

C. Pleus, Multi-criteria Decision Analysis and Environmental Risk Assessment for Nanomaterials, *J. of Nanoparticle Research* (2007) **9**, 543554.

M.C. Roco, Broader Societal Issues of Nanotechnology, *J. of Nanoparticle Research*, (2003) **5**, 181189.

M.C. Roco, The Emergence and Policy Implications of Converging new Technologies Integrated from the Nanoscale, *J. of Nanoparticle Research*, (2005) **7**, 129143.

M.C. Roco and W.S. Bainbridge, Societal Implications of Nanoscience and Nanotechnology: Maximizing Human Benefit, *J. of Nanoparticle Research*, (2005) **7**, 113.

E. Rashba and D. Gamota, Anticipatory Standards and the Commercialization of Nanotechnology, *J. of Nanoparticle Research*, (2003) **5**, 401407.

V.N.T. Satyanarayana A.S. Kuchibhatla, Karakoti, D. Bera, S. Seal, One Dimensional Nanostructured Materials, *Progress in Materials Science*, (2007) **52**, 699913.

W.O. Soboyejo, C. Theriault, P. Mulambo, S. Chi, R. Chanrashekar, Y. Oni, A.B.O. Soboyejo, In-Vitro Studies of Cancer and Non-Cancer Cell Death Due to Hyperthermia and Localized Drug Delivery, The 4th International Conference, The African Materials Research Society (AMRS), Dar es Salaam, Tanzania, December 10 14, 2007.

OUR UNIVERSE: A Physics Perspective on its Structure and Destiny

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One of the greatest strengths of the human consciousness is the ability to conjure up plausible concepts, models and logical schemes on the relational unity of our reality. This is achieved on the basis of innate processes that rationalize the objectivity of our perceptions. The sum total of our diverse perceptions on the manifestations of reality is what we refer to as our universe.

Our current understanding of the universe is no doubt a cumulative summary of what has been accrued from efforts of many peoples over thousands of years through observations and rigorous testing of ideas. In this article we present some aspects of the ongoing human endeavors on the establishment of reliability codes for the reconciliation between observational evidences and mental abstractions about physical reality. These efforts have over the ages evolved into a body of knowledge that is today known as physics. As such, physics provides a perspective on the compliance of our thoughts and imaginations with the relational principles of the universe that are presumed to underlie all the structures of nature as well as the fabrics of our perceptions on physical reality.

Our Senses

Our perceptions and interactions with the world around us are directly influenced by the nature of our senses in relations to a diversity of stimuli signals. Basically, we humans are capable of sensing signals from over a trio of distance ranges. Confined to the shortest range are our senses of taste and touch that are effective only when one's body is in physical contact with a relevant signal source. Next are our senses of hearing and of smell that are adapted to respond to signals from up to medium range distances of up to a few kilometers away. Finally, it is our sense of sight that enables us sense the longest range from up to the ends of our observable universe.

Laws of Motion

Some of the most distant light sources that we see and wonder about are the stars, including our

sun and other reflecting bodies such as our moon and neighboring planets. Over the ages countless observers have been able to track and document the apparent movements of such heavenly bodies. Most have been driven by mere curiosity yet others have been compelled by the innate human desire to comprehend and to manipulate the workings of nature. The earliest known documentation of observational data on the nature of planetary orbits is development of the three planetary laws as summarized by Johannes Kepler. These Kepler's laws were highly specialized and have served as fairly reputable references for subsequent theoretical advances in the studies of astronomy; that is, studies of the realm extending from beyond the nearby atmosphere to the most distant reaches of the universe.

Although many minds have pondered over the faraway twinkling little stars, a greater number of minds have no doubt been fascinated by the beauty and nature of our nearby earth-bound objects and phenomena. From childhood, we are almost by instinct inescapably inquisitive and experimental in our attempts to uncover and exhaust the available possibilities of surrounding reality. We play, we observe and mimic nature while learning and internalizing the objectivity of our experiences. Historically, it is however Galileo who takes the credit for the earliest known documentation and communication of objective experimental investigations on the nature of the motions of concise objects. His works lead to the concepts of inertia and momentum, which were later summarized by Newton into three laws of motion. Newton's presentation was that all motions are a manifestation of the underlying imbalances of forces. Forces were conceived as mass-based compulsions that enable energy transfers. Newton however, went further than Galileo by asserting that his laws of motion applied as well to the very distant celestial motions of heavenly bodies just as they did apply to the local terrestrial dynamics. He accomplished this by formulating a law of gravity as a natural long-range attraction between any two bodies of mass.

Gravity has since been established as a long-range force among a trio of natural forces of which the strong nuclear force is of the shortest range being effective only within the nucleus of atoms where it bonds tiny elementary particles called quarks to form protons and neutrons while also providing the glue to keep protons and neutrons together within the nucleus of an atom.

A third natural force completing the trio is the electroweak force which is effective up to distances

of a few atomic radii and is responsible for both molecular bonding and radioactivity that makes large unstable nuclei explode rather randomly like popcorns in a frying pan. It is this force that is operational in the interactions between electric charges, and is adequately described by Maxwell's four simple equations of electromagnetism. The force is mediated by electromagnetic radiations that are collectively referred to as photons.

This trio of natural forces is considered as solely responsible for all the observable physical interactions and phenomena in nature.

Newtonian Space and Time

In all of Newton's works, he considered space and time as some sort of divine background stage for the drama of nature. Space and time to him were immovable and remained always similar such that energy transfer and indeed, all causes could be configured over them without relation to anything external. Newton's view was hence that space and time are not part of physics but are rather only the frameworks for physics. This idea is also captured in diverse cultures through such notions as in the Luo saying: "Piny osiko to ok sikie", which translates to: "The universe persists forever but no entity persists on it forever".

Energy Transfers

In the Newtonian framework, all phenomena are viewed as energy transfer processes which are evidenced by the coordinate transfer of matter over space and regardless of time. As such instantaneous actions at a distance are considered admissible. Newton thus contended that energy transfer may be determined through any direct measurements of corresponding changes in the positions of the center of any mass distribution.

Kinetic Energy: Any energy conveyed by the motion of a particle courtesy of some specific cause, is termed as kinetic energy. Kinetic energy is proportional to the square of the velocity of the particle. The summation of kinetic energies delivered by equal masses therefore relate in accordance with well known Pythagoras theorem which was originated and developed as the relational property of the sides of right angled triangles. The kinetic energy of a body may thus be greater than or equal to the sum of the kinetic energies of its parts. The difference if any is referred to as the binding energy of the parts to make the whole body. Such binding energy is released when the body is broken apart. By observational experience, we know that when a fragile object like a cup falls off to a floor and breaks, it releases energy as evidenced by the generation

of sound and heat.

It is also known that a fragile cup may fall off to a floor and suddenly break into pieces under natural forces yet there are no known natural forces under which the pieces may suddenly gather themselves together off the floor and jump back to form a whole cup on the table without the action of an external agent. From this observational evidence, it is deduced that under natural forces, all systems evolve with the progression of time to situations of reduced temperature. This time dependent process of natural cooling is embodied in the statement of the second law of thermodynamics.

Since the temperature of systems are found to be directly proportional to their kinetic energies, the temperature of a body may thus be greater than or equal to the sum of the temperatures of its parts.

Mass-Energy Equivalence: Further insights on the nature of space and time led Albert Einstein to consider space and time as part of a single framework (space-time) in such a way that energy transfers need not occur regardless of time as earlier assumed by Newton. To expound on this, let us introduce here an analogy in which we consider the energy E as a message that is delivered by a messenger (particle) of mass m courtesy of some specific cause as directed by the orientation of the cause over the space-time and the destination for the message. As such the numerical values of the energy, the mass and the velocity thus provides the relevant measures of the message, the messenger and the messenger's path over the space-time respectively in some appropriate units. By this analogy, the Albert Einstein's idea of mass-energy equivalence that he presented $E=mc^2$, where c is a constant equal in measure to the speed of light in free space, may be recast to mean that the messenger is equivalently a message. Einstein further asserted that the messenger and the message contribute to influence the nature of their path and vice versa.

Potential energy: In the formulations advanced by Newton's laws of motion and his concept of action at a distance, energy is conveyed by forces through shortcut paths. But it is also known that energy may be stored, that is, restrained from reaching any farther destinations until some viable shortcuts are availed. Although energy may be stored in a diversity of constrained forms, it is only termed as potential energy if there is some known means for its conversion into kinetic energy form. For any such a means the sum of the potential energy and available kinetic energy remains a fixed measure of energy without regard to the evolution of time. This is what

is termed as the principle of conservation of energy and is equivalently the first law of thermodynamics in which such concepts as work and heat are reconciled as equivalent aspects of energy.

In this regard, Einstein's mass-energy equivalence relation therefore implies that any amount of mass is a potential energy that may be converted to kinetic form to the tune of mc^2 .

Modeling the Universe

From observations, it has been established that the stars in our universe are receding from each other according to the Hubble law which states that the speeds of recession increase in direct proportion to the distances between respective stars. As such, the kinetic energy between any two stars is directly proportional to their distance separation. The potential energy on the other hand is provided by the gravitational impetus courtesy of the attraction between the star masses in accordance with Newton's gravitational law. This potential energy is converted to kinetic energy form when the masses advance towards each other. The total sum of kinetic energy and potential energy of such a system of stars is thus conserved to a fixed value in accordance with the principle of conservation of energy

Composite Curvature Model: In the Newtonian formulations, all systems are considered to evolve in accordance with the net energy derived from the sum of all effective causes. In addition, Einstein noted that all masses respond to inertia in equivalent form as they do respond to gravity. As such, the inertial evolution of a system may thus be considered equivalently as a pure gravitational effect. Consequently, the nature of the evolution of the system is such that if we suppose that the kinetic energy balances out the gravitational potential energy at a distance R , then the inertial evolution of a system of masses becomes a function of the distance, such that the masses will;

- move towards each other if they are separated by distances less than R
- maintain their separation if they are exactly at a distance R apart, and
- recede from each other if their separation is more than the distance R

These three options define the structure of the composite curvature model and each separately satisfies the homogeneous cosmological models that are referred to as the closed, flat and open systems respectively.

Static Model: Since time immemorial many peoples

including such personalities as Isaac Newton, have considered the large scale structure of our universe as an unchanging space that is neither contracting nor expanding. Sticking to this notion against all odds is what Albert Einstein referred to as the greatest blunder of his life since it made him introduce mathematical predictions that were contrary to observational evidence of the expansion of the universe.

The Newtonian universe in which gravity is the only long range force applies in a static background space in which case kinetic energy opposes the gravitational potential energy. This implies that there is either no net motion or that the motion associated with gravity is of imaginary type. Since gravity is a ubiquitous force on all matter, it follows that in the absence of any mass, space has to evolve in according with the Hubble law. If there were no mass then there would be no observer, that is, you and me. It is this line of thought that has evolved the notion that the universe consists only of the observable or detectable energy forms. This has in addition been entrenched by the art of experimentation and verification as a principal part of physics and indeed, of all sciences.

From careful analysis of the dynamics of celestial bodies and large groups of galaxies, it has become apparent the some of the motional trajectories project marked deviations from predictions based on Newtonian equations. The inference is that there are yet unobservable energy sources that account for these deviations. Some of these unobservable entities that produce gravitational influence are hence referred as Dark Matter.

Big Bang Model: The study of the observable large scale energy forms in the entire universe is referred to as cosmology. Cosmologists study the origin, form, shape, size, age and destiny of the observable universe as a whole. Since it has been observed that the universe is expanding and is filled with very low energy background radiation of about 3K (compare to cold water which freezes at 273K), cosmologists contend that these are evidence of what might have been the original hot dense violent burst of matter and energy that has so far cooled down over time. This proposed violent burst is referred to as the Big Bang origin of our universe.

Inflationary Model: In attempts to extend our knowledge of the universe to before the Big Bang, it has been hypothesized that the universe may have been born in even more turbulent events at a time when the entire universe that we see today may have fitted in a volume smaller than a proton. This is referred to as the inflationary stage of the

universe. Theories with such notions suggest that the universe may have originated from a false vacuum of repulsive gravity that inflated the universe in unimaginably brief time, and that the energy for such an expansion was derived from the separation of previously unified forces of nature into their familiar separate forms as gravitation, electroweak and the strong nuclear forces. It is surmised further that some of this energy went on to create the masses that we observe in the universe.

Conclusion

By the nature of the expansion of the universe as described by the Hubble law, the visible universe has dimensions that are limited by our inability to observe signals from more than 15 billion light years away, that is, the distance that light travels in 15 billion years. We cannot see beyond this range even if the universe may extend beyond that distance. This limitation denies us the conclusive data that would enable us determine a structured calculation of the fate of the universe, that is, whether it will expand forever, whether it will slow down and eventually stop or whether it will re-collapse and end in a big fireball that is sometimes referred to as the Big Crunch. Whatever will be the actual fate of the universe may not depend on our perceptions of it but who knows what future scientists may design or discover about the workings of nature and on how to manipulate the very large scale end of our physical reality!
