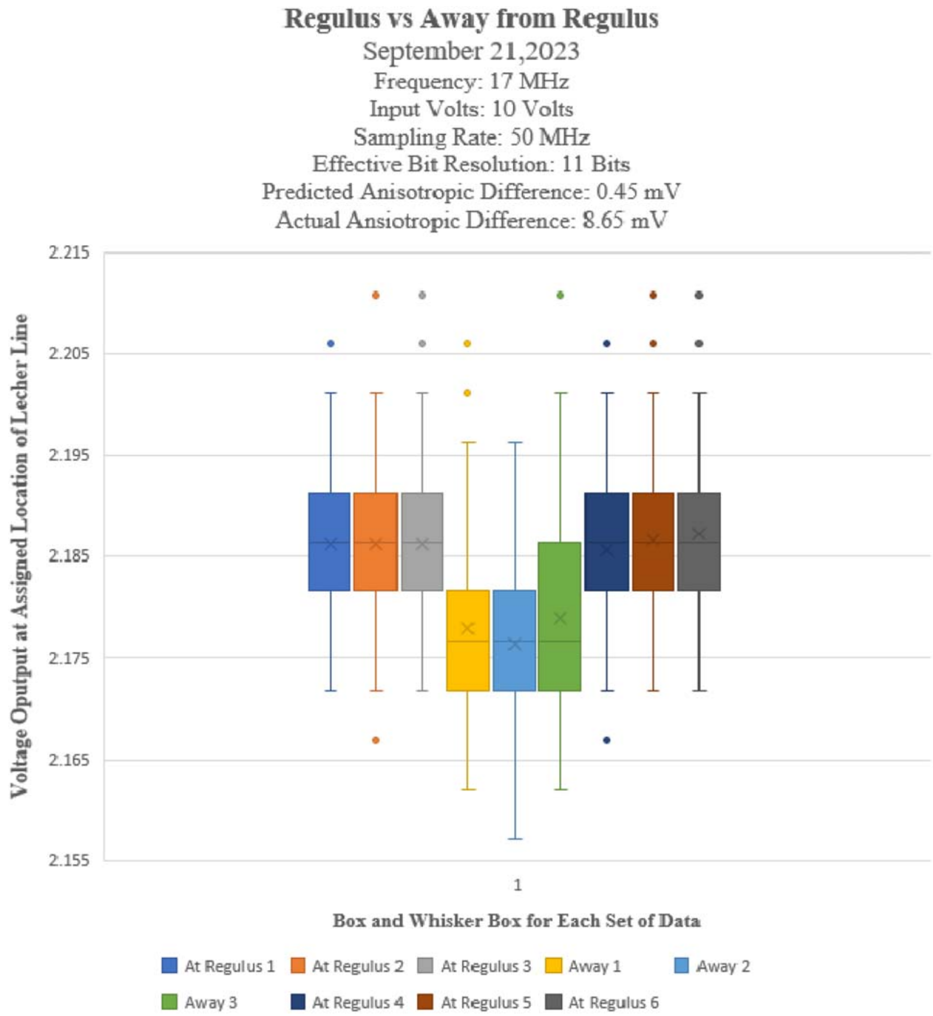
III. RESULTS

This experiment was completed hundreds of times using multiple frequencies and power settings. Experiments were completed on more than one Lecher line and in multiple locations. Not every experiment completed is described in this text. This experiment was also completed at the University of Nevada in Reno at their anechoic chamber. In all of these experiments, an anisotropic difference was identified when the instrument was rotated 90° away from Regulus.

The oscilloscope used has an associated data logger which allows for multiple aspects of the signal to be logged. This document describes changes in the peak values of the signal obtained at the assigned location; however, additional experimentation also found changes in V_{rms} as well.

Using the data logger of the USB oscilloscope, peak values were obtained from the signal at the assigned location for a period of 10 s. The data logger requires manual input to stop logging data. During the 10-s measurement period, about 180 data points are obtained. These data points are obtained for the nine measurements as described above. Once all data have been obtained, the results are placed into a single Excel worksheet for data management and

TABLE II. Anisotropic difference obtained during experimentation.



interpretation. Since the datalogger requires manual termination of the logging, each set of results may have a different number of data points. As such, the last few data points are deleted so that all columns of data have the same number of data points.

The data are then graphically displayed as a box and whisker plot of the data. Each of the nine sets of measurements obtained during an experiment is represented by a box and whisker. The box is able to demonstrate the minor baseline variation that occurs during the experiment. It also allows for a clear visual demonstration of anisotropic difference between the three middle measurements as opposed to the six measurements obtained while pointing at Regulus (Table II).

It should be noted that the anisotropic difference obtained was significantly higher than predicted. In the above result, the predicted result was 0.45 mV while the actual anisotropic difference was 8.65 mV. The results displayed here are similar to other results. Additional results are publicly available and permanently available online.

IV. DISCUSSION

The use of the Lecher line as an instrument for this experiment is clearly a departure from the concepts of interferometry utilized by the Michelson–Morely experiment (MME). Scientific literature review finds no published papers describing this experiment in relation to evaluating variable speed light. The MME experiment was designed to create a pathway where a light beam traveled a greater distance in one direction than in the other direction with the expected phase change related to difference of the distance traveled by the light beam. The Kennedy–Thorndike experiment also utilized interferometry and the experimental design and also had a null result with a suggestion that the null result indicated both constant light speed and time dilation. Unlike the interferometry type designs that may be affected by time dilation and length contraction, as associated with special relativity, the Lecher line obtains a measurement that is directly related to the wavelength and is not directly affected by time dilation or relativistic length changes.

It should be noted that MME and the Kennedy–Thorndike experiment demonstrated null results while the Lecher line experiment demonstrated an obvious anisotropic difference. Early experimentation at this laboratory with the Lecher line was unable to demonstrate an anisotropic difference until the instrument was modified with higher sensitivity equipment. In a similar fashion, the LIGO gravitational wave detector spent 9 years with a null result. The LIGO instrument also uses interferometry to look for a phase change and the first measurements of a gravitational were not obtained until an extensive overhaul of the instrument was completed to increase its sensitivity. Since the prior experiments used to search for viable light speed were designed to detect a phase change related to a specific distance, these instruments were unlikely to notice a phase change related to the shrinking or lengthening of a wavelength since a light wave is much smaller than a radio wave.

Finally, all other experiments related to this phenomenon have been utilizing light rays instead of radio waves. While both light and radio are transmitted via electromagnetic radiation, radio waves do not have photons associated with the phenomenon. It is unknown if the association of photons in such an experiment can affect the results. However, utilizing radio waves, rather than light waves, has produced an obvious anisotropic result as described in this experiment.

The results obtained and described in this document clearly show an anisotropic difference is obtained when the instrument is rotated 90° away from Regulus. However, for these data to support the hypothesis that the anisotropic difference observed is due to the phase change secondary to wavelength stretch related to change in the velocity of c, alternative hypotheses must be evaluated and ruled out as the cause of the anisotropic difference.

It should be noted that the anisotropic differences obtained during this experiment were obvious differences that were exceedingly greater than can be accounted for by any baseline variation. These observed anisotropic differences occurred in experiments that utilized multiple frequencies and multiple voltage inputs. However, observations that predicted very small changes in electrical output provided results that were difficult to observe an anisotropic difference in relation to baseline due to the bit resolution of the instrumentation. When measurements were obtained with greater voltage output, all results demonstrated anisotropic difference without a single instance of a measurement being obtained where an anisotropic difference was not obtained. Finally, these observations were concluded at various times of the day and night with the position of Regulus in multiple locations including below the horizon, above the horizon, at the horizon, in the East and in the West. With each of these observations, an anisotropic difference was obtained.

Despite the results demonstrated as predicted, the results must be scrutinized in relation to alternative hypotheses that may explain the nature of the anisotropic differences observed. Described below are some alternative hypotheses and explanations that were considered as a possible cause of the anisotropic difference observed in the experiment.

1. *The differences observed are caused by movement of the instrument during the experiment*—Experimentation was completed to determine if the physical movement of the instrument from the position pointing toward Regulus to the position 90° away from Regulus would cause an anisotropic difference. During the routine experiments, care was taken to limit the force associated with the movement of the instrument such that it would prevent vibration after movement. Furthermore, an experiment was completed where measurements were taken as usual. However, during the experiment, the instrument was quickly rotated 90° from Regulus and then returned back to the original position and a measurement was taken. The measurement did not record an anisotropic difference. Additionally, an experiment was conducted where measurements were obtained while the experimenter jumped heavily on the wood floor. Same baseline variation was noted, but no difference was recorded that would have been great enough to be considered an anisotropic difference.
2. *The difference observed is caused by radio frequency interference*—RF interference has been a consideration since the early stages of this experimentation. While measuring output from the Lecher line, the computer screen is displaying a wave form from the oscilloscope and a display from a spectrum analyzer. During this time, no spurious noise was observed on the spectrum analyzer. Additionally, RF interference would likely cause the anisotropic changes observed to be well outside of the predicted results. If RF interference were present in the Laboratory, the results should present as generalized noise that affected measurements in all areas and would likely cause a baseline variation so great that no anisotropic difference could be obtained. If the RF interference were localized to a specific device in the laboratory, and in which the direction of the antenna was also associated, it would present with unusual measurements while pointed in a specific direction of the laboratory. However, since observations were obtained at multiple times of the day and with the position of Regulus at various locations in the sky, there is no localized direction from which such an RF signal could be affecting this experiment in such a way that it would produce an anisotropic difference. Furthermore, during experimentation, all care was taken to reduce RF interference in the lab by powering down all nonessential electrical equipment and using battery power for completing the experiment. Furthermore, in September of 2023, this experiment was completed at the University of Nevada in Reno inside an anechoic chamber. This specialized chamber was isolated from RF interference and experiments conducted demonstrated an obvious anisotropic difference while conclusively ruling out RF interference as a cause of the anisotropic difference.
3. *The input characteristics have changed*—The Lecher line voltage output is affected by numerous variables. As described previously, RF interference and other explanations did not create significant variation as to be able to cause the observed anisotropic differences. Other changes that could easily affect the output would be a change in frequency, voltage, or impendence of the Lecher line. Once the experiment has been initiated, there is no equipment added to the Lecher line that would change the impedance. Impedance is not measured in this experiment. Impedance can affect the actual output of the Lecher line, but unless it is changed

by adding equipment or changing the width between the arms of the antenna, there is no change of output during the experiment and cannot be the cause of the difference measured. The signal generator is a scientific instrument with high resolution and is unlikely to have random changes in the output of the frequency or voltage and such random changes would not be associated with changes in movement of the instrument as demonstrated from the experiment described previously.

4. *The difference is due to thermal variation*—Thermal variation has been observed during experimentation. During excessively hot days, thermal variation appeared to cause a slowly changing voltage output on the instrument. As such, measurements were not obtained at times where excessive heat was likely to cause thermal variation. Shorter time measurements were used to decrease the total time of the experiment. The most recent Lecher line was built of copper pipe instead of copper wire in an effort to reduce the variation as greater heat would be needed to cause the variation in a larger structure. Furthermore, differences observed that would be caused by thermal variation would demonstrate a continued deviation of the electrical output and would not demonstrate a return to baseline as was observed during these experiments.
5. *The differences observed are caused by the Doppler effect*—The Doppler effect is noted when the source of a signal and the observer of the signal are moving in relation to each other. In the case of the experiment, the Lecher line is the source of the signal, and the experimenter is the observer. As such, there is no relative motion between the signal and the observer and no Doppler effect would be noted.
6. *The oscilloscope readings are inaccurate*—The digital signal generator utilized in this experiment has 14-bit vertical resolution. The USB oscilloscope used in this experiment has a capability of 16-bit resolution, but due to frequencies utilized and the associated sampling rate, the highest oscilloscope resolution utilized for this experiment was 11-bit. At 11-bit resolution, the equipment can observe a 0.36 mV difference. This resolution is easily able to accurately obtain the measurements recorded in this experiment.

Obtaining measurements from a Lecher line with an oscilloscope is a complicated process. Inductance can be changed simply by changing how far apart each arm of the antenna is from the next. Signal loss and voltage loss can drop while using coaxial cables that are 20 ft in length. However, it should be noted that with each of the variables described, any change in measurement related to signal loss, voltage drop, or impedance would be equally applied to readings taken while pointing toward Regulus and pointing away from Regulus. As such, these variables are not capable of causing the anisotropic difference noted in the experiment.

The difference between the predicted result and the actual result may be a result of inaccurate oscilloscope readings. The construction of the Lecher line may have created an amplification effect of the output readings, but nothing about the construction would result in an anisotropic difference. The difference between the predicted and actual results may also be related to a difference between actual speed of the Earth though the universe and the presumed speed of the Earth though the universe.

The results of this experiment clearly and repeatedly demonstrated an anisotropic difference as predicted would occur if the speed of light were variable. Alternative hypothesis for the cause of the anisotropic difference were examined and none were found to be the cause of the difference observed. Most certainly a difference has been observed and if no other causes can be identified as to the reason for the difference identified in the experiment, the logical conclusion is that there was a stretching of the wavelength associated with an increase in velocity of electromagnetic propagation and that this stretching was demonstrated by a phase change as evidenced by the change in the electrical output at the assigned location on the Lecher line.

The results of this experiment support variable light speed theory. The consequence of this result will be impactful for the foundation of physics. This result is in clear contradiction of the MME results which were the foundations for general and special relativity theory; however, today's instrumentation allows for higher accuracy than has been previously available to scientists. This result suggests that a new understanding will need to occur related to the foundations of physics. Early astronomers observed the movement of the stars and determined the Earth was the center of the universe. As science evolved, we learned that the Earth was not the center of the universe. The stars continue to move and the observations of the movement of the stars remain the same. All that has changed in the understanding related to these observations. So too will it occur that the observations supporting relativity will remain the same, but the understanding of these observations will change.

[1]A. A. Michelson and E. W. Morley, Am. J. Sci. **s3-34**, 333 (1887).
[2]See https://www.docsity.com/en/the-michelson-interferometer-lab-experiment-4-phys-375/6098732/ for "The Michelson Interferometer—Lab Experiment 4, docsity" (2023).
[3]T. Pruttivarasin, M. Ramm, S. G. Porsev, I. I. Tupitsyn, M. S. Savronova, and M. A. Hohensee, Nature **517**, 595 (2015).
[4]A. Einstein, *Relativity: The Special and the General Theory*, 100th Anniversary ed. (Princeton University Press, Princeton, NJ, 2015).
[5]C. M. Khodabakhsh, Phys. Essays **30**, 444 (2017).
[6]L. Mohsen, Phys. Int. **10**, 8 (2019).
[7]N. Mohammadi, N. Riazi, and M. H. Dehghani, Ann. Phys. **440**, 168820 (2022).
[8]R. L. Moore, A. C. S. Readhead, and L. Baath, Nature **306**, 44 (1983).
[9]G. B. Malykin and E. A. Romanets, Opt. Spectrosc. **112**, 920 (2012).
[10]I. Pătraşcu, Prog. Phys. **4**, L8 (2011).
[11]H. Sizun, *Radio Wave Propagation for Telecommunication Applications* (Springer, Berlin/Heidelberg, Germany, 2005).
[12]A. Schure, *R-F Transmission Lines* (John F. Rider Publisher, Inc., New York, 1956).
[13]S. Maddio and S. Selleri, URSI Radio Sci. Bull. **2018**, 10 (2019).
[14]A. Fraknoi, *Universe in the Classroom* (Springer, Berlin, 2007).