UNIT 1 RELATIVISTIC REVOLUTION: SCIENTIFICO-PHILOSOPHICAL IMPLICATIONS

Contents

1.0 Objectives
1.1 Introduction
1.2 Historical Background of the Theory of Relativity
1.3 The Special Theory of Relativity
1.4 The General Theory of Relativity
1.5 Some Philosophical Implications of Relativity
1.6 Let Us Sum Up
1.7 Key Words
1.8 Further Readings and References
1.9 Answers to Check Your Progress

1.0 OBJECTIVES

The main objective of this unit is to introduce the student to one of the most revolutionary and creative theories in science and to point out some of its deeper philosophical implications. The theory under consideration is the Theory of Relativity, which was discovered by Albert Einstein. This unit will first present the historical and scientific background in which the theory was born. This is done to bring home to the student that scientific theories do not arise in a vacuum. They have a clear-cut historical setting and context. Next we will present the basic elements of the Theory of Relativity. This discussion will show that many of the concepts in science have a philosophical aspect. Finally, we will discuss the important consequences and philosophical implications of this theory. This section will show that the Theory of Relativity has tremendous philosophical significance. From the philosophical point of view the most important objective of this unit is to show that philosophy and science are closely related. Often many think that these two are very different, and hence philosophy of science is something unnatural and artificial. Our study of the Theory of Relativity and its philosophical implications will show that philosophy and science are closely interconnected. In this theory we will see the close connection between the two. In fact, Einstein himself was both a scientist and a philosopher. Often he is considered a philosopher-scientist because in his thoughts and discoveries one can see both science and philosophy coming together in a natural and harmonious way.

1.1 INTRODUCTION

The advent of the Theory of Relativity and of Quantum Mechanics has revolutionized the whole domain of science. They questioned some of the age-old concepts such as absolute motion, absolute space, absolute mass, wave nature of particles, unlimited perfectibility of experimental results, etc. They brought in certain radically new concepts, and gave new insights into several puzzling phenomena in nature.

Towards the end of the nineteenth century it became abundantly clear to scientists that the real trouble spots in scientific inquiry were in the subatomic world at one end and in the fathomless depths of intergalactic space at the other end. Quantum Mechanics arose in an effort to answer the problems hovering in the subatomic world and Relativity in the 'ultra-giant' and 'ultra-fast' world. In this chapter we discuss the Theory of Relativity only.

THE IMPORTANCE OF THE THEORY OF RELATIVITY

To show the all-pervasive importance and relevance of Relativity in theoretical science today, we give a few quotations from leading writers. Thus H. Margenau writes, "In fact the theory is now so well corroborated by experience and assimilation into the whole of modern physics that its denial is almost unthinkable. The physicist is impressed not solely by its far flung empirical verification, but above all by the intrinsic beauty of its conception which predisposes the discriminating mind for acceptance even if there were no experimental evidence for the theory at all." Again, Hutton, "Relativity has profoundly changed the whole of physics. By the analysis of the fundamental concepts of space and time, of mass and of force, it has given a new orientation not only to science, but also to our approach to philosophical problems in general. The concepts of space and time, force and mass and causality have undergone a radical revision through relativity. The model we make of the physical universe has changed." Again, "Here the concept of thing and mass are replaced by the concept of field, and with it disappear the forces between things. Since force and causality are closely connected in classical physics, the concept of causality is also affected." Also L. Barnett says, "Relativity and Quantum Mechanics are the two pillars of modern physical thought." Such quotations can be multiplied indefinitely. The quotations here from eminent science writers show that the coming of Relativity brought very important changes in the fundamental concepts of space, time, mass, force, etc. Since these concepts are closely related to philosophy, Relativity had a very important impact on philosophy as well.

1.2 HISTORICAL BACKGROUND OF THE THEORY OF RELATIVITY

Sir Isaac Newton was one of the greatest scientists ever lived. He is famous for his discovery of the Law of Universal Gravitation. This law states that all material bodies attract each other with a certain force. The more the mass or quantity of material stuff in a body, the higher the force with which that body attracts other bodies towards it. Thus the sun exerts an attractive force on the earth. That is why the earth goes around the sun. Now we need to keep in mind that the sun is 150 million kilometres away from the earth. Still the sun exerts a physical force on the earth and drags the earth around it. Surprisingly, there is no observable physical connection between the sun and the earth – no rope or string is tied from the sun to the earth. So the sun seems to be dragging the earth around it without any physical connection. This situation is usually referred to as "action at a distance." Now in physical science such a situation is not understandable since some kind of linkage is needed for one body to move another body physically. It was proposed that there was a medium linking the sun with the earth, and the sun exerts its gravitational attractive force through this medium. This medium was named "ether." This ether was expected to pervade all space.

Ether was called in to play another role also. This came from the discovery that light is made up of waves which go up and down like water waves. Now this kind of up and down wave motion also requires a medium. It was found that light travels not only in the atmosphere where there is air as the medium, but also in vacuum or empty space where there is no known physical medium. For instance, when light comes from the sun to the earth, it passes through areas which are empty of matter. How can real light waves travel through empty space? This also was unthinkable in physical science in the 19th century. Hence scientists assumed that the whole empty space was filled with ether, and light waves were travelling through the ether medium. Again, Newton believed that absolute motion existed. As we know, usually we experience motion as relative. For instance, a little child inside a smoothly moving bus will say that the people on the road are moving (in the opposite direction), whereas the people on the road will say that the child and the bus are moving away from them. When a body is having absolute motion, everyone in the universe will say that that body is moving. Now this absolute motion needs an absolute frame of reference. Newtonian scientists said that ether was this absolute frame of reference. Thus ether medium became very important in science in the 19th century having many crucial functions to perform. But no one had any experiential or experimental knowledge of this ether medium. Scientists, therefore, started an all-out hunt to detect and identify this medium of ether.

Many new theories were proposed and ingenious experiments were devised by scientists to identify and detect this medium of ether. The most important one was done by two ingenious experimental scientists by name Michaelson and Morley in 1887. This was a brilliant experiment, and was performed with utmost care and ingenuity. They got the Nobel Prize for this experiment. Commenting on this experiment a science writer, Gaston Bachelard, wrote: "Michaelson-Morley Experiment roused Classical Physics (Newtonian Physics) from its dogmatic slumber." We will not go into the theories and technicalities of this experiment. The interested student can find them in any standard book on the topic. Suffice to say that the experiment was a grand success, but it could not detect any ether medium. The failure to detect the ether medium by such an ingenious and well-executed experiment became a shocker for scientists. Several attempts were made to explain the "negative result" of this experiment. Practically all of them tried to save the ether medium by saying that the medium existed, but because of certain special circumstances we were not able to detect it.

It is here that Einstein showed his real genius and creativity. First of all he said that a well-performed experiment would never give a negative result, it would always reveal a positive fact about nature. It is our duty to find out what this positive fact is. According to him, what the Michaelson-Morley experiment had revealed was that there was no way to detect the ether medium. He further showed that there was no need for the ether medium in science. Einstein's answer to the "negative result" of this experiment gave rise to the Theory of Relativity.

It may be noted that some historians of science hold the view that the Michaelson Morley experiment did not have any central role in the origin of the Theory of Relativity. In this small unit we will not discuss this view since our focus is not on the history of science, but is on the philosophy of science.

Check Your Progress I

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1) Why is a discussion of the Theory of Relativity important in philosophy of science?

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

2) Explain the historical background of Relativity and its significance for philosophy of science.

…………………………………………………………………………………….

……………………………………………………………………………………..

……………………………………………………………………………………..

WHAT IS RELATIVITY?

Some Important Concepts

The Theory of Relativity is a highly technical theory, and so to understand it clearly we need to clarify a few concepts.

Absolute: Absolute in this context means same for all or applicable for all in all places and at all times. Thus an absolute principle is a principle that is applicable to all human beings in all places and at all times. For instance, when I say "2 + 2 = 4" is an absolute statement, what I mean is that this equation is accepted by all at all places at all times.

Relative: Relative is the opposite of absolute, and it means "in relation to something else." When I say that the motion of a car is relative, what I mean is that the car is in motion relative to or with respect to the surface of the earth. The earth here is taken as stationary.

Frame of Reference: A frame of reference is the point or place from which observations are made and measurements are taken. Any place can be a frame of reference. Your school compound can be a frame of reference since from there observations can be made and measurements can be taken.

Velocity: Velocity is the same as speed, with one difference that for velocity we have to specify the direction of motion. A car moving at 60 kilometres per hour from North Delhi to South Delhi has a speed of 60 kilometres, but it has a velocity of 60 kilometres towards south.

Mass: The concept of mass is something very special in Newtonian science or classical science. It is deeply involved in the mathematical aspects of Newtonian mechanics, and hence it is difficult to offer a clear definition of it. It can be considered as the quantity of material stuff of a body. The more the material stuff of the body, the larger its mass. Note that mass and weight are often taken to be identical. Although these two often have the same numerical value, conceptually they are very different. Weight is the **force** with which a body is attracted by the earth, whereas mass, as mentioned already, refers to the quantity of material stuff of a body.

Body: The term body is very often used in physics and other sciences. This is a general concept and refers to any material body. Thus a stone is considered a body in the physical sciences. The human body is also a body in so far as it is made up of matter.

THE THEORY OF RELATIVITY

In everyday language we can say that Relativity is a theory which holds that concepts like motion, length, time, mass, etc., are not absolute, but relative. They make sense only when related to a frame of reference. Thus an astronaut of mass say 80 kilograms on the surface of the earth (first frame of reference) may have a mass of 100 kilograms while inside a fast moving rocket (second frame of reference). A different technical definition is given by Eddington, when he says that Relativity is "An attitude which leads to the conclusion that we observe only relations between physical entities."

TWO DIFFERENT THEORIES OF RELATIVITY

Einstein gave us two theories of Relativity: The Special Theory of Relativity, given in 1905, and the General Theory of Relativity, given in 1915. The Special Theory of Relativity considers a special case of bodies which are moving with uniform speed in a particular direction. On the other hand, the General Theory of Relativity considers bodies moving with any kind of speed, uniform or non-uniform.

1. 3 THE SPECIAL THEORY OF RELATIVITY

The Special Theory of Relativity is less difficult to understand compared to the General Theory of Relativity. We will discuss this one in some detail.

TWO POSTULATES OF THE SPECIAL THEORY OF RELATIVITY

To develop his theory Einstein had to accept two claims as given facts which cannot be changed. He called them "Postulates." There are different ways of stating these Postulates. We will take a simple, non-technical version.

Postulate 1: This says that all frames of reference are the same as far as physics is concerned, provided they are moving with uniform speed or velocity with respect to each other. They all behave in the same way. The laws of physics are equally applicable in all frames of reference.

For instance, let us take two frames of reference: The platform of a railway station and the compartment of a train moving smoothly with the same speed all the time. Those playing cards can do so inside the train just as well as on the platform. Since all frames of reference behave in the same way, we cannot talk of a preferred frame of reference. Since there is no preferred frame of reference, Einstein concluded that there was no absolute frame of reference because an absolute frame of reference had to be a preferred frame of reference.

Postulate 2: This Postulate talks about the special, unique nature of the velocity of light. Relativity assumes that the velocity of light is something very unique. According to it, the velocity of light is absolute, i.e., same for all at all places and at all times. It is the highest velocity possible for any material body. No material body can have a velocity higher than the velocity of light. This velocity is independent of the motion of the source or of the observer.

It may be noted that Relativity is now introducing something absolute into its very core. In other words a theory which advocates the relativity of space, time, mass, etc., is built on the assumption that the velocity of light is absolute.

SOME IMPORTANT CONSEQUENCES OF THE THEORY OF RELATIVITY

Basing himself on these two Postulates and using very important mathematical tools and other principles, Einstein developed the Theory of Relativity. It has a number of very surprising, counterintuitive consequences.

Relativity of Length

According to Relativity, length (space, distance) is not absolute, but relative. It is relative to a frame of reference. Usually, when we say that a stick is 5 feet long, what we mean is that it has a length of 5 feet with respect to the earth taken as the frame of reference. What Einstein says is that if we were to take some other frame of reference, this length need not be 5 feet. For instance, suppose the same stick is put in a space-shuttle moving with a velocity comparable to the velocity of light, then the same stick will have a different length with respect to an observer standing on the surface of the earth.

Relativity goes further to say that the length of the stick inside the moving space-shuttle decreases with respect to an observer standing on the surface of the earth. That is, if an observer standing on the surface of the earth measures the length of the stick that is placed inside the moving space-shuttle, the observer will find that the length of the stick is **less than 5 feet!** This, obviously, goes against our ordinary experience. But Einstein says that this is a law of nature.

Some people may say that what is reduced is only the measured length of the stick, not the real length. To this Einstein's answer is that the actual length and the measured length are the same. There is no real length different from the measured length.

Relativity of Time

According to Relativity, time is not absolute, but relative. It is relative to a frame of reference. Here also usually we take the surface of the earth as the frame of reference and say that duration of the lecture was 45 minutes. Relativity says that for an observer in another frame of reference the duration of the same lecture need not be 45 minutes. In fact, Relativity says that time slows down in a moving frame of reference with respect to a stationary observer. Thus as in the case of relativity of length, when the same lecture takes place inside a space-shuttle moving with a velocity comparable to the velocity of light, an observer on the surface of the earth will notice that the duration of the lecture is **less than 45 minutes.**

The Clock Paradox

This slowing down of time inside a moving frame of reference with respect to an observer is often illustrated by the "Clock Paradox." Suppose we have two identical clocks in all respects. Suppose also that they have been synchronized so that both show exactly the same time. Let us say that they both show 3 pm now. We keep one on the surface of the earth and we place the other inside the super-speeding space-shuttle. After 6 hours on the surface of the earth when we look at the clock on the surface of the earth, it will show 9 pm. But if from the surface of the earth we look at the clock inside the space-shuttle, it will always show less than 9 pm! **A clock inside a moving frame of reference slows down with respect to a stationary frame of**

reference. This too goes against our ordinary experience. But Einstein says that this is a law of nature.

Relativity of Mass

Mass of a body is not absolute; it is relative; relative to a frame of reference. The mass of a moving body increases with respect to a stationary frame of reference. Thus the mass of a stone may be 250 grams on the surface of the earth. If the same stone is placed inside a fast moving space-shuttle, it will have an increased mass when measured by a scientist on the surface of the earth. This result of Relativity also goes against our ordinary experience.

Mass-Energy Equivalence – $E = mc^2$

This is the most important consequence of Relativity from the practical point of view. According to this, mass and energy are equivalent, i.e., of equal value. Mass and energy are inter-convertible. Mass can be converted into energy and energy can be converted into mass. These two are basically two aspects of the same reality. This result is expressed in the famous equation, $\mathbf{E = mc^2}$, where E stands for the energy produced when a particular body having mass m is converted into energy. c stands for the velocity of light.

Importance of this Equation

This result and the equation show that when a small quantity of matter is converted into energy, the amount of energy produced is enormous since the multiplier factor is the square of the velocity of light. Since the velocity of light itself is a very high quantity, when the multiplication is done by the square (velocity of light multiplied by velocity of light) of that velocity, the resulting quantity is incredibly large. This formula is at the basis of nuclear energy. A nuclear device like a nuclear bomb or a nuclear reactor is capable of releasing an enormous amount of energy because of this multiplier effect.

Philosophically also this equation has serious significance, particularly for Aristotelian philosophy. In Aristotelian philosophy substance and accidents are very different, and it is not possible to convert one into the other. Now energy, since it is related to motion, belongs to the world of accidents in the Aristotelian system, whereas mass belongs to the world of substance. Since, according to Mass-Energy Equivalence, mass can be converted into energy, it shows that substance can be converted into accidents and vice versa. This deals a serious blow to the Aristotelian system.

Space-Time Continuum

According to the Special Theory of Relativity, not only do space and time behave differently from what we used to believe, the relationship between space and time also has changed. Space and time are not to be looked upon as separate entities, rather they are intimately interlinked. In fact, in actuality they form a single whole. This is referred to as spacetime continuum.

1. 4 THE GENERAL THEORY OF RELATIVITY

The General Relativity Principle

General Relativity says that motion, whether uniform or non-uniform (accelerated), does not affect physical laws. The general laws of physics are the same in all moving systems whatever be their motion. In the Special Theory we found that in a uniformly moving system the laws of nature or natural phenomena take place as though the system is not moving at all. For instance, in a uniformly moving train, a person can walk, eat, play, etc., just like a person on the platform. Because of this non-influence of uniform motion on the laws of nature, we are not able to detect and measure the velocity of the moving system from within. But if the motion were to influence the laws of nature, we would be able to note the deviation produced by the motion. From this deviation the velocity could be determined.

What about accelerated or non-uniform motion? An example of an accelerated motion would be a bus taking a curve. Here centrifugal force comes into play and there is acceleration. Now we experience that when a bus takes a curve, the passengers inside are thrown to one side. This shows that those **within** the bus do experience the influence of accelerated motion. So here the situation is the opposite of what happens in the case of uniform motion. Hence the question arises whether the accelerated motion affects the general laws of physics. In other words, will the laws of physics be one thing in one accelerated world and something else in another? Einstein's answer is that the laws will be the same in both the systems.

THE NEW INTERPRETATION OF GRAVITATION

According to Newton, gravitation is a force of attraction between two bodies. Thus the sun attracts the earth, and because of this gravitational force the earth revolves round the sun. Gravitation causes the earth and other planets to describe curved paths in a straight space. In the General Theory of Relativity Einstein gives a completely different idea of gravitation. In this view gravitation is not a force, but a geometrical property. Gravitation is the distortion or curving or bending of spacetime continuum due to the presence of matter. Einstein explains that massive bodies distort the spacetime around them. This distortion or curving he calls gravitation. Since gravitation refers to change of shape, it is considered a geometrical property. This new concept of gravitation is a revolutionary conceptual change, and has transformed our whole idea of the nature of the universe.

One might ask how such a revolutionary theory can be established. How do we know that this revolutionary theory is scientifically acceptable? We will not discuss the technical aspects of this process. We only point out that when this new idea of gravitation is applied to known cases in cosmology, the results obtained are more accurate and more reliable than when we apply Newton's old concept. Today most theoretical scientists engaged in cosmological study employ Einstein's idea of gravitation with more satisfactory results.

Check Your Progress II

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1) What is Relativity? Explain the two postulates of the Special Theory of Relativity.

………………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….

2) What are some of the consequences of the Special and General Theory of Relativity?

…………………………………………………………………………………….

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

1. 5 SOME PHILOSOPHICAL IMPLICATIONS OF RELATIVITY

It goes without saying that so revolutionary and original a theory like Relativity leaves indelible marks on philosophy. It has been rightly observed that the making of a new philosophy follows the making of a new science. It is true that Einstein was not a philosopher by profession, but he was certainly one by attitude. Naturally this fact should show up in the master product of his intellect.

DEATH OF ABSOLUTISM

Relativity dealt a death blow to the so called absolutes: Absolute time, absolute space, absolute simultaneity, absolute mass, absolute frame of reference, absolute objectivity, etc. In doing so it has revolutionized the traditional notions of space, time, etc. According to Relativity, space and time are relative. Space is the relation between things and time the relation between events. As Jeans says, "When we question nature through our experiments, we find that she knows nothing of a space or time common to all men. When we interpret these experiments in the new light of the Theory of Relativity, we find that space means nothing apart from our perception of objects and time means nothing apart from our experience of events. Space and time fade into subjective conceptions, just as subjective as right or left hand.” Only the 4-D spacetime continuum is objective. As Minkowski says, “Space in itself and time in itself sink to mere shadows and only a kind of union of the two retains an independent existence.”

Since every moving observer has his/her own local time, no event in time can be located in an objective way, i.e., no event will be looked upon exactly in the same way by all observers at a particular time.

REFUTATION OF MONISM

The basic belief of monism is that there is only one being in the universe. This view becomes untenable in the context of Relativity since by its very definition it implies plurality since what is relative should be relative to something else.

CHALLENGE TO THE ARISTOTELIAN THEORY OF SUBSTANCE AND ACCIDENTS

This point has been already pointed out in connection with the Mass-Energy Equivalence. We have seen that mass can be converted into energy, and vice versa. Since mass is closely associated with the substance aspect and energy to the accident aspect, the Mass-Energy Equivalence allows conversion between substance and accident. This is not allowed in the Aristotelian system.

1.6 LET US SUM UP

In the past many schools of philosophy held that scientific concepts, once established as scientific, could not undergo any serious change. For instance, Newton in 1687 gave the Law of Universal Gravitation, according to which gravitation was an attractive force between material bodies. This theory was scientifically established. The claim was that this was a fact that could not be changed. But the General Theory of Relativity shows that Newton’s theory, though very valuable and served science admirably for centuries, is not the last word on the nature of gravitation; a better idea can be given, and this idea differs significantly from the Newtonian one. Thus scientific ideas, laws, theories, etc., are not for ever. They can and do undergo change.

Check Your Progress III

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

What are some of the important philosophical implications of Relativity?

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….

1.7 KEY WORDS

Special relativity is a theory of the structure of space-time. Special relativity is based on two postulates which are contradictory in classical mechanics:

1. The laws of physics are the same for all observers in uniform motion relative to one another (principle of relativity);
2. The speed of light in a vacuum is the same for all observers, regardless of their relative motion or of the motion of the source of the light.

General relativity is a theory of gravitation developed by Einstein in the years 1907–1915. The development of general relativity began with the equivalence principle, under which the states of accelerated motion and being at rest in a gravitational field (for example when standing on the surface of the Earth) are physically identical.

1.8 FURTHER READINGS AND REFERENCES

Earman, John. *World Enough and Space-Time: Absolute versus Relational Theories of Space and Time*. Cambridge, Mass.: MIT Press, 1989.

Einstein, Albert. *Ideas and Opinions.* New York: Crown, 1954.

——. *The Meaning of Relativity*. Princeton, N.J.: Princeton University Press, 1956.

——. *Relativity: The Special and the General Theory*. New York: Bonanza, 1961.

——. *Sidelights on Relativity*. New York: Dover, 1983.

Goenner, Hubert, et al., eds. *The Expanding Worlds of General Relativity*. Boston: Birkhäuser, 1999.

Howard, Don, and John Stachel, eds. *Einstein and the History of General Relativity*. Boston: Birkhäuser, 1989.

1.9 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress I

1. It is often thought that philosophy and science are radically different, and there is no close relationship between the two. A serious discussion of the Theory of Relativity shows that this belief is not correct. There is a close relationship between the two. Many great scientists were very deeply philosophically-minded, and many great philosophers were scientifically-minded. This discussion of Relativity shows that there can be and there should be a discipline called Philosophy of Science.

2. The historical background of Relativity is the search for the medium of ether and the famous experiment performed by Michaelson and Morley. See the details in the text. This historical study shows that scientific theories, especially very creative ones, have a context, and a knowledge of this context can be very valuable in understanding the meaning and significance of the theory. It also throws valuable light on the philosophical aspects of the theory.

Answers to Check Your Progress II

1. Relativity is a theory which says that concepts like length, time, mass, etc., are not absolute, but relative; relative to a frame of reference. Einstein gave two theories: The

Special Theory of Relativity and the General Theory of Relativity. The Special Theory of Relativity has two Postulates. The first says that all frames of reference which are moving with uniform velocity with respect to each other behave in the same way. That is, the laws of physics are equally applicable in all these frames of reference. The second Postulate talks about the special, unique nature of the velocity of light. It says that the velocity of light is a constant and absolute quantity. It is the highest velocity any material body can have. It can neither be increased nor decreased.

The Special Theory of Relativity has many important consequences. Some of them are: Relativity of length, relativity of time, relativity of mass, and the Mass-Energy Equivalence. For details see the discussion above. The General Theory of Relativity also has several important consequences. We have discussed only one: The new understanding of gravitation. Newton had said that gravitation was an attractive force between material bodies. According to Einstein in the General Theory of Relativity, gravitation is a geometrical property. It is the distortion or curving of spacetime continuum in the presence of matter.

Answers to Check Your Progress III

1. Some of the important philosophical implications of the Theory of Relativity are the following. It went against the belief in absolutism. For details see the text. It showed that Monism could not be accepted. It exposed the weakness of the Aristotelian theory of substance and accidents. It also showed that scientific concepts were not fixed, but underwent change, even very serious change.