INTRODUCTION

Our proposed model for cosmic consciousness is made from a cellular dynamical network (CDN), a new category of discrete mathematical model.[1] From a master CDN in the abstract universe outside of space and time — called QX, corresponding to the subtle akasha, henceforth simply akasha — we construct another CDN — called ST, corresponding to the gross akasha, henceforth simply spacetime, the phenomenal

world of space, time, matter, motion, and multi-leveled cosmic consciousness — in a process we have called *condensation*. In this work we extend our recent book with an explicit discussion of the construction of time as a sequential, discrete, or step-wise, process, We begin with a review of the historical background of atomism and discrete time from the East (Buddhism and Vedanta) and the West (from Pythagoras to the Renaissance), with special attention to the 16th century philosopher Giordano Bruno, one of the last of the atomists to include spirit or soul in his cosmology.[2]

PART ONE: PHILOSOPHY

We begin with a review of atomism before, during, and after Bruno.

1. Atomism before Bruno

Atomism is a long and important thread in the history of science and philosophy,

> The conception of atomism has been the spearhead of the advance of science.[3]

Further, it is the backbone of our models for individual and cosmic consciousness. We now give a brief history of this thread in the East, then in the West.

Eastern Atomism

The concept of atomism has been widely discussed by various schools of Indian Philosophy several centuries before Bruno. We will focus our discussions mainly on Jaina, Buddhist, and Carvaka views on atomism, with special emphasis on the concept of discrete time by Jaina and Buddhist philosophers.

Indian philosophical systems can be broadly classified into two classes: *astika* and *nastika*. Astika establishes their authority by considering the Vedas as infallible, whereas nastika does not. Buddhist, Jain, and Carvaka belong to this nastika school,

[2](Michel, 1973; ch. 4)
[3](Whyte, 1961; p. 3)

whereas Samkhya, Yoga, Nyaya, Vaisesika, Vedanta, and Mimamsa belong to the astika school.

Carvaka. The term Carvaka was first used in the 7th century. This word is perhaps a combination of *caru* (sweet) and *vak* (speech) and hence meaning sweet-tongued. It is claimed that pleasure is the ultimate aim of life for all human beings. They believe that the four elements or atoms — earth, water, air, and fire — exist, which make up the body and lead to consciousness. They did not consider the existence of akasha as a fifth element or atom.

Carvaka is considered to be a materialistic school. It has a significant objection to the necessity of introducing the idea of causality as the result of the relation between antecedent and consequent. That is, they oppose any ontological or logical connection between the antecedent and consequent as the basis of causality.

Jaina. The Jaina school is a distinct school of Indian philosophy as old as the Buddhist school. The metaphysical view of Jainism known as *anekantavada* is distinct from that of the Buddhist or Brahmanical schools. The atomic conception of time was elaborated in depth by the Jaina school.[4]

The characteristic of atomic time is different from that of atomic space or matter in the sense that time atoms cannot be combined or mixed , whereas those of space or matter can. In this framework, atomic time or *kalanu* is different from the conventional time of minutes, day and night, months, years, etc. The former is considered as unconditioned or absolute time, whereas the later depends on outside factors like measurements. Conventional time has beginning and ending, whereas there is no beginning and ending for the instants comprising absolute time.

According to the Jaina view, instants or time atoms have no extension or volume and they are not simultaneous. Thus it agrees with the Yoga and Buddhist concepts of time atom. However, the instants or time atoms in the Jaina view are imperishable, in contrast to the Buddhist view. It is to be noted that whereas the atom of matter is said to have sense qualities like smell, color, etc, the time atom does not have any such sense qualities, but can be perceived through inference alone.

Discreteness vs Continuum. The concept of ksana or instant has been used and discussed by various schools of Indian Philosophy. According to Jaina or Yoga views, time as instant is real, whereas time as continuum is unreal. The Buddhists advocate that the discrete character of time and the sequence or *krama* of instants is a mental construction as in Yoga philosophy. In fact, the discrete nature of time

[4](Balslev, 2009)

made a profound impact on Buddhist understanding of metaphysics and perception. We shall discuss the discreteness of time and cognitive activities in the brain from a neurophysiological perspective next.

Timing in Cognition: Discreteness vs Continuity. The timing problem in cognitive neuroscience has drawn much attention from scientists in the last few decades.[5] The temporal structure of cognition and the activity of its neuronal network play a key role in understanding perception and information processing.

Magnetic and electric recordings from the human brain have revealed the existence of coherent oscillatory activity near 40 Hz. A magneto-encephalography (MEG) system was used by Joliot et al. to test whether the 40 Hz oscillatory activity relates to the temporal binding of sensory stimuli.[6] The results showed that the 40 Hz oscillations not only relate to primary sensory processing, but also reflect the temporal binding underlying cognition.

Experimental results have shown that there exists a time interval of 1014 ms (corresponding to the up trajectory of the 40 Hz oscillations) which is the minimum time required for the binding of sensory inputs to the cognition of any single event. This was proposed as the cognitive quantum of time. Again, the delay in conduction speeds along different axons and the integration time for individual neuronal elements in the circuit are both of the same order of magnitude as the temporal quanta. So, in spite of such delays, the concept of simultaneity of the external event will be considered valid for a functional space, that is, as an operational definition of simultaneity. In the present context, the operational definition has been used to study one event at a certain place and particular instant of time in the external world as cogitated by the brain. Here, the simultaneity is between the event in the external world and the event in the internal world. Broadly speaking, an operational definition specifies the type of observations that are relevant to making decisions about the applicability of the defined terms in a particular situation.

Western Atomism

We are now going to give a capsule history of atomism in the Western tradition, based on three important texts:

[5](Fingelkurts, 2006; pp. 135-162)
[6](Joliot, 1994)

- *The Metaphysical and Geometrical Doctrine of Bruno*, by Serbian philosopher Ksenia Atanasijevic (Xenia Athanasievich, 1894-1981),
- *Essay on Atomism from Democritus to 1960*, by Scottish engineer Lancelot Law Whyte (1896-1972), and
- *A Short History of Atomism from Democritus to Bohr*, by historian Joshua Gregory (b. 1875).

Gregory begins his history of atomism with Mochus the Phoenician, of Sidon, 12th century BCE.[7] Atanasijevic begins her book on Giordano Bruno's Latin poem on atomism (discussed in our next section) with a brief historical chapter, *Forerunners of Bruno's Doctrine of the Minimum*. In her history, the earliest forerunners were the Pythagoreans of the 6th century BCE, noted for their ideas that number is the fundamental principle of all things, and the point (monad) is the principle of geometric bodies.

The second forerunners are the Greek atomists of Abdera, Leucippus and Democritus, 5th century BCE.[8]

According to these Greeks,

- movement is impossible without empty space,
- matter is composed of atoms, separated by empty space,
- atoms are full, that is, they do not contain empty space,
- atoms are impenetrable, continuous, and extended,
- atoms have parts, and yet are indivisible,
- atoms are so small that they cannot be perceived by the senses,
- changes in things are based on the union and separation of atoms,
- atoms are qualitatively equal, but differ in form,, size, and position in space.[9]

Democritus appealed to interactions between atoms of things and atoms of souls for the qualitative richness of appearances.[10]

[7](1931; p. 1)
[8]Whyte begins his chronology at this point, 450 BCE (1961; p. 31).
[9](Atanasijevic. 1972; pp. 13-15)
[10](Gregory, 1931; p; 18)

The views of the Greek atomists were popularized later by the Roman poet and philosopher, Lucretius, in *De Rerum Natura (On the Nature of Things)* of 54 BCE. According to Gregory,

> ... the *De Rerum Natura* presented the essential and uniform characteristics of the Greek atomistic tradition. We can know the Greek Atomism through Lucretius.[11]

Gregory includes an excellent paraphrase of Lucretius. For example,

> When the body walked the atoms of the soul had struck it within, and, helped by inrushing air, it was borne along like a ship by oars and wind.[12]

For Gregory, atomism was essential dead (or in exile, as he says) from 200 CE until the 17th century.[13] Actually, Lucretius was rediscovered and translated in the Early Renaissance, in 1418.[14]

The third forerunner, according to Atanasijevic, comprised the medieval (late 9th century) Arab scholastics known as the *Mutakallimun* (Arabic for practitioners of *kalam*, or discourse; theologians). In this Islamic atomism, each body consists of atoms which are point-like monads. Bodies are formed by the association of atoms in empty space. According to this theory, time is also atomic, that is, is composed of discontinuous temporal instants.[15] Consequently, motion is discontinuous as well. This aspect of atomism, anticipated by Isadore of Seville $(560 - 636)$,[16] is basic to our cellular dynamical network (CDN^3) model for consciousness.

Giordano Bruno, the 16th century Renaissance philosopher, represents the apex of the historical trajectory of spiritual and material atomism. According to Atanasijevic,

> Bruno, who was acquainted with all the doctrines of his predecessors, also knew, without a doubt, the doctrine of the Mutakallimun and was receptive to its influence.[17]

[11](Gregory, 1931; p. 5)
[12](Gregory, 1931; p. 8)
[13](Gregory, 1931; p. 20)
[14](Gregory, 1931; p. 23, and (Michel, 1973; p. 29)
[15]Islamic atomism is thought to derive from Indian sources, rather than Greek. See (Sorabji, 1983; p. 399) and (Abraham and Roy, 2010; p. 44).
[16]See (Whyte, 1961; p. 44), and also (Sorabji, 1983; chs. 5, 24, 25).
[17](Atanasijevic, 1972; p. 19)

While Bruno is known for his support of the Copernican model, he is less known for his atomism, to which we now turn.

2. Atomism of Bruno

The Renaissance progressed from Italy to England by a slow process of cultural diffusion. The Early Renaissance in Italy was characterized by the philosophy of Marsilio Ficino, from 1470 or so. The Late Renaissance in Italy, shifting into the Baroque around 1500[18] overlapped the Early Renaissance in the North, where John Dee was a central figure. One important vector in this diffusion was Bruno, our hero of atomism. We will begin here with his life and work, and then proceed to a detailed account of his atomism.

Life of Bruno

Bruno was born in Nola, near Naples, in 1548 [190].[19] At age 15 he entered a Dominican convent. After 13 years there, he was accused of heresy. He shed his robes and fled, becoming an itinerant philosopher and teacher of the memory arts. Thus began his professional career, in 1576, at age 28. He traveled during the next 16 years through Switzerland, to Toulouse, Paris [190], London [205], back to Paris [291], Wittenberg [306], Prague [313], Helmstedt [315], Frankfort [318, 325], Venice and Padua [346], ending in Venice in 1592, where he was jailed by the Inquisition [348]. After 8 years of interrogation, he was burned alive at the stake in Rome on February 17, 1600.[20] It is said that 100,000 thrill seekers flocked to the Campo de' Fiori to witness the event. The site, marked with an impressive statue of Bruno since 1887, is a venue for noisy parties even today. His itinerary is indicated in Figure 1.

[18](Abraham, 2011; p. 81)

[19]Numbers in brackets indicate page numbers in (Yates, 1964), where full details may be found.

[20]It was the custom in the Inquisition to behead victims in prison, and then to burn the dead bodies at the stake. Bruno was burned alive, exceptionally, as he refused to recant. (Yates, 1964; p. 349)

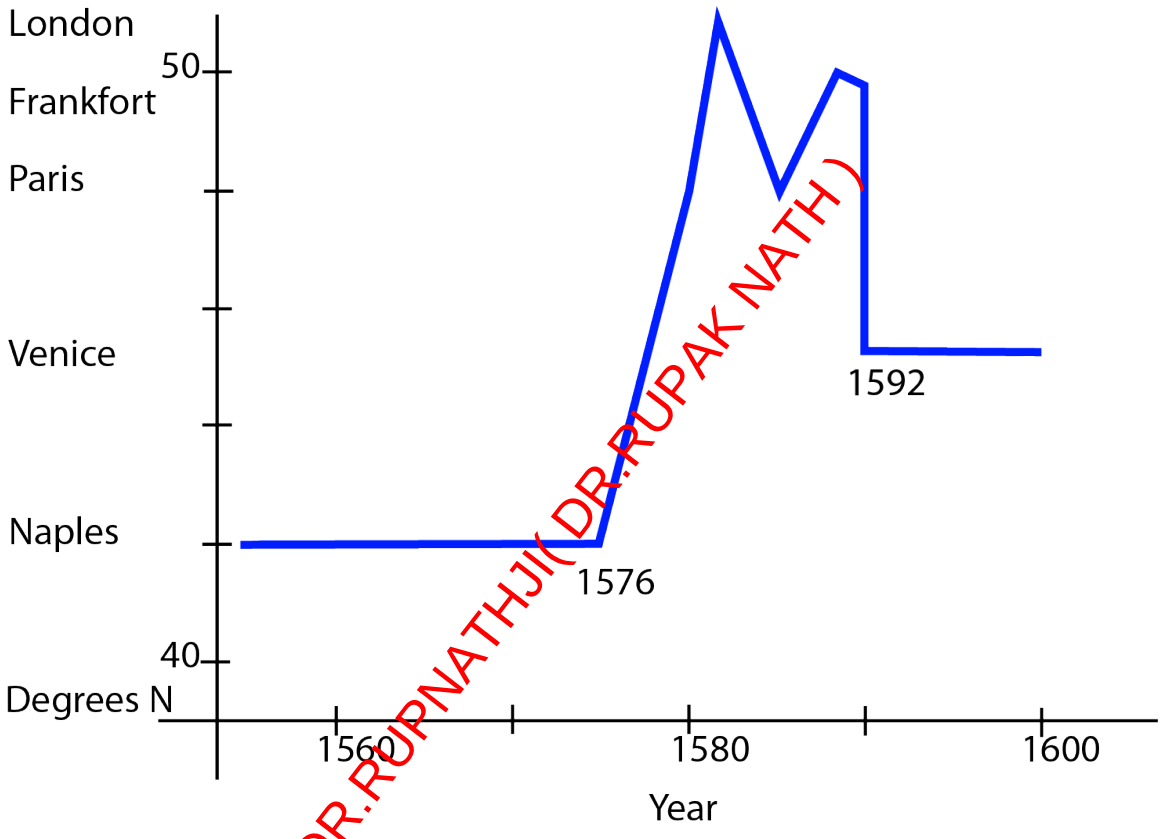

Figure 1: Travels of Bruno, 1576-1592.

Works of Bruno

Bruno's writings began in his first stay in Paris, in 1582, with two Latin works devoted to the memory arts [192]. After a number of other works in Latin, he arrived in London in 1582. Inspired by the emergence of vernacular literature there, he wrote six dialogues in Italian, published during 1583-1585:

1. The ash wednesday supper *(La cena de le ceneri)*
2. Cause, principle and unity *(De la causa, principio et uno)*
3. On the infinite universe and worlds (*De l'infinito universo et mondi)*
4. The expulsion of the triumphant beast *(Spaccio de la bestia trionfante)*
5. The kabbalah of the horse Pegasus (*Cabala del cavallo Pegaseo)*
6. The heroic frenzies (*De gl' heroici furori)*

all of which exist in English translations. He also wrote three poems in Latin:

1. On the triple minimum *(De triplici minimo et mensura ad trium speculativarum et multarum activarum principia libri V)*
2. On the monad *(De monade, numero et figura liber consequens quinque de minimo magno et mensura)*
3. On the immense *(De innumerabilibus, immenso et infigurabili, seu de universo et mundis libri octo)*

which were published in Frankfort in 1591, and are as yet unavailable in English.[21] These appeared just as Bruno's philosophical career was coming to an end. It is the first of these which presents his atomistic ideas, and is of special interest to us here. Althoough there is no English translation, we have a detailed account in the English translation by George Vid Tomashevich (1972) of the French paraphrase and commentary of Ksenia Atanasijevic (1931), to which we now turn.

[21] (Michel, 1973; p. 49)

Atomism of the Triple Minimum

The Latin original of *De triplici minimo* has three sections, on atomism, angles, and triangles.[22] The table of contents of the first section lists five books:

1. De Minimi exsistentia. (On the existence of the Minimum, 14 chs, 53 pp)
2. Contemplationes ex minimo. (Considerations starting from the Minimum, 15 chs, 43 pp)
3. Inventio minimi. (Invention of the Minimum, 13 chs, 34 pp)
4. De principiis mensurae ac figurae. (On the principles of Measure and Figure, 10 chs, 40 pp)
5. De mensura. (On Measure, 9 chs, 18 pp)

Of these 70 chapters we have explanations from Atanasijevic of 41 chapters: 8 of the 14 of Book 1, 7 of the 15 of Book 2, all 13 of Book 3, 9 of the 10 of Book 4, and 4 of the 9 of Book 5. We are indebted to her for the clarity of her exposition of Bruno's Latin, which, she generously states, *is surcharged with a complex and original, but sporadically very entangled, content.*[23] As Bruno is centuries ahead of his time, modern mathematics is really needed to clearly express his ideas, so the explanations of Atanasijevic are also rather demanding. From her text we now extract the few ideas of Bruno that we require.

Book 1, Ch. 2, p. 24.[24] The minimum is an indivisible unity, the element of everything composite, the principle and seed of everything existent. It is triple: (1) the general metaphysical minimum or monad, (2) the physical minimum or atom, and (3) the geometrical minimum or point.

Book 1, Ch. 7, p. 36. There are two smallest parts: the minima and the termini. The termini are the limits of the minima, and separate minima so that they cannot coincide.

Book 1, Ch. 9, p. 44. The minimum of nature is smaller than the minimum of sense perception. The minimum of nature cannot be perceived by the senses.

Book 1, Ch. 10, p. 46. Each category has its own minimum: the point for geometry, the letter for grammer, and so on.

[22] Available online as *oplatI_III.pdf* from warburg.sas.ac.uk.
[23] (1972; p. xvii)
[24] These page numbers refer to (Atanasijevic, 1972).

Book 1, Ch. 11, p. 47. Each genus has its own minimum: force, order, faculty, affection, form, distance, time, moment, weight, and so on.

Book 1, Ch. 13, p. 50. The minimum is the first dimension of length and width; it is that of which dimension is composed. The terminus has no dimension.

Book 1, Ch. 14, p. 51. The minimum cannot be perceived by the senses, and yet it can be observed as it becomes large through composition.

Book 2, Ch. 4, p. 63. The atom of the soul is the monad.

Book 2, Ch. 9, p. 68. An atom touches an atom through a terminus.

Book 2, Ch. 10, p. 69. Between atoms there must be empty space.

Book 3, Ch. 2, p. 75. Plurality increases through the minimum and can be decomposed into minima.

Summary

We may now synthesize Bruno's atomism. Every physical minimum (atom) has a corresponding soul minimum (monad). A body is an aggregation of atoms, and has a soul which is a corresponding aggregation of monads. A physical system is a network of interacting bodies, and has a soul which is a network of interacting souls. The motion of a physical system is comprised of a sequence of networks separated by discontinuous temporal instants.

All this suggests describing a system by a mathematical model which is a cellular dynamical network (CDN). The physical system and its soul may be modeled by isomorphic CDNs, and the body/mind connection modeled in turn by mathematical links between the two CDN models, as in fact we have proposed in our joint book of 2010. We have here a two-level tiered cosmology, body/soul or body/mind, which is common to the spiritual cosmologies of many different cultures.

3. Atomism after Bruno

The writings of Bruno, in his short career, had an enormous impact on philosophy and science right up to the present. In particular, his work on atomism, published in

Frankfort in 1591, had an important impact on his immediate successors, Galileo, Kepler, Descartes, and Leibniz. Yet so suppressive was his public torture and execution of 1600 that he has never received the credit that he is due. Not only the spectacle made of Bruno, but a whole sequence of Inquisitional persecutions contributed to this suppression: [25]

- 1570, Cardano arrested and tried,
- 1592, Bruno arrested and tried,
- 1593, Telesio's works condemned,
- 1594, Patrizi's works condemned,
- 1594, Campanella arrested,
- 1615, Galileo's works banned.

Galileo

Galileo did not credit Bruno in his *Sidereal Messenger* of 1610, and Kepler remonstrated with Galileo for this omission in his *Conversation with Galileo's Sidereal Messenger* of the same year. Galileo's crime was repeated in 1623, with his publication of *The Assayer*, a text on atomism owing much to Bruno.[26]

Descartes

Another slight to Bruno may be detected in the works of Descartes (1596-1650). He is credited with the revival of atomism, in the form of his *corpuscular philosophy*.[27] In addition, Descartes is routinely blamed for creating the mind/brain problem.[28] Yet Descartes had a soul (mind) theory quite similar to that of Bruno. Descartes' final work, *The Passions of the Soul*, written in 1646 and published in 1649 just before his death in 1650, comprises 212 short propositions called *articles*. Part I, *About the Passions in General*, is devoted to the mind/body connection. Among its 50 articles we may select the titles of just a few to give an indication.

[25](Schmidt, 1988; p. 253)
[26](Abraham and Roy, 2010; p. 47)
[27](Gregory, 1931; ch. 4)
[28](Abraham and Roy, 2010; pp. 18, 111)

Article 20. About imaginations and other thoughts that are formed by the soul

Article 30. That the soul is jointly united to all parts of the body.

Article 34. How the soul and the body act on one another.

Article 43. How the soul can imagine, be attentive, and move the body.

So Descartes was a close follower of Bruno.

Cell Biology

A realization of Bruno's atomistic scheme in the context of cell biology has been proposed by cell biologist Bruce Lipton in his book, *The Biology of Belief*. In an epilogue entitled *Spirit and Science*, Lipton identifies the individual soul of a living body with a complex of environmental signals that know the identity code of that body. This identity code is a unique set of identity receptors floating on the surface membranes of the cells of the body.[29] In terms of Bruno's atomism, this suggests that the identity receptor atoms are especially sensitive to communication from their monads.

Yoga

In our joint book, *Demystifying the Akasha*, we situated our CDN model for the mind/body system in the context of Kashmiri Shaivism. This philosophical system evolved from Advaita Vedanta in medieval Kashmir. The first distinction of Kashmiri Shaivism, according to Swami Lakshmanjoo, is in the practice of yoga. A second distinction concerns the relation between individual soul and the universal soul.[30] But the two systems agree in their multi-level cosmological models: the pancha-kosha, or five-sheaths model of the cosmos, and the simpler three-bodies model, of physical, astral, and causal body. Taking this simpler Vedantic approach, we may identify our mind/body problem with the question of connection between the physical and the astral bodies.

The Ramakrishna Mission Institute of Culture in Kolkata hosts a series of seminars on Science and Consciousness. The third of this series, in 2006, entitled *Consciousness:*

[29](Lipton, 2005; p. 189)

[30](Laksmanjoo, 2007; Ch. 15)

A Deeper Scientific Search, was aimed at experiential reports. The first report in the published proceedings was from Swami Vidyadhishananda Giri, an experienced yogi from the Kriya-yoga (Vedanta) Giri tradition of Himalayan meditation with a Ph.D. in neurobiology. He wrote,

> In the second part of his paper, I present to the reader some very secret knowledge of the Himalayan yogis and mystics who are adept in advanced meditation or yogic methods.

Actually, in his presentation in 2006, he said that he had received permission from his order to present secrets never before made public. And his presentation was accompanied by highly sophisticated three-dimensional graphics showing the neurophysiology of all three bodies. Only three planar graphics were published in the proceedings. Based on these three graphics, his written report describes explicitly the information exchange among the three bodies. The personal ego plays the role of identity receptors in this exchange.

PART II. MODELS

Given this background on atomism, it is time to describe the category of mathematical models in which our work on consciousness and the mind/body problem resides.

4. Cellular Dynamical Networks

Rather than a full mathematical specification of our model, we wish simply to introduce, step-by-step, the cellular dynamical network, or CDN, category. We will proceed from graph, to network, to complex dynamical system, and at last to CDN.[31]

Graphs

This is math, but of the simplest sort: graph theory. We begin with a finite set of points. In the mathematical theory of point sets, unlike Euclidean geometry, a

[31] This is an expansion of (Abraham and Roy, 2010; Ch. 6).

point is a totally abstract and basic thing, without an ambient geometric context. For example, a set of six points might be indicated symbolically as, $\{P_1, P_2, ..., P_6\}$. Here, P_1 is an abstract point, P_2 is another, and so on. While they may be totally abstract, it may still be helpful to visualize them in a geometric context. For example, let us think of them as geometric points around a circle in a plane. In the context of graph theory, the points are called *nodes*.

Having visualized our nodes in a circle, we may now visualize connections among them as line segments though the circle, as shown in Figure 2. These are called *links*. In this figure we have indicated three links. For example, the nodes P_5 and P_6 are connected by a link. A *graph* in graph theory is a finite set of *nodes*, some pairs of which are connected by *links*.

A directed graph, or *digraph*, is a graph in which each link has a direction. Thus P_1 may be linked to P_4 while P_4 is not linked to P_2, as shown in Figure 3.

CDNs

We begin with a positive number, N, possibly very large, and a digraph with N nodes, $\{P_1, P_2, ..., P_N\}$.

We assume that each node has an attribute, a natural number (zero or a postive integer), called its *charge*.

Given any two nodes, P_i and P_j, if $i < j$, we then say P_i precedes P_j, or equivalently that P_j follows P_i.

We next assume that if P_i precedes P_j, then there is a directed link from P_i to P_j, called a *bond*. Thus from any node, there are directed links (bonds) to all following nodes. For example, if $N = 6$, there are 15 bonds:

- from P_5 to P_6,
- from P_4 to P_5 and to P_6,
- from P_3 to P_4, to P_5, and to P_6,
- from P_2 to P_3, to P_4, to P_5, and to P_6,
- from P_1 to P_2, to P_3, to P_4, to P_5, and to P_6,

Next, we assume that each bond has a state, its *bond-state*, which is $+1$, 0, or -1. If P_i and P_j are nodes with $i < j$, then the bond-state $+1$ means charge may only flow

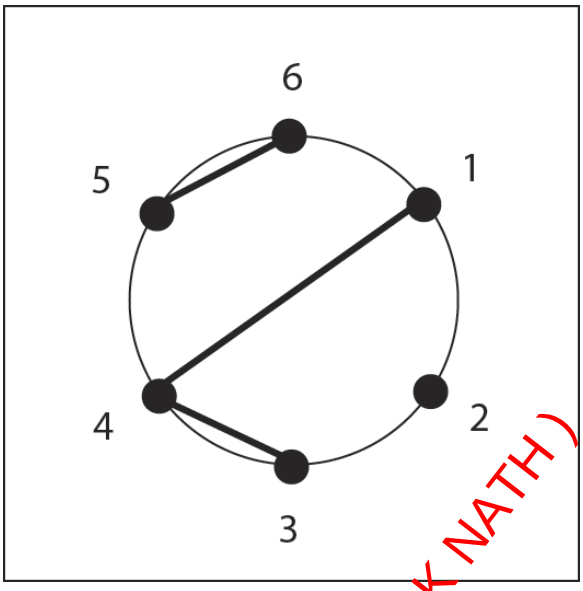

Figure 2: A simple graph.

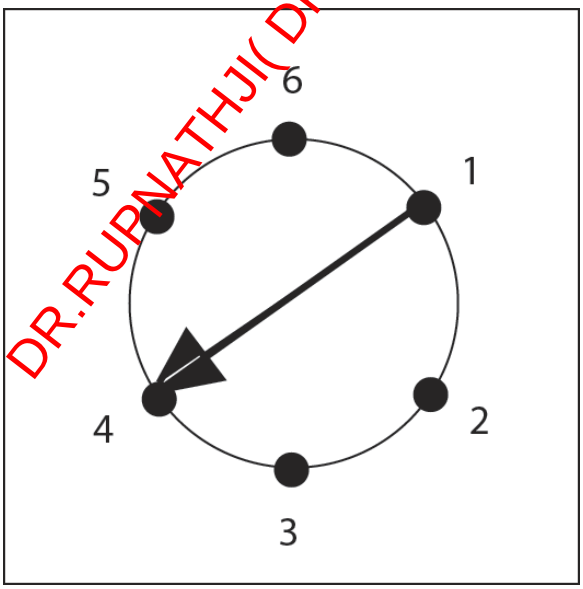

Figure 3: A simple digraph.

along that bond in the positive direction, that is, from node P_i to its following node, P_j. If on the other hand the bond-state is -1, that means that charge may flow in the opposite direction only. And bond-state zero means that the bond is closed, that is, no flow may occur in either direction.

Finally, it is assumed that there is a master clock ticking off discrete instants of network time, and with each click, the charges flow according to some given rules, called the *dynamical rules*, thus the node-states change, and then the bond-states change.

Typical rules

While we cannot know the dynamical rules for the entire akasha, we may give an example. These rules are from the CDN model of Requardt and Roy for the quantum vacuum.[32] Here, A_i denotes the node with index i, s_i its corresponding node-state (or charge), and $s_{ik} = s_k - s_i$ the difference in charge between two nodes.

- Each node-state is increased by the net amount of incoming information from all its bond neighbors
- Each bond-state, J_{ik},
  - is unchanged if the node-state at node A_i is equal to that at node A_k ($s_{ik} = 0$)
  - becomes $+1$ if the difference is positive but not too much so ($0 < s_{ik} < \lambda_1$)
  - becomes -1 if the difference is negative but not too much so ($-\lambda_1 < s_{ik} < 0$)
  - becomes 0 if the difference of node state at A_i and that at A_k is too large ($s_{ik} > \lambda_2$ or $s_{ik} < -\lambda_2$)
  - becomes $+1$ if J_{ik} is not 0 and the difference is medium positive ($\lambda_1 < s_{ik} < \lambda_2$)
  - becomes -1 if J_{ik} is not 0 and the difference is medium negative ($-\lambda_2 < s_{ik} < -\lambda_1$)
  - becomes 0 if $J_{ik} = 0$ and the difference is medium positive or negative

[32](Abraham and Roy, 2010; p. 89)

Of course, we must have some initial conditions, $s_i(0)$ and $J_{ik}(0)$ in order to begin a dynamical trajectory of the cellular network.

All this comprises the definition of a CDN. All CDNs are the same, except for the size, N, and the rules. **Note.** Digraphs are convenient, but not really needed, in the definition of a CDN.

5. Condensation

We recall now the fundamentals of our mathematical model for cosmic consciousness.[33] There is a CDN, QX, which is similar to the model of Requardt and Roy (2001) for the quantum vacuum. It is outside of ordinary space and time, following the ideas of Vedanta (eg, Swami Vivekananda) and Kashmiri Shaivism. It has an enormous number of nodes, and its node-states and bond-states evolve with each tick of a very fast network clock, according to rules that we do not pretend to know.

Condensation is a multi-step process.

1. Firstly, given the state of the master CDN, QX, at network time, t, a second CDN, S_t, which has the characteristics of macroscopic three-dimensional space, is derived from QX by a graph-theoretic process.
2. Secondly, a continuous three-dimensional space, $3S_t$, is created by an isometric embedding of S_t into euclidean three-dimensional space, followed by a spatial smoothing process.[34]
3. After some large number of ticks, comprising an *occasion* or time-atom of macroscopic time, T, this two-step process is repeated, again and again.
4. The successive CDNs, S_t, combine to create a discrete CDN embedded in a four-dimensional spacetime, the gross akasha, ST,
5. The successive smoothed three-dimensional spaces, $3S_t$, combine to create four-dimensional continuous spacetime, $4ST$,

The illusion of continuous world-lines in space and time is a post-production special effect applied to a discrete or atomistic model.

[33] This occupies about 40 pages, Chs. 6, 7, and 8, of our joint book of 2010.
[34] (Abraham and Roy, 2010; pp. 83-87)

Although the perspectives of quantum mechanics and general relativity might by accommodated by this modeling process, we have sought here the simple intuition of ordinary consciousness: the past is past, that is, condensed, the future is yet to condense, and the present moment is the last occasion to have condensed. Nevertheless, all times and events are known to QX, which exists outside (or above) space and time. We have described this situation previously as *two-dimensional time*.[35]

6. Time

Finally we have arrived at our main target in this essay, a model for time-anomalous phenomena. Throughout history there have been reports of mystics, yogis, and ordinary people as well, of time anomalies, for example: precognition, retrocausation, and entanglement.. These are accommodated in our model as follows.

Firstly, recall that our models have evolved in the context of monistic philosophy: consciousness is primary, and consensual ordinary reality is secondary. The individual mind (conscious and unconsciousness) is a component of the individual soul (alternatively spirit, subtle body, and so on). Thus an individual consciousness is influenced by the states of the QX network and vice versa.

Precognition

Precognition means an intuition of a future event before it happens, as in precognitive dreams and presentiment experiments. Such an intution amounts to receiving a message from the future.

We are going to make an assumption here, that the individual may query the QX network for an advance or predictive condensation. Thus an approximation of a future occasion (time-atom snapshot of the whole spatial universe) may appear in the individual mind as a precognition. Of course, in the interval between the predicted occasion and the official present-moment condensation later on, the QX network, and its derivatives, will have greatly changed.

[35](Abraham and Roy, 2010; pp. 113-115)

Retrocausation

Retrocausation refers to an event in the past which is caused by an action taken in the present. Or equivalently, an event in the present which is caused by an action taken in the future. In other words, the cause follows its effect, rather than the usual order, in which the cause precedes its effect. For example, a recorded computer tape containing a sequence of numbers in order is placed in a sealed vault, and later, a psychic changes some of the numbers out of order.

This may occur in our model because an actor in the present is part of the QX network, which is outside of space and time. The actor may influence the state of QX, which then is condensed into a past moment, overwriting all prior condensations.

Entanglement

Quantum entanglement is an aspect of subatomic particles, predicted by Schrödinger in 1935, in which two particles, having once interacted locally, are correlated forever, even nonlocally.[36] This prediction was verified experimentally by John Clauser in 1972, and subsequently by many others.[37] Ordinary (macroscopic) entanglement is sometimes called *synchronicity*, and appears as a startling coincidence.

Entanglement may occur in our model because of a strong network of bonds in QX created by local interaction, which them persist in QX, and manifest in correlation in all subsequent condensations.

CONCLUSION

And so, our CDN model provides for time-anomalous phenomena. Many other phenomenal, also regarded as paranormal on conventional science, may also be accommodated in our model. But this is not the only justification for such a complex model.

Our modeling strategy is consistent with the ancient atomistic traditions of both Eastern and Western philosophy, as well as with modern quantum theory and exper-

[36](Kaiser, 2011; p. 33)
[37](Kaiser, 2011; p. 175)

iments. It fits closely with the connectionist paradigm of neural network theory. And finally, it provides for an evolutionary story of its own creation, as in the growing field of artificial life.

References

Abraham, Ralph (2006), Vibrations and Forms. In: *Consciousness: A Deeper Scientific Search*, J. Shear and S. P. Mukherjee, eds. Kolkata, India: Ramakrishna Mission Institute of Culture; pp. 192-212.

Abraham, Ralph (2011). *Bolts from the Blue: Art, Mathematics, and Cultural Evolution*. Rhinebeck, NY: Epigraph.

Abraham, Ralph H. and Sisir Roy (2007). Planck scale and agent based simulations of quantum spacetime. *International Journal of Pure and Applied Mathematics*, vol. 39, no. 4; pp. 445-458.

Abraham, Ralph H. and Sisir Roy (2010). *Demystifying the Akasha: Consciousness and the Quantum Vacuum*. Rhinebeck, NY: Epigraph.

Atanasijevic, Ksenia (1923/1972). *The Metaphysical and Geometrical Doctrine of Bruno: As given in his work De Triplici Minimo*. St. Louis, MO: Warren H. Green.

Balslev, Anindita Niyogi (2009). *A Study of Time in Indian Philosophy, Third Edition*. Delhi: Motilal Banarasidass.

Fingelkurts, Andrew A., and Alexander A. Fingelkurts (2006). Timing in Cognition and EEG Brain Dynamics: Discreteness versus Continuity, *Cognitive Processing*, Vol.7, no. 3; pp. 135-162. Berlin: Springer.

Gatti, Hilary (1999). *Giordano Bruno and Renaissance Science*. Ithaca, NY: Cornell University Press.

Gatti, Hilary (2011). *Essays on Giordano Bruno*. Princeton, NJ: Princeton University Press.

Giri, Swami Vidyadhishananda (2006). The internal instruments of the witness-consciousness. In: (Shear, 2006), pp. 47-69.

Gregory, Joshua C. (1931). *A Short History of Atomism from Democritus to Bohr*. London: A. & C. Black.