Always the Same Speed of Light

FRANC ROZMAN
fr.rozman@gmail.com

Introduction

The understanding of a certain physical phenomenon, in this case always the same speed of light in a vacuum, should be based on understandable and direct measurements. In physics, we miss some fundamental measurements in this field, although measurements are feasible.

Indirect conclusions about always the same speed of light in a vacuum are not sufficient, simply because it has not been measured. We need the measurement, for example, of how the speed of a comet affects the speed of light from a comet. There is also no measurement of how gravity affects the speed of light.

The missing measurements, when made, may not confirm current views in science. The results of measurements that have not yet been performed may change one day and complement both physical science and the teaching of light in the educational process.

The following article is dedicated to such measurements that fill this scientific gap.

Measurements show that the speed of a light source affects the frequency of light, but not its wavelength

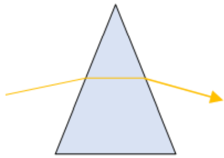
The speed of light is measured in circumstances where the source and sink of light are stationary. In this article, we focus on circumstances where light is positioned in different conditions. We primarily address the question of how gravity or the motion of the light source affects the properties of light.

The measurement of the speed of light from a moving source is shown in Figure 8. But first, let us look at the measurements that are the basis for measuring the speed of light incident from space.

In the measurement, we focus on the differences in the refraction of light on a diffraction grating and an optical prism. For example, there is no description in the scientific literature of a measurement that shows how the speed of a light source affects the refraction of light on an optical prism when the light comes from a moving light source and where the light source is located under well-known circumstances. Such a measurement is of key importance for the design of a speedometer for light from space.

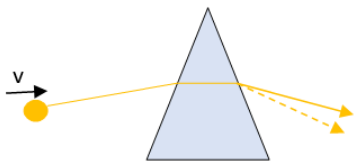
When we direct white light into an optical prism, it splits it into a color spectrum. An optical prism refracts the different colors of light contained in white light at different angles.

In the color spectrum, different colors have different brightnesses. Some colors are brighter, others darker. The brightness of some colors stands out. This outstanding brightness is called a spectral line. Let us choose one of the outstanding colors or one of the spectral lines and focus on it.



The sketch on the left shows how yellow light is refracted by an optical prism, that is, the yellow spectral line emitted by a stationary light.

This ray and its refraction are shown again in the picture on the right figure where, however, the light originates in different circumstances. In the sketch on the right, the light comes from a moving light source.



We therefore check whether the speed of the light source affects the angle of refraction of light, as shown by the dashed line in the picture, or whether the angle of refraction remains the same as for a stationary light source.

Wikipedia[1] je states that at different speeds of a light source, light is refracted at different angles and that the angle of refraction of light depends on the speed of the light source. This opinion is widespread in the literature and we usually follow this opinion.

Let us ask ourselves when and where different angles of refraction of light were measured at different speeds of the light source. Experts answer that different angles of refraction of light were measured several times and in different ways. They are convinced of the correctness of the answer given and do not doubt it.

On the Internet, we can find numerous physics forums dedicated to physics topics where we observe heated discussions about such and other points of view. Experts answer on the forums. When we ask them about one of such measurements, embarrassment arises. There are only measurements that are methodologically too different from the measurement we ask about. We

[1] Wikipedia – Doppler effect https://en.wikipedia.org/wiki/Doppler_effect.

want measurements as described later in the chapter Measurement Plan on page 6. Such or similar measurements are not known in the field.

In this measurement, we use a comet or meteor from our solar system as the light source. These sky bodies move at speeds suitable for measurement.

The measurement described in the measurement plan is feasible. We could have done it just out of curiosity about what results it would bring.

However, when looking for a measurement provider, i.e., an observatory, we encounter resistance to the measurement. The experts answer that we do not need this measurement because the measurement result is already clear. We experience a rejection of the measurement, even though the measurement is one of the fundamental measurements and should be the basis for teaching in school.

It is therefore sensible to draw attention to these measurements, for example, by giving them a name, e.g., pending measurement. Pending measurement should be understood as a fundamental measurement in the profession, with a known measurement method that is feasible but not yet published and for which we observe resistance to the measurement.

Such measurements usually lead to varied discussions and mutual disagreements. Searching for measurement results based on discussions and reasoning is redundant since discussions and reasoning can replace the measurement.

What is common to pending measurements is that the expected results of the measurements cast doubt on existing physical knowledge. The measurement might yield results that we would not want. Experts in the respective fields fear that the measurement threatens the credibility of some sciences, such as the theory of relativity.

Similar disagreements with measurements have already occurred in history. “And yet it moves” (E pur si muove) is a phrase that the Italian mathematician, physicist, and philosopher Galileo Galilei (1564–1642) is said to have uttered in 1633 after he was forced to abandon his claims that the Earth moves around the Sun.

The measurement of the refraction of light on an optical prism, when light comes from a moving light source, has indeed not yet been measured. However, there are known measurements in which the results of the measurements unambiguously show the expected result. Let us look at two of them. Both measurements were performed for different purposes. We are therefore interested in the side effects of these measurements.

Comet measurement: In one of the measurements[2], the wavelength of light coming from a comet was measured while it was moving at a speed of 21.9 km/s. The measurement shows that the speed of the comet does not affect the wavelength of the majority of the light.

In continuation, we can ascertain with this measurement that the measured light comes from the comet and that it does not originate from atmospheric radiation. We can ascertain this by redirecting the telescope to a dark part of the sky after the measurement and the measured light disappears.

Meters that are sensitive only to the wavelength of light, such as an optical prism, but not to its frequency, e.g., a diffraction grating, do not show the Doppler effect. Among all the measurements made in the history of measurements, we cannot find a single such measurement where an optical prism would show the Doppler effect. Let us look at the following example of a similar measurement.

Measuring solar flares: The ESA and NASA space agencies launched the SOHO satellite into Earth orbit in 1995. It is intended to observe the

---

[2] LARGE-APERTURE [O I] 6300 PHOTOMETRY OF COMET HALE-BOPP: IMPLICATIONS FOR THE A□ PHOTOCHEMISTRY OF OH JEFFREY P. MORGENTHALER,1 WALTER M. HARRIS,2 FRANK SCHERB,1,3 CHRISTOPHER M. ANDERSON,4 RONALD J. OLIVERSEN,3,5 NATHANIEL E. DOANE,3,6,7 MICHAEL R. COMBI,8 MAXIMUS L. MARCONI,9 AND WILLIAM H. SMYTH10 Received 2001 April 17; accepted 2001 August 10.

Sun. In addition to other instruments, the satellite also has a meter[3] that is sensitive to the wavelength of light but not to the frequency of light. The meter is intended to measure the speed of solar flares. In 1998, this instrument was declared inoperative.

The meter detects spectral lines. It detects even slight shifts of spectral lines, which is a sufficient condition for assessing that the meter is operational. The measurement result shows that the speed of the light source does not affect the wavelength of light. The meter works but the authors of the measurement did not accept such a measurement result.

The measurements generally show that the diffraction of light on an optical prism does not depend on the speed of the comet. The situation is different with a diffraction grating. There, the speed of the comet affects the diffraction of light.

To answer this question, it makes sense to conduct our dedicated measurement, as educationally simple and understandable as possible, thereby making the measured results more broadly educationally understandable. In the continuation, there is a plan for such a measurement.

---

[3] LASCO C1, includes FPI.

Some educational explanations of phenomena are not justified by measurements. I would like to highlight one of the measurements that we are missing. The measurement is not technologically demanding. The problem arises in accepting the measured results.

Measurement plan of light diffraction on an optical prism

Objective: We measure light from a moving object in our solar system, for example from a comet or an asteroid. We measure the diffraction of light from the selected object separately on a diffraction grating and an optical prism. We compare the measured diffractions of light with each other. We also compare the compliance of the diffraction of light with the Doppler law.

Measurement object:

The speed of the selected object should be at least 10 km/s. The object should have a known speed, measured independently. Gravity at the light source should not exceed 30 g. There should be no significant turbulence at the light source. Objects outside our solar system do not meet these criteria. There, conditions are poorly known and can lead to erroneous conclusions.

Measuring equipment

Astronomers use spectrometers (*e.g. Ocean Optics HR4000*) which are sensitive to both the frequency and wavelength of light. Consequently, spectrometers are not suitable for this measurement. This measurement is based on a strict separation of measuring the diffraction of light, firstly, on an optical prism and, secondly, on a diffraction grating.

Telescope: A reflecting telescope or a telescope based on lenses can be used to collect and direct light from a light source towards a diffraction grating or an optical prism. When measuring light refraction with an optical prism, the telescope must not contain a diffraction grating or a grating for any other purpose. Namely, we consistently separate the measurement of light refraction with an optical prism from the measurement of light refraction with a diffraction grating.

Sometimes telescopes have a grating that shows the image of where the telescope is pointed. During the measurement with an optical prism, the telescope must not contain either this or any other grating.

The optical prism should be sensitive enough in relation to the expected Doppler shift of the spectral line. For example, an optical prism of the *SF10 Flint Glass Prism* type is suitable.

The CCD camera shall be intended only for recording spectral lines. It must not contain a spectrometer or anything else that would affect the refraction of light.

Measurement method:

We aim the telescope at the selected sky body and we measure how the speed of the light source affects the refraction of light in the optical prism and on the diffraction grating. The measured results are compared.

Expected result of the measurement

The measurement confirms one of the hypotheses:

- Light is deflected on the diffraction grating and the optical prism according to the Doppler law.
- The diffraction of light on the diffraction grating follows the Doppler law. The situation is different with the optical prism. It does not detect the diffraction of light depending on the speed of the light source.

We research and interpret phenomena differently at different levels, scientists differently than teachers for the need to spread knowledge. Teachers seek widely understandable approaches that simply present phenomena, with measurements and other as direct observations as possible.

In education, therefore, we process, adapt, and organize knowledge in a form that is as acceptable as possible to a wider field. When we have direct observations or direct measurements available, we try to avoid more complex hypothetical explanations when presenting knowledge. When we have a measurement available that can directly answer a question, this is an excellent starting point for presenting material. In education, we can even perform a measurement for educational purposes. The latter explains and grounds a phenomenon to a wider field. This is the example of a measurement described.

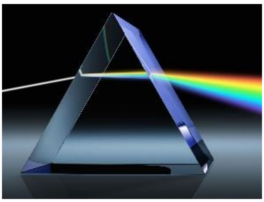
Such uneasiness in education does not usually occur in science which has direct effects on our everyday lives. It occurs where phenomena primarily only contribute to the understanding of phenomena in the universe.

The measurement described in the measurement plan or a similar one has not yet been recorded in the professional literature. It will be published eventually. Until then, however, we must not be impatient. Just as in the time of Galileo and Copernicus, the Sun rose and set regardless of what our idea of the solar system was. Quite the same, light serves its purpose as it will serve later when we understand it better.

Measuring the speed of light coming from space

1

In physics, we are missing one of the measurements of the refraction of light on an optical prism.



Refraction of light in an optical prism.

Figure 1

In the measurement described above, we measure the angle of refraction of light when light comes from a comet or an asteroid. I choose a comet or an asteroid as a light source because it is a moving light source and because there is no disturbing turbulence or disturbing gravity on it for measurement.

We direct the light from the asteroid into an optical prism as shown in Figure 1. We measure the angle of refraction of one of the colors of the light (spectral line). Figure 2, as mentioned, shows two hypothetical ways of refraction of the observed light:

A. The angle of refraction of light **does not depend** on the speed of the asteroid and is the same as for a stationary light source.

B. The angle of refraction of light **depends** on the speed of the asteroid.

Refraction of light on an optical prism at different speeds of the light source.

Figure 2

The same measurement can also be made with a Fabry–Pérot interferometer if it does not contain any grating for any purpose.

Because such a measurement has not yet been published, objectively speaking, we must understand both versions of light refraction (A and B) as hypothetical although the results of other measurements show that the speed of the light source does not affect the angle of refraction of light. A definitive answer will be given by a dedicated measurement.

Both supporters and opponents of the measurement, the method of which is described in the measurement plan, agree that such a measurement can provide a definitive and unambiguous answer to the dilemma posed.

2

The time for measurement is not yet right.

.

Given an understandable, methodologically simple, and feasible measurement, we ask ourselves why we do not perform this measurement. Why do we remain at the level of discussions, hypotheses, and writing about the measurement?

Some people have already performed the aforementioned measurement. However, there are problems with publishing the results. An optical prism does not detect the Doppler effect. Such measurement results are not acceptable to many because they do not conform to expectations.

People give priority to results that confirm and build on what we already know. Even though the measurement results are clear, we are unable or unwilling to accept this.

An individual who has performed the measurement does not mean much to science until these results are recognized as true by others. We encounter cognitive bias. Due to bias, we overlook evidence because it contradicts our beliefs and previous knowledge of the scientific field.

Those who doubt the measurement result say that they know the measurement result even without measurements. Therefore, measurements are not necessary for them. Opponents of measurement state that we would live in a different world if the light was refracted by an optical prism independently of the speed of the light source.

The peculiarity of measurement is that it requires a change in the view of some existing knowledge and concepts, which, however, many do not want. As the ancient Greek philosopher Epictetus wrote, you cannot learn what you think you already know. There, thought is closed to new things. Perhaps the existing knowledge about light in science is too entrenched to be changed and upgraded without opposition. Let us be optimistic. Perhaps the time for a new openness will arrive soon.

3

Measuring the frequency and wavelength of light separately shows that the speed of the light source affects the speed of light.

When different colors or wavelengths of light are directed at an optical prism, the optical prism refracts them at different angles. Therefore, an optical prism is sensitive to different wavelengths of light.

Despite its wavelength sensitivity, an optical prism does not detect changes in the wavelength of light as a result of the speed of the light source. Therefore, the speed of the light source does not affect the wavelength of light as the measurement described in the measurement plan convinces us.

Similar to how an optical prism deflects light, a diffraction grating also deflects it. A diffraction grating is a device with dense slits that divides a beam of white light into colors, as shown in Figure 6.

In contrast to an optical prism, we observe different diffractions of light at different speeds of the light source at a diffraction grating. Therefore, a diffraction grating detects the effect of the speed of the light source on the diffraction of light. A diffraction grating is sensitive to the frequency of light and shows that the speed of the light source affects the frequency of light according to the Doppler law.

The influence of the speed of the light source on the frequency of light, but not on its wavelength, means that the speed of the light source affects the speed of light.

The general opinion is that the speed of light in a vacuum is always the same. It is determined by the constant ***c*** which has the property of causality. This means a speed that covers everything from cause to effect. Many believe that it cannot be otherwise. In their opinion, therefore, it is not necessary to measure it.

Separate measurement of the wavelength, frequency, and speed of light from space is necessary because science is based on measurements, not on unverified assumptions. Only measurement can unambiguously show us the mentioned properties of light in different circumstances.

4

Are phenomena in the universe really such as we imagine them?

Composite optical and X-ray image of the Crab Nebula.

Figure 3

We observe unusual phenomena in the universe. It seems as if things are happening that go beyond our imagination. Perhaps the phenomena are really strange. Perhaps, however, we are just observing and evaluating them inadequately.

A pulsar, for example, is a neutron star with an extremely fast rotation. The fastest known rotating pulsar *PSR J1748-2446ad* rotates approximately 716 times per second. Given the size of the pulsar, its circumferential speed is said to exceed a quarter of the speed of light.

Another incomprehensible phenomenon is dark energy. Dark energy is a mysterious force that accelerates the expansion of the universe. Scientists estimate that there is more dark matter and dark energy in the universe than there is visible matter. This amazes us.

And something more about the origin of the universe. The inflation of the universe is said to be the unimaginably rapid expansion of the universe at its origin. The inflation of the universe occurred in a fraction of a second after the big bang. At that time, the universe is supposed to spread from a small grain into something larger than our galaxy.

Doubts about the speed of light of one kind or another force us to consider whether we understand phenomena in the universe correctly. When light travels near a star, its path curves in the direction towards the star. The curvature of light can hypothetically mean two things: In the theory of relativity, we understand this as curved space. The curved path of light is interpreted as light traveling straight in curved space. In Newtonian physics, this phenomenon is described as the gravity of the star attracting light and bending its path.

I wonder whether the curvature of the path of light when it travels near a star can be described in both ways, both with curved space and with a change in the speed of light.

Curved space is based on the always equal speed of light. If we can identify different speeds of light incident from space by measurement, only Newtonian physics describes objectively what happens in the universe. This means that gravity changes the speed of light, thereby bending the path of light near a star.

There are more such phenomena than we assume. However, perhaps the phenomena listed are not really such as we imagine them.

5

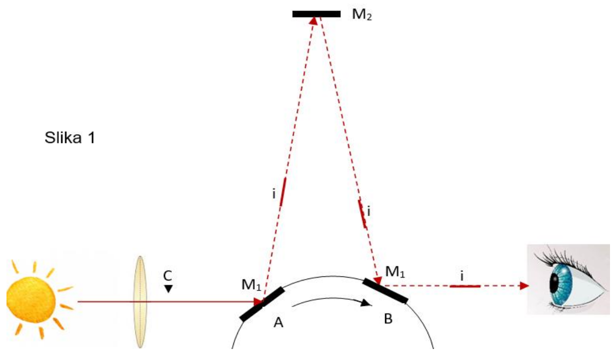
Measuring the speed of light from space is possible but has not yet been performed.

The speed of light can be measured by measuring the frequency and wavelength of light separately. However, this is not the only way to measure the speed of light. The speed of light coming from space can also be measured directly.

In 1932, one of the measurements of the speed of light was made by physicists Francis Gladheim Pease and Julius Pearson. They measured that light emitted by a stationary light source travels at a speed of 299.774 ± 2 km/s. The design of the measurement is shown in Figure 4.

Mirror M_1 in Figure 4 circles past point A towards point B. I direct the light beam toward mirror M_1. At the instant, that is, at the moment when it is at point A, the mirror directs a light pulse (i) towards the stationary mirror M_2.

Mirror M_1 continues its path along the circle towards point B. During this time, the light pulse travels to mirror M_2 and back to point B where the mirror and the light pulse meet again simultaneously, and the observer detects the light pulse. If the mirror does not appear at point B exactly when the light pulse arrives, however, the observer does not notice the light.



A measurement of the speed of light, as made in 1932 by physicists Pease and Pearson.

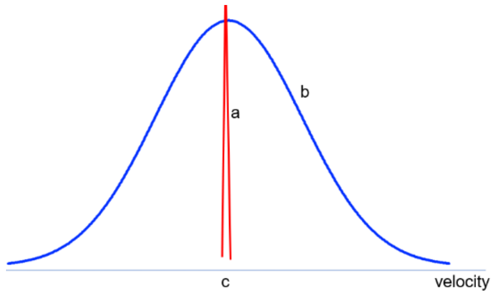
Figure 4

Based on the speed of rotation of the mirror, we know how long it takes the mirror to travel from point A to point B. During this time, the light pulse travels a known distance from point A via reflection from mirror M_2 to point B. Therefore, the time in which the light pulse covers a known length of path is known. This means that the speed of light is known.

The result of the measurement is shown in Figure 5. The horizontal axis shows the speed of rotation of mirror M_1, and the vertical axis shows the brightness detected by the eye. The narrow curve ***a*** always shows the same speed of light when the light comes from a stationary light source.

Their method also allows for measuring the speed of light from space. With this measurement, we can measure, for example, the speed of light coming from the Sun. The Sun differs from a stationary light source in that that the glowing particles on the Sunt that radiate light move at speeds of up to several hundred km/s. Therefore, I measure how these speeds of the glowing particles affect the speed of light.

The measurement shows that light from the Sun arrives at different speeds. The eye perceives the brightness at different speeds of rotation of the mirror



Detected brightness at different mirror rotation speeds: <u>diagram a</u> – rays enter at the same speeds, <u>diagram b</u> – rays enter at different speeds.

Figure 5

M_1, which means different speeds of light. These speeds of light from the Sun are shown by curve ***b*** in Figure 5.

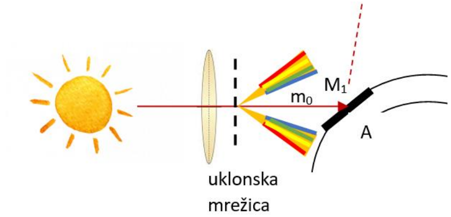
The measurement also shows that the speed of light is conserved when light is reflected from the mirrors and when light passes through the lens.

6

A diffraction grating adapts any speed of light to the speed of light c.

In the measurement in Figure 4, I add a diffraction grating between the lens and the mirror M_1, as shown in Figure 6. The diffraction grating bends the beam but also creates a beam m_0 that travels straight. I direct this into the mirror M_1.

I measure the speed of the beam m_0. On a rotating mirror, I measure that the light exits the diffraction grating with a speed determined by the constant c. The speed of the light source and consequently the incident speed of light are not important. For the diffraction grating, we always detect the same speed of light which is shown in diagram ***a*** in Figure 5.



Before we measure the speed of light, we pass it through a diffraction grating.

Figure 6

If I remove the diffraction grating, I measure different speeds of light, as shown in diagram ***b*** in Figure 5. Therefore, the diffraction grating adapts any speed of light to the speed of light, as determined by the constant c.

The frequency of light does not change on the diffraction grating. As many waves reach the grating per second, as many come out at the exit.

A diffraction grating changes the wavelength of light while maintaining frequency and changing the speed of light.[4] In the case of a moving light source, a different wavelength of light is measured behind the diffraction grating than in front of the diffraction grating.

7

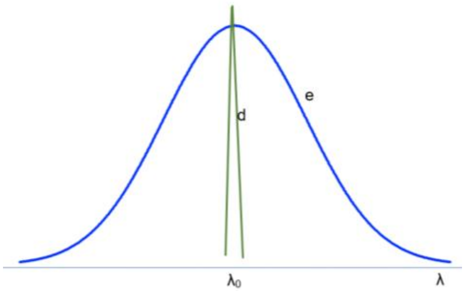
An optical prism does not detect changes in wavelength in light from the Sun as a result of the speed of the light source.

The measurement in Figure 6 does not yet give a complete picture of the properties of the light coming from the Sun. The picture is completed if we measure the wavelength of the spectral line of light with both an optical prism and a diffraction grating.

When I measure the wavelength of the spectral line of light from the Sun with an optical prism, I measure a very narrow spread of the wavelengths of light from the Sun, as shown by curve d in Figure 7. Curve ***d*** shows that the

[4] The speed of light is the product of the frequency and wavelength of light $c = f.\lambda$.

speed of the radiant particles on the Sun does not affect the wavelength of the measured light.



Wavelength distribution in light from the Sun.

Figure 7

When we measure the wavelength of the spectral line of light from the Sun with a diffraction grating, we measure a spread of wavelengths, as shown by curve ***e*** in Figure 7. The spread of wavelengths is consistent with the speeds of the radiant particles on the Sun and Doppler's law.

However, the dispersion of wavelengths on the diffraction grating is not the consequence of different wavelengths of light coming from the Sun but of changes in the wavelengths of light on the diffraction grating, as described in the previous chapter.

The measurement results show that the speed of the light source affects the speed and frequency of light but not its wavelength.

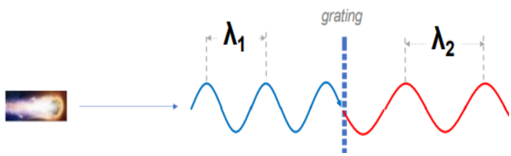
I also observe something similar with water waves. Water waves are different from light. Therefore, I only mention this illustration as an interesting example. When I row against waves, the frequency of the waves hitting the boat depends on the speed of the boat. However, the wavelength does not depend on the speed of the boat, similarly as in the case of light.

8

Measuring the frequency and wavelength of light separately allows the speed of light to be measured.

The described properties of the optical prism and diffraction grating enable a separate measurement of the frequency and wavelength of light and, thus, also its speed indirectly.

I direct the light coming from a moving light source into the diffraction grating, as shown in Figure 8. The light behind the diffraction grating has a speed determined by the constant c. Its speed is measured in the measurement in Figure 6.



The path of light from a moving light source through a diffraction grating.

Figure 8

For a diffraction grating with an optical prism or with a diffraction grating, I measure the wavelength of light (λ2). Thus, I know both the speed of light c and its wavelength for a diffraction grating.

The known speed and wavelength of light enable measurement of the frequency of light f=c/λ2.

The diffraction grating does not change the frequency of light. Thus, I also know the frequency of light before the diffraction grating. Before the diffraction grating, I measure the wavelength of light λ1 with an optical prism. The optical prism does not change the wavelength of light and measures such wavelength as it arrives from space.

This means that we know both the frequency and the wavelength of the light before the diffraction grating. Based on these measurements, we also know the speed of light c + v, with which it arrives from space. The speed of light before the diffraction grating is equal to the product of the measured frequency of the light and the measured wavelength of the light before the diffraction grating λ_1.

9

A change in wavelength indicates mass or gravity on the light source.

Based on the measurements described, one might mistakenly conclude that only the frequency of light always changes while its wavelength remains the same. This is not the case.

When we measure the wavelength of light coming from the distant universe with an optical prism, we measure a variety of wavelength changes.

The change in the wavelength of light is caused by the gravitational spectral line shift which is a consequence of the mass of the star from which the light originates. In very massive stars, the shift in the color spectrum is so great that the wavelength of the spectral line changes even by a factor of several[5].

It is wrong to attribute the change in wavelength to the speed of the star. In this case, we might conclude mistakenly that the star is moving away, perhaps even very quickly. A large change in wavelength means that the star is very massive but this does not tell us anything about its speed. Indiscriminate measurement of the frequency and wavelength of light can lead us to the mistake of thinking that the universe is expanding, instead of attributing the change in wavelength to the mass of the star.

Measuring the frequency of light allows us to measure the speed of stars, and measuring its wavelength allows us to measure the mass of stars. Together, the two allow us to understand the universe.

---

[5] **Discovery of a radio galaxy at *z* = 5.72**
A Saxena, M Marinello, R A Overzier, P N Best, H J A Röttgering, K J Duncan, I Prandoni, L Pentericci, M Magliocchetti, D Paris, F Cusano, F Marchi, H T Intema, GK Miley.

10

Conclusion

Measuring the frequency of light separately from its wavelength will allow us to understand at least some of the unexplained phenomena in the universe. Perhaps we will not need dark matter to explain the origin of the universe. The measurements described will open up new insights into both the knowledge of light and the understanding of the universe.

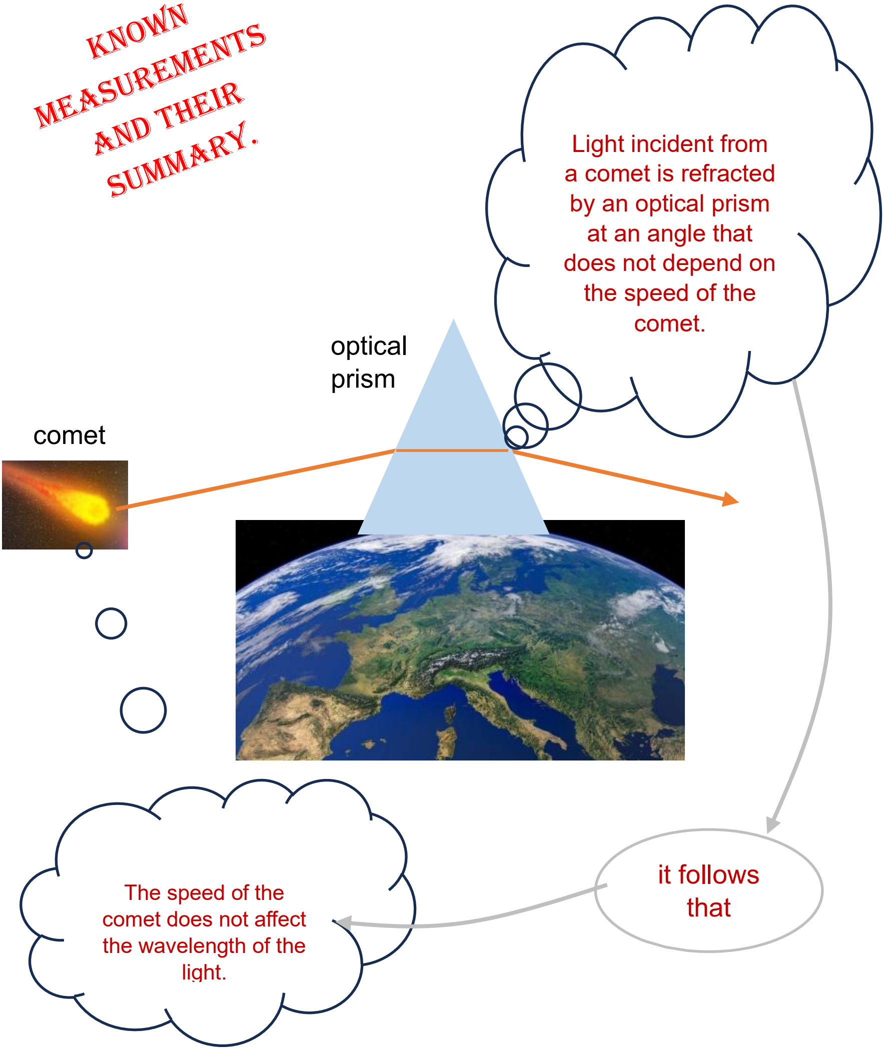
Whether we will perform the *Measurement Plan* or any of the other measurements described or not is not self-evident. Researcher and writer Richard Gaughan believes that three conditions are necessary for every discovery. The first condition is that we are aware of the opportunity for new insights. The second is that we know how to seize the opportunity, which, in this case, means that we know the *measurement plan* that deepens our view of the properties of light. And the third condition is whether we want to accept the opportunity offered. Gaughan believes that the last condition has discouraged many new insights for a long time.

Conclusion

For a better understanding of physics, some fundamental measurements have not been made. Let us make these measurements! Let us not wonder whether the results of these measurements will merely confirm or supplement and thereby transform current physical knowledge.

Let us set the goal of replacing the current indirect observations regarding the speed of light with direct measurements for the needs of education. In the teaching material, therefore, let us offer students a simple, direct, and clear measurement of the speed of light in various circumstances.

KNOWN MEASUREMENTS AND THEIR SUMMARY.



Diffraction grating and optical prism.