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EINSTEIN AND EPICURUS

Atoms and space. Clinamen. Individual existence. Isotachy. The contemporary epilogue to Epicurus's physics. The problem of death and fear of death in Epicurus and Einstein. The gods of Epicurus and Einstein's God.

I. ATOMS AND SPACE

In 1923 a new edition of Lucretius's *De rerum natura* was published in Germany. The second volume—a translation of the poem into German—was prefaced by Einstein.[1] In it one reads that "Lucretius's book will enchant anyone who is not yet completely dominated by the spirit of our time, and who feels able to take a step back to take stock of the present age, and judge our contemporaries' spiritual attainments."[2]

But why must we not subjects ourselves to the spirit of our time but view it from a certain distance? Einstein clearly regards this insubordination, this ability to take a detached view of our time, as an intellectual advantage, and maybe even as a necessity which is characteristic of our time itself. And this is certainly the case. Post-classical science demands that one should analyse

Translated by N. Slater.

[1] Titus Lucretius Carus, *De rerum natura*, Ed. H. Diels, vol. II, Berlin, 1923.
[2] A. Einstein, *Sobraniye nauchnykh trudov*, IV, Moscow, 1967, p. 61.

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the present moment in science from the point of view of its dynamics, formulating certain predictions, forseeing the further development of contemporary ideas, and venturing into the past, to make new retrospective evaluations. The fact of resisting the present, and the ability to take a detached view, are characteristics which form an integral part of the truly contemporary style in scientific thought. We are drawn—now even more than in 1923, when Einstein wrote his preface to the new edition of Lucretius's poem, by the flexibility and dynamism of ancient thought, which created, in the newness and naïveté of its world-view, the prototypes of all sorts of ideas on physics, some of which have still not been embodied in an unequivocal form to this day. Among these we may quote the idea of the being, the self-identity of the subject of a change. Ionian philosophy attributed this role to concrete substance—water, air, fire, or "apeiron," nearer to the characterless substance of the atomists. The Eleatic philosophers connected being with absolute identity: the substance neither moves nor changes, movement is illusory, the predicates of the subject are all immutable, the subject is identical with itself in the most absolute sense of the word, nothing opposes this self-identity; thus the very problem of the self-identity of the subject of a change disappears: one is dealing with the immutable substrate of non-existent, null changes, with *trivial self-identity.*

In the works of Leucippus and Democritus, we see the appearance of a *non-trivial self-identity*: the subject possesses different and mutually exclusive predicates, and still remains self-identical despite this. At different moments, the atom occupies positions in space, but is always the same atom. If one combines positions in space and moments in time into a single concept of spatio-temporal localization (termed, in 1908, a "point of the Universe," with three spatial coordinates and a fourth temporal coordinate), then the movement of an atom represents a continuous series of non-coincident spatio-temporal localisations, of non-coincident points of the universe. If one limits oneself to space, the movement of an atom is an uninterrupted series of non-coincident positions. At each moment, the atom occupies only one real position, and an infinite number of potential positions, which constitute space, Democritus's "non-being." The world is divided into "being" and "non-being." The atoms, with their

self-identity and their substantial and immutable predicates, which persist through changes in spatial position, constitute Democritus's "being;" while the changing real and potential positions of the atoms constitute his "non-being," i.e. empty space.

Ancient atomism was the prototype of rationalism—an inarticulate prototype in which various theories mingled and merged with one another, later to be differentiated one from the other, while preserving their genetic and logical links. The world of atoms in motion can be grasped by reason; reason identifies empirical impressions, groups them into classes, and introduces general notions in which individual differences are lost. It is impossible to understand the world without such identification which introduces order into the chaos of our immediate impressions. But in this function of identification and ordering, reason still does not transcend the limits of judgement, as it was called in the 19th century.

Reason, in its proper sense, in its function which cannot be brought down to judgment, takes into account the individual differences which break and twist the ancient identifications and classifications, modify concepts, and make rationalism inseparable from its sensualist accompaniment.

Since the "letter to Herodotus" in which Epicurus's gnoseological standpoint is expounded, it has been impossible throughout the history of philosophy and science to separate thought which identifies, from empirical impressions which individualise. In a very important document of the new rationalism, Einstein's *Autobiographical Remarks*, there is a discussion of the transition from isolated perceptions to imaginary pictures, and of continuous series which appear in this way, each of the links drawing the next by association. Already these series cannot be set up without some recourse to concrete imagery. But then, thought identifies the images belonging to the different series, arranges them in order, groups them; the identified images become concepts, instruments which serve to put the associative series in order.[3]

Such a gnoseological point of view was an active element in Einstein's conception of the world. He based his research which led him to the theory of relativity upon it: the theory is in

[3] A. Einstein, *op. cit.*, pp. 260-261.

no way the logical result of experimental discoveries without a conscious gnoseological foundation. The theory of relativity is based on a rigorously rationalist point of view; but a rationalism which is not in opposition to sensuality and empirical sources of knowledge. The criteria for the choice of a scientific theory, *internal perfection*, that is to say natural and logical deduction from premises that are as general as possible, and *external justification*, that is to say experimental confirmation of the theory, are combined in the demand for a physical content for ideas; basic ideas involved in logico-mathematical deduction must (at least in principle, at least by way of intuitive supposition) lead to experimentally verifiable results. Logical deduction and empiricism, the rationalistic and sensualistic components of knowledge, are complementary, mutually exclusive, and at the same time they lose all real significance in isolation from each other.

The empty space of atomist philosophy is the totality of distances between bodies; without them, the notion has no meaning. Empty space, "non-being" to Democritus, was, as we have already said, a negative predicate of a body, the place not occupied by the body, the place where the body is not at a particular moment. But a negative predicate has meaning only if there is a corresponding positive predicate: empty space is the potential place for a body, the place which can be occupied by a body, which has been or will be occupied by a body, and which can thus be attributed as a predicate to the body. But an attribution of this kind differs from real possession in the impossibility of acting upon the sense organs, in the absence of the sensualist empirical component of knowledge. Here we are at the source of purely speculative constructions which lay claim to independence. The real basis for including non-being (or incomplete being, with no empirical component) is the idea of movement. This allows of the consideration of non-being, space, as a place abandoned by the body, or as a place that the body can occupy: as a potential place, a potential predicate, of the body. This assimilation of potential positions and real positions allows one to consider space as distance, to identify points which are equidistant from a given point, an axis, etc., to use measuring systems, and in general to erect geometrical and logical constructions.

The idea of space as a set of potential predicates of bodies is a relativist one. It deprives empty space of physical meaning, unless the space contains bodies perceptible to the senses; similarly, it connects the spatial position of a body with the distance which separates it from other bodies perceptible to the senses (perceptible, that is, in principle). Spatial displacement should figure in this world picture as a potential trajectory of movement.

Similar ideas were probably entertained already by Democritus, and more probably still by Epicurus; in Lucretius we see them clearly. Lucretius speaks of empty space as a necessary condition of movement.[4] Furthermore, empty space is one of the conditions not only for the movement of bodies, but for their individualisation. The problem of individualisation is a fundamental problem of the mechanistic view of the world, denying as it does primary qualitative distinctions between bodies. If a body has no qualitative properties, but only geometrical properties, and is not distinct from the position it occupies, then what enables one to talk of its existence, what distinguishes it from its surroundings? Descartes could not solve this problem, but the atomists solve it by reference to empty space. An atom is surrounded by space, which is not impermeable, and which, therefore, has no effect upon the sense organs. It is because of this that space limits a body. Space in its turn, as we know, forms part of the image of the world, since it is the sum of the distances which separate bodies, and they limit it. Hence the idea of the alternation of space and bodies which allows a definition of them, and is therefore infinite.

> "Then, Nature sees to it that the assemblage of things cannot limit itself: She makes space the frontier of the body, and constrains the body to limit space, making everything infinite by this alteration."[5]

The fact of deducing the *infinity* of the Universe from the spatial *limitation* of bodies and of space shows the gnoseological nature of the Epicurean world-view. Objective thought, thought concerned with being, discovers the identity of an individual

[4] Lucretius I, 330-345.
[5] Lucretius I, 1008-1011.

object with other objects, and replaces individual objects by general notions in which their non-identity is obscured. But every step in this speculative direction requires limitation, and empirical registration of individual bodies which are non-identical, and exist in the present. This operation cannot stop. To stop would be an erroneous notion, void of physical significance, because it would be just the same as a body unlimited by space and a space unlimited by bodies would be to Epicurus.

From the idea of an infinite universe is derived the idea of a homogeneous space in the sense that it has neither centre nor limits, nothing which might set up a privileged system of measurement. But one idea is found in Epicurus's work, which is not to be found in Democritus's or Aristotle's—spatial anisotropy. Atoms move from high to low, and the notions of "high" and "low" have an absolute meaning. Here, as far as his positive conceptions are concerned, Epicurus is regressive in comparison with his immediate predecessors. But what is the "interrogatory" aspect of this idea of spatial anisotropy?

It is the thought of a cosmic law to which the movements of atoms are subject, of a law which has lost its connection with the *static* schema of the cosmos. Such a schema is not found in Democritus, but neither does one find a law which rules the cosmos in its entirety. The movements of atoms take very diverse directions, atoms do not have a determined and general background movement applicable to the whole cosmos. In Aristotle, the cosmos is ruled by a static system of natural positions. Epicurus describes a kinetic harmony of the world: atoms, by virtue of a general cosmic law, possess linear movement in one and the same direction.

This flight of thought, ordering existence and levelling out individual differences, is checked by two questions. The first one is physical: how can the visible world, where atoms cluster in macroscopic bodies and thus acquire the ability to act upon the sensory organs and hence upon physical existence, form itself out of cosmically ordered parallel movements of atoms? The second question concerns man: can he retain his liberty, that is to say his existence as a human being, if nature is subject to a single cosmic law which determines the behaviour of the atoms which constitute it?

II. CLINAMEN

The answer to these questions is linked with the Epicurean concept of the microcosm, or rather of an ultramicroscopic world, which is inaccessible to direct observation. Is the omnipotence of cosmic law concerning the parallel paths of atoms, the omnipotence of macroscopic laws as a whole, maintained in the ultramicroscopic world? And yet a more radical question: is the constant movement and constant existence of atoms maintained?

A purely rationalist representation of the world, insofar as it is possible, is not hampered by the division of space into parts of ever-decreasing size. Such a constraint would be an intervention of empiricism into the process of speculative thought, and would contradict its basic line. When we attribute different predicates to a subject, we should be sure that we are contemplating the same subject, identical with itself. The possibility, in principle, of following an atom from one point to another, and from one moment to another, enables one to ascertain that in a given case the prince has not been replaced by Tom Canty, as in the Mark Twain story. But does not such continuity of movement upset the physical existence of the atom, the distinction between it and its spatial location, the distinction between its movements and its trajectory, and between "being" and "non-being"?

We may reply at once that if continuity of movement is essential for speculative thought, operating upon the potential positions of an atom which is identical with itself, then the existence of an atom at a given moment requires a local "event," not reducible to its continuance upon its uninterrupted trajectory. Let us examine how this encounter between continuous and discontinuous movement is brought about in Epicurus and Lucretius.

These two qualities are relevant to two worlds—the macrocosm which acts directly upon the sensory organs, and the microcosm of discrete objects and events which cannot be subjected to direct observation. This demarcation starts with the atoms themselves. They are smaller than any visible particle of matter, but they have finite dimensions. The same distinction affects the behaviour of atoms, and judging by certain indirect testimonies about Epicurean ideas, it often affects their very existence. The behaviour of atoms

in the macroscopic, observable realm, and in the microscopic realm, is different. In the macroscopic world atoms move along continuous paths which are entirely determined by the cosmic law governing falling from high to low and the collision of atoms. In the microcosm, they are subject to spontaneous deviation (*clinamen*). The idea of *clinamen* has two kinds of roots: the first are truly physical, the others are what might be called moral criteria. We will start with the second.

The idea on which the whole of Epicurus' work is based is Man's liberation from the power of religion, from the fear of death, from everything which ties the individual down and robs him of a truly human existence. But the forces which are hostile to Man also include Nature's absolute determinism, which excludes human liberty. This is what Epicurus says in a letter to Menecaeus:

> "In fact, it would be better to follow the myths about the gods than be the slave of the physicists' destiny; myths allude to the hope of softening the gods' hearts by honouring them, while destiny implies an inflexible necessity."

In Lucretius's work, ideas concerning natural science are less subordinated to the idea of moral harmony and liberty as the basis of human existence than in Epicurus's work. His artistic temperament prompts the Roman poet to describe Nature for its own sake, without moral reference. But even in Lucretius *clinamen* is connected with the defence of human liberty against the determinism of natural science. The break with macroscopic determinism in the microscopic domain acts as a guarantee [5].

Moral motives link with truly physical motives. The rigidly vertical path of atoms excludes their collision and the formation of macroscopic bodies. It is from this basis that Lucretius begins his exposition of the concept of *clinamen* [7].

III. INDIVIDUAL EXISTENCE

In the history of philosophy, *clinamen* has not, on the whole, been considered as a fundamental principle, which could take

[6] Lucretius, II, 289-293.
[7] Lucretius, II, 216-229.

on ever new concrete forms in relation to the study of new phenomena unknown to antiquity. The one thinker to see in *clinamen* a deeper collision of being was Marx. What, then, are the fundamental problems which Marx found that the Epicurean conception of *clinamen* posed?

The straight line which a body describes in falling is not a sum of bodies but of places—in the simplest case, a sum of points. At the same time, the points which make up the straight line are not independent, the line absorbs them and they disappear in it. Nothing occurs at the points that would distinguish them from bodies, or which reveals a specific characteristic of a body. Marx writes:

> "Any body, when we examine it as it falls, is thus no more than a point in motion, and moreover a point without independence, which loses its individuality in a determined being—the straight line which the point describes."[8]

Marx says that the deviation of the atom from the straight line does not constitute a particular, special, fortuitous definition, but that it is the expression of a law which permeates Epicurean philosophy. Lucretius, according to Marx,

> "...is right to affirm that the deviation is a breach of the *fati foedera* (the laws of destiny) and at once applies this fact to consciousness, so that one might say that the deviation of the atom is something in his breast which can struggle and resist."[9]

Marx is thinking of Lucretius's lines on man's resistance to external force:

> "But in our breast there is hidden
> Something that rises against it and can fight it."[10]

The revolt against the *fati foedera* which exists in an atom's breast, analogous with the readiness to fight that is harboured

[8] K. Marx and F. Engels, *Works*, vol. I, Moscow/Leningrad 1929, p. 43.
[9] K. Marx and F. Engels, *op. cit.* vol. I, p. 44.
[10] Lucretius, II, 279-280.

in the human heart, is not a mere metaphor. To Epicurus, this revolt breaks the absolute fatality of the natural sciences and liberates Man. Therefore the generalisation of the "revolt" is not an arbitrary assimilation of essentially different phenomena. What is more, the problem of individual existence is a real problem in physics as well. It is not discussed in Epicurean philosophy alone, but also in contemporary science. This makes it possible to see the limitations of the Epicurean philosophy of "revolt."

In Epicurus, the individual being has a defensive character. "Thus the aim of activity is abstraction, the avoidance of pain and struggle, it is ataraxis."[10] The idea which we have of the individual now is different; it is dynamic, active. And this is not only in relation to a moral ideal—we will refer to that in relation to Epicurean hedonism—but also in relation to a contemporary ideal of physical explanation. Contemporary science does not consider elementary particles as passive, ignored by the macroscopic laws of the universe—a role which classical thermodynamics attributed to them. But contemporary science no longer limits itself to establishing the "local revolt" of the particle, the local indeterminateness of its dynamic variables. Local revolt becomes the starting point of a chain-reaction, it modifies the development of macroscopic processes. Moreover, only where local revolt modifies the macroscopic universal line (relatively macroscopic: here we are concerned with the path of the particle, with its trace on a photographic plate), only in this case does the local event become physically real.

Here we confront a fundamental peculiarity of science: it always yields more than one asks of it. Whatever applied, technical or moral problems are presented to it, science answers in more general terms. What Poincaré called elegance—the avoidance of *ad hoc* explanations, the aspiration towards internal perfection, towards general solutions—these are inseparable characteristics of science, which, when faced with an applied problem, always tends to follow Hercules's example, and alter the course of a river to supply Augias's practical requirements. To Epicurus as to Lucretius, the prime mover of their work was the desire to liberate the human consciousness

from fear of death and the gods; but Epicurus's thought tended towards more general physical concepts which could not yet be couched in unequivocal, incontestable results, and also, he was able to find a moral equivalent not in the passive avoidance of pain, but in the active transformation of existence. In Lucretius's work, this broadening of physical and moral conclusions was enriched by his poet's love of nature and his actively social temperament. We will now examine what it was that took Epicurus's and Lucretius's thought so far beyond the limits of the ancient scientific and moral ideals, and so near to Einstein's own.

IV. ISOTACHY

Epicurus expounds the idea of isotachy—of the constant and uniform speed with which atoms are displaced—in his letter to Herodotus, in relation to the distinction between continuous time which is accessible to the senses, and discrete time, reached by thought alone. According to Epicurus, sensory perception and its rational conception belong to different worlds: the senses perceive what we could call the macroscopic world, and reason conceives the microscopic world. To him, the one and the other are both true. But he relates them differently from Democritus. The latter proceeded from the true world of atoms to the illusory and multi-coloured world of bodies accessible to the senses. Epicurus points the way from the true and objective world of atoms to the macroscopic world of visible bodies. Here a new gnoseological principle is at work. It differs from the old absolute opposition between empiricism and rational conception by moving the problem into the world of objectivity, turns it into an ontological problem, sees something in reality which is accessible to reason, and something which is accessible to the senses. But these two worlds cannot be wrested from each other. Macroscopic movements are real because *they* are made up of microscopic processes conceivable only by reason; those processes are real because it is *from them* that movements appreciable to the senses are formed.

In a similar way, Epicurus's physics presents a world which is rationally conceivable, in which atoms possess a constant and

uniform speed. This is the first constant of the microscopic world: microscopic speed, which is constant, very great, though finite, of atoms. Epicurus can only define it in a subjective and qualitative manner. He calls the speed of atoms *the speed of thought* or an inconceivable speed (referring to sensory perception and the imaginary concrete image). Atoms move in space at this speed before they encounter other atoms, but even after colliding, though their direction changes, their absolute speed is not altered [11]. The collision of atoms has the consequence that the macroscopic speed of a body is different from that of the atoms which make it up ("... for the movement of a body as a whole is the external expression of the internal collisions of the atoms which make it up" in Epicurus's words).

Despite the obscurity in certain lines of the letter to Herodotus, Epicurus's thoughts may be understood in the following way: the elementary and free movements of atoms (which were named *kinemata*) give the body a macroscopic speed which is different, owing to the dissymmetry of these movements. In a case of total symmetry, the body would remain macroscopically immobile. In a case of total dissymmetry, if all the atoms carried out their elementary movement in the same direction, the body would move in the same direction at the constant "speed of thought," that is to say, a limiting speed, equal to the absolute speed of the kinemata. In fact, the atoms enter into collision, modify their direction and the macroscopic real movement of the body; approximately, the macroscopic movement of each atom during "a period accessible to sensory perception" is very small in relation to the limiting speed and depends upon the predominance of fortuitous displacements in one direction rather than others.

Is there a movement—the Aristotelian φορά, "local movement" displacement—in the ultramicroscopic intervals of space and time, in the "moments conceivable only to thought"? Epicurus speaks of such a movement. And yet, did a doubt not worm its way into the mind of Epicurus or of his pupils concerning the mechanical nature of the microscopic processes? The combination of the self-identity of the subject and of the

[11] K. Marx and F. Engels, *op. cit.* p. 45.

transformation of its predicates, by means of which the atomists wanted to resolve the conflict between Heraclitus and the Eleatics, depended upon the constant existence and constant movement of atoms. But when the behaviour of the atom became detached from the perceptible macroscopic world, the certainty that the atom repeats, on a small scale, the actions characteristic of macroscopic bodies, might be shaken. Or rather, doubt might arise as to whether the atom repeats the *mechanics* of the real world, the movement of self-identical bodies. The non-mechanical ideas of the atomists indicated that the atom had ceased to be the self-identical substrate of movement. Processes of destruction and of rebirth seeped through the pores of the atomist world-image, under the name of the elementary processes which made up continuous movement.

At the beginning of the second century A.D., Alexander of Aphorodisia wrote thus about the Epicureans:

> "In asserting that space and movement, and time, are composed of indivisible particles, they assert that a moving body moves through the whole extent of the space which is composed and that in each indivisible particle which composes it there is no movement, but only the result of movement."

"There is no movement, but only the result of movement." This sentence might designate the annihilation of the atom in a given cell of discrete time and space, and its regeneration in the neighbouring cell. The result is identical with that of movement. But how can we explain these processes which recall the birth (γένησις) and the destruction (φορά) of which Aristotle spoke, but which are situated at a much greater depth than the continuous movements of the atoms which make up the dynamics of the universe? It is difficult to imagine that the Epicureans did not ask themselves such questions. But one can easily imagine that Epicurus and his disciples had resigned themselves to being unable to answer them. Science goes further than one asks it to, but its progress stops if it does not receive a constant supply of applied or moral problems to drive it on. The moral impulse behind Epicurus's philosophy was the desire to liberate men from their fear of death and

the gods. Subsequently, Epicurus's ideas in a developed and modified form, together with new answers to the questions which he had posed, turned out to be related to new stimuli, more radical, more active, and broader.

V. A CONTEMPORARY EPILOGUE ON EPICURUS'S PHYSICS.

This chapter claims the role of an epilogue in the novels of the good old days, in which the reader is told how the heroes of the tale are living today, many years after the events of the story. The heroes are here represented by the division of reality into matter and void, and the limit between the macroscopic and microscopic worlds.

The result of the powerful and seminal intervention of pure speculation ("pure," of course, in a conventional sense: subject to empirical verification) in the representation of nature, was the notion of empty space. This means the potential positions of bodies, distinct from the bodies themselves, but necessary to their movement, and therefore to their action upon the sensory organs. One must emphasize that this notion plays a particular role in Newton's system. It no longer means merely the sum of the possible positions of a body in movement; it now involves the distances which separate them and across which forces act. After the peripatetics and Descartes, this filling of space had dynamic meaning; the notion of fields embraced the forces acting between bodies and a certain medium which, for a very long time, aspired to the role of yet another body, all-pervading and filling all the space between ordinary bodies. These ideas were overthrown by the theory of relativity. The ether disappeared from our picture of the world. The field cannot act as a measuring body, and one cannot simply identify it with Democritus's "being," along with the atoms and bodies made of them, by giving it the function of a substance which fills everything. Today, after the appearance of the theory of relativity, the Democritean antithesis has been modified. In ancient atomism, as in classical science, one of the elements of this antithesis, "non-being," space, was the domain of *ratio*, subject to rational understanding. The other branch, "being," atoms, was the source of sensory perceptions, acting upon the sense

organs. The linking of sensation and speculation took place when spatial properties such as position or distance were attributed to atoms; it was these properties of atoms that made up the rationally conceivable picture of the universe.

In the physics of relativity, distances have lost their purely rational and geometrical character. Distance is the distance covered by a body. In other words, it is the spatial component of a spatio-temporal process in four dimensions occurring in time, of *movement* or something perceptible to the senses and not merely to speculation. There has been objectivization of rationally conceivable "non-being." But this has become a new "being," it has not been simply equated with the atoms, as happened with the mechanistic theories of the ether.

Einstein deprived distances of their independence from material bodies of measurement. But the dependence of distances upon bodies of measurement had to be shown in concrete form by a picture of the effect of the atomic structure of a ruler upon its length [12]. Therefore it is a matter of deducing the properties of the macroscopic world from those of the microscopic world.

We find this problem in the works of Epicurus and his disciples. *Clinamen* is a characteristic of the microscopic world; macroscopically, it is not possible either to predict or to record the spontaneous deviation of an atom. Nevertheless, it is indeed through *clinamen* that macroscopic bodies are formed. Kinemata, the elementary displacements of atoms with one and the same macroscopically unattainable speed, are also a feature of the microscopic world. But kinemata make up the macroscopic movements of bodies with different speeds. Both *clinamen* and kinemata belong to history. At the present time and for the future this is the relevant question implicit in those notions: how, starting from the chaos of microscopic processes, is the order of the macroscopic world made up?

The theory of relativity cannot answer this question except according to notions introduced by quantum mechanics, and above all according to notions of the probability of the elementary processes of being.

[12] Epicurus, *Letter to Herodotus*, 61-62.

Quantum mechanics largely concretises the interpenetration of "being" and "non-being." In other words, it reveals *being*, without inverted commas, even more precisely, *being* in which mutually exclusive definitions can coexist. Quantum mechanics regards the behaviour of the atom (of the contemporary atom, that is to say the microscopic particle) as being subject only to the laws of probability in general. For every point in space, at every moment in time, there is a certain probability of a particle being present. The location of a particle is the place in which it would be most likely to be found. Space (Democritus's "non-being") is the diversity of probable locations of the particle (Democritus's "being"). For ancient atomism "non-being" is real, because it is made up of possible positions of atoms. To Democritus and Epicurus, "being" is an actual particle, and "non-being" a potential particle. But today, this thought has not only become a qualitative rather than quantitative juxtaposition. It is not merely a matter of moving from a possible place to a probable one (with a precise quantification of probability). The particle—"being"—is here inseparable from the probability waves which fill space—"non-being."

VI. THE PROBLEM OF DEATH AND THE FEAR OF DEATH IN EPICURUS AND EINSTEIN.

As soon as we move on from the question "how is the world made?" to the question "how do we alter our representation of the way in which the world is made?" we bridge the gap between the study of nature and the study of Man. Post-classical science, with its imprescriptible circumspection, so characteristic of the theory of relativity as of quantum mechanics, in relation to the possibility of reaching truth by pronouncing it, with its constant appeal to gnoseological concepts to pose ontological problems, with its inclusion of a perceptibility in principle in the definition of being, post-classical science is in this respect a very "human" science.

It is on account of this that Einstein's moral interests, and,

[13] Einstein, *Collected Works* (Russian edition), IV, p. 280.

in a general way, his humanitarian interests, his attitude to truly human problems, are not only a biographical trait, but also an historical feature of the new science. The characteristic here is not the meeting of scientific and moral ideals in the same man, but their interrelation, even their synthesis. Even more characteristic is the meeting of scientific and moral authority, the fact that a scholar should have become the conscience of an age, that he should have had both a great intellect and a great heart.

Did this combination realise Epicurus's ideal, that of a man who, understanding the structure of the world, liberates himself from the fear of the gods and of death, and achieves the calm and peaceful joy of being?

This, too, is not merely a biographical question, nor even merely an historico-philosophic one. It is inseparable from the more general question of the effect of contemporary post-classical science upon the attitude of man to his destiny, upon the realisation of moral harmony, upon men's emotions. Here, for a comparison between the emotional effect of science upon Epicurus and Einstein, we will limit ourselves to a question that was of prime importance to Epicurus, that of the fear of death.

Let me quote some lines from Epicurus's letter to Menecaeus, that famous incantation against the fear of death which has crossed centuries:

> "The worst evil death, does not concern us at all, since while we exist, death is not yet there, and that when death is there, we no longer exist."[14]

The Greek thinkers conversing in Epicurus's garden probably appreciated the unimpeachable logic of this thought. It is probable that Epicurus himself did not fear non-being. Shortly before his death he wrote to Idomeneus: "On this happy day which is at the same time the last day of my life, I write to you the following..." He then speaks of violent pains which prove the approach of death, and declares: "But in the face

[14] Epicurus: letter to Menecaeus, 124-125. In Lucretius, *De rerum natura*, vol. II, *Extracts from Epicurus* pp. 591-3.

[15] Diogenes Laertius, X, 22. Lucretius, *De rerum natura*, II. *Extracts from Epicurus* p. 635.

of all this stands the spiritual joy aroused by the memory of our past discussions."

Nevertheless, this outlook was not widespread in the ancient world. Even among the intellectual elite, logical victory over the fear of death did not become a state of mind. What was common, clearly, was something else, a resigned evening sadness, a quiet regret for the transience of life, such as permeates the *Odyssey* in particular.

In Einstein, Epicurus's formula "death has nothing to do with us," became a permanent state of mind, to such an extent that even in his thoughts he never returned to that formula. We have several proofs of this, and everything that we know of Einstein confirms their absolute authenticity.

Leopold Infeld clearly remembers what Einstein once said to him:

> "Life is a magnificent and exalting spectacle. It pleases me. But if I found that I had to die in three hours, the news would not make a great impression on me. I would try to think of the best possible way of using the three hours remaining to me. Then I would put my papers in order and lie down peacefully to die."[16]

In 1916, during a serious illness which placed his life in danger, Einstein spoke of it so peacefully that Hedwig Born (Max Born's wife) asked him if he had no fear of death. "No," he replied, "I am so much merged with everything that is alive that I don't care where in this infinite flux anyone's concrete existence begins or ends.[17]

Apart from certain purely personal traits, such an attitude to death expresses the characteristics of Einstein's view of the world, connected with the content of his scientific discoveries, the style of scientific thought, and the character of post-classical science. We will approach this question more closely, after first recalling that Spinoza, whose ideas had a deep effect on Einstein's vision of the world, said: "A free man thinks of death less than of anything else, his wisdom lies in the fact that he thinks

[16] *Uspekhi fizicheskikh nauk* ("Progress of the Physical Sciences," 59, first edition, 1956, p. 158.

[17] *Helle Zeit - Dunkle Zeit*. Hrsg. C. Seelig, Zurich, Europa Verlag, 1956.

not of death, but of life."[18] Contemplation of death and fear of death are not only logically devalued as in Epicurus's thought, but psychologically pushed out of consciousness by thoughts about life, by the feeling of continuity of life's infinite flux, of which Einstein spoke to Hedwig Born.

Why does Spinoza attribute the rejection of thoughts about death to the *free man*? And what connection is there between post-classical science and man's attitude to the infinite flux of life?

The infinity of this flux acts upon the individual consciousness and upon every local situation of the individual consciousness, because it is a matter of the Hegelian "true infinite" which is reflected in all its elements, which cannot be reduced to the simple repetition and accumulation of finite elements. Feuerbach spoke of this reflection of the infinite in the finite, the whole in the part: "At every instant you empty the cup of immortality to the depths, which fills again like Oberon's chalice."

The feeling of infinity and of fusion with nature do not allow man to drain that cup of immortality. Schiller's words: "You fear death? You dream of immortal life? Live in the whole! You will perish, but it will survive eternally"—do not refer to nature as the whole, nor to the cosmic process, but the infinite process of human life, of infinite knowledge, and the infinite transformation of nature and of the conditions of men's lives. And it is precisely in the real possibility of local individual action upon this dynamic, moving and living whole that man's liberty is found, as a positive definition, which cannot be reduced to the negative definition of independence from the whole; liberty which includes the dependence of local events upon the whole and the dependence of the whole upon local variations.

In post-classical science, the line of the world is not only blurred, but it may be altered as a whole by the action of local variation. This is not a semantic matrix for the laws of human conduct and the relationship of the individual to the whole, to nature, to our knowledge of it, to the historical process. The practical application of post-classical science produces a specific effect: the mobility of its laws gives great dynamism

[18] *Ethica*, IV, prop. LXXXI.

to all domains of production and culture; moreover, integral transformations which occur in these fields can be the result of a "chain reaction" engaged by an individual and local creative act. As regards the liberation of Man from the unlimited power of elemental social forces, post-classical science contributes something toward the abolition of the alienation of the individual, towards filling consciousness with the problems of immortal life, and thus rejecting the fear of death, already logically discredited by Epicurus.

VII. THE GODS OF EPICURUS AND EINSTEIN'S GOD.

Epicurus's philosophy as a whole (and—if one can put it that way—at a first approximation) does not demand that consciousness be filled with problems of the *transformation* of representations of the world, and of the transformation of the world. It reflects the features of a slowly developing, quasi-static civilization.

Let us examine Epicurus's gods from this point of view. They live in the spaces between the worlds, absolutely indifferent to the affairs of the world, inert by virtue of their perfection. This idea has provoked laughter. "And yet, these gods are not of Epicurus's inventing. They existed," wrote Marx. "*They are the plastic gods of Greek art...* Theoretical immobility is the principal aspect of the Greek gods' character, as Aristotle has it: "That which is better than everything does not need action, it is an end in itself."[19]

Indeed, the static character of the ideals which, by the force of their immobility, become not ideals but canons, is typical of the whole of Greek culture—of its art, with its perfect canon of plasticity, and of its static moral codes, and of the static harmony of the universe.

Epicurus's conception of happiness finds its place in the static schema. It consists, according to him, in the absence of misfortune, which includes unsatisfied needs. Therefore happiness is ensured by limiting one's needs. This negative hedonism, this purely negative definition of happiness as absence

[19] K. Marx and F. Engels, *op. cit.*, vol. I, p. 46.

of unhappiness, shows the limitation of need as something traditional, well-known and immutable.

The greatest sum of this negative happiness appears as an ethical criterion. Einstein, having read Solovin's book on Epicurus, wrote to the author:

> "It is difficult to doubt that he was basically right in his ethics. However, it seems to me that he did not exhaust the subject, for the values which he considers to be positive are to a certain extent incommensurable, they cannot be directly added together or subtracted. For example, let us suppose that we are convinced that the sum of happiness of ants is higher than that of human beings. Would it then be ethically fair that men should yield their place to ants?"[20]

If happiness is equivalent to the degree of satisfaction of traditional needs, the sum of happiness of ants could very likely exceed that of human beings. What is special to Man is the historical transformation of his conception of happiness, which comprises values which are different in principle, and qualitatively incomparable with elementary values. They ensure the transformation of existence, the rapidity and acceleration of that process, and include ever-renewing values, and, in particular, newly-discovered laws of life.

To Epicurus, the knowledge of these laws is part of the sum of values, insofar as it liberates man from an afflicting submission to the gods and a no less afflicting and equally unfounded fear of death. But that is all. When the mortality of the soul is proved, and man is freed from fear of death and the sufferings which follow it, when the deterministic nature of existence is proved, and Man is free of fear of the gods, when *clinamen* has freed man from the "power of physicists," from fatalism, then the stimulus to knowledge disappears.

From this point of view, Epicurus differs markedly from the tragic figure of Democritus, who, ever aware of the contradictions and aporiae implicit in the atomist world view, turned towards empirical knowledge, and finally, according to

[20] A. Einstein, *Lettres à M. Solovine*, Paris, 1956, p. 87.

legend, committed suicide.[21] Democritus constantly discovers collisions and contradictions in Nature, Epicurus, on the other hand, never encounters anything which surprises him or causes him to doubt the truth of what reason and observation make him discover.

But it is here that the "second approximation" comes into play, the tendency towards dynamism and dialectic in Epicurean philosophy. For Epicurus, reason and observation are two equal agents of knowledge. Both provide Man with an adequate representation of reality, but observation (Epicurus's φύσεως θεωρία) illuminates the macroscopic world, while speculation and reflection upon Nature (Epicurus's φυσιολογία) bears upon the microscopic world. Epicurus's canon seems to perpetuate this division. But at the same time, the philosopher takes a step towards a problem in which the isolation of observation and reflection is broken. It is broken because the isolation of the macroscopic and microscopic world disappears here. This is the problem of the genesis of the macroscopic world, of the formation of perceptible bodies from microscopic particles which can only be grasped by thought, and this requires the *clinamen* of perceptible movements, formed for kinemata that can only be conceived by thought. But this is only one step. It is enough for the negative task, that of abolishing fear of the gods. Epicurus goes no further.

He ousted the gods from the universe, and their only reality turned out to be the images of them presented by poetry, painting, and sculpture. Later, their halo of beauty and perfection was transferred to nature as conceived by reason, and the term "god" became metaphorically synonymous with nature.

Such is Spinoza's God—*deus sive natura*. That is the irrational pseudonym of the cosmic ration, not by any means of a static system of immutable objects and movements. To Spinoza, nature is rationally explicable not only in relation to the disposition, the movement, the interaction, and in general the *behavior* of the bodies which make it up, but also in relation to the very existence of those bodies. If a statement about movement consists of a subject (*what* is moving?) and a predicate (it *moves*!) then

[21] Cf. Lucretius, *De rerum natura*, III, 1039-1041.

Spinoza explains rationally and causally not only the predicate but also the subject. For this explanation, he has recourse to the notion of being, which is its own cause (*causa sui*). This is a distant antecedent of the notion of the "auto-action" of a substance, which figures in some concepts in contemporary physics. It thus goes far beyond the limits of classical science which endeavoured to find the explanation of modal processes, the explanation of the behaviour of bodies, without aspiring to the paradox of the *causa sui* and the causal explanation of the very existence of the universe. To Spinoza nature is not only created (*natura naturata*) but also creative (*natura naturans*). Of course, it is not a static system; it does not include *a priori* and thus immutable definitions.

Now let us turn to Einstein's "God." Here the inverted commas are justified: Einstein used the term "God" most of the time as an ironic pseudonym for the order of the world, the causal order which transformed chaos into cosmos. The word "religion" to Einstein has a psychological and moral meaning, and denotes a feeling of the harmony of the world and the meaningfulness of existence. "God" indicates, therefore, the laws which govern the being, its causal rationality, which is by its nature material. Einstein's God has nothing in common with a personal God. "I cannot accept this illusory God who rewards and punishes his creatures..." wrote Einstein; "I cannot and do not want to imagine a man continuing to live after his physical death; what feeble souls must those people have, whose egoism or ridiculous fear gives rise to such hopes."[22]

In this case, the question of terminological concessions to religion is a biographical one; another problem appertains to the history of philosophy and science, and that is the problem of the nature of that cosmic harmony which in Einstein is hidden behind the (largely ironic) pseudonym. Let us limit ourselves to two aspects of that harmony: to its *paradoxical nature*, and also to the exact, unequivocal, dynamic, or on the contrary, the probable, sense of the laws of being.

One may find engraved upon one of the chimneys at Princeton the following words of Einstein's: "God is cunning, but not mean." The laws of being are paradoxical, but comprehensible.

[22] A. Einstein, *Comment je vois le monde*, Paris, 1934, p. 13.

Their paradoxical nature which is so precisely demonstrated by post-classical science had already appeared in classical science at every decisive moment. At present, the paradoxical turns taken by science make up its evolution almost all the time, and it is from them that relativist and quantum physics draws the dynamism that it contributes to contemporary culture. Science's paradox and life's dynamism are very closely linked in our time. In Epicurus's time, the staticity of human life, and of cosmic harmony as described by ancient science, corresponded to a static moral ideal and a static idea of the gods, who did not intervene in the destiny of the world. For a contemporary thinker, Spinoza's God is nearer: indistinguishable from nature, that is infinitely complex and truly cunning, setting men unexpected riddles, revealing even more unexpected solutions to their eyes.

Let us now examine the dynamic, unequivocal or static nature of the fundamental laws of being, or to use Einstein's expression, the question of whether God plays at dice. "You believe in a God who plays at dice, and I in laws which govern an objectively existing world," is how Einstein wrote to Max Born in 1947.[23]

A god who does not play at dice, who does not leave chance to determine every event, but determines it himself in a precise and unequivocal way, is in accordance with classical science, with statistics. Behind the macroscopic laws of thermodynamics, which can only operate with the probable behaviour of particles, there are laws of mechanics which are dynamic and precise, which determine the fate of every particle in an unequivocal way. In quantum mechanics, elementary events—particles occupying points in the universe—are determined according to probability.

But are these events really elementary? Has the notion of the randomness of the behaviour of particles any meaning in the absence of its polar opposite—the idea of a rigorously determined universal line for the particle? Quantum mechanics answers this question in the negative. The randomness of the behaviour of a particle is a notion without physical content in the absence

[23] Cf. *Uspekhi fizicheskikh nauk* ("Progress in the Physical Sciences,") 59, vol. I, 1956, p. 130.

of classical notions of the impetus and position of a particle, and of a corresponding notion of a particle in constant movement along a predetermined unequivocal trajectory. The most paradoxical thing in quantum mechanics is not the negation of classical notions, but the fact that the negation is indissociable from a classical presumption, that of the existence of a representation which has been denied. Moreover, randomness in its turn gives a physical meaning to these classical representations and ideas. A particle whose properties all pertain to localisation and change of localisation has no physical existence and its line in the universe remains a purely geometrical notion. The randomness of quantum physics blurs the line, but it is precisely this that gives it physical existence.

Here is something quite new in relation to Epicurus's ideas. To the Greek thinker, ultra-microscopic transgressions limited the macroscopic laws, and preserved Man and nature from fate and the inexorable "power of the physicists." In contemporary science, the representation of ultra-microscopic events does not so much limit the authority of macroscopic laws as contribute a physical content to them. To Epicurus, the gods bore no relation to this authority. The gods of contemporary science are the symbols of the causal harmony of being, the symbols of the laws and order of nature. They play at dice over every event, determining its probability, or dictating it directly and unequivocally. It appears that Einstein's God, who does not play at dice, and Heisenberg's, Bohr's and Born's God, who directs the probability of events, represent complementary notions. Macroscopic, generally relativist causality really rules the world only because it grows out of ultra-microscopic events which are subject to ultra-relativistic causality.

This profoundly paradoxical and contradictory situation of physics is in opposition to Epicurus's tendency to calm and iron out contradictions. But it continues and concretises the dialectical contradiction-seeking and future-oriented tendency of Greek thought. What then is the relation of the present situation to the problem which above all engaged Epicurus's attention, that of human happiness?

Here we have to mention another god, who is completely metaphorical. In Rousseau's "Discourse on art and science" he

recalls a legend which came to Greece from Egypt, in which it is said that "Science was created by a divinity which has hostile to human peace." This was already true in antiquity, and became even truer in the 17th century, when the foundation of science involved differential laws, and the static harmony of the universe yielded to a dynamic harmony; in our time it has become quite obvious. It appears that Epicurus's static hedonism —happiness as a negative category, as the absence of suffering, based on the limitation of needs and desires—that happiness is now impossible. But happiness as something positive can only occur if the desires to be satisfied multiply at an increasing rate, and if their level of satisfaction grows. Thomas More wondered, in "Utopia," whether men might not grow accustomed to constant satisfaction of their desires, and if at last the feeling of happiness might disappear. Here the divine discontent of science answers the question. It changes not only the human power of production—the degree of practical realisation of ideal physical schemes—but it alters those schemes themselves, thus lending undiminished speed, or even acceleration, to progress. However, science is not hostile to men's peace of mind in the application of its results alone. Knowledge in itself, and, even more, the changing of his picture of nature, becomes a need for man, and the satisfaction of that need (not only knowledge, but also the rate of its growth and change) is one of the sources of human happiness.