The article in this table is by Prof. Roman U. Sexl, page 241 to page 285.

Professor Sexl used the hollow-world theory as an illustrative example.
In his teaching and lectures, he did not address the straight section spreader as proof of measurement.

Prof. Roman U. Sexl also gave this lecture at the general meeting of the German Association for the Promotion of Mathematical and Scientific Education in 1983 in Tübingen

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Wilfried Kuhn

Director of the Institute for Didactics of Physics

Justus Liebig University Giessen on his 60th birthday on May 6, 1983

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Roman U. Sexl THE THEORY OF HOLLYWOOD

The hollow-world theory is a physical theory that was advocated in the US in the 19th century and in Germany in the 20th century, among others. According to it, the Earth is a hollow sphere in which we live and where the stars, the sun, and the moon are also located. At first glance, this theory sounds completely nonsensical, and it is believed that it can be refuted with a few brief arguments. However, it soon becomes clear that, no matter how detailed the considerations are, difficulties still arise and that an experimental refutation of this theory is in principle impossible if one proceeds from suitable fundamental laws of physics. This opens up interesting aspects regarding the cross-connection between physics and philosophy, the question of the correctness of the physical worldview, and the provability of theories by means of experiments.

1. The magic of the hollow world.

One of the most beautiful motivations for engaging with physics lies in the fusion of exact mathematical representation with profound philosophical questions, with questions about the origin, history, form and fate of the universe. In cosmology, the separation between (1.) the "Two Cultures" described by CP Snow, or the "Two Mindsets" that

when human works are weighed, with three treatises on formic acid, and if there were thirty?! On the other hand, what do you know about the Day of Judgment if by then you do not even know what can become of formic acid?!"

The combination of exact mathematical and experimental analysis with epistemological, philosophical, historical, humorous and essential considerations of this world is necessary if physics is not to present itself to the student as a science from which "remarkable nothing comes", as music does, he states in the first chapters of his book. How necessary the merging of different worlds is for a truly profound understanding of physics is demonstrated here by means of one of the most remarkable and also most enchanting "alternative worldviews", the hollow-world theory (3.).

One of its origins lies in the small American town of Utica in the state of New York. There, in 1870, the homeopath Cyrus Reed Teed published a booklet titled "The Illumination of Koresh:

"Marvelous Experience of the Great Alchemist in Utica, New York". In a nocturnal vision, a beautiful woman revealed a new worldview to him: the hollow world theory was born, according to which the Earth is a hollow sphere and we live (Fig. 1). Inside the Earth, the sun, moon, stars, planets, and comets are also found and show themselves in all their splendor. The antipodes, on the other hand, remain hidden from us because the atmosphere inside the sphere is too dense. The sun itself was, in Teed's theory, composed of two hemispheres: one luminous, one dark. Their rotation causes day and night. However, it does not appear directly to our eyes, but—just like the other celestial bodies—only in reflections on various surfaces.

Teed also worked out the physics of the hollow world in detail. In his book "The Cellular Cosmogony," he discusses optical phenomena, among other things, and shows that the apparent spherical shape of the Earth is an optical illusion. But he also discusses the Foucault pendulum, whose movement is attributed to the influence of the sun. Just like 'Scientology,' Teed turned his worldview into a religion. He first began preaching in Chicago, where he found more than 4,000 followers. Later, he founded the city of Estero in Florida, where only 200 of his followers followed him, and even founded his own magazine, "The Flaming Sword," which was published until 1949. Finally, in 1962, the "Hollow World National Park" was established in Estero, as the "Miami News" reported on April 22.

During the Third Reich, the hollow world theory also gained a foothold in Germany. In 1938, one of its most important representatives, Johannes Lang, was able to present his book "Die Hohlwelttheorie" in the second, "significantly larger and improved edition."
(4). The heading of the first chapter, "Is the Copernican system proven?", immediately touches upon a central question that also proves to be of eminent scientific-theoretical importance. The answer Lang finds is not surprising: "The Copernican worldview, which is now generally regarded as proven, is in reality completely unproven in all its parts" (5.).

However, at that time the doctrines represented in different countries differed: "In the institutions of higher education in Switzerland, it is therefore taught that it
The Copernican worldview is unproven, but requires no proof because it is the only one.

is a worldview that describes and can uniformly explain all phenomena in the universe in an informal way.

This position may once have been justified. Now it has become untenable, since there is another worldview that also explains all phenomena uniformly and informally" (6).

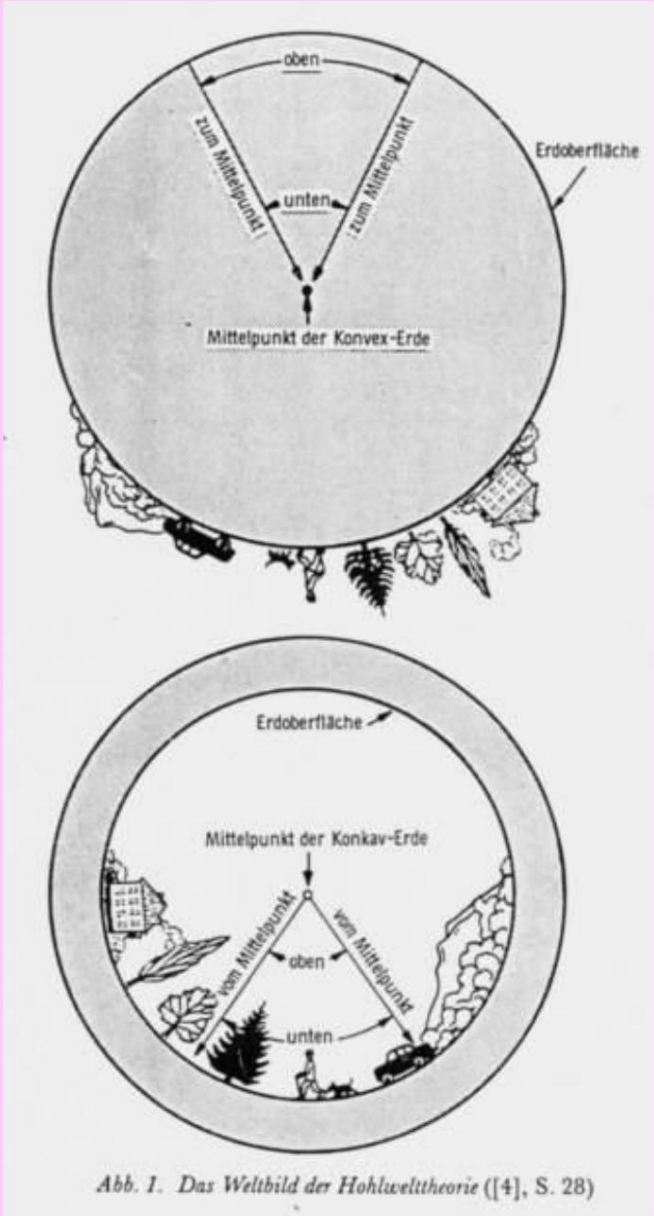

Abb. 1. Das Weltbild der Hohlwelttheorie ([4], S. 28)

This is also explained in detail in the following, and explanations of gravity, centrifugal force, electricity, and the formation of the horizon in the concave are found, as well as remarks on "hollow world theory and religion". Lang even seems to have found a unified field theory in the chapter "The various forces as manifestations of the primordial force". We will have to return to some of his explanations.

But Lang offers not only physical 'proof' for his cosmic alternative solution. Philosophical arguments are also put forward:

Is the theory of the hollow world not of miraculous unity?
From the very largest (cosmos) to the very smallest (microscopic egg cell), characterizes the same relationships. If modern man could still think truly philosophically, he would create the beautiful harmony as the Ancients did, and unity in the entire creation must be acknowledged.

Man emerges from the egg, this image of the cosmos. The cells of which he is composed are an image of the cosmos. All life originates in a hollow sphere" (7.).

Thus Lang concludes: "For the philosophically thinking person, the conclusion by analogy is a by

and through sufficient

credibility of the new worldview of the earthly world" (8.).

2. Alternative worldviews and what to do about them.

This brief history of the hollow-world theory has served me for years as an introduction to a lecture on "Space - Time - Matter". In it, the hollow-world theory is presented and it is explained that the Earth should contain the sun, moon, planets, and stars within its interior, as evidenced by the writings of the theory's founders. The students are now asked to comment on this curiosity regarding the alternative world based on their knowledge of physics. The uniform rejection is quickly justified by a number of recurring objections. Usually, the following problems emerge:

- How do day and night originate?
- How is the horizon created?
- How is gravity explained?
- How can the little sun produce the necessary energy?
- What happened during the moon flight?
- Don't the photos of the Earth from space clearly show a solid sphere?
- What is outside the world?

These are the most important of the recurring objections that are addressed and refuted in the lecture on the basis of a slightly modified form of the hollow-world theory (9.). Insofar as the objections relate to the propagation of light and the origin of day and night, they can easily be refuted by referring to an illustration from Lang's book (fig. 2). It shows that light rays propagate in circles that always pass through the center of the earth. The speed of light is not constant, but decreases quadratically towards the center of the earth, so that this point in the world is never reached by the light.

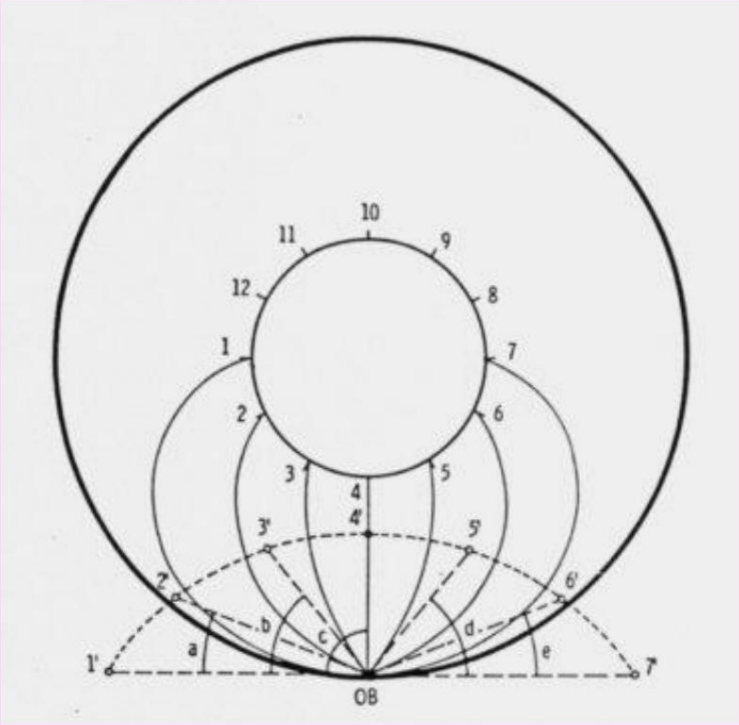

Figure 2	**Light spreads in the hollow world in circles through the center of the earth ([4], page 148).**
Outer circle:	Earth's surface (equator)
Inner circle:	fixed star ball
IF:	location of the observer
1 to 12:	True places with fixed stars
1' to 7':	Apparent locations of the fixed stars 1 to 7
Straight line (1'to' dashed) :	horizon
Semi-circle line (dotted) :	firmament
a toe:	corner

The law of propagation of light also explains how the horizon is formed and shows why the Earth is seen as a solid sphere from space. This optical illusion is also due to the laws of propagation of light.

All questions regarding the motion of bodies in the hollow-world theory can also be easily analyzed. Newton's equations of motion turn out not to be entirely correct. Instead, these equations should read:

$$m\left(\ddot{x}-\frac{4\dot{r}\dot{x}}{r}-\frac{2\ddot{r}x}{r}+\frac{6\dot{r}^2x}{r^2}\right)=\frac{r^2}{R^2}F, \qquad (1)$$

where r = 1xIf is the distance of the observed point from the center of the Earth and R = 6370 km indicates the radius of the Earth. In the case of gravity, the corresponding force word for the Earth's gravitational field is, for example (10.);

F = (mMG/R4) rx (2)

It is, of course, not immediately clear that the newly formulated "Lang's equations of motion" correctly represent the orbits of all celestial bodies and can also describe the motion of terrestrial objects. However, students are usually willing to accept that the calculation of orbital shapes, which can easily be performed using a computer, does indeed lead to results that correspond to observations.

But what about moon rockets? According to hollow world theory, the moon should be only about 1 km in size and about 120 km away from the center of the Earth. Wouldn't a moon rocket appear too large here, which contradicts the images that have become known from the moon landings? It must be taken into account here that, in hollow world theory, all objects shrink as they approach the center of the Earth. Mathematically, this relationship is expressed in the expression

$L = L_0 (r^2/R^2)$ (3)

summarized, where L represents the size of the object on the Earth's surface.

This law is surprising at first, but there are similar phenomena in other areas of physics. For example, objects can also expand under the influence of temperature or contract under the influence of velocity, as in the theory of relativity.

teaches. In any case, the remarkable formula (3) can now explain why people on the moon appear so small. Its length was also only 3.4 cm. Fortunately, (3) is a reversible shrinking process and upon returning to Earth the astronauts were back in their usual human form. I

Now the important energy production of the sun, which has a diameter of only about 2.2 m because of its small distance from the center of the earth, about 270 m, is also clear. The atomic nuclei, electrons, light quanta in the sun have also shrunk to small sizes because of (3).
The calculation shows that the hollow-world theory arrives at the same number of particles in the sun as the usual "confused school wisdom".

This answers some typical and recurring questions. However, we have avoided a difficult problem in our considerations above: what happens if a supporter of the full-world theory tries to drill a hole through the earth and ends up at the antipodes? First of all, a fervent supporter of the hollow-world theory might answer here that this is a metaphysical question as long as no one has performed the experiment.

But after some thought, he could also find an answer within the hollow-world theory: if the experiment has the outcome his opponent expects, then this too is easy to explain. Because atoms—in the hollow-world theory—contract towards the center of the Earth, they expand more and more as they penetrate the Earth's shell. The deeper you go into the Earth, the

larger the atoms you find there. However, this cannot be determined immediately, since the drill used for penetration consists of increasingly larger atoms. According to (3), the increase in size is so strong that the drill will soon reach infinity (11.). But then the hollow world theory must be supplemented by a remarkable law of symmetry, which applies to all wave functions of quantum mechanics (if you want to use that modern language). It applies

$$\psi(x) = \psi(-x) \text{ für } |x| \to \infty . \qquad (4)$$

The drill, advancing in one direction towards infinity, therefore returns from the opposite direction and breaks through the Earth's surface again at the antipodes. This - "Metaphysical" - fact also finds its convincing explanation.

This dialogue usually lasts about one to two hours, during which all the students' objections to the new worldview can be refuted. The mood in the lecture hall fluctuates between resignation and indignation. For empirical reasons, studying physics makes it impossible to dismiss such a senseless assertion as the hollow-world theory in a few minutes. Everything that previously appeared as proof of the Copernican theory now becomes proof of the hollow-world theory. If it is true that the conventional worldview of physics has been experimentally proven, then those same experiments have now also proven the hollow-world theory. The empirical view of the world, which has become second nature to the physics student through his work in practicals and laboratories, is beginning to falter.

3. The three-tiered world age of the Bible.

A few years ago, a book by Fritz Braun (12.) appeared in Rauschenberg in Central Franconia: "The Three-Story Universe of the Bible". It attempts to demonstrate that all contradictions between a literal interpretation of the Bible and the worldview of the natural sciences can be eliminated by the theory of the hollow world. The qualified physicist Fritz Braun also reveals the mystery of the hollow world: "Like a flash of enlightenment all these questions are answered and the contradictions disappear when the so-called 'transformation of mutual rays' is used.

Through this operation, a mathematician connects the space outside a sphere with the space inside. If one applies this transformation to the Copernican worldview, one suddenly recognizes a world that corresponds down to the smallest details to the three-tiered universe of the Bible. The model-like laws and relationships discovered by Kepler and Newton remain intact. The terrifying distances of billions of light-years disappear, as do the infinite void and meaninglessness. One recognizes heaven as the throne of God at the center of the universe!

Through this transformation, the straight light rays of the Copernican worldview are converted into curved rays. This explains the fact that the small solid star sphere at the center of the universe appears enormously magnified, so that it becomes visible as the celestial sphere. The speed of light, which according to Copernican theory is constant throughout the universe, will decrease sharply towards the center after the transformation. This explains, for example, why a light ray from the Sun to the Earth's surface takes about 8 minutes, even though the distance is now much shorter than in Copernican theory. ...

Braun's book thus shows the solution to the riddle. To arrive at the laws (1,2,3), it is only necessary to use the transformations of the inverse rays in all known laws of physics.

rH *rK = R² (5)

to carry out, where r and r„ represent the distances from the center of the earth in the hollow world or in the Copernican worldview. In this way, one worldview can be converted into the other. If the old worldview is experimentally irrefutable, the new one is too. The change in topology caused by the transformation (5) can also be corrected by the boundary condition (4) that we have formulated here for wave functions.

The mystery is solved, and the hollow world now appears solely as a mathematically equivalent form of the conventional worldview. Both can be converted into one another. During the lecture, everyone leans back in their chairs, satisfied. But immediately the next problem arises: the conventional worldview of physics is based on experiments. These same experiments now also support the theory of the hollow world. Therefore, no physicist can refute the notion that the earth is hollow and that we live inside. Do you intend to teach this view as equal in the future, or if not, why not? Should the hollow-world theory become the new school curriculum? As an alternative worldview more in line with the Bible than our conventional physical education? Fundamental problems of the philosophy of science become relevant for the physics student. The listeners address professional ethics and draw up a list of arguments against the Hollow World Theory.

4. The wrong worldview?

In 1962, Joachim Herrmann published a report titled "The False Well Image" containing "a critical study of astrology, world ice theory, hollow world theory, solar habitability, flying saucers and other astronomical heresies" (13.).

Herrmann says:
Of course, space travel in the hollow world would be unthinkable. The moment the first rockets can leave Earth, not only for strides through the atmosphere, but for hundreds of thousands or millions of kilometers, the arbitration regarding the hollow-world theory would be more definitive, but especially for those who have no astronomical knowledge at all. ...

Millions of people have seen the small artificial moons in the sky with their own eyes. The time of the hollow-world theory is finally over. Unfortunately, refuting the alternative worldview is not that simple.

Yes, as we have seen, a refutation in the sense of an experimental proof to the contrary cannot exist at all (or it would also refute the usual worldview). This problem is also important because it is typical of many arguments with the "alternative worldviews" often proposed by "outsiders of science" (14.). As an introductory remark, it should first be noted that the systematic mathematical treatment by the transformation of the inverse rays (5) is not typical of the emergence of such an alternative worldview.

In Johannes Lang, for example, there is no systematic representation of the hollow world. A follower of the new doctrine would usually not welcome this, as his worldview would be merely a reformulation of "outdated school wisdom". Instead, experimental evidence is sought for the new views. Within the "rational reconstruction" of alternative worldviews presented here, this presents itself as an incomplete transformation of the standard worldview. The transformation equations (5) are not applied to all phenomena, but usually a part of the old physics is adopted unchanged. Lang's 'sailing experiment' is an example of this. As the image shows:

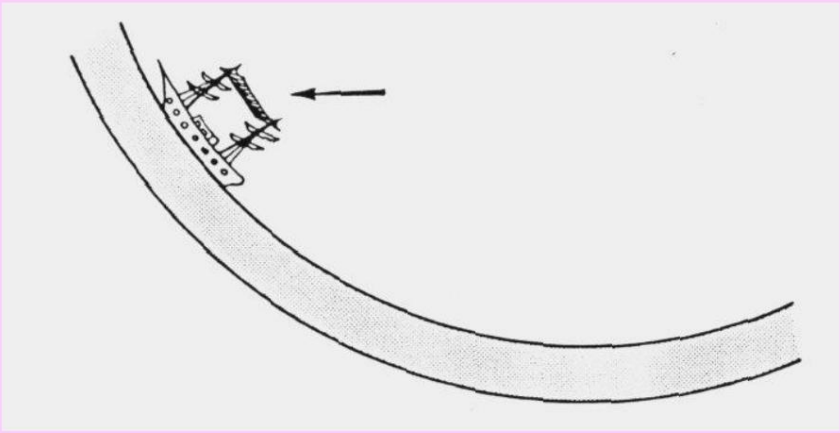

Fig. 3: The sailing experiment. Na 141, p. 32.

The ship went out to sea and "the red piece of canvas gradually became smaller and smaller and the dazzling white of the upper canvas surface suddenly appeared and became increasingly clear! The observing" scientists looked astonished..." (15.) But even the hollow-world theorists should look astonished if the experiment really turned out this way, for a little later (fig. 4) there is a drawing (16.) in the book that shows the curvature of the light rays, which is to be postulated by the hollow-world theory. Whereas in the first figure the paths of the light rays were not covered by the transformation (5), they are now included in the second figure.

This is typical of the situation one often encounters. The transformation to the new worldview is carried out incompletely and modified as needed within the general theory. If there is "experimental evidence" to the detriment of the new theory, the incomplete transformation can be added at this point. This results in a very flexible adaptation to new empirical findings, and an attempt to refute the proponent of the new theory based on experiments proves to be "transcendental"—which here may mean going beyond any possible human patience.

Moreover, many objections to the theory of relativity, and many alternatives in this field, follow exactly the scheme given here, using mathematical transformations that imply a partial return to the theory of the ether, as indicated elsewhere (16.).

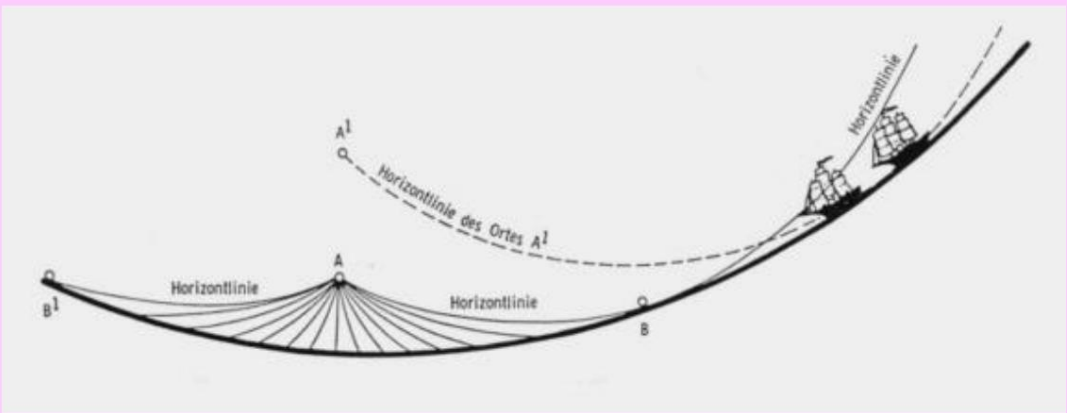

Fig. A: In the correctly transformed hollow-space theory, the observer should see the underside of the sail exactly as usual.
According to (4.), p. 172.

But now back to the scientific-theoretical objections to the hollow world. What objections are usually raised in the lecture against the 'wrong worldview'? After it has been made clear that no experimental refutations are possible, the reasons cited for the preference for the old, Copernican wave view are usually:

a) Simplicity

b) clarity

c) Freedom of choice

To justify a), it is argued that the laws of motion (1.) in the hollow world theory are much more complicated than Newton's laws. However, of two theories explaining the same facts, the simpler one is preferred. There is certainly a kernel of truth in this argument, but it is also problematic.

To explain, for example, the deviation of Mercury's orbit from Newton's ellipse, one could just as well use a simple modification of the $1/r^2$ law by the
to change the exponent instead of the complicated theory of relativity. Would this argument then not also support the replacement of general relativity by .? speak for more easily understandable theories?
Clarity is now put forward as the most important argument for the standard theory. In it, the theoretical explanations correspond much more directly to appearance than is the case in the hollow-world theory. But is it really so clear that the sun is an enormous glowing ball of gas?

Does a 1 km wide moon not correspond much better to the impression of the night sky? With regard to arbitrary freedom it is argued that instead of transformation (5) one could just as well use many other transformations that offer alternatives to our standard worldview. One could thus construct a theory of a hollow moon, or even a theory of a flat earth. On the other hand, could a representative of the hollow world theory not think that the Copernican worldview is merely one of the many arbitrary transformations of the hollow world?

These arguments and answers reveal all the uncertainty that befalls the physicist untrained in the theory of science when he becomes involved with questions concerning the foundations of his field, but which cannot be easily resolved experimentally. It also demonstrates the necessity of a scientific-theoretical and historical foundation for the subject, which Wilfried Kühn frequently emphasizes and which is also expressed in his books.

Finally, it should be outlined how the problem can be approached from, for example, Popper's theory of science and how historically interesting parallels arise with the controversy of ether theory versus relativity theory. Popper emphasizes falsifiability as a "demarcation criterion" of scientific theories (17.). How do hollow-world theory and Copernican theory differ in this respect? For the hollow-world theorist, decisive changes take place in an experiment when it is not performed on the Earth's surface, but at some height in space. When the experimental setup is lifted, the size of all atoms in it changes, the speed of light changes, forces are altered, and structures are altered.

But miraculously, all experiments far from the Earth's surface yield the same result as on the Earth's surface itself: the gravitational constant has the same value, elementary charges and masses, and the speed of light measured in "naive units" remains the same.

It seems unsurprising to the hollow world theorist, but he would easily have another

can explain the result. If, for example, he finds a value of the gravitational constant at a certain height that deviates from that at the Earth's surface, he can easily account for this by adjusting his theory. Such a change does not seem surprising to him; it is rather surprising to him that the numerous complex effects resulting from a shift in height always stand out in the result of all experiments due to enormous randomness.

For the "Copernican," on the other hand, the agreement of results obtained at different heights is a matter of course. After all, the homogeneity and isotropy of space—i.e., invariance against spatial shifts and rotations—are built into the basic structure of his worldview from the very beginning. Any height dependence of the experimental results would not only be a surprising result for him, but one that calls into question the foundations of his theory. His theory is therefore easier to falsify than the hollow-world theory, which knows no homogeneity of space and can therefore accept any possible height dependence of the experimental results.

From the physicist's point of view, we can view the result differently: the symmetry groups in every theory are fundamental. In fact, these symmetry groups make it possible to combine results obtained in different systems, by different observers, or at different times. The numerous relationships arising from the group structure are among the most important predictions of the theory. Due to their strictness, these predictions are particularly easy to falsify. From Popper's point of view, theories with invariance groups are therefore essentially superior to other theories because of their falsifiability.

The history of the theory of relativity offers an instructive example of these considerations. In the ether theories, there was no special point in space, but a special velocity, and thus a special reference system, namely the one in which the ether is at rest. To what extent the ether wind, which was supposed to cause movement through the ether, influenced the test results was a question that had to be resolved primarily experimentally.
Therefore, countless experiments on various bases attempted to determine the movement of the Earth through the ether.
The negative result of all these experiments could always be interpreted without contradiction in ether theory by a suitable modification of the basic equations, such as by incorporating the Lorentz contraction.
However, every positive result of these experiments could have found a satisfactory explanation within ether theory. While ether theories are therefore difficult to falsify, the situation in special relativity is quite different.

Here the ether is eliminated as an element of theory formation and a much larger symmetry group, the Lorentz group, characterizes the structure of the theory. It now necessarily follows that an experiment the movement of the earth through the - non-existent - ether can determine, and it also necessarily follows that the result of every experiment must therefore be independent of the speed at which the laboratory in question moves. Here finds a convincing explanation for the negative outcome of all experiments that have set themselves the aim of determining the movement of the earth in the ether.

However, a positive outcome of the experiments would be completely incompatible with the theory and would mean a falsification of the foundations. Therefore, from an epistemological point of view, the theory of relativity is superior to the ether theory. This is at least one possible viewpoint capable of describing the "dynamics of the theory", i.e. the historical replacement of various physical theories, in this case (18.).

The hollow world theory presents itself in a completely analogous way: there is a special point in space that prevents every spatial symmetry group.
Incidentally, that also applies to the Aristotelian worldview, in which the center of the

earth (albeit a full earth) was distinguished. With the 'Copernican turn', the transition to a theory with a larger symmetry group and consequently an elevated position takes longer.

We have presented these historical and epistemological considerations here solely by means of the example of Popper's philosophy. In a similar way, the statements and arguments of other philosophers of science can now be applied to hollow-world theory and similar cases and put into practice. The profound emotional result that the empirical irrefutability of hollow-world theory offers many physics students is always, in the background, the driving force for further studies.

This demonstrates once again how a didactically suitable starting point can be an essential and decisive driving force for dealing with new territories and unknown arguments. Physics, didactics, history, and philosophy of science merge into a unity that is also reflected in the writings of Wilfried Kuhn.

Comments

1. **CP Sneeuw, The Two Cultures. Stuttgart. 1967**
2. **Robert Musil, The Man Without Qualities. Reinbek near Hamburg. 1960. p. 248.**
3. **Here I follow the presentation by M. Gardner, 'Fads and Fallacies' in the Name of Science, New York. 1952. pp. 16-27. I also thank Mr. Martin Gardner for providing important source material on the hollow world theory.**
4. **Johannes Lang, The Theory of the Hollow World. Frankfurt. 1938**
5. **See 4, p. 11**
6. **Reference 4, p. 14**
7. **Reference 4, p. 150**
8. **Reference 4, p. 20**
9. **The classification of these abnormalities is discussed in Chapter 3.**
10. **Equations (1) and (2) were not found in Lang, but were obtained from the transformation (5), as well as the following information about the sun and the moon.**
11. **Thus the earth extends here into infinity, whereas in Lang it is said that it is merely a spherical shell with a thickness of 200 km.**
12. **Fritz Braun, The Three-Story Universe of the Bible. Rauschenberg OJ. I only had access to the book in an English translation. The quotations have therefore been translated back into German by me.**
13. **Joachim Herrmann, The Wrong Worldview, Stuttgart. 1962, p. 116. 1141 Roman U. Sex, Physikalische Blatter, 30, 19 (1975). 115t ref.4, blz. 32 en blz. 172**
14. **Roman U. Sexl and Reza Mansouri, General Relativity and Gravity 8, 497 (1977).**
15. **Karl Popper, The Logic of Research. Tubingen 1971**
16. **See for example Elie Zahar, Why Einstein's programs replaced those of Lorentz? British Journal Philosophy of Science 24, 95-123 and 223-262 (1973). This article is written from the perspective of Lakatos' philosophy of science.**