Darshana Jolts

Ceaseless Progression: Time

V V Raman

Time is rhythm: the insect rhythm of a warm humid night, brain ripple, breathing, the drum in my temple – these are our faithful timekeepers; and reason corrects the feverish beat.

–Vladimir Nabokov

What is Time? ***The nature of time is puzzling*****.**

Time is the most insubstantial element in human consciousness. It is with us all through our waking hours, drifting silently in the external world as well as within the very core of our being. We may look upon our individual conscious life in these terms: each one of us tastes a slice of time and then suddenly drops out or strays away from its course. In Tamil, when a person dies the expression is that one has merged with time[1].

Countless thinkers have wondered about the nature of time. From Upanishadic seers of India and Pythagoras of Greece, through scholastics from all traditions to philosophers and scientists, keen minds have pondered the nature and mystery of time, and acquired glimpses of its essence. At the one extreme, thinkers have wondered about the reality of time itself, some contending that it is a mere illusion. Others have insisted that time is as much an entity in the external world as the sun and the moon which help us measure it. No matter what, time is an ever-present feature of perceived reality, powerful and useful in our grasp and description of the world.

Time has been compared to a steady stream gliding smoothly or rushing torrentially, for now it seems to linger on, and now we feel it galloping away at undue speed.. Time has been called a robber of our possessions, a poison, the dissolver and destroyer of all, for it seems to gobble up every thing and event and episode. Shakespeare described time[2] as "the king of men, he's both their parent, and he is their grave...". Time has also been called precious, and praised as a healer of heartaches, a consoler in grief. In the words of Ovid, *temporis ars medicina fere est*: time is generally the best medicine[3]. Historians have referred to chunks of time as stagnant or tumultuous.

1 *Avar kálam agivittár*.

2 *Pericles*, Act ii, scene 3.

3 *Remedia Amoris*: 131.

We feel intuitively that it is time that keeps the world going, for a world where time stands static and lifeless would be more still than a painting on canvas, more frozen than a sculpture.

We cannot picture a moment beyond which there will be no time, nor one before which no time existed. Like expansive space and never-ending numbers, time is another baffling infinity.

Time Reckoning: ***Time is, and can be, measured only by change.***

We see the rising and setting of the sun, the waxing and waning of the moon, the changing configurations of constellations. From the shedding of leaves by trees and the blossoming of flowers we conclude that nature is touched by seasonal changes. But it is not obvious that the behavior of some animals are affected by solar activity and lunar phases, that oysters, even in the depths of water where there is no light, open and close, shell-dancing as it were, with lunar phases[4].

Time is one of the first parameters of the physical world that came to be measured. In all societies where humans have reflected, time has been recognized, recorded and reckoned. Aside from the biorhythm that subtly governs our moods and potencies, periodic changes in our environment have provoked insights into the nature of time and temporal units too. Linear time is registered with cyclic changes. Thus, we have the hour, which was inspired by the rising of a star before daybreak; the day, reckoned by sunrise and sunset; the week, resulting from the naked-eye visibility of five planets, the sun, and the moon; the month, related to the periodic reappearance of the full moon; and the year, provoked by seasonal cycles. Astronomers speak of the *great year* which consists of 26,000 years, corresponding to the earth's precession period. Ancient Hindu thinkers defined still larger time units, stretching to the *yuga* which spans several million years. The *maha-yuga* is 3.32 million solar years. At the other extreme, we define and measure mind-bogglingly small fractions of a second, reaching picoseconds and nanoseconds[5]. Some of the so-called resonance particles of high energy physics, which have life-times of the order of 10^{-21}s, have been tracked down experimentally. Cosmologists talk of Planck time, whose magnitude is beyond visualization[6].

The only linear time reckoning is in the Julian Day (JD) calendar of modern astronomy in which days are numbered consecutively from an arbitrarily chosen day: January 1, 4713 BCE. In this

[4] Frank Brown, Jr. Evidence for External Timing of Biological Clocks, Chapter 7 in (J D Palmer Ed.): *An Introduction to Biological Rhythms*, Academic Press, New York, 1975.

[5] A nanosecond is a billionth part of a second (10^{-9} s), , and a picosecond is a trillionth part of a second (10^{-12} s). Processes involving such orders of time are utilized in our computers and telephone circuits.

[6] The so-called Planck time, which emerges from the equations of cosmology/elementary-particle-physics, refers to the period when the universe was 10^{-42} s old.

system, for instance, August 15, 1947 would be JD 2,432,412.

Countless devices have been constructed for measuring time: from sundials and hour glasses to pendulum chronometers, spring watches, digital clocks and more. All time-measuring devices have one thing in common: *change*. One cannot measure time if there is no change. This intertwining of motion and time-measurement is at the origin of what is known as the *relational theory of time*, according to which the concept (and reality) of time is intimately related to changes in the world. Time, in this view, is merely "the order of succession of perceptions."

Homogeneity and Continuity of Time: *Time is the same al all instants*.

As with space, an important characteristic of time is homogeneity. This simply means that all along its ceaseless flow, the entity we call time is uniformly the same. There is no difference, *qua* time, between an hour or an instant some eons ago and the same in our temporal locality. Using a spatial analogy, time is like an interminable line, any sector of which is identical in its essential nature to any other. It is like a smooth highway that is being continuously created. In essence and rate of formation it is the same at every inch or mile of the path, though a host of different entities may be seen along it. Every instant of time has another whence it emerged, yet another into which it merges.

This implies that there was no beginning, nor will there be an end to time, for terminal points are, by definition, different from all others in being without a predecessor or successor. Even in the theological framework in which the universe had a moment of creation, that was a significant point *in* time, rather than the starting point *of* time.

Recall that space has local inhomogeneity, matter scattered here and there in a vast empty wilderness. This is not the case with physical time. However, psychological time is experientially non-homogeneous, some durations appearing to be denser (longer) than others. Like the spatial line, time cannot be broken down to ultimate indivisible units. We speak of instants and points, but they all merge into neighboring instants and dots in a smooth continuity. That is why we speak of time *flowing*, not *dropping* like pebbles. However, if one takes the space–time analogy too far, it may lead to some paradoxes[7]. Some theoretical physicists have toyed with the notion of a fundamental indivisible time interval, dubbing it the *chronon*[8]. Aside from some neat mathematical formulations, the idea of the chronon, once held by the Stoic Chrysuppius,

[7] The classic paradoxes of Zeno to the effect that there can be no motion, hence no time, arose from an identification of space and time.

[8] See, for example, P Caldirola, 'Introduction of the Chronon in the Relativistic Theory of the Electron' in Mario Pantaleo and Francesco de Finis (Eds) *Relativity, Quanta, and Cosmology in the Development of the Scientific Thought of Albert Einstein*, New York, Vol.I, p.187, 1979.

has not led to any significant insight or verifiable result[9].

Absolute Time: ***There is no such thing as an absolute universal time.***

Isaac Newton spoke of[10] an "absolute true and mathematical time," called duration, which flowed uniformly, and distinguished this from "relative, apparent and vulgar time... estimated by the motions of bodies." This is true in our intuitive grasp of the world, for we are inclined to imagine an instant of time that is universally pervasive. Right now, there is a fleeting moment in our conscious experience of the world corresponding to which, we imagine, there is a moment that ticks away in every nook and niche of the universe. We cannot escape picturing a cosmic pulse, a steady stream of subtle seconds flowing imperceptibly, carrying the universe along a single temporal course, a cosmic simultaneity.

The notion that an absolute time endures in an absolute space is a philosophical predilection, based on our intuitive grasp of perceived reality. It has served as a cornerstone on which three centuries of classical physics rested. But as we delve deeper into the roots of perceived reality, we find there is no such thing as absolute time, though for practical purposes one may assume such an entity, and this notion is still useful in speaking about the age of the universe. For when current cosmology proclaims that the universe is some fifteen billion years old, an unspecified absolute reference system is implied.

Information Transmission: ***It takes time for information to travel.***

Light is a primary information source for the goings on in the world. When we fix our eyes on a star, contrary to our intuitive impression, we are not seeing the star in its current state. Actually, we are looking into the distant past every time we cast our glance in stellar space. Thus, even if there was an absolute time, our perception of events in the world depends on how far we are from the point where the events occur, for it takes time for light to travel the intervening distance. In mathematical terms, if c is the velocity of light and x is the distance between the observer and the point where an event occurs, then it takes a time of at least $t = x/c$ for the information to reach the observer through light. It may take much longer if the information is carried by other means.

Since nothing can travel with a speed exceeding that of light, instantaneous transmission of information is a physical impossibility. However, careful experiments with photons and

[9] Plutarch reported that the Chrysippus (c. 279–106 BCE) believed in the atomicity of time.

[10] Scholium I in Newton's *Mathematical Principles of Natural Philosophy*.

electrons conducted during the past few decades suggest that in certain microcosmic phenomena, an event in one point of space may affect the status at a distant point without any lapse of time! This has given rise to some confusion, speculation, and controversy among physicists and philosophers as to the ultimate nature of physical reality[11].

Relativity of Time: ***Time duration is always relative a system of reference.***

The special theory of relativity uncovered a fundamental error in the ancient view of space and time which held the two as separate and absolute aspects in the physical world. It revealed an intertwining of space and time which results in the demolition of their independent absoluteness. What this means is that an instant of time makes sense only in relation to a point in space. This gives a death-blow to the classical notion of simultaneity.

An important consequence of this is that the duration of an event or the time interval between two occurrences depends on the reference system. Thus, if two observers set their perfectly functioning watches synchronously, and one of them gets into a train that begins to move at a certain speed, then the moving observer's watch (i.e., time in the moving reference system) will be advancing at a slower rate than for the stationary observer, and vice versa. Physicists call this puzzling phenomenon *time dilation*. For this to be observable, however, the train should be zooming at nearly three hundred million kilometers a second which is a technological impossibility (as of now). The veracity of time dilation is a verified consequence of Einstein's theory in experiments with elementary particles that move at such speeds[12].

Asymmetry of Time: ***Time is like an arrow always moving in one direction.***

There is an important difference between spatial extension and temporal evolution. Given a line and direction one may move forward or backward on it. This is impossible on the temporal axis. We always move from the present *into* the future, but the opposite is never true. There is an asymmetry in the flow of time.

This has two consequences: On the one hand we cannot move back in time. Whatever has transpired has left its relic, legacies, and records. No one can bring back yesteryear, or even the second just elapsed. As Aristotle said[13]: "This is denied even to God: the power to undo the past."

---

[11] For a popular account and interpretation of these experiments, see, for example, Gary Zukav, *The Dancing Wu Li Masters: An Overview of the New Physics*, New York, 1979. Murray Gell-Mann, in his *Quark and the Jaguar* describes such interpretations as 'flap-doodle', New York, p.172, 1994.

[12] Time dilation effects were first observed in the decay of pions in cosmic rays in the 1930s.

[13] *Nichomachean Ethics*, Book vi, Chapter 2, Section 6.

Yet we can and often do recall the past, for that is what memory is. Here we recognize an interesting aspect of mind and consciousness: they accomplish things that are impossible in the physical world. The scenes and events of days gone be can be brought back in an instant to the mind's eye; even ancient episodes of the distant past that we never witnessed may be brought back to vivid reality through the pages of history. One might object that it is not the past that comes back, but only its visions. But then is not the present also a vision? True, it is tangible, but not for more than an instant. Perceived reality consists of fleeting transformations of the subtle into the concrete, of the insubstantial into the tangible, but only for a moment.

Sheer familiarity makes us feel that what has happened cannot *unhappen*. However, if we rely on the fundamental equations that articulate the laws governing the world, there is something unacceptable in this state of affairs. It turns out that if we reverse the direction of time in these equations, nothing is intrinsically affected[14]. The most solid laws of physics, crystallized in their mathematical purity, say that the world can evolve along one direction just as easily as along the other. This is apparent in the case of the pendulum: if it swings one way, it does so with equal ease the opposite way too. However, this does not seem to be happening in all cases. A child grows into a full grown person, but a full grown person does not revert back to a child, like the pendulum does. In the case of most phenomena, changes seem to occur only in one direction.

Cosmologists and particle physicists have been grappling with this paradox for a long time. Current thinking links time's asymmetry with the initial conditions of the universe. A theoretical solution to the paradox comes from the application of quantum mechanics to the description the universe at large (cosmology). Though wrought with conceptual complexities such as fuzzy time and time seeping into space, this theory, introduced by Stephen Hawking and James Hartle in the 1980s, is more than an intellectual *tour de force*. The essence of the theory is that time had its origin with the Big Bang, and that the starting direction determined which would be the past and which the future[15].

Time and Causality: ***Cause and effect may determine which came first.***

Time going in the opposite direction is equivalent to the future occurring before the past. Thus, if you fall down and hurt your knee, the reverse order in the chain of events would be your knee bleeding first and then your falling. This is impossible, because the hurt knee is a consequence of the fall. Falling is the *cause* of hurt which is the *effect*. Two fundamental tenets of physics are:

[14] In technical jargon, the laws of classical physics are invariant under time-reversal. What this means is that if t is replaced by $-t$ in a physical law, the results are not affected.

[15] For a good discussion of the Hawking–Hartle theory of imaginary time (as it is called) see Stephen W Hawking, *A Brief History of Time*, New York, 1988.

(a) every effect has a cause; and (b) the cause invariably precedes the effect.

The word *precedes* drags in the notion of time in our conception. The forward passage of time is intimately related to the notion of cause and effect. To imagine time moving in the backward direction is equivalent to imagining that an effect has occurred before the cause.

Mathematical analysis reveals that any source which emits electromagnetic waves must also be receiving them at the same rate. This is very perplexing because what it implies is that the antenna in the radio station is not only emitting waves, but also absorbing the same waves. The emerging waves are called *retarded* because they take time to reach a destination; and the incoming ones are known as *advanced* because they are arriving even before they were emitted from a source. What is intriguing is that according to mathematical reasoning both types of waves must be present.

The paradox resulting from the symmetry with respect to time in the mathematical formulation of physical laws may be understood by means of an analogy. Suppose a juggler continuously throws upwards a series of balls. The balls keep falling down and he keeps throwing them up. Both processes are occurring and we find nothing strange in it. Suppose, however, that while the juggler is throwing the balls, none of them are falling back to the ground. Would not this be very strange?

In the case of electromagnetic waves, though one expects this from mathematical analysis, it would be very strange if advanced waves arrived, because that would be equivalent to effects preceding causes. Then the question is whether there is a mechanism in the physical world that makes this impossible though it is mathematically permissible and expected?

One explanation to the paradox was provided by the Wheeler–Feynman dissection of the problem[16]. These two physicists showed that in fact both advanced and retarded waves are always present, but that because of the various masses distributed all over the universe, electromagnetic waves are reflected back from everywhere in such quantities that all advanced waves are (for all practical purposes) simply canceled out (by interference effects), and hence never observed. It is as if some kind of a counter-process is continually taking place, instigated by matter all over the universe, preventing the future from materializing itself prematurely. For this to happen, however, there must be sufficiently large amounts of matter in the universe to

[16] J A Wheeler and R P Feynman, *Reviews of Modern Physics*, Vol.17, p.157, 1945. In an earlier presentation of the key ideas in this paper, R P Feynman and J A Wheeler, *Bull. Am. Phys. Soc*., Vol.16, p.683, 1941, they had already stated: "In an universe in which all light is absorbed, the absorbing material scatters to an accelerated charge a field, part of which is found to be independent of the properties of the material. This part is equal to one-half of the retarded plus one-half the advanced field generated by the charge."

absorb and radiate. This leads to the intriguing conclusion that the principle of causality is a consequence of the enormous quantity of matter in the universe!

Que Serà Serà and Precognition: *Knowledge of the future is physically impossible*.

Another consequence of time's asymmetry is that, in the phrase of a popular song, "the future's not ours to see." While we have footprints on the sands of time, there is no trace of things yet to come. To be told that one recognizes the marks (to be) left by events yet unborn smacks of psychic mumbo-jumbo, offensive to rational modes.

Even though an omnipotent being cannot undo the past, an omniscient being can know the future. This means that the future is pre-ordained, and simply remains hidden from our view, time serving as the unveiler of events already determined, but implicit. From this perspective, in the words of the Persian poet Omar Khayyam,

> The First Dawn of Creation wrote
> What the Last Day of Reckoning shall read.

What we are witnessing is the actualization of what was pre-ordained. One may imagine a fate-etching God to have done the job of writing the script for the universe. Mechanistic physics would attribute this to the initial conditions of the universe. A ball projected in air moves in accordance with the laws of gravity, but the particular path it follows depends on the speed and angle of projection. So too, the world evolves in accordance with immutable physical laws, but the specific modes by which its countless atoms and molecules move and interact were determined by the initial kick that each received.

This picture was painted by the physicists of the eighteenth and nineteenth centuries on the basis of their understanding of physical laws cast as differential equations. They believed that the primordial push to the burst-out universe determined once and for all times how every single atom and molecule would behave at every single instant in the future. This implied that every aspect of the universe that emerges could be foreseen by a calculating super-intelligence that can track down the dynamic states of the constituents of the world. In a sense, such a view does away with time as a significant entity, for the phenomenal world is simply like the turning of the pages of a book: everything is already inscribed. Time does not play a part in the evolution of phenomena, it is a static track on which things appear to be happening. In this view, events in the world are like images on the walls of a long tunnel through which the train of consciousness is moving. Each of us, a passenger in the train, zooms past the images, experiencing the scenes that come our way. In the process, we feel as if the scenes are changing (i.e., that time is flowing) when, in fact, it is the conscious spirit that is hurtling forward.

Time Ranges in the Universe: ***Durations range from the unimaginably small to the inconceivably large.***

It takes but a few minutes to glance through the newspaper, an hour or two to sit through a show, a few days or weeks to accomplish a task, a month for the moon to return to its phase, a year for the season to come back, and so on. Things happen, events take place, episodes last in the phenomenal world, for varying durations of time. The range of time intervals, from the fleeting lifetime of a fundamental particle, to the immense age of the cosmos itself, with human history and life-span in between, is impressive indeed.

We measure time in seconds or hours, days or weeks or years. Each such unit is human-made, contrived for contextual convenience. In terms of these, we live for a hundred years at most, while our species itself has been around for a couple of million years at least. But our recorded history is barely ten thousand years. Mammals have been around for many more million years, roaches and fern for perhaps a billion years, while our planet itself has been spinning around for a few billion years. By current reckoning, the age of the cosmos is between twelve and fifteen billion years.

In physics we define a natural unit of time that is independent of human concerns and experiences. The radius of the electron as it was pictured and measured by the beginning of the 20th century was of the order of 2.82×10^{-15}m. The time that light takes to traverse this standard distance is 10^{-23} (human-defined) seconds. We take this as the natural unit of time. In this framework we live, not for a mere hundred years, but for about 10^{32} natural time units: an impressive figure, but not really any longer than a hundred years. The universe is about 10^{40} natural time units.

Transcending Time

No creature or thing we know of can disappear out of space, nor jump away from the temporal axis. The notion of anything beyond the touch of time is simply inconceivable. The whole universe, from minute matter to gigantic galaxies, is embraced in the arms of time, for we cannot imagine a world where time never ticks.

But would it be fair to say that what cannot be accommodated in the human mind does not or cannot exist? An entity that is both particle and wave is a conceptual oxymoron, yet the building bricks of the material universe are *corporundals*: particle-waves.

Are they then perhaps right, those mystics who declare there is a reality that transcends space and time? If change is what engenders time, if time is a mere manifestation of change, then if

there is something that is changeless, it must be beyond time. If we define or envision the Divine as that which is immutable, as the never-changing principle behind the ceaselessly changing universe, then of course the Divine has to be beyond time.

However, it is not even necessary to go into esoteric talk of transcendence beyond time. Fundamental physics, strengthened by hard core mathematics, has dragged us willy-nilly to states in this very tangible universe of ours where time as an entity disappears naturally, not mysteriously. If anything should ever fall into the dark depth of a black hole, according to current cosmology, the black holes singularity would squeeze out the entity beyond time. Unbelievable, inconceivable, fantastic, and whatever: but this is the translation into plain English of what the mathematical telescope unveils.

So, as with everything pertaining to the beginning and end of things, as with the ultimate essence of the most common experiences, time too is passive and serving us when we are indifferent to it, but it is teasing and baffling when we try to probe into its secrets.

Being and Becoming: ***Static and dynamic aspects of the world.***

The notions of *being* and *becoming* have been analyzed by philosophers since ancient times. From a common-sense perspective, perceived reality is characterized by *things* and *changes*. We may refer to things as *beings*, and the changes themselves as *becomings*. For anything to be out there, space is essential. We may therefore look upon space as the receptacle for beings in the universe. Space is the static root of the perceived reality.

But in order for events to happen (more exactly, when things do happen), time becomes essential. If there is no flow of time, all will be frozen indefinitely. In other words, for the *becoming* aspect of the world, time is essential. Time is the receptacle for whatever is happening. It is the dynamic root of perceived reality.

It is not surprising that space and time are fundamental in our apprehension of perceived reality. At this point two questions come to mind. What exactly are *these* things that exist? And what happens when space and time jointly act on the things. The answer to the first question is *matter*; and to the next one is *motion*. These will therefore be our concerns in the next two articles.

*****

Previous Parts:

The World Above, Vol.15, No.10, pp.954–964; No.11, pp.1021–1030, 2010;
The Physical World, Vol.15, No.12, pp.1132–1141, 2010; Vol.16, No.1, pp.76–87, 2011;
On the Nature of Heat, Vol.16, No.2, pp.190–199, 2011;
Sound: The Vehicle for Speech and Music, Vol.16, No.3, pp.278–292, 2011;
Light: The Revealer of Chromatic Splendor, Vol.16, No.4, pp.359–371, 2011;
M**ore on Light**, Vol.16, No.5, pp.468–479, 2011;
Matter: The Stuff the World is Made of, Vol.16, No.7, pp.670–681, 2011;
More on Matter, Vol.16, No.8, pp.784–793, 2011;
Restless Motion: Its Variety and Relevance, Vol.16, No.10, pp.987–998, 2011;
Cause of Unsteady Motion: Force: Vol.16, No.11, pp.1061–1070, 2011;
More on Force, Vol.17, No.1, pp.83–91;
Waves, Vol.17, No.2, pp.212–224, 2012;
Sound, Vol.17, No.3, pp.299–309, 2012;
Electricity: An Underlying Entity in Matter and Life, A Sustaining Principle in Modern Civilization, Vol.17, No.4, pp.393–405, 2012;
Magnetism, Vol.17, No.5, pp.512–522, 2012;
Atoms and Molecules: Beneath the Tangible World, Vol. 17, No.6, pp.604–615;
The Nuclear World: The Kernel of Matter, Vol.17, No.7, pp.694–703;
The Microcosm: The World of Quantum Mechanics, Vol.17, No.8, pp.797–809;
The Standard Model: The Ultimate (Reductionist) Framework, Vol.17, No.11, pp.1085–1099, 2012;
Space: The Expanse of Void, Vol.18, No.1, pp.87–96, 2013.

V V Raman is Emeritus Professor of Physics and Humanities at the Rochester Institute of Technology, Rochester, New York 14623, USA. He is available for giving Skype lectures in Indian universities. Email: vvrsps@rit.edu
http://en.wikipedia.org/wiki/Varadaraja_V._Raman