technical transactions
No. 2023/003
mechanics
sciendo

The concept of a mechanical system for measuring the one-way speed of light

Karol Szostek
kszostek@prz.edu.pl | https://orcid.org/0000-0002-3279-4090
Department of Aerospace and Space Engineering, Rzeszow University of Technology

Roman Szostek
rszostek@prz.edu.pl | https://orcid.org/0000-0002-5904-9760
Department of Quantitative Methods, Rzeszow University of Technology

Scientific Editor: Jacek Pietraszek, Cracow University of Technology
Technical Editor: Aleksandra Urzędowska, Cracow University of Technology Press
Language Verification: Timothy Churcher, Merlin Language Services
Typesetting: Małgorzata Murat-Drożyńska, Cracow University of Technology Press

Received: January 13, 2023
Accepted: February 14, 2023

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing interests: The authors have declared that no competing interests exist.

Citation: Szostek, K., Szostek, R. (2023). The concept of a mechanical system for measuring the one-way speed of light. *Technical Transactions, e2023003*. https://doi.org/10.37705/TechTrans/e2023003

Abstract

The work presents the concept of a device for the measurement of the one-way speed of light. The minimum parameters of this device have also been determined based on the Special Theory of Ether without transverse contraction. The Special Theory of Ether is a relativistic theory of kinemat-ics with a universal frame of reference in which light propagates and is an alternative explanation for the null result of the Michelson-Morley experiment. An experiment based on the proposed device can be one of the ways to falsify the Special Theory of Relativity and Special Theory of Ether.

Keywords: one-way speed of light, measurement of light speed, universal frame of reference

1. Introduction

The speed of light in a vacuum is generally considered to be constant in every direction and relative to any frame of reference. The Special Theory of Relativity is based on this assumption. However, it has never been possible to accurately measure one-way light speed. Measurements of one-way light speed have been performed with astronomical methods, but these are inaccurate measurements. In all precise measurements of the laboratory speed of light, only an average speed of light (not momentary) has been measured, which covers the path along a closed trajectory. It is usually a path to a mirror and the return. A review of numerous experiments in this respect is presented in the literature (Yuan, 1997).

Armand Fizeau performed accurate measurements of the average light speed for the first time in 1849 (ring wheel method) and Jean Foucault in 1850 (rotating mirror method). One of the most accurate measuring methods for average light speed back and forth on a path is discussed in the literature (Nagel, 2015). All the methods used to measure average light speed along a closed trajectory have shown at most that this average speed does not depend on the direction of measuring device settings, or on the measuring device movement (i.e. time of day and year).

The Special Theory of Relativity (STR) is based on the assumption that one-way light speed (momentary not an average) is absolutely constant, in each direction and for each observer. This STR assumption is not contradictory to the results of light speed measurements, but it is a stronger assumption than the one precisely derived from these experiments.

Never has the speed of light been measured in one direction, as this is a problem that has not been technically solved. This is because precise atomic clocks do not measure time the same if they are in relative motion. If two atomic clocks are synchronised and one of them moves to another location, then these atomic clocks are slightly out of synchronisation and no longer indicate the same time. Therefore, they cannot be used to measure the flow time of light which has such a high rate of speed that even a slight desynchronisation of clocks has a significant influence on the flow time measurement.

The proposed device for measuring the one-way speed of light was presented in 2006 in a patent (CN101000265 A). The author of this invention proposed a device which used a rotating wheel.

In this article, we present our proposal for a patented one-way light-speed measuring device (P.414434). This device also uses a rotating wheel, but is based on a different measuring mechanism than the device presented in the patent (CN101000265 A). In order to estimate the technical parameters of such a device, it is necessary to rely on a theory predicting the effect which we want to measure. The theory of kinematics, which predicts the dependence of the one-way speed of light in a vacuum on the direction of its emission, is the Special Theory of Ether derived in previous works (Szostek, Szostek 2022: 457–467; Szostek, 2017: 1868–1883; Szostek, Szostek, 2018a: 429–437; Szostek, Szostek 2018b: 413–421; Szostek, 2020a: 684–704; Szostek, 2022a: 01–19; Szostek, 2022b: 10244–10262). These works present an explanation of Michelson-Morley's and Kennedy-Thorndike's experiments (an explanation of the zero result of these experiments). It has been shown that these experiments do not demonstrate a constant one-way speed of light in a vacuum and do not exclude the existence of a universal frame of reference (ether), in which the light propagates. Coordinate and time transformation for the theory with ether without transverse contraction was derived in the literature (Szostek, 2017: 1868–1883). In another article (Szostek, Szostek, 2018a: 429–437), on the basis of this transformation, a formula for one-way light speed in a vacuum (1) has been derived. This article is based exactly on this formula. Previous work (Szostek, Szostek, 2018a: 429–437) shows that Michelson-Morley's and Kennedy-Thorndike's experiments, which were thought to have proved the non-existence of ether, not only did not do so, but there are infinitely many theories of ether that are consistent with these experiments. There is even a possible theory with ether in which time is absolute. So far, there are no known experiments that unequivocally determine whether the correct model of real processes is the Special Theory of Relativity or the Special Theory of Ether. The problem with falsifying these theories has been briefly discussed in the literature (Szostek, Szostek, 2018b: 413–421).

It should be mentioned that there are publications which show that the Michelson-Morley experiment gives a positive result, although it is much weaker than originally predicted from the kinematics of Galileo Galilei with a luminiferous ether. If this were the case, it would mean that even the average velocity of light flowing in a vacuum along a closed trajectory is not constant. These results, however, have not been sufficiently confirmed, and the articles that present them are overlooked by official physics (Maurice, 1998: 26–32; Miller, 1933: 203–242).

In this article, minimum parameters of the measuring device have been determined on the basis of a formula (1) for light speed in vacuum derived from the Special Theory of Ether (Szostek, 2018a: 429–437). This formula (1) was also derived from previous work (Rizzi, 2004: 1835–1887). The authors received it in a different way by introducing another method of clock synchronisation to the Special Theory of Relativity.

The measuring device proposed in this article is not used for the precise measurement of light speed but only for measuring one-way light speed with sufficient accuracy to check whether the one-way speed of light in a vacuum depends in our frame of reference on the direction of its emission.

2. Description of the measuring system

A diagram of the measuring system is presented in Figure 1.

The rim connected to the rotating wheel has one hole and a measuring scale on the opposite side. The light goes through a hole and flows along the wheel diameter. Light marks a trace on the scale. If the wheel does not rotate, a track is created in point A. If the wheel rotates at a fixed speed ω, then the light trace on a scale will be moved in relation to point A (point B or C). Displacement will

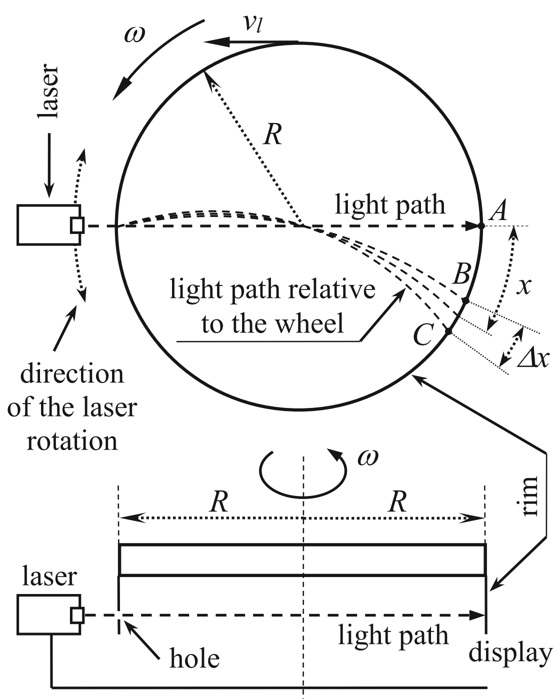

Fig. 1. Measuring system of the one-way light speed

occur because the wheel will rotate before the light covers path $2R$. If the speed of light is higher, then displacement on the scale will be smaller (point B). If the speed of light is smaller, then displacement on the scale will be greater (point C).

Based on light track movement x, it is possible to determine one-way light speed, along the rim diameter, from the hole to the measuring scale. If the experiment is performed in different directions, the differences in light track movement x will indicate that the speed of light varies in different directions. For that purpose, it is necessary to stabilise the rotation speed and to measure the light trace position on the measurement scale for various laser-rotation settings.

3. Estimating parameters of the measuring device

Estimation of the parameters of the measuring device was conducted on the basis of the following formula:

$$c_{\alpha'} = \frac{c^2}{c + v\cos\alpha'} \tag{1}$$

The average speed of light in a vacuum measured in previous experiments was determined as c. The one-way light speed running at an angle α' to speed v of the measuring system (solar system) with regard to the universal frame of reference (Figure 2) was determined as $c_{\alpha'}$. Speed $c_{\alpha'}$ depends on the angle α' and speed v of the measuring system with regard to the universal frame of reference.

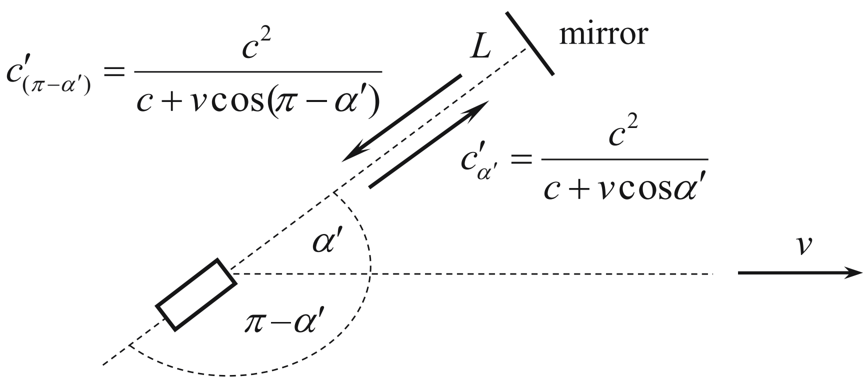

Fig. 2. The light path running at an angle α' to speed v of the measuring system in relation to ether

Speed of light expressed as dependence (1) is in accordance with the average speed of light measured so far. According to this formula, the average speed of light running on path L to the mirror and returning along the same path is equal to c. For the following occurs:

$$\bar{c} = \frac{2L}{t_1 + t_2} = \frac{2L}{\frac{L}{c_{\alpha'}} + \frac{L}{c_{(\pi-\alpha')}}} = \frac{2L}{\frac{L}{\frac{c^2}{c+v\cos\alpha'}} + \frac{L}{\frac{c^2}{c+v\cos(\pi-\alpha')}}} \tag{2}$$

$$\bar{c} = \frac{2}{\frac{c+v\cos\alpha'}{c^2} + \frac{c-v\cos\alpha'}{c^2}} = \frac{2}{\frac{2c}{c^2}} = c \tag{3}$$

The time of light flow through means $2R$ (Figure 1) is:

$$t = \frac{2R}{c_{\alpha'}} \tag{4}$$

The distance x by which the light trace on a scale moves in relation to the trace created when the rim does not rotate is as follows:

$$x = v_l t = \omega R t = \frac{2\omega R^2}{c_{\alpha'}} = \frac{4\pi f R^2}{c_{\alpha'}} \tag{5}$$

After taking into account the relation (1) depending on displacement (5), the following is obtained:

$$x = \frac{4\pi f R^2}{\dfrac{c^2}{c + v\cos\alpha'}} = 4\pi f R^2 \frac{c + v\cos\alpha'}{c^2} \tag{6}$$

If the laser is rotated to a different position, angle α' of the light flow will change. If it is as derived from the Special Theory of Ether that the speed of light depends on an angle α', during the laser rotation, the light trace on a scale will change.

According to the first formula (1), the light has the highest speed when it propagates in a direction opposite to speed v of the solar system with regard to the universal frame of reference, i.e. when $\alpha' = \pi$ rad. The light speed is minimum when $\alpha' = 0$ rad. Therefore, the maximum change in the light trace displacement is as follows:

$$\Delta x = x_{\max}(\alpha' = 0) - x_{\min}(\alpha' = \pi) \tag{7}$$

$$\Delta x = 4\pi f R^2 \left[\frac{c+v}{c^2} - \frac{c-v}{c^2} \right] = 8\pi f R^2 \frac{v}{c^2} \tag{8}$$

that is:

$$f R^2 = \frac{\Delta x c^2}{8\pi v} \tag{9}$$

Based on this relationship, we can determine the minimal requirements for the measuring system from Figure 1. If the radius of the wheel is great, the frequency of its rotation can be smaller. The higher R and frequency f, the greater the displacement Δx and the easier it is to measure it.

On the basis of the estimation presented in the literature (Szostek, Szostek, 2018a: 429–437), we assume that speed v of the solar system in ether is 369300 m/s. Due to the high value of the average light speed $c = 299\,792\,458$ m/s, the light trace displacement x will be very small. Changes Δx of this displacement will be even smaller when the laser is rotated. If Δx is read using a microscope with an accuracy of 10^{-7} m (0.1 μm), the device parameters must meet the following conditions:

$$f R^2 \geq \frac{10^{-7} \cdot 299792458^{\,2}}{8\pi \cdot 369300} = 968.33 \frac{\mathrm{m}^2}{\mathrm{s}} \tag{10}$$

It follows that, for example, if the rim has radius $R = 17.9$ m, it is sufficient to rotate it at a frequency of $f = 3.01$ 1/s. For these device parameters, the linear speed of rim points is as follows:

$$v_l = 2\pi R f = 2 \cdot 3.14 \cdot 18 \cdot 3.01 = 340.3 \frac{\mathrm{m}}{\mathrm{s}} \tag{11}$$

i.e., v_l is the value of the speed of sound.

For the minimum parameters of the measuring device, we obtain from (8) the value of the light trace movement on a rotating scale.

$$x_{\max}(\alpha'=0)=4\pi f R^2 \frac{c+v}{c^2} \tag{12}$$

$$x_{\min}(\alpha'=\pi)=4\pi f R^2 \frac{c-v}{c^2} \tag{13}$$

Thus, the following is obtained:

$$x_{\max}(\alpha'=0)=40.91\ \mu\text{m}=0.04091\,\text{mm} \tag{14}$$

$$x_{\min}(\alpha'=\pi)=40.81\ \mu\text{m}=0.04081\,\text{mm} \tag{15}$$

We will now write formula (9) in a different form. From (11) we get:

$$f=\frac{v_l}{2\pi R} \tag{16}$$

After inserting into (9) and substituting the assumed numerical values, we get:

$$R=\frac{\Delta x c^2}{4v}\frac{1}{v_l}=\frac{10^{-7}\cdot 299792458^{\,2}}{4\cdot 369300}\frac{1}{v_l}=6084.2\frac{1}{v_l}=\frac{6084.2}{340.3}=17.9\,\text{m} \tag{17}$$

4. Conclusions

In this work, a measuring device has been proposed for measuring one-way light speed. The minimum requirements for this device have also been estimated. The estimation was conducted assuming that the dependence (1) on speed of light in vacuum is valid, which is derived from previous work (Szostek, Szostek, 2018a: 429–437).

The construction of such a device seems realistic. The reduction of the required rotational speed can be achieved by installing an optical system at point *A*, which will enhance slight movements of the light trace by projecting it on a scale not connected to the rotating wheel. It may be advantageous to place the rotating wheel in a vacuum chamber. It is logical to expect that with a small hole in the rim, the light trace on the measuring scale will be in the form of interference bands. However, this should not interfere with the measurement. Determining the position of the light trace will be based on determining the position of the selected band. If during the experiment it transpires that the light trace moves during laser rotation, this will prove that the speed of light varies in different directions.

An experiment based on the proposed device can be one of the ways to falsify the Special Theory of Relativity and Special Theory of Ether. The existence of such falsifying experiment proves that the Special Theory of Relativity and the each Special Theory of Ether describe different physical realities, which is that the one-way speed of light is not only a conventional convention of the kinematics model.

The measurement of one-way light speed is a difficult and technically unresolved task. In the literature (Cahill, 2012: 43–45; Israel, 2011: 1–8; Iyer, 2010: 195–203), problems with measuring one-way light speed are discussed. Other work (Greaves, 2009: 894–896) proposes an electronic system for measuring one-way light speed, which according to the author determines it with an accuracy of 0.4%. This accuracy is smaller than that required for the testing of the first formula (1). In other papers (Finkelstein, 2010: 877–877; Klauber, 2009: 894–896) the accusation of this previously mentioned work (Greaves,

https://doi.org/10.37705/TechTrans/e2023003

2009: 894-896) is raised claiming that the method shown there does not really determine one-way light speed. In other research (Gift, 2012: 387–389), the author shows that GPS system indicated that the speed of light in vacuum is not isotropic. The literature (Spavieri, 2012: 795–797) also discusses the influence of the transport of clocks on the measurement of light speed and a conclusion is addressed that the discussed experiments do not lead to the measurement of one-way light speed. A negative falsification of the invariance of one-way light speed would have different consequences for theoretical physics. They could be the basis for the modification of dynamics (Szostek, 2019: 153–166) and have an influence on the interpretation of the theory of gravity (Szostek, Góralski, Szostek, 2019: 39–56).

Numerous works discuss the zero result of the Michelson-Morley experiment, from which the Lorentz-Fitzgerald contraction results (Yuan, 2021: 1–9; Akram, 2020: 60–64). There are also published papers showing the paradoxes of the Special Theory of Relativity concerning rotating frames of reference (Javanshiry, 2021: 1–8). The article (Choi, 2022: 155–164) investigates the subject of the addition of relativistic velocity. There are many papers on relativistic mechanics with significant theoretical results. Previous research presents the original definition of acceleration in the Special Theory of Relativity (Koczan, 2021a: 1–19) and develops the formalism for three-vector and four-vector relative velocity (Koczan, 2021b: 401–406). Other papers address important insights into time dilation in relativity (Nawrot, 2004: 518–520; Nawrot, 2014: 598–600), and present alternative ideas for relativity (Nawrot, 2017: 95–112).

Bibliography

Akram, L. (2020). The correct formulas of Michelson-Morley experiment. *Maghrebian Journal of Pure and Applied Science*, *6*(2), 60–64.

Cahill, R.T. (2012). One-Way Speed of Light Measurements Without Clock Synchronisation. *Progress in Physics*, *8*(3), 43–45.

Choi Yang-Ho (2022). Multiple velocity composition in the standard synchronization. *Open Physics*, *20*(1), 155–164.

Finkelstein, J. (2010). Comment on “A one-way speed of light experiment” by E. D. Greaves, An Michel Rodríguez, and J. Ruiz-Camacho [Am. J. Phys. 77 (10), 894–896 (2009)]. *Am. J. Phys.*, *78*(8), 877–877.

Gift, S.J.G. (2012). A simple demonstration of one-way light speed anisotropy using Global Positioning System (GPS) technology. *Physics Essays*, 25, 387–389.

Greaves, E.D., Rodriguez, A.M., Ruiz-Camacho, J. (2009). A one-way speed of light experiment. *Am. J. Phys.*, 77, 894–896.

Israel, P. (2011). On the experimental determination of the one-way speed of light. *Eur. J. Phys.*, *32*(4), 1–8.

Iyer, C., Prabhu, G. (2010). A constructive formulation of the one-way speed of light. *Am. J. Phys*., *78*(195), 195–203.

Javanshiry, M. (2021). The Mechanical Behavior of a Multispring System Revealing Absurdity in the Relativistic Force Transformation. *International Journal of Mathematics and Mathematical Sciences*, Vol. 2021, ID 2706705, 1–8.

Klauber, R.D. (2009). Can One-Way Light Speed be Measured? Comment on E. D. Greaves et al. *Am. J. Phys.*, *77*(10), 894–896.

Koczan, G.M. (2021a). New definitions of 3D acceleration and inertial mass not violating F=MA in the Special Relativity. *Results in Physics*, 24, 104121, 1–19.

Koczan, G.M. (2021b). Relativistic Relative Velocities and Relativistic Acceleration. *Acta Physica Polonica A*, *139*(4), 401–406.

Maurice, A. (1998). The Experiments of Dayton C. Miller (1925–1926) And the Theory of Relativity. *21st century – Science & Technology*, Spring, 26–32.

Miller, D.C. (1933). The Ether-Drift Experiment and the Determination of the Absolute Motion of the Earth. *Reviews of Modern Physics*, 5, 203–242.

Nagel, M., Parker, S.R., Kovalchuk, E.V., Stanwix, P.L., Hartnett, J.G., Ivanov, E.N., Peters, A., Tobar, M.E. (2015). Direct terrestrial test of Lorentz symmetry in electrodynamics to 10^{-18}. *Nature Communications*, *6*(8174), 1–8.

Nawrot, W. (2004). The Hafele and Keating Paradox. *Physics Essays*, 17(4), 518–520.

Nawrot, W. (2014). The Hafele-Keating paradox – Serious problems of the special theory of relativity?. *Physics Essays*, *27*(4), 598–600.

Nawrot, W. (2017). Alternative Idea of Relativity. *International Journal of Theoretical and Mathematical Physics*, *7*(5), 95–112.

Rizzi, G., Ruggiero, M.L., Serafini, A. (2004). Synchronization gauges and the principles of special relativity. *Foundations of Physics*, *34*(12), 1835–1887.

Spavieri, G., Quintero, J., Unnikrishnan, S., Gillies, G.T., Cavalleri, G., Tonni, E., Bosi, L. (2012). Can the One-Way Speed of Light be used for Detection of Violations of the Relativity Principle?. *Phys Lett A*, *376*(6–7), 795–797.

Szostek, K., Szostek, R. (2022). The existence of a universal frame of reference, in which it propagates light, is still an unresolved problem of physics. *Jordan Journal of Physics*, *15*(5), 457–467, ISSN 1994-7607, https://journals.yu.edu.jo/jjp/JJPIssues/Vol15No5pdf2022/3.html

Szostek, K., Szostek, R. (2017). The explanation of the Michelson-Morley experiment results by means universal frame of reference. *Journal of Modern Physics*, *8*(11), 1868–1883, https://doi.org/10.4236/jmp.2017.811110

Szostek, K., Szostek, R. (2018a). The derivation of the general form of kinematics with the universal reference system. *Results in Physics*, 8, 429–437, https://doi.org/10.1016/j.rinp.2017.12.053

Szostek, K., Szostek, R. (2018b). Kinematics in the Special Theory of Ether (in English). *Moscow University Physics Bulletin*, *73*(4), 413–421, https://rdcu.be/bSJP3 (open access) or https://doi.org/10.3103/S0027134918040136

Szostek, K., Szostek, R. (2018c). Кинематика в Специальной Теории Эфира (in Russian). Вестник Московского Университета. Серия 3. Физика и Астрономия, 4, 70–79, http://vmu.phys.msu.ru/abstract/2018/4/18-4-070

Szostek, R. (2019), Derivation method of numerous dynamics in the Special Theory of Relativity. *Open Physics*, 17, 153–166, https://doi.org/10.1515/phys-2019-0016

Szostek, R., Góralski, P., Szostek, K. (2019), Gravitational waves in Newton's gravitation and criticism of gravitational waves resulting from the General Theory of Relativity (LIGO). *Bulletin of the Karaganda University. Physics series*, *4*(96), 39–56, https://physics-vestnik.ksu.kz/apart/2019-96-4/5.pdf

Szostek, R. (2020a). Derivation of all linear transformations that meet the results of Michelson-Morley's experiment and discussion of the relativity basics (in English). *Moscow University Physics Bulletin*, *75*(6), 684–704, www.vixra.org/abs/1904.0339 (open access) or https://doi.org/10.3103/S0027134920060181

Szostek, R. (2020b). Вывод всех линейных преобразований, удовлетворяющих эксперименту Майкельсона-Морли, и обсуждение основ релятивизма (in Russian). Вестник Московского Университета, Серия 3. Физика и Астрономия, 6, 142–161, http://vmu.phys.msu.ru/abstract/2020/6/20-6-142

Szostek, R. (2022a). Explanation of what time in kinematics is and dispelling myths allegedly stemming from the Special Theory of Relativity. *Applied Sciences*, *12*(12), 6272, 01–19, https://www.mdpi.com/2076-3417/12/12/6272/htm

Szostek, R. (2022b). The original method of deriving transformations for kinematics with a universal reference system. *Jurnal Fizik Malaysia*, *43*(1), 10244-10262, https://ifm.org.my/viewpublication/637edcf8ef0a867aa5a22b39

Sposób pomiaru prędkości światła *i urządzenie do stosowania tego sposobu* (in Polish: *Method for measuring the speed of light and the device for the application of this method*), P.414434.

Yuan, Tony (2021). Why the Michelson-Morley Experiment Cannot Observe the Movement of Interference Fringe. *Open Access Library Journal*, *8*(11), e8011, 1–9.

Yuan, Zhong Zhang (1997). *Special Relativity and Its Experimental Foundation*. Singapore: World Scientific Publishing.

One-way light velocity instrument (in Chinese), Chinese Patent Office, CN101000265 A.