Information Theory
David D. Moran

Wandering Towards a Goal *– How can mindless mathematical laws give rise to aims and intentions?*

This particular *wandering* started some years ago during a magic week at the Santa Fe Institute. One warm sunny afternoon Dr. Murray Gell-Mann posed three questions to me and asked me if I thought there were any solutions. The three questions were:

- Is there a place in the space-time continuum where the logarithm of xy does not equal the log of x plus the log of y?;
- Is there a place or time in the development of the universe where entropy naturally decreased?; and,
- Can you derive a model for 'thinking out of the box'?

In the process of attempting to solve these problems it became increasingly clear that in my mind they were inter-related and had a more universal perspective. The universal similarity between them is information in the universe. This present "wandering" derives from his challenge and those issues.

Information is the primary "substance" of the universe, meaning that, without information, the universe is just mass and energy without interaction or conceptual laws of behavior. Without information the universe is dead in the dimension of time.

Without conversion or recognition as "conceptual" knowledge, our universe would be stagnant in space-time without any interactive organization.

Without robust conversion mechanisms (from raw information to concept) by some sort of effort or presence (such as human intellect and the building and assimilation of knowledge of understanding) it is simply a mythical ether of "data" or "information bits" having no functional purpose. All of the universal laws-concepts have existed throughout all of the space-time presence of this universe, and they are embodied in the organization of information.

The fundamental postulate of this presentation is that: To convert information content of a concept-or-law to knowledge requires energy expenditure. We are the source or the effectors of that energy focusing. There may exist other "effectors" elsewhere in space-time but we are presently the only ones of which we have any awareness.

We, humans, we are all nothing more than information. We are immersed in a Universe of information and we find ourselves in the unique position of being synthesizers and coordinators of information. We may have many roles to play in our Universe, but one of them is surely the creation of understanding, the development of concepts, out of the information that surrounds us, makes us and forms the fabric of our Universe.

Our ultimate and most significant goal is to find this understanding of all that is around us, of physical and mathematical laws, of all relationships that determine the way in which all matter and energy interact, and the very special goal of what we as humans are and how important our quest is.

These are tasks that we have been pursuing diligently ever since we have achieved that modicum of conscious deliberation that seems to set us apart from the other species from which we have evolved. Our clear mandate is to find if there anything here that might make a difference in the way we look at information now in our current over-enlightened state of universal knowledge, big data, artificial intelligence, mass media, international internet and all other electronic communications.

Christophe Galfard ["The Universe In Your Hand: A Journey Through Space, Time, and Beyond; Flatiron © 2015] reminds us in his gedanken experimental approach to cosmology that we are all confined in the universe to taking only mental trips. This observation is the essence of the deep and personal relationship between us humans and the ocean if information in which we are immersed.

He goes further to encourage our self-realization by noting that, "You, I, everybody and everything, we are surrounded by all the information that reaches us now, at this instant, from the past." I maintain that this is a true statement for the future as well, and since that future contains all of our "pasts" it is in fact a pre-existing (from our poor human conceptualization) fact for all time that process will form our human experiences.

"We, humans, we are all nothing more than information." But we have to dig more deeply into this Gedanken (δείκνυμι:deiknymi) world in order to rationalize a statement as broad, demanding and frightening as that one.

Information is a quantifiable quantum. John Wheeler brought to our understanding that the fundamental quantum of information is the 'bit.' [John Archibald Wheeler, Information, Physics, Quantum: The Search for Links, Proc. 3rd Int. Symposium. Foundations of Quantum Mechanics, Tokyo, 1989, pp.354-368.]

Accepting this as the fundamental unit we begin this *wandering* with five hypotheses that need to be explored separately and then in conjunction:

- Information is ubiquitous in the space-time of the universe. It is everywhere at all times. The measure of information is the "bit" and we are surrounded in a foam of information.

- Knowledge is the manifestation of information. For humans, it is the discovery of concepts and understandings based upon fundamental information and the reflection of that information as human understanding.

- Information is neither created nor destroyed. It exists in the space-time continuum as a permanent feature of space-time. For our simple minds it is proposed that we think of information as the component structure of an unseen, and perhaps undetectable, foam in which all matter and energy reside.

- Knowledge is more fragile, and it is subject to change, evolution, proof and potential rejection.

- The laws of physics may have evolved over space time since the beginning. They may be evolving now. If so, that means that there may be a different information base in various parts of space-time. If this is a possibility then we have to consider the laws in the intersection space-time continuum.

More generally, I am implying that the space/time continuum is just information, information on where mass exists, plus information on dark matter. Gravity and all of the forces of nature are just information.

Further, I am asserting that the diffusion of information throughout the universe is processed at the speed of light. (There may have been a different diffusion of information during the inflationary period of the big bang, but this is an exploration that I do not believe we can undertake at the moment, at least for this specific presentation.)

In the near future we will need to resolve this diffusion equation with Einstein's Field Equations and our observations of all of the strange characteristics of our universe that are currently being observed.

It is more important in this *wandering* to continue our development of the role of us humans in the formulation and justification of concepts and laws out of the information with which we are surrounded. In order to accomplish this, the following presumptions are entertained:

First, understanding is the creation of order around a concept from the bits of information that constitute the fundamental principles of the concept. We are the synthesizers, we are the machine that processes the bits of information and creates a concept or law that we must then prove and justify through our observations and efforts.

This process requires energy that we must supply in all forms, conventional and unconventional. Conventional forms of energy are everything that we need to sustain our physical lives and our mental processes. These elements of energy include all of the physiological, emotional and ideological processes that constitute our continued existence as humans in the space/time we occupy. That energy includes everything that we need to record and transmit these concepts to each other. Our entire world educational, and telecommunications systems are an integral part of the energy. Without it we would have no dispersion of understanding on this planet and therefore have no way of continuing to develop concepts and achieve understanding.

Our role is to convert raw information into knowledge. This is not to imply that we "discover" any new concept. Those concepts exist in the universe without our interactive efforts. Every concept that can exist already exists, it is all part of the universal information domain and is contained in the bit structure of universal information. Our role is simply to extract those understandings from the bit-base.

All laws of physics and mathematics exist and have always existed, even if they underwent some unknown changes during the birth and expansion of the space/time continuum we call the universe. The fundamental law of matter and energy, e=mc**2, existed and was a universal law before Einstein "discovered" it. Einstein was the human who extracted that law from the universe of information and made it known to us and increased our understanding of the nature of matter and energy.

The result of these assumptions, propositions and thoughts can be summarized in a relationship between "Understanding" and "Information" as follows.

Knowledge, U, is the human embodiment of understanding of concepts and laws of physics. The rate of increase in understanding, dU, is proportional to the rate of concept development or what we might have termed in the past, the discovery rate of the laws of the universe, which we will represent as

dC. The proportionality is a function of the effort or expenditure of energy, E, that we apply to the problems of concept building (discovery) and the its understanding. The energy of understanding, or the energy that we must expend to create knowledge out of the universe of information, also can be thought of as the "energy of discovery" of the laws of the universe is an all-encompasing summation of everything that humanity needs to make this transition happen. It includes all of the individual efforts of the "discoverers," the combined universal support systems that make it possible for the "discoverer" to work and make progress, all of the scientific and technical resources necessary to proceed, every prior "discovery" compounded through the complex interrelationships that are necessitated for the "discovery," every erg of energy that the world of humanity expends in the pursuit of the knowledge, the library and reference resources dedicated to the entire universal body of knowledge, the food and the quill pens of the monastic scribes that recorded and translated history, the gasoline in the school busses that transported the young scientists from home to school, the entire civilization budgets of the whole globe, the cost of all medical processes that made the advancement of life possible, the whole of all governmental and rights-protection services of the globe, and every person in existence throughout history. This is the enormous cost of the process of translation of information into human understanding and knowledge. Indeed, every Nobel prize belongs to every person on earth who ever lived, not just to the single individual who benefited from this body of prior knowledge and the vast energy that was necessary to bring it into fruition. Newton should have said, rather, "I stand upon the shoulders of the entire history and evolution of this planet."

The relationship

$$dU = E * dC \qquad 1$$

represents the growth of, or change in, Knowledge or Understanding as a proportionality of the change in concepts entertained by humanity and the energy that humanity invests in this understanding of the laws of nature and mathematics and physics. These fundamental laws or concepts are postulated to be proportional to the amount of ordered information, u*s, that is necessitated in order to develop the concept or law. Mathematically this is represented simply as

$$C = u * s \qquad 2$$

$$\text{Such that } dC = du/ds * s * ds + u * ds = (s* u' + u) ds \qquad 2B$$

Where u is the information content in the concept ordered through the process that some have referred to as the entropy s. The equation of concern is in detail:

$$dU = E(u,s) * [s*u'(s) + u(s)] d s \qquad 3$$

which may be integrated (by parts, in formal notation) to yield (specific derivation available but not included in this paper):

$$U = \{E/c'\} * [u + u' + \{1 / E\} * \text{INTEGRAL}\{ E * (u' + u'') ds \}] \qquad 4$$

$$\text{Where, } E(s), u(s), \text{ and } c(u,s) \text{ yielding } c' = (u,s)' = u + s * u' \qquad 5$$

The final integral term in Equation 4 may be shown (later) to be a small error correction to the major relationship developed for understanding. This principal relationship may therefore be written as:

$$U = E * [(u + u') / (u + s*u')] \quad (6)$$

Or letting $T = u / u'$ (7)

which defines a fundamental relationship (entropy) for information diffusion in the universe, providing our fundamental relationship as:

$$U = E * [(T+1) / (T+s)] \quad (8)$$

Since $T = u / u'$ is a very large quantity (as needs to be proven through experimental observation), the simplest relationship for understanding or knowledge derived from information is:

$$U= E * T / (T+s) \quad (9)$$

Our next task is to build the relationships between information diffusion and consolidation.

So, how do we recognize this information that is all around us? Wheeler has encouraged us to think of the information that we have access to as language [Proceedings, Third International Symposium on the Foundations of Quantum Mechanics, Tokyo, 1989, pp.354-368]. This thought is probably best summarized by Luigi Foschini in his 2013 analysis of John Archibald Wheeler's 1989 essay, where, in Foschini's words, "Wheeler has tried to answer the eternal question of existence. He did it by searching for links between information, physics, and quanta. The main concept emerging from his essay is that "every physical quantity, every 'it,' derives its ultimate significance from bits, binary yes-or-no indications" ["Where the 'it from bit' Come From, Essay for the 2013 FQXi, History and Philosophy of Physics (physics.hist-ph), arXiv:1306.0545, Cornel University Library]. This concept has been summarized in the catchphrase "it from bit". In the Wheeler's essay, it is possible to read several times the echoes of the philosophy of Niels Bohr. The Danish physicist has pointed out how the quantum and relativistic physics - forcing us to abandon the anchor of the visual reference of common sense - have imposed a greater attention to the language. Bohr did not deny the physical reality, but recognizes that there is always need of a language no matter what a person wants to do." [Additional reference: Hermann Wimmel (1992). Quantum physics & observed reality: a critical interpretation of quantum mechanics]

It may be reasonably assumed that information is diffused throughout the Universe in a manner commensurate with the dispersion of all known quantities under the common definition of "conservation of information." Employing the conservation law in spherical radial space, the conservation of information throughout the universe would become:

$$De/dt = - dPhi/dr = Q$$

Where: Phi is the amount of information flowing per unit time through the space/time continuum per unit surface area in that space; Q is the information created from the synthesis of other information or through the interaction of information bits through mechanisms that we will examine later; and, e(r,t) is the information density in the universal foam or information ether of the universe.

We further postulate that the information density "e" can be structured as follows from three properties of the field,

e(r,t) = c(r) * rho(r,t) * u(r,t)

where the fundamental variables are:

c is the information energy that must be supplied to a unit of information ether to raise its information content by one bit

rho(r,t) is the information ether density per unit volume and is independent of time,

and, u(r,t) is the measure of information in the units of bits.

In order to construct our information diffusion equation it is necessary to revisit the fundamental assumptions and re cast them as a (Fourier-like) law which in this case has four underlying principles:

1. If the bit-count is constant in a region, u(r,t)=Constant, then there is no flow(diffusion) of information, so phi(r,t)=0
2. If u(r,t) not=0, then information flows from a region of high bit-count to a region of low bit-count, this will justify the minus sign in precept #4.
3. Information flow Phi is proportional to u. In other words, the greater the bit-count difference delta u, the greater the information flow Phi.
4. Flow of information is a function of the information foam or ether space K0, or

Phi(r,t) = - K0 * du(r,t)/dr

Introducing an information diffusivity constant k = K0/c*rho, the final diffusion equation for information in the space/time continuum of the universe (simplified to radial spherical diffusion only, at this time) is the generalized Helmholtz Equation in the spatial and temporal dimensions of the universe:

$$\nabla^2 \text{Phi}(r,t) + C * \text{Phi} = 0$$

The solution to this equation is a well-known process that employs the Green Function. The greatest information map that we can observe in our universe is the non-homogeneous distribution of background radiation temperature (Reference) that we have been refining in accuracy through astrophysical observations since its discovery by Arno Penzias and Robert Wilson in 1965.

Since all “wanderings toward a goal” must pause at the next step of investigation, we are forced to leave this a standing challenge to our community of fellow scientists, “to solve the diffusion equation for the background radiation in the universe using our continually improving data base. It will then, finally, be possible to solve and respond to the three questions from Santa Fe. And we do so, once we have the solution coefficients for the Green Function of the Universe of Information, we shall do so.

Submitted by: (14,947 characters without spaces)
David D. Moran, Ph.D.
Professor, Adjunct, WVU
P.O. Box 7,Eglon, West Virginia 26716
304-288-9533; dddmoran@aolcom