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Dialectical Materialism and the Question of Black Holes

To the question "*Does dialectical materialism need a defence?"* the answer is an emphatic yes. This is because of the ongoing class struggle all over the world. Let me explain.

Com E.M.S.Namboodiripad used to say that in order to understand dialectics well and the role of Marx and Engels in the formulation of this philosophy it was necessary to go to the earliest writings of these revolutionaries. Three important books had been published in the years 1843-45: *The Conditions of the Working Class in England* by Engels, *Hegel's Philosophy of Right* by Marx, and *The Holy Family* by Marx and Engels.

Even before their partnership, their outlooks had coincided on the major questions of philosophy and revolution. Engels had discovered the key role of the working class, not merely as an object of pity, but as a potential leader of revolutionary changes. Marx had discovered the role of private property as the key to understand the exploitation of the workers, and the role of consciousness or philosophy in the task of liberation. He highlights the need for philosophy for the working class, the *need for the exploiters to destroy philosophy*, and the consequent need for the defence of philosophy by the working class. The following important proposition appears in this book: "As philosophy finds its *material* weapon in the proletariat, so the proletariat finds its *spiritual* weapon in philosophy."

This means that the class basis of philosophy was already clarified. The new philosophy of dialectical materialism would surely be the world outlook of the working class. The exploiters needed to hide the fact of exploitation, whereas the working class had nothing to hide. Its philosophy would be the true philosophy, which depicted the world just as it was.

HOLY FAMILY

Marx and Engels were scientists working with an open mind. The philosopher Descartes is often portrayed as a dualist philosopher, and so having nothing to do with materialism. But in the *Holy Family* Marx and Engels write: "We shall merely say the following: Descartes in his *physics* endowed *matter* with self-creative power and conceived *mechanical motion* as the manifestation of its life. He completely separated his physics from his metaphysics. *Within* his physics, *matter* is the sole *substance,* the sole basis of being and of knowledge." Here is deposited the seed of dialectics, the refutation of dualism, and the endowing of matter with the capacity of evolving consciousness and *knowledge.*

Com E.M.S. emphasized that the early writings of Marx and Engels were important because here we see deposited the key ideas of dialectical materialism in the process of their formation. The class nature of philosophy having been exposed by Marx in Hegel's *Philosophy of Right*, he emphasized the need for philosophy for the working class. Such a philosophy is required for bringing about the change that needs to be brought about by the working class. This is stressed in the spring 1845 *Theses on Feuerbach* by Marx: "The philosophers have only interpreted the world in various ways; the point is to change it".

A basic principle of cognition is also deposited as a gem in Marx's statement: "The chief defect of all previous materialism (that of Feuerbach included) is that things (Gegenstand) reality, sensuousness, are conceived only in the form of the object, or of contemplation, but not as sensuous human activity, practice, not subjectively… The question whether objective truth can be attributed to human thinking is not a question of theory but is a practical question. Man must prove the truth, i.e. the reality and power, the this-worldliness of his thinking, in practice. The dispute over the reality or non-reality of thinking which is isolated from practice is a purely scholastic question".

Practice is the test of truth or knowledge. The test of knowledge of objective reality cannot be identified with any of the so called criteria, such as, of predictability, and so on. Social practice is the test of knowledge. Thus the process of acquiring knowledge is an ongoing exercise. So also is the process of the development of the working class philosophy. The working class has no need for a philosophy which stands above the world and is not tested in practice.

In essence, dialectical materialism holds that the world develops in accordance with the laws of movement of matter and stands in no need of a "universal spirit". This position is summed up in the following words of Engels: "*The materialistic outlook on nature means no more than simply conceiving nature just as it exists, without any foreign admixture*." A working summary of the principles of dialectical materialism has been given in my earlier article '*In Defence of Dialectical Materialism'* in *Marxist* XXX 2 (April-June 2014).

Engels describes what is required of a philosophy of the working class, which needs to understand the reality of exploitation and the need to change the world. It has to expose the falsity of all foreign admixture, such as, of gods, ghosts and spirits, with which the working class is held in thralldom.

OTHER PHILOSOPHIES

The very opposite is the demand of the ruling classes who, through their philosophies, wish to hide the reality of exploitation. They should like a world view in which the development of the world is not in accordance to the laws of the movement of matter. They would like to step out of all laws and bring in their inverted world view with a “foreign admixture”, or a Hand that set the clock moving. This is the objective need of the exploiters which is expressed in their philosophies.

This is not the place to comment on philosophies other than dialectical materialism. It is not our intention to brush aside all such philosophies as having no roots, or being of no consequence. As Lenin had pointed out in a much quoted paragraph from his work *On the Question of Dialectics* (Collected Works Volume 38), “Philosophical idealism is only nonsense from the standpoint of crude, simple, metaphysical materialism. From the standpoint of dialectical materialism, on the other hand, philosophical idealism is a one-sided, exaggerated development of one of the features, aspects, facets of knowledge, into an absolute, divorced from matter, from nature, apotheosized. Idealism is clerical obscurantism. True. But philosophical idealism is (“more correctly” and “in addition”) a road to clerical obscurantism through one of the shades of the infinitely complex knowledge (dialectical) of man.”

This may be mistaken as Lenin’s being charitable to philosophical idealism. But the truth is far from this. For, in the very next paragraph, which also happens to be the closing paragraph of the piece, he makes it clear that, while philosophical idealism has epistemological roots, in reality**,** *it is a sterile flower*. The following words from this paragraph are very clear: “Rectilinearity and one-sidedness, woodenness and petrification, subjectivism and subjective blindness – voila the epistemological roots of idealism. And clerical obscurantism (=philosophical idealism), of course has epistemological roots, it is not groundless; it is a sterile flower undoubtedly, but a sterile flower that grows on the living tree of living, fertile, genuine, powerful, objective, absolute human knowledge.”

In the working class’s ideological requirements, such sterile flowers are not going to be useful. Take the example of *the philosophy of scientific realism* which states that “among the limitless set of truths, there are some that we know now, some that we don’t know now and will find out later and some that may lie beyond the furtherest reach of our knowledge seeking powers…”.A position such as this about truths, which lie beyond the furtherest reach of our knowledge seeking powers, will open the way for the introduction of foreign admixtures in our attempts to understand nature.

Indeed, anything that comes in the way of understanding nature just as it is, without any foreign admixture, needs to be fought and eliminated. The class struggle in the world is fought not merely in the daily lives of trade unions struggles, or street struggles with the oppressive governments, but also on the level of ideology. Every effort is made by the ruling classes to make the ideology of the working class appear as irrelevant and false.

The development of the natural sciences shows that they are not neutral towards philosophy, but that they are a scene of struggle between two world outlooks. We see that the achievements of natural science quite often serve as the point of departure for diametrically opposed philosophical conclusions by the ideologists of hostile classes. *This is where the working class has to rise continually in defence of the materialist positions.*

The developments in science, particularly in physics, in the early years of the twentieth century were used by the ruling classes to support Mach's empirio-criticism (the early form of positivism).This was why Lenin came out with his book in defence of materialism: *Materialism and Empiriocriticism*. And in the process of defending materialism against the distortions of the discoveries of science, Lenin further enriched dialectical materialism. For example, he explained the infinite depth of nature in its motion: "The electron is as inexhaustible as the atom, nature is infinite but it infinitely exists". It must be remembered that the task of defending dialectical materialism is also linked with the deepening of this philosophy. As Engels said: "...To me there could be no question of building the laws of dialectics into nature, but of discovering them in it and *evolving* them from it."(Emphasis added). The task of defending dialectical materialism remains a primary responsibility of the working class as long as the class struggle continues.

II
THE THEORY OF RELATIVITY AND BLACK HOLES

We have seen in our earlier article how philosophical idealism in the form of positivism influenced many leading scientists during the construction of quantum theory. The quantum theory in its Copenhagen interpretation, on the basis of what was called the uncertainty principle, ruled out any causal laws at the level of quantum phenomena. In this version of quantum theory, it is *in principle not possible to understand the motion* of an elementary particle like the electron, or the breaking up of a radium atom, by looking for underlying causes. This was the philosophical position that the bourgeoisie was ready to support. It was welcomed by the leaders of Western science.

Thus we have the physicist Walter Heitler, who contributes an essay in *Albert Einstein Philosopher Scientist* (Ed.P.A.Schlipp), declare with a sigh of relief: "But what is clear is that the new situation, with which we are confronted in quantum mechanics, has created room for an approach to the problems of life, (and other domains of human thought) which is chained not to the deterministic views of classical physics". What Heitler was looking for was a science which left room for faith.

A very similar situation is to be found in the development of Einstein's great theories, the special theory of relativity (1905) and the general theory of relativity (1915). The general theory of relativity was utilized to propagate various kinds of idealistic and creationist views of the world, e.g., the so called big bang theory which propagates that the world was formed about 15,000 million years ago.

One of the offshoots of this theory is the proposition of the existence of objects, called the *black holes***,** as final stages in the development of certain types of stars. Such astronomical objects defy the principles of dialectical materialism, such as about the knowability of the world or of the existence of contradictory processes within such objects. If the black holes, as posited by the general theory of relativity, exist with the above properties, then it means that dialectical materialism does not hold, and will have to be discarded. Hence the question of black holes is of great importance. Here is a case where the question of defence of dialectical materialism is posed before the working class.

THE SPECIAL THEORY OF RELATIVITY (SRT)

Let us begin by briefly considering the special theory of relativity on which the general theory of relativity stands. First let us consider how even in the first decade of the twentieth century the special theory of relativity was distorted in its presentation to suit the needs of philosophical idealism.

Lenin was especially interested in the theory of relativity as can be discerned from his detailed notings on the velocity of light in the1915 copy he made of a technical book (see *Collected Works* Vol. 38, p. 335). He was aware of how the SRT was being used in building support for all forms of religion. He writes: "One has only to recall the vast majority of the fashionable philosophical trends that arise so frequently in European countries, beginning with those connected with the discovery of radium and ending with those which are now seeking to clutch at the skirts of Einstein, to gain an idea of the connection between the class interests and the class position of the bourgeoisie and its support of all forms of religion on the one hand, and the ideological content of the fashionable philosophical trends on the other"(*On the Significance of Militant Materialism*).

Lenin clarifies that Einstein himself was not responsible for this situation. Referring to an article on Einstein's theory of relativity by Timiryazev, Lenin says that "Einstein… is himself not making any active attack on the foundations of materialism". But his theory "has already been seized upon by a vast number of bourgeois intellectuals of all countries; it should be noted that this applies not only to Einstein, but to a number, if not to the majority, of the great reformers of natural science since the end of the nineteenth century".

We shall not go deeply into the theory itself, but shall examine some of the distortions that have been introduced in the various concepts relating to physics. For details of the STR one may refer to my book *Dialectics, Relativity and Quantum,* National Book Agency, Kolkata (*DRQ*).

The special theory of relativity has its roots in the contradictions that arose between two theories of physics, namely, the mechanics of Galileo and Newton, on the one side, and the electromagnetic theory of Faraday and Maxwell, on the other side.

Techniques in physics had improved to such an extent by the end of the nineteenth century that the velocity of light could be measured very accurately, and could be compared with what was predicted by Newtonian mechanics. It was discovered that there was a contradiction between what was expected, if Newton's theory was right, and what was observed while measuring the velocity of light.

According to mechanics, the velocity of an object would depend on the velocity of the observer. Since light was a form of motion, its velocity was expected to be different under different conditions of the motion of the observer, say, the observer on the earth would expect the velocity of light to depend on the earth's own motion with respect to the sun; also velocities in different directions could also be expected to show small variations. But detailed experiments with light, running over the last two decades of the nineteenth century, failed to find any such variations. The velocity of light, the fastest form of propagation, showed this strange property, namely, *that its velocity did not depend on the state of motion either of the emitting body or the observer*. This unique feature of the constancy of the velocity of light caused much worry and puzzlement to scientists of the end of the nineteenth century. This special velocity, of about 300,000 kilometers per second, is denoted in physics by the symbol *c.*

To set this situation right, what Einstein did was to resolve the contradiction by reconsidering our definitions of time measurement and the simultaneity of two distant events.

WHAT IS AN EVENT?

An event is an abstraction that we make when we deal with some processes like the burst of a small cracker, which take place in a short duration of time and in a small region of space. Suppose someone tells us that yesterday an aeroplane burst into flames mid-air. We would want to know when and where it happened. We would get the answer 10 a.m. at a place for which the latitude and longitude are given along with the altitude at which the plane burst. Thus the event of the bursting of the aeroplane is described by three numbers giving the location, and one number which gives the time. While we speak of the event we have ignored all the details like the length of the plane, the time it took to burn out, as well as all other details. This is what we mean by saying that an event is an abstraction. It is described by three numbers giving the space and one number giving us the time of occurrence. Such numbers are called the coordinates of the event.

Einstein examined the question of how one determines whether two distant events are simultaneous or not. This is done with the help of observation of the light emitted by the events which travel all the way from the two events and reach the observers. Einstein chose light as the signal, because it was the fastest signal possible to correlate two events. Through such an analysis, using the physical facts about the speed of light given with the utmost accuracy by experiments conducted over two decades, it was deduced that two distant events E and F which were observed as simultaneous by one set of observers in one frame of reference S would not be simultaneous as observed by another set of observers if they were in a frame of reference S' which was in relative motion to S. In other words, the simultaneity of distant events was not absolute, but was relative to the frame of reference. If the two distant events E and F are simultaneous in one frame of reference, in another frame which is moving, E could be earlier or later than F, and there would be a time interval between the two events.

The implication is that the measurement of time that elapses between two events is not an absolute, but depends on the frame of reference in which the observation is made. Now, the frames of reference that Einstein was using here were non-accelerating frames, or what are called inertial frames. They were frames of reference like the compartment of a railway train moving with constant speed, or the stationmaster's office on the railway station.

If S and S' are inertial frames of reference, (moving with uniform velocity relative to each other), then not only are the time measurements *not the same* for both observers, but the spatial measurements are also relative. Einstein gave the formula for the relation between the space coordinates and time coordinates of a given event in the two frames of reference S and S'. These are the Lorentz formulae given in his first paper on relativity in 1905. Since these formulae allow us to calculate the new coordinates when we change from one frame of reference to another, they are called Lorentz *transformations*.

To derive these results Einstein used the principle of the constancy of the velocity of light, and another principle called the principle of relativity, which Galileo had originally stated, namely, that all inertial frames of reference are equivalent.

SPACE-TIME

It was shown by Minkowski in 1908 that even though, for the inertial frames S and S', the measurement of the time elapsed between two events E and F were different, and so were the distance measurement between E and F, it was possible to combine these measurements of time elapsed and spatial distance in such a way that one got the same result for both reference frames. This result for the given pair of events, which is invariant for S and S' is called the "interval" between the two events.

This mathematical result was interpreted by Minkowski as a welding together of space and time into one space-time. He proclaimed that space by itself and time by itself have no separate independent existence, but it was only space-time which had physical meaning. An event in space-time was given by four numbers, the three numbers giving the spatial position and one number giving the time of occurrence of the event E. Space-time was thus described as four dimensional, and these numbers were the four coordinates of the event.

In the same paper, Minkowski worked on an idea originally of Henri Poincare which considered the Lorentz transformations as forming a group of rotations. When we are dealing with rotations, we are actually treating space and time in the same way as equals. Thereby the interlocking of space and time was complete. The spatial and temporal behavior of any object could be treated together.

This welding of space and time into one structure was a very powerful construct. The earlier equations in electromagnetic theory given by Maxwell in the nineteenth century could now be written concisely using the four dimensional language. For this the mathematical tool of four dimensional vectors and tensors is used. Einstein's later work on the phenomenon of gravitation, namely, the general theory of relativity, was based on this apparatus of a four dimensional space-time structure.

It must be stated here that, while space and time were welded into space-time on the basis of the *common features* of space measurements and time measurements, what was neglected was that in abstractly uniting space and time, the *essential difference* between space and time was ignored. What was being ignored in this process of unification was the existence of concrete differences which were being united in the new construct called space-time. This weakness was to show itself soon in the attacks on materialism from idealist philosophers. This situation should draw our attention to the need for the dialectical materialist principle of "*the ascendance from the abstract to the concrete*" as suggested by Marx. We consider one example below.

ATTACK ON MATERIALISM BY RUSSELL

Since our objective is to consider the general theory of relativity and the concept of the black holes, we shall not deal with the SRT in detail. However, it is necessary to refer to one important writer who took this concept of the relativity of time and the unification of space and time into one space-time to project an idealist view regarding the nature of the physical world. This was the Nobel Prize winner Bertrand Russell.

In his book *History of Western Philosophy* (1946) Russell states: "What is important to the philosopher in the theory of relativity is the substitution of space-time for space and time. Common sense thinks of the physical world as composed of "things" which persist through a certain period of time and move in space. Philosophy and physics developed the notion of "thing" into that of "material substance", and thought of substance as consisting of particles, each very small, and each persisting throughout all time. Einstein substituted events for particles; each event had to each other a relation called "interval", which could be analysed in various ways into a time element and a space element. The choice between these various ways was arbitrary, and no one of them was theoretically preferable to any other. Given two events A and B, in different regions, it might happen that according to one convention they were simultaneous, according to another A was earlier than B, and according to yet another B was earlier to A. No physical facts correspond to these different conventions.

"From all this it seems to follow that events, not particles, must be the stuff of physics. What has been thought of as a particle will have to be thought of as a series of events. The series of events that replaces a particle has certain important properties, and therefore demands our attention; but it has no more substantiality than any other series that we might abstractly single out. Thus "matter" is not part of the ultimate material of the world, but merely a convenient way of collecting events into bundles".

Here was a powerful attack on materialism. As Lenin had suggested in 1923, here was a bourgeois philosopher in 1946 clutching at the skirts of Einstein to attack materialism. The question is does not dialectical materialism need to be defended against such an onslaught? Can the ordinary worker, who slogs for fourteen hours of the day to earn his bread, defend himself when, in the religious discourse that he attends, he is told that science had proved that the world is not real, but only made of bundles of events which can be collected in different ways? This is where all the defenders of the philosophy of the working class must come together and give a fitting defence.

DEFENCE OF DIALECTICS

One such scientist was the Marxist physicist and mathematician A.D.Alexandrov. (It may be remarked that he was a student of the Russian scientist V.A.Fock and a member of the communist party). He concentrated on the differences between space and time, which had been ignored by Minkowski in his programme of unification of space and time into space-time. He pointed out that Minkowski himself had stated that the space vector and the time vector were actually differently placed. Using the technical concept of the *light cone*, it was shown that the time vector was always within the light cone and the space vector was always outside the light cone. Alexandrov showed mathematically that the Lorentz transformation preserved this property of separating the space like vectors and the time like vectors. He further showed that taking the light cone as the fundamental concept one could derive time and space from matter in motion. (For details see *DRQ*.)

The meaning of Alexandrov's work is that it is matter in motion that is the fundamental reality. Moving matter or processes (events) are interlinked by various chains of other processes, for example, by causal chains. The light cone of a given event is the outer limit of the causal influence of the event. Using this material link between processes, space and time are to be defined.

Now let us look at Russell's argument. He speaks of two events A and B. He then says that according to one *convention* they may be simultaneous, according to another A was earlier than B and according to yet another B was earlier to A. Firstly, Russell is speaking about "conventions", when he should have been speaking of frames of reference. Now a frame of reference is a rigid material structure like the moving railway train, with its numerous passengers as observers, or the station-master's office along with his colleagues. So there is no question of any convention between people. Everything here is objective, no subjective element is involved in the observations.

Bertrand Russell has deliberately chosen events like A and B, which are simultaneous in a certain frame of reference, "according to one convention". Presumably, he is dealing with distant events. Now, distant simultaneous events like A and B are outside any physical relations between themselves. This is because the fastest influence, e.g. a ray of light, would take some time to travel from either A to B or from B to A. He has chosen such unrelated events because *he knows well* that for all physically related events, where, for example, one event is the cause of the other, the theory of Einstein strictly preserves the priority in time.

In fact this is the crux of the work of Alexandrov. It is the physical relationship of cause and effect, or development, which is at the basis of the concept of time. As dialectical materialism states, time is abstracted from matter in motion. David Hume used to say that temporal priority was at the basis of concept of cause and effect. The teaching of relativity theory, contrarily, is that it is the physical reality of causal-effect which forms the basis of the concept of time.

Russell further argues that events, not particles, are the stuff of physics. We have already seen how the concept of an event is an abstraction from a physical process. The concept of a particle is also an abstraction of a small moving physical object. Russell is working with abstractions, replacing a moving physical object with a moving particle and then replacing the moving particle with a series of events. Then he declares that matter has disappeared into "bundles of events"! Engels speaks about abstraction and sensuous reality: "It is the old story. First of all one makes sensuous things into abstractions and then one wants to know through the senses, to see time and to smell space. The empiricist becomes so steeped in the habit of empirical experience, that he believes that he is still in the field of sensuous experience when he is operating with abstractions."

The above argument shows how idealist philosophy tries to present an important discovery of science in a way which opposes materialism. *The defence of materialism had to be done, in this case, by using the weapon of the 'dialectics of the abstract and the concrete' given by Marx.*

Einstein's special theory of relativity represents a revolutionary break from Newtonian mechanics, and from the old ways of conceiving space and time: space as a huge receptacle in which all things exist and move, and time as a universal flow independent of nature and its infinite movement. The physical consequences of the SRT need not be described here, e.g., the relativity of time and space, the relation of mass with motion, (viz. the increase of mass of an object with its velocity of motion), and the equality of mass and energy given in the famous formula $E = m c^2$.

SRT CORRECTS NEWTONIAN MECHANICS

Even though the special theory of relativity represents a revolutionary break from Newtonian mechanics as far as ideas are concerned, in practical terms the corrections involved are negligible. The Lorentz transformations involve the velocity v of the frame of reference, but it is compared to the speed of light c, which is a huge quantity. Even the fastest speeds on earth, which our frames of reference, say a jet plane, can attain, are microscopic compared to c. The earth itself goes around the sun in its orbit at a speed of about 30 km per second. But this speed is only one-ten thousandth of the speed of light. Even with this dizzying speed, the corrections involved to the mechanics of Newton would only be one millionth of one percent! Hence the genius of Newton is not challenged by the accuracy of the results.

THE GENERAL THEORY OF RELATIVITY (GR)

The general theory of relativity is Einstein's theory of gravitation. Newton had discovered the law of gravitation, which says that all objects in the world attract each other. He further describes this force of attraction as dependent on the masses of the bodies directly and falling away as the distance between them is increased.

In the case of the earth and the moon, the earth attracts the moon, making it go round the earth, and the moon attracts the earth as an equal and opposite reaction, producing as one of the results the tides on the earth.

Action and reaction are equal and opposite and occur simultaneously. This is an instance of simultaneous action at a distance.

Einstein pondered over this situation of action at a distance, which Newton's theory of gravitation involved. The special theory of relativity had shown that such simultaneous action at a distance was not permitted since different inertial frames would not agree with this concept. Newton's theory had to be recast. Einstein tried to remodel Newton's theory on the pattern of the electromagnetic theory which spoke of electric and magnetic fields. He tried to find a field theory of gravitation.

Einstein tried to adapt the law of motion of a mass point in a gravitational field to the requirements of the special theory of relativity. One implication of the SRT was that when a body was falling its inertial mass would increase because of its speed. This investigation brought him face to face with the question of the relationship between inertial mass and gravitational mass.

INERTIAL MASS AND GRAVITATIONAL MASS

Now inertial mass is the measure of the resistance of a body to a force acting on it. If I were to push a cart, the speed with which it will move and the increase of speed (acceleration) would depend on how massive it is. The more massive the cart, the less will be the acceleration when I push it. This mass, which measures the inertness or laziness of an object, is called its inertial mass.

The effects of inertial mass can be seen in several common place phenomena. If the train in which we are travelling suddenly stops, we are thrown forward. This is an example of an inertial force acting on us. While travelling in a bus, when the bus makes a sharp turn, we are thrown sideways. This is also an example of an inertial force acting on us. These inertial forces are seen to arise from the acceleration of our frame of reference. In science, some examples of inertial forces are centrifugal forces and Coriolis forces.

Newton's theory of gravity says that the gravitational attraction depends on the masses of the objects. Here we are speaking about the attractive power of the masses. This gravitational attractive power of the object is called its gravitational mass.

The weight of a body is the result of the attraction of the earth on it. It expresses the gravitational mass of the body. We can measure gravitational mass by the weight of an object.

In 1890 the scientist R.V.Eotvos performed an ingenious experiment designed to test the ratio of inertial mass to weight. On the basis of this experiment it was concluded that the two masses, inertial mass and gravitational mass, are equal to each other within one part to 10^8 (that is, one part in one hundred million). Further experiments have improved on this result. So the equality of inertial mass and gravitational mass had been well established.

Einstein realized that the principle of equality of inertial mass and gravitational mass was to be placed at the centre of any theory of gravitation. He says in his autobiographical book *The World as I see it*: “This law, which may also be formulated as the law of equality of inertial and gravitational mass, was now brought home to me in all its significance. I was in the highest degree amazed at its persistence and guessed that in it must lie the key to the deeper understanding of inertia and gravitation.”

GRAVITATION AND THE GEOMETRY OF SPACE-TIME

On the basis of this principle of equality of inertial mass and gravitational mass Einstein argued that there was no difference between the effects of gravitational forces and inertial forces. We omit the details of the argument.(Please see *DRQ*). If a number of friends enter a lift, they experience a momentary increase in their weights just as the lift starts. This is because of the acceleration of the lift. To their original weights is added this additional weight that arises from the acceleration. We can say that there is an inertial field of force in the lift, since it is experienced at all points inside the lift. Is this inertial field different in quality from the gravitational field? Einstein postulated that the inertial field is the same as the gravitational field, not only for mechanical problems, but for all phenomena including electric and magnetic phenomena. This is called Einsteins’s principle of equivalence.

Basing himself on this postulate and logic, he examined the situation of a ray of light passing close to the massive body of the sun. He based his calculations on this principle of the equivalence of gravitation and the field inside an accelerating lift. He derived the result that the ray of light would be bent slightly towards the sun. This prediction was made in 1915. It was actually verified by accurate measurements conducted by the astronomer Arthur Eddington during the total solar eclipse of May 1919. This was indeed a dramatic proof of the correctness of Einstein’s theory. He called this theory of gravitation the general theory, because he was dealing not with uniformly moving frames of reference but accelerated frames of reference as well.

On the basis of the postulate of the equivalence of all frames of reference, he considered a rotating frame of reference and tried to ask the question about the geometry of the space in such a frame of reference. Does the geometry we studied in school called Euclid’s geometry hold? Is the sum of the three angles of a triangle two right angles? Is the ratio of the circumference of a circle and its diameter the same old constant pi? Einstein argued that in an accelerated frame, as well as in a gravitational field, these results do not hold. Slight corrections will have to be incorporated into the results of Euclidean geometry. In a gravitational field the geometry is non-

Euclidean. A more general form of geometry discovered by Riemann was to be used.

Further we could not restrict ourselves to the three dimensional space but, because of the motions involved, time has to be incorporated. It is the construct of space- time that is to be the foundation of our geometry. Einstein linked the nature of space-time to the presence of matter which was responsible for the gravitation. He linked up geometry of space- time with the distribution of matter. *These were his famous field equations for gravity*. They relate geometric quantities, like curvature, on one side and physical quantities, like the motion and flow of matter, on the other side of the field equations. These are ten equations in all.

It may be stated here that Einstein went a step further and *identified gravitation with geometry*. This was a false step, as was shown later by the Marxist physicist V.A.Fock.in his book *The Theory of Space, Time and Gravitation*.

THE MAIN RESULTS OF THE GR, AND HOW GR CORRECTS NEWTON'S THEORY

Like his special theory of relativity, the general theory was also a revolutionary theory, in as much as it made further corrections to Newtonian mechanics and his theory of gravitation. Einstein applied his field equations to the solar system. Here the gravitating object is the sun. The planets can be taken to be test particles. Einstein obtained the following results, which we give under three headings:

(a) The laws of Newton regarding gravitation are rederived as a first approximation of Einstein's theory.

(b) However, in addition to this, new predictions are made which cannot be derived from Newton's theory. These are:

(i) The path of a ray of light passing near a heavy body like the sun will be deflected towards it.

(ii) The path of a planet around the sun is not a closed ellipse, as required in Newton's theory, but an elliptical curve which is not closed but slowly turning in its plane forming something like a rosette.

(iii) The light emitted from a strong gravitational field, such as that of a star, and received on earth, will have a slightly longer wave length and appear to be redder. This is called the gravitational red shift.

These results have all been confirmed to a very high degree of accuracy.

GRAVITATIONAL WAVES

The theory of gravitation of Einstein differs radically from Newtonian theory in respect of the solutions of the field equations. Under certain assumptions, the field equations of Einstein's theory predict gravitational waves. If large masses have accelerated motions, then they emit energy in the form of gravitational waves.

In particular, the *emission* of energy by a certain pulsar (star pair) through gravitational waves was indirectly confirmed in the year 1979. Now, with the recent announcement on February 12, 2016 of the *detection* of gravitational waves by the Laser Interferometry Gravitational Waves Observatory (LIGO**)**, the existence of gravitational waves has been finally confirmed.

Einstein's GR takes forward the work of Newton. It represents an advance in the theory of gravitation.

GR AND DIALECTICAL MATERIALISM

Before we go into the idealist distortions introduced into GR such as the detailed properties about the posited *black holes*, we would show how the general theory of relativity further supports positions of dialectical materialism especially with regard to space and time. A full discussion of this matter is beyond the scope of this essay, and could be found elsewhere. (See for example *DRQ*).

The problems of space and time have held the attention of philosophers and scientists from ancient times. Two major views emerged in history: the view which considered space and time as independent entities existing prior to the existence of matter, and the view which considered that space and time depended on matter which was assumed to have priority.

The Pythagorean thinker Archytas, for example, considered that; "since everything which is moved is moved in a certain place, it is plain that the place where the thing which is moving or being moved shall be, must first exist. Perhaps it is the first of all beings, since everything that exists is in a place and cannot exist without a place."

Aristotle took the opposite stand on the question of space and time. He recognized the objective reality of space and time and contended that spatial properties and relations were inseparable from matter, having no existence outside matter.

We have already stated that Newton believed that there was an absolute space independent of matter in which all bodies moved as though in a receptacle, and that time flowed like a stream independently of all material processes.

The highly influential eighteenth century philosopher Immanuel Kant argued that space and time were concepts not derived from experience, but that they were somehow already rooted in the mind prior to any experience. In his arguments he used the assumption that the rules of Euclid's geometry (the only known geometry in his time) were absolutely true and admitted of no exceptions. He had pinned his arguments on the validity of the propositions of Euclidean geometry.

However, the mathematical work of Lobachewsky, Bolyai, Gauss and Riemann in the nineteenth century demonstrated that this assumption is not correct. The mathematicians had demonstrated the possibility of having geometries which were non-Euclidean.

The most revolutionary philosophical consequence of Einstein's theory of gravitation was that the physical space revealed by processes such as light rays and test particles motions is in fact non-Euclidean. The special theory of relativity (SRT) had shown that space and time were meshed into one structure space-time, and this structure could itself be constructed by linkages between events. The GR takes this programme further by showing that the linkages themselves were determined by the presence of matter. Einstein says: "There is no thing as an empty space, i.e., a space without a field. Space-time does not claim existence on its own, but only as a structural quality of a field."

It will be easily seen that the above conclusion of Einstein is very similar to the position of dialectical materialism on space and time which is stated by Lenin when he quotes from Feuerbach. Lenin says: "it is not things that presuppose space and time, but space and time that presuppose things, for space or extension presumes something which extends, and time, movement, for time is indeed only a concept derived from movement, presupposes something that moves."

In short Einstein's SRT as well as GR fully support the stand of dialectical materialism on space and time as against the idealist views of Archytas, Newton and Kant.

III
SOME IDEALIST DISTORTIONS OF EINSTEIN'S THEORIES

We shall deal in this section with two idealist conclusions derived from the general theory of relativity, namely, what are called causal pathologies and the black holes.

A.CAUSAL PATHOLOGIES

The problem of causal pathology can be stated as follows: It is possible to prove that the theory of relativity is consistent with the existence of what are called closed time-like curves. A time-like curve in a space-time graph represents the motion of a particle. For example a straight line with a certain slope in the earlier mentioned graph could represent the motion of a car with a constant speed. Since a time-like curve represents the motion of a particle, a *closed* time-like curve would represent the motion of a particle which could return to its starting point at the starting time. For example a particle could start from Mumbai on January 1, 2016, travel to some distant place, say the Moon, and return to Mumbai from the past and reach Mumbai on the same date, January 1, 2016.

Obviously, this leads to an impossible situation. For, a person could undertake an imaginary journey to the past in a rocket along such a path and return to his own past. Then he could arrange things in such a way, e.g., by killing his own grandfather, that the original journey did not take place. This goes against the principal of causality.

Thus the existence of such closed time-like curves constitutes a paradox. This is an example of a causal pathology. In modern literature on relativity and cosmology such a situation is avoided by making additional assumptions, such as the causality principle*. It is postulated that the space-time structure is strongly causal.* The field equations of the GR are not sufficient to avoid such causal pathologies.

Now let us examine why such a situation arises in the SRT and GR. We have seen that in the construction of space-time Minkowski was treating space and time on an equal footing, abstracting away the differences between space and time. In this process of abstraction, the actual difference between space and time is ignored. To have a better understanding of the reality it is necessary to follow Marx's advice, and "ascend from the abstract to the concrete".

Another fact to be understood is that, having found the *linkage* between the nature of the geometry of space time with gravitation, Einstein went ahead and *identified* space-time with gravitation. As we have pointed out, this was criticized by Fock. Einstein's followers like Hawking and Ellis, went further and made an identification of any abstract mathematical structure called a manifold having a Lorentz metric with physical space-time. Accordingly, any manifold with a Lorentz metric is a space-time, and hence represents a gravitational field. As Pankaj S.Joshi says, "When the manifold has dimension four, and when it is equipped with a globally defined Lorentzian metric tensor field, it is called a space-time." (Pankaj Joshi: *Global Aspects in Gravitation and Cosmology,*Oxford Univ Press 1993).

Minkowski's construction of space-time was given a mathematical structure by Einstein's gravitation theory, which defined the "interval" on the basis of the gravitating matter present, converting the space-time into a curved geometrical structure called a manifold. A manifold is like a smooth sheet of paper in which all directions are equivalent. The mathematicians who worked with Einstein's theory then justified working with the space-time manifold just as we work with a smooth manifold such as a sheet of paper. The operations of cutting, pasting and folding of a paper again results in a manifold structure. The mathematicians, following Einstein, identified the gravitational field with the space-time manifold, and then started operating with this manifold just as you would work with the paper manifold.

What is the result of accepting such an abstraction as a space-time? If we have a rectangular sheet of paper, we may roll it up and paste a pair of opposite sides to form a cylinder. Thereby we create a two dimensional space in which we may, for example, go west and return from the east. Such spaces belong to our world of experience.

Now suppose we draw a space-time graph on a sheet of paper taking the space representation on a horizontal line(axis) and time representation on a vertical line (axis). Such a graph can be used to described, for example, the motion of a car on a straight road. Each point on the graph would represent the position of the car at a given instant of time. Such graphs are used in schools for solving problems graphically.

Having made a space-time graph as above, we are not allowed to roll up the time axis and to paste the opposite edges. Because if we did this we would be depicting a false situation where we could go into the future and return from the past to the starting point. We would have in this case, what is called a "closed time-like curve". The time axis would form such a closed curve.

Although such cutting and pasting does not affect the manifold structure, or the Lorentz metric, this operation destroys the capacity of the structure to represent reality faithfully because a fundamental property of space and time is denied in this new structure. It is essentially this way of using abstract mathematics on a proper representation that gives rise to such causal pathologies.

CONTRIBUTION OF ALEXANDROV

We have referred to the work of the Russian mathematician A.D.Alexandrov who dealt with the problem of space and time as depicted by Minkowski, but also incorporated the difference between space and time. He defined space-time as the set of all events in the world abstracted from all its properties except those that are determined by the effect of some events upon others. On the basis of the physical relationship of cause-effect, using the technical device of the light cone, he was able to reconstruct space and time.

Alexandrov established a close connection between the light-cones and the Lorentz transformations of Einstein's special theory of relativity Einstein.

It is to be noted that even when we go beyond the realm of the special theory of relativity and study general space-times, such as of GR, which are not given by Minkowski's definition of interval, a structure can still be given to space-time using the light cones. This structure is called the Alexandrov topology.

MANIFOLD TOPOLOGY AND ALEXANDROV TOPOLOGY

We have seen that the field equations of general relativity do not rule out such diseases as causal pathology. You can have in the GR closed time-like curves. In order to avoid such problems, additional postulates are required. The root of this problem is the treating of space-time like a sheet of paper, or as a manifold. The manifold structure which treats space and time as equal, abstractly, gives rise to problems. It can be proved that the manifold topology is inadequate for avoiding such causal pathologies. Roger Penrose has shown that the Alexandrov topology does not pose such problems.

He has shown mathematically that the space-time described by the Alexandrov topology is free from causal pathologies. He shows that if the manifold topology does not suffer from causal pathologies, then the structure it defines coincides with Alexandrov topology. Conversely, if the manifold topology agrees with the Alexandrov topology then it is strongly causal (that is, there are no causal pathologies).(For details see *DRQ*)

To sum up this discussion, we can say that from Einstein's work Minkowski constructed space-time through the process of abstraction, where the differences between space and time were ignored. We had an inverted structure where you could travel into the past, kill your own grandfather and ensure that you were not born, so that the original journey does not begin! Alexandrov, by recognizing the diverse qualities of space and time in concrete reality, reconstructed space- time on a material basis.

With Minskowski space-time was standing on its head. Alexandrov did to Minkowski the service Marx rendered to Hegel when he set his dialectics back on its feet.

B.BLACK HOLES

According to the general theory of relativity, the final stages of certain types of stars can only be structures called black holes, with some amazing properties, that go against the principles of dialectical materialism. Some such properties are: of matter disappearing into a point, structures having no internal contradictory motion but only inward motion, or of matter entering a so called 'event horizon' from which no information is in principle possible to obtain.

Of all the laws of dialectics the central one is concerned with the unity and struggle of opposites and the corresponding category of contradiction. Astronomy provides ample examples of the operation of this law of contradiction in the processes of nature. One example is the constant working of contradictory processes in all stages of the development of a star.

The condensation model, which is the most widely accepted, assumes that stars are formed by condensation of huge clouds of gas and dust found in the galaxies. Gravitation is the main force at this stage. If the cloud is above a critical size it starts condensing due to the gravitational attraction of the parts to each other. Smaller clouds dissipate due to the motion of the particles. Note that it is at a critical quantitative stage that dissipation becomes condensation – an example of quantity changing to quality. This critical size happens to be a mass equal to hundreds of ordinary stars. Hence from such a cloud hundreds of stars can be formed.

At a certain stage of condensation, because of instability, the cloud breaks up into sub-units called protostars. In the next stage the fragment gets further condensed because of gravity and becomes an object which emits light. It has become a star. Here, as condensation proceeds, the gas gets heated up and massive pressure is built up. It is this pressure (thermal pressure) which keeps the system stable without collapsing due to gravity.

The process of heating up continues until the temperatures are high enough to start nuclear processes within the central region. Here again there is a critical stage when the repulsive forces between the hydrogen nuclei is broken by the energy of the particles so that they can coalesce to form helium nuclei. This is another example of the law of quantity getting transformed into quality. But this is also an example of the play of the opposing forces of thermal pressure and gravitational attraction. The star has now become a thermonuclear reactor, producing huge quantities of energy.

The star remains in this stage, converting hydrogen into helium for a long period of time (running into thousands of millions of years). Our own star, the sun, belongs to this class of stars. During this phase the star is in equilibrium. But gradually inhomogeneities develop in the core of the star as the hydrogen gets depleted and the content of helium increases. The star adjusts to the new situation by the expansion of its outer part and the further condensation of its core. The temperature of the core rises further until new processes start within its interior. This is the nuclear process of conversion of helium onto carbon. Again, opposite forces are at work, the attraction due to gravity and the pressures developed by the new energy sources.

We shall not go into a further narration of the successive stages of development of stars, different scenarios being seen in different conditions such as of the masses of the stars. In each case, there is a struggle of opposite forces, the gravitational attraction and the pressures being provided by different modes of energy production. We can observe stars in different conditions, the so called red giants, the white dwarfs, the neutron stars, and pulsating pairs of stars called pulsars.

The white dwarfs are stars which have reached an extremely high density. The brightest star in our hemisphere, Sirius (Vyadh), has a faint companion star which is a white dwarf. The white dwarf has a new method of providing oppostional pressure to gravity, by what is called pressure due to degenerate matter. For stars which had masses more that the above requirement of white dwarfs, they become what are called neutron stars. Neutron stars have densities around 100 times the density of white dwarfs.

Here again gravity and pressure act in opposite senses, inwards and outwards, providing a confirmation of the dialectical law of the unity and struggle of opposites.

In the case of still heavier stars, they can explode into supernova, or they can get compressed until they become smaller than a critical size given by the general theory of relativity called the Schwarzschild radius. A supernova results when the inner part of the star, its core, collapses and releases energy to such an extent that the outer region, its mantle, explodes. In a sense this is the death of the star.

The inner part becomes a white dwarf or a neutron star (pulsar).The outer mantle continues in a new form of motion. Inner contradictions are still at work.

WHAT HAPPENS WHEN THE FUEL IS EXHAUSTED?

The second possibility of a star, which has exhausted all the above sources of energy, is that it will continual keep on shrinking till it becomes smaller than its Schwarzschild radius. This would result in what is called a black hole. According to a solution of Einstein's field equations of gravity developed by the mathematician Schwarzschild, there is a quantity for each attracting body called its Schwarzschild radius R. (For the Sun the quantity R = 1.5 miles, and for the earth it is just 9 millimeter).

A star which has exhausted its nuclear fuel would go into this stage of a black hole if its mass is above a certain critical size, called the Chandrasekhar limit, so named after the Indian Nobel prize winning astronomer S.Chandrasekhar. What would be the behavior of such objects whose radius is less that the Schwarzschild radius?

The gravitational field inside such an object (the black hole) would be so strong that even the light emitted by it would be pulled back. In fact the geometry of space-time inside the Schwarzschild radius would be such that the light cones would bend inwards, and thus there is only one form of motion, namely motion inwards. Any object in the vicinity of the black hole would be attracted inwards. There would be no way to know anything about the matter in the black hole. All the material would shrink ultimately into a point of infinite density. Such a point is called a singularity. This is called gravitational collapse. There is a theoretical sphere surrounding the black hole called the event horizon which swallows all information about objects falling within. Because of the event horizons which prevent information from coming out, all black holes are of the same form except for their mass, angular momentum and charge. In this sense all black holes are bare. Hawking and Penrose have described this situation by saying that a black hole has no hair!

From the viewpoint of GR, anything that happens to matter inside the Schwarzschild sphere cannot even in principle be known by the external observer. Physically this situation imposes limits on the knowledge of how matter evolves. This is a philosophical position which is consistent with bourgeois philosophy. We have already quoted the position of scientific realism that there are some truths that may lie beyond the furtherest reach of our knowledge seeking powers. Are we to accept this position about the world? Or are we going to examine the assumptions that have led to these conclusions about black holes? We will thereby attempt to defend the position of dialectical materialism that *the world not only exists but is knowable*.

IN DEFENCE OF DIALECTICAL MATERIALISM

This situation calls for the defence of dialectical materialism. In this case, we examine the postulates on the basis of which mathematics inexorably draws the conclusions about space-time around such an object. One postulate, of course, is that the general theory of relativity is absolutely valid even in the situations where matter is assumed to have densities which have never been dealt with observationally, and no occasion has been present where the principle of equality of interial mass and gravitational mass has been tested in such circumstances. Another postulate is the so called energy condition, which is at the basis of all the theorems on black holes. We shall not go into details (Please see *DRQ*). But let us take the first assumption about the absolute validity of the GR.

The Marxist scientist V.A.Fock had put Einstein's general relativity to a detailed criticism. In 1959 he wrote a foundational book, *The theory of space,time and gravitation.* He showed how Einstein was mistaken in assuming the identity of the geometry of space-time with the physical gravitational field. By doing so he had reduced gravitation to a matter of the coordinate system, and technically the result was that in his gravitation theory there was no law of conservation, as in the case of electric and magnetic fields. *Thus a gravitational field could be just switched off by taking up new system of coordinates*. The identification of inertial fields with gravitational fields was also shown to be faulty.

From the point of view of mathematics, Fock showed that the number of equations in Einstein's field equations (which is ten) was not enough to actually determine the structure of the geometry and the coordinate system. He also debunked Einstein's belief that he had proved the equivalence of all frames of reference, including accelerated frames, which had made Einstein call his theory *the general* theory of relativity.

Drawing upon Newton's theory of gravitation, where the gravitational field fades away with distance from the attracting body, Fock considered the case of island universes, with the condition that at infinity, the geometry should be flat. Hence there was a natural coordinate system**,** *the harmonic coordinates*, which held a cardinal place in the theory. With the four conditions for the harmonic coordinates, now the theory was able to determine the structure of space time associated with the gravitational field. He gave a new structure (metric) to space-time which was different from the earlier accepted 'Schwarzschild' structure.

Here it must be mentioned that, historically, for all practical work, Einstein's field equations were used along with the harmonic coordinates which provided the extra equations for determining the space-time structure. Even to prove the existence of gravitational waves, harmonic coordinates were used. *Dirac had recognized this* when he said, "For the discussion of gravitational waves, however, harmonic coordinates are very useful" (*General Theory of Relativity*, 1975).

Hence, strictly speaking, the 1979 experiments that indirectly proved the emission of gravitational waves by pulsar stars, as well as the recent detection of gravitational waves by *LIGO*, are actually confirming the joint working of (a) Einstein's field equations along with (b) the harmonic conditions; i.e. ten equations plus four equations, respectively.

Fock's work was further continued by Denisov and Logunov in 1982.They took over Einstein's grand idea that gravitating matter determined the geometry of space-time, but insisted that gravitational fields should be material fields having conservation laws like the electromagnetic and other fields. Their theory called the relativistic theory of gravitation (RTG) reaffirms Fock's work but does not require the assumption of island universes. Technically, the RTG has four equations in addition to the field equations generally called the Einstein-Hilbert equations. Hence there is no need for additional assumptions.

In this theory, RTG, the gravitational field is a physical field with a conservation law. It cannot be switched off by a choice of coordinates since it is a material substratum. It describes the entire body of gravitational experiments, and shows that Einstein's formula for gravitational waves follows directly from the theory. Most important for the present discussion is that gravitational collapse does not lead to infinite contraction of matter. In the RTG there are no black holes, for there can be no objects having radius less that a certain quantity related to their mass. There are no objects in which the gravitational collapse results into black holes.

OTHER THEORIES AND THE BLACK HOLES

Jayant Narlikar and Fred Hoyle had worked with Einstein's field equations and amended them in order to bring in a C-field to account for the creation of particles in the field of gravity. This was to neutralize the fall in density of matter as the universe expanded in the so called Big Bang model of the universe. With the introduction of the C-field, they derived the result that gravitational force which was seen to be attractive through and through, would exhibit the property that when particles came very close, *attraction* *would change to repulsion.* This was exactly as predicted by Engels over a hundred years ago. In their theory also there was no scope for the existence of black holes.

Working with Einstein's general theory, Hawking later on came to the conclusion that black holes would radiate energy because of what is called pair production. In space near the black holes, because of a result in quantum mechanics, there would be pairs of particles of positive energy and negative energy produced spontaneously, and equally spontaneously they would annihilate each other. Some of the particles of negative energy could be swallowed by the black holes while the corresponding particles of positive energy would come out in the form of a radiation. By studying the situation quantitatively, Hawking came to the conclusion that the radiation coming from a black hole took the form of thermal radiation. He also showed that the negative energy particles which were swallowed would reduce the mass of the black hole. The black hole would eventually be eliminated. He called this as "black hole evaporation". In his book *A Brief History of Time* he described this by saying that *black holes ain't so black.*

More recently, Hawking went back on some of his earlier predictions that black holes would swallow all information, and admitted that some of his predictions were wrong. As black holes disintegrate, *they send their information content back into the world*.

Even more recently, working on the same lines as Hawking, and following the work of W.G.Unruh on black hole evaporation, an American scientist, Laura Mersini-Houghton, in a note dated 15th September 2014, declared that black holes were just not possible!

She says that the evaporation of the collapsing star can equivalently be described as a negative flux of radiation travelling *radially inwards* towards the centre of the star. "We include the back radiation of the negative Hawking flux. We find that quantitatively the radiation emitted by the star just before it passes the Schwarzschild radius reduces the mass of the star substantially, and so the star bounces back. There is no black hole!"

This is still in the stage of investigation. But what is clear from this is that the above mentioned attacks on the laws of dialectics were premature. Contradictory processes are seen to be working at the level of the interior of stars even in this posited stage. Knowledge is not, in principle, unavailable through the short-circuiting of matter in the black hole. And most important, *matter does not disappear.*

DIALECTICS OF THE INFINITY OF NATURE

From the above discussion we see that dialectical materialism is not demolished by the new discoveries of science, even though every important discovery is sought to be presented in such a way that idealist philosophy is reinforced. But let us take these laws of dialectics a little further. Lenin's law of the inexhaustibility of nature should lead one to the law that matter in *motion* is inexhaustible.

Lenin deals with Hegel's *Book on the Doctrine of Essence*. He quotes marginally that what Hegel says about infinite movement of being is of "objective significance", and he quotes: "*Essence...is what it is...by virtue of its own infinite movement of Being*." (*Collected Works* Volume 38).

Inexhaustibility of motion would mean that by withdrawing energy it would not be possible to reduce matter to a state of motionlessness, where the internal motion is zero. This immediately suggests the possibility of inexhaustible reservoirs of energy in nature. Here it may be pointed out that the present theories of the nuclei of galaxies are not able to account for the tremendous outbursts of energy from these nuclei.

Gravitational fields appear to be seats of tremendous amounts of energy. This is reflected in the *negative sign* we give to the potential energy of gravitation. The Hoyle-Narlikar theory relates the formation of new galaxies to the withdrawal of energy from this negative reservoir of energy. While discussing the C-field in his book *The Nature of the Universe*, Narlikar gives the argument as to why they took it as a negative field. From a negative field if we withdraw energy, the field does not get exhausted but becomes even more negative. In algebra, if from *negative 5* we take away 2, it becomes *negative 7*. So we get out 2 as a positive quantity, without affecting the negativity of the source!

The concept of *negative energy* is also used in some of the theories of the positron, and also in the calculation by Hawking regarding the way energy is withdrawn from a black hole through pair production. Similarly, in the work of Unruh as well as the recent work of Laura Mersini-Houghton, the concept of pressure of the negative Hawking radiation is used. Negative energy, it appears, reflects the infinity of motion of matter.

VLADIMIR A FOCK

When we say that the scientists A.D.Alexandrov and V.A.Fock were Marxists, it is to demonstrate that only through the conscious use of the Marxist philosophy of dialectical materialism were they able to rescue relativity physics from the idealistic misappropriation of the theory by bourgeois philosophers in order to use it for their own class purposes. In fact, in his preface to his 1959 work, *The theory of space, time and gravitation,* Fock acknowledges his debt to Lenin's book *Materialism and Empirio-Criticism*, which helped him "to approach crtically Einstein's point of view concerning the theory created by him and to think it out anew".

It has been said that while V.A.Fock helped rescue general theory of relativity from idealistic distortions, "Fock was a firm supporter of the Copenhagen interpretation throughout his life". Let us look into this charge.

Fock was born in 1898 and died in 1974. He was one of the founders of quantum theory and was responsible to bring quantum theory into the Soviet Union through his book *Foundations of Quantum Mechanics* in 1931, where he introduced the latest work of Dirac about the existence of the positron. In fact he did foundational work in quantum mechanics, and this is seen in the several processes which are named after him. For example, in 1926 he derived the Klein-Gordon equation, and in 1930 he developed the Hartree-Fock method.

But to say that he was a firm supporter of the Copenhagen interpretation would be as much of a howler as to say that Schrodinger, another founder of quantum theory, was a firm supporter of the Copenhagen interpretation. It is well known that Schrodinger and Einstein were among those who ferociously attacked the Copenhagen interpretation.

The Copenhagen interpretation was the idealist interpretation of certain results of quantum theory which was introduced by Niels Bohr, the influential physicist from Copenhagen. The Copenhagen interpretation should be distinguished from the quantum physics of that time. It may be of interest to note that even in this book of 1931, Fock was critical of some assumptions of Dirac about the sea of electrons filling up all of space. He was also critical of Niels Bohr's idealist stand.

Fock's opposition to Bohr and his principle of complementarity is seen in the first chapter of the book itself. He considered it of prime importance to formulate the basic concepts of quantum mechanics from a proper materialistic standpoint. The revised edition of the book, published posthumously in 1976, has the following comment in its foreword about his discussions with Niels Bohr: "In fact, there is evidence that Fock's criticism of 'non-observability in principle' prompted Bohr to abandon this idea in his later views."

The Copenhagen interpretation is the agnostic stand of '*non-observability in principle'* in quantum theory. Fock, as a dialectical-materialist, opposed this stand in quantum mechanics, even as we have, in this essay, opposed such a position (of non-observability in principle) with regard to black holes in the general theory of relativity.