Arrow of Time: Towards a New Epistemology of Science

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ABSTRACT: Humanity has tried to comprehend two fundamental events since time immemorial: the birth of the universe and the emergence of life. Recently, it is claimed that these events can be understood comprehensively by means of a metaphor: the 'arrow of time.' The purpose of the present paper is twofold: (1) to build an epistemological structure that underlies the principle of time's arrow; and (2) to pursue the unity of science in a novel fashion.

(A) WHAT IS AN ARROW OF TIME?

The events which we see in the universe are classified into two categories: the reversible and the irreversible. The arrow of time is relevant to the latter than the former. It is alongwith the reversible-irreversible syndrome that a major light can be thrown on the notion of time's arrow.

Concept of Reversibility

The reversible events are those which occur regularly and repeatedly, the cycles of seasons, harvesting , pendulum swinging in a frictionless medium , the motion of earth and the moon , are some of the examples. Reversibility is an idealized concept . A process is said to be reversible if and only if the system which undergoes that process together with all parts of its environment which are affected, can be restored reproducibly to their original states. In short, in the reversible process all relevant parts of the universe must be capable of being put back to how they were! Time is not so considered to be an important ingredient in this system. The entire Newtonian Science is of this sort. Newton's laws , Maxwell's equations, Einstein's general relativity and even quantum mechanics- all remain effectively unaltered if we reverse the direction of time (Replace the ' t ' which represents time by '-t'). Even in life and the social sciences, time is not considered to be important component in these system of knowledge.

The notion of time's arrow is very important in the context of irreversible processes.

Irreversibility defined

Irreversibility is the negation of reversibility. It is a realistic notion. Moreover, it is the one-way time evolution of the system, giving rise to the non-repetitive , non-cyclic processes or events. The examples are , mixing a milk in the coffee, transfer of heat from a hotter body to a cooler one, chemical changes, the state of turbulence and chaos, rhythms, non-equilibrium systems, metabolism etc. Irreversibility is an open system in the sense that it

interacts with its surrounding area and evolves simultaneously. There are two important properties of irreversibility. One when a system is far-from-equilibrium, irreversibility pushes that system onwards to evolve it as time passes by; two, the concept irreversibility has another dimension where it is understood as a non-linear process which means whenever a system changes into another form never returns to its original state in the future, Hubble's law is the example of irreversible process. In chemistry the notion of irreversibility is very important especially when chemical changes occur, e.g., when a magnesium ribbon is burnt in the air, produces magnesium oxide alongwith large amount of heat and light.

e.g. Magnesium + Oxygen = Magnesium Oxide

The properties of magnesium oxide are altogether different from those of magnesium ribbon. This process is irreversible . Similarly the phenomenon of life is the outcome of an irreversible process. Aging is irreversible in the sense that old man can never return to his own childhood days as time passes.

Let us see how 'Arrow of Time' has been variously interpreted in different fields of inquiry. The arrows are mainly Six which are described as under:-

KINDS OF ARROWS OF TIME

(1) Thermodynamic Arrow of Time
(2) Electromagnetic Arrow of Time
(3) Biological Arrow of Time
(4) Psychological Arrow of Time
(5) Sociological Arrow of Time
(6) Cosmological Arrow of Time

(1) Thermodynamic Arrow of Time

The larger part of the universe is contained with thermodynamic events. According to second law of thermodynamics heat transfer always take place from the hotter body to a cooler one until the temperature of both becomes equal. The reverse to this cannot happen. Such processes progress from order to chaos. Entropy is a measurement of disordered form of energy which is always dissipated in nature. Entropy increases within irreversible system. This fundamental property of nature is explainable by time's arrow.

(2) Electromagnetic Arrow of Time

In the field of electromagnetism only retarded waves are considered to be scientific while advanced waves not, because physicists believe that fundamental laws of physics can explain only retarded waves (e.g. alternating current or in short AC circuit) and not their counterpart.

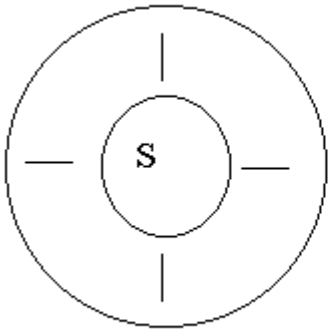


Fig. (A) : Retarded Waves

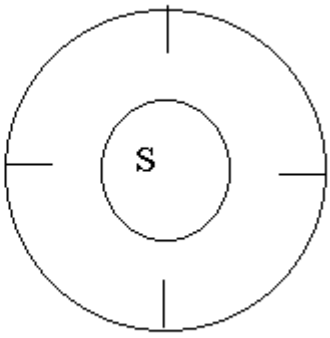


Fig. (B) : Advanced Waves

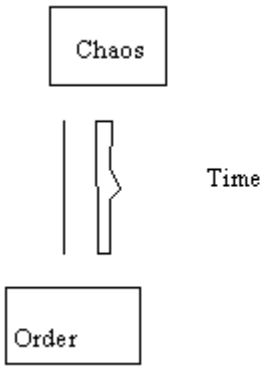
The principle of causality is followed in the case of retarded waves; but it is violated in the case of advanced waves which is why scientists admit only retarded waves.

Here the laws of nature are considered to be operative in the expanding mode but not in the contracting mode. This particular nature's phenomenon is logically meaningful by considering its one-sided behaviour, i.e., irreversible advancement.

(3) Biological Arrow of Time

In Biological Science, the evolution of an organism is related with time . In evolutionary process, as time progresses, the elements of process also undergo change, and hence the overall change is, therefore, irreversible. Life has evolved from simple to complex, from a single-celled ameba to a multi-celled human being. This growth always arises from chaos to order which is known as aging.

But then there is a paradox between second law of thermodynamics and the evolution of life. Second law states that the growth is from order to chaos whereas life evolves from chaos to order. Now the fundamental question is how to settle or resolve this paradox amicably. For this we have to go more farther and deeper. The same paradox is schematically demonstrated in the following way.



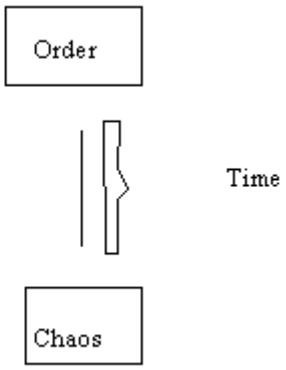


Fig. (A) : Second law of Thermodynamics Fig. (B) : The Phenomenon of Life.

(4) Psychological Arrow of Time

It is difficult to talk about the psychological arrow of time, because human brain is quite complicated and so far we have not understood its functions thoroughly and totally. However, some portions of thinking is understood in the light of functioning of human memory. The human memory recollects and stores past information but cannot remember

the future. The past events are recorded in the mind but not the future ones. This is because of the time's directionality. The constraints imposed on the memory forbids us to peep into the future. It is time's arrow which permits memory to act in this particular way only. The computers are analogously built on the functioning of human memory. Memory is said to be remained in the chaotic form so far as it is unused but becomes orderly when it is put to use. This particular process is related with the nature of knowledge, so more will be said while considering the epistemological dimension of time's arrow.

(5) Sociological Arrow of Time

A human action can be understood meaningfully with reference to time. The most important aspect of human action is that it is non-repetitive. Every action is unique by itself. So the very fabric of society is based upon the notion of time of time's arrow. All social actions are time-asymmetric.

As we have seen in the context of biology that 'aging' is an irreversible process. Old man cannot become younger as time passes. All social relations are established on time-sense. Habits are formed or reformed based on time-sense.

It is impossible to go and live in the primitive society. You cannot bring about social reforms of the past society ; but you can, if you wish, bring about social change in the future society. Clock time is an idealized time-sense whereas social time is a real time-sense , based upon the presupposition of the distinction between past and future. Social structures are organized on the basis of social time-sense. The goal of society is future directed.

(6) Cosmological Arrow of Time

There is nothing that exists outside the universe , however , everything is within its jurisdiction. This is what the cosmological arrow of time wants to tell us about . The cosmological arrow of time enjoys a privileged place , since ontologically rest of all arrows are directly or indirectly depend on it. According to cosmological arrow of time , universe expands with time, this is what is known as Hubble's constant in Astronomy. According to this , after the Big Bang explosion * the universe is continuously expanding. Galaxies, nebulae and other celestial objects are going away from each other. It is precisely because of this tendency of the universe, the things are existing as they are today. All arrows are existing and meaningful because of the functioning of cosmological arrow. The universe cannot exist , as it is today in the contracting phase.

After this survey , let us see some distinguishing features of time's arrow by making the comparisons between reversible and irreversible processes.

Distinguishing Features of Time's Arrow

Reversible Process	**Irreversible Process**
1) Time is not an important element	1) Time plays a central role
2) Stability and order are vital	2) Instability and order are vital
3) System attains perfection at equilibrium	3) System collapses at equilibrium
4) Reversible system is a closed system	4) Irreversible system is an open system
5) Reversible process is static	5) Irreversible process is dynamic
6) Reversible process is cyclic and repetitive	6) Irreversible process is non-cyclic and non-repetitive
7) Small inputs would give small outputs huge inputs would give huge outputs	7) Small inputs of change would bring about huge out puts of change.

The discussion so far carried out is to prepare a background for the construction of epistemology of time's arrow. This is the main task which is I would like to carry out as my further research project. This is a huge task and my proposed research project is just a small stepping stone towards building a grand system of knowledge.

(B) ARROW OF TIME: TOWARDS A NEW SYSTEM OF EPISTEMOLOGY OF SCIENCE

A considerable amount of knowledge has been extracted of nature by treating 'time' as absolute and separate from 'space' within the Newtonian system. Einstein's relational approach of "Space-time continnum" forming a single concept , has taken us further to understand mysteries of the universe. And by realizing the importance of "time's arrow" , has further enlightened us how to understand the deepest mysteries of the universe. In otherwords, time's arrow has enlarged the scope of human knowledge in manifold ways.

The important question might be asked: why so much intense philosophical discussion is needed in the case of time's arrow ? Is it so much rich and invaluable for philosophization ? It is very difficult to answer these questions right now. Nonetheless, so much rich and fertile contents are involved in time's arrow that the philosophical discussion , in this regard, will enlighten us considerably. The outcome will throw a new light on the system of knowledge.

Scientific information of the universe has sufficiently made it crystal clear that universe is expanding after the Big Bang explosion. Life is also evolving in the expanding phase. Nothing can exist in the contracting phase of the universe. Therefore, knowledge of discrete phenomena cannot give us satisfactory answer to the two questions which we have raised at the very beginning, i.e., birth of the universe and the emergence of life. Here the main problem is how can be knowledge of the discrete give us the knowledge of the complete or the whole reality ? The central difficulty is how to put these discrete pieces back together again so that a unified knowledge of reality is possible?

Physically or empirically it is impossible to make unification of these scattered pieces together again. So this issue is to be tackled not merely at the physical level but essentially at some higher epistemological (or philosophical) level. Moreover, different arrows of time function in a different and paradoxical way, e.g., thermodynamic arrow functions from order to chaos , whereas , biological arrow functions from chaos to order. So how to understand the relationships of different arrows in a coherent way ? The underlying concern is mainly metaphysical. In the light of what has been said , let us pinpoint some important features of epistemology of time's arrow.

Epistemological Features of Time's Arrow

Let us first of workout presuppositions on which epistemological argument of Time's Arrow is grounded.

I) Presuppositions of Time's Arrow

i) Time's arrow basically depends on dualism. Dualism between past and present, right and left , up and down etc. Unless dualism is presupposed , no arrow can be realized. This dualism exists only at the apparent level. Any arrow to operational , there must be beginning and end.

ii) Knowledge of arrow is possible because of change. Arrow always moves from the previous point to the subsequent point. The knowledge of any system is extracted when it is moving . The knowledge of change depends upon the knowledge of a dual. In the absence of dualism no change is perceived.

iii) Change is a forklike behaviour which is irreversible. Arrow exists in forklike or branching phase . It is from the roots to the branches and not the other way round that the information of the world is gathered.

iv) Irreversible change makes any system to expand with time. Knowledge of any system is possible in the expanding mode.

v) Arrow always exist in an open system.

vi) Small input will give high output.

Having worked out the presuppositions, let us see the nature of knowledge in the context of an arrow of time.

II) Nature of Knowledge

What time's arrow illuminates that knowledge is always fallible as against infallible. Always it is subject to change and revision. At least this is correct so far as natural sciences are concerned. Here criteria or conditions of knowledge always undergo change and alteration. So such change points towards dynamic change which is irreversible, e.g., Copernican system of knowledge is preferred over Ptolemaic system. According to Popper , knowledge always grow through falsifiability. But here falsifiability is of the nature of irreversibility. Patterns of knowledge is recognized in the dynamic state.

Arrow of time pin points towards the direction of increasing knowledge of events. Events for which we have information of their actual occurrence are in the past and not in the future. A world in which events occurred in the reverse order can be imagined , but a reversal to our sense of before -and- after would imply a state of mind in which we began with maximum information of the occurrence of events and ended with minimum , and this is selfcontradictory. In this context , the sixth presupposition which we have stated previously will support this view.

Man's relationship with nature is understood on a completely new way with the arrow of time. Of course , this is to be explored in the proposed research programme. Apart from this, man's relationship with himself is to be understood in the light of time's arrow.

Arrow of time shows how irreversible process poses limitations on our knowledge of the world. We know world in one way only. One of the most important limits arrow of time imposes on the physical reality is that world cannot spontaneously join together because it has limitations to go backward in time. So synthesis of these scattered pieces cannot be made merely at the physical and empirical level but which could be thought of at some higher epistemological level. Of course, this looks like a Kantian programme but the notion irreversibility takes us beyond Kant's transcendental philosophy.

III) Goal : Unity

Arrow of time repeatedly pin points towards unification of man and nature . Man is not just a spectator in the cosmic dance but he is also actor and participator in the process . To realize his goal he unites with nature by establishing a dialogue with it . His goal is to know the birth of the universe and the mystery of life. Different arrow talk about the knowledge

of isolated systems but not the whole reality. The major task is, therefore, how to link these different arrows together in a meaningful way.

The implicit meaning of arrow of time is that the more you go at the higher and deeper level , the more you are holistic. Oneness is found at the transcendental level. On the other hand, the more you go at the empirical and physical level, the more you become discrete and diverse. This is what arrow teaches .Arrow of time inspires us to build a grand system of knowledge.

After this deliberation ,the last point is to be mentioned. It is the unity of science.

(C) UNITY OF SCIENCE

Arrow of time enlightens on the issue of Unity of Science. How to seek unity when there is already a diversity? This question is to be pursued further in the light of directionality of time. Branching (or forking) system tells us how reality is understood in one way only, i.e. , in the expanding and discrete mode. Empirical or chaotic scattered knowledge is forward moving but its expanding synthesis is realized at the transcendental level only. Various arrows cannot be reduced into one grand system; but by recognizing their respective roles and positions in their own system, can one make valid inferences from them and thereby build such a system of knowledge which illuminates them all.

So first of all epistemologies of each arrow is to worked out and then inferences of each could be derived. Then these inferences are to be linked together. After this a grand inference can be drawn. This is in short is said to be the aim of the present research paper.

Notes

(1) "Arrow of time " is a metaphor used by Arther Eddington for the first time in 1927. Arrow of Time, Directin of Time, Asymmetry of Time, Anisotropy of Time, Irreversibility of Time, Unidirectionality of Time, all these terms are used in synonymous way. The meaning of these terms is that time is sliced into past, present and future and that it always pass from past to future and not in reverse way.

(2) Big Bang is a process which explains how universe has come into existence. The age of the universe is calculated as 10 is raised 15.

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