WHAT PHYSICS CAN & CAN'T DO?

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INTRODUCTION:

Unless we know what Physics has done, it is difficult to visualize what it can not do. It has made us understand both our immediate and distant surroundings. It has helped us understand what are the constituents of matter and the nature of the variety of radiations. We also understand about the variety of motions the matter particles undergo and the various energy sources that govern both living and non-living systems. The latter are based on thermal stabilities of different kinds while the former still needs adequate understanding.

All this has happened as we discerned the laws governing the various physical processes taking place in and around the world. As we understand the variety of energy sources, we evolved techniques to unleash hidden resources, e.g. fossil, fission, fusion, solar, wind and hydro-based ones. We also encountered conditions that limit us. One has to worry about renewable and non-renewable sources. Have we been able to create anything in the universe that was non-existent earlier! Is it possible to circumvent or overcome such limitations? The universe has shown both change and stability, just as we have birth/death with somewhat stable intervening life.

There are things we are unable to handle, e.g. what existed prior to the Big Bang birth of the universe, what constitutes dark matter/energy that dominates the universe with only 4 % visible matter. The latter is baryonic (nucleons form nuclei that are baryonic structures) in nature while the former is non-baryonic (particles like neutrons, protons and even the known quarks are all fermions). Any probing radiation sent by the former can not interact with the latter. However, both these must have originated from the same primordial matter created at birth.
Mysteries lie ahead for us to unravel, some may get solved with our technological advance in instrumentation while some others may well remain beyond limits of instrumental capacity. Finally, the capability of the human mind to visualize, analyze and apply logical rationality may limit our analytical and conceptual strengths. Struggle seems to lie between individual consciousness vis-à-vis cosmic consciousness that may well have given rise to our physical universe!

SIGNIFICANT DEVELOPMENTS:

The list is truly extensive. We have worked out the laws of motions for both earth bound and heavenly bodies. We have isolated the different interaction fields that govern the same. Looking at the cosmological data, we understand that the evolution of the universe required the four field components to emerge sequentially. First to come was gravitational field, followed by strong nuclear, electromagnetic and finally the weak nuclear. The gravitational field led to the gradual conversion of the primordial matter into visible (4 %) and dark matter (23 %) and associated dark energy (73%). The latter is providing the repulsive acceleration to the visible part vis-à-vis dark matter. It may well be some kind of gravitational like interaction field that still needs to be identified. Later, as the strong nuclear field came into play, the visible matter started to form nuclei of light elements, mostly hydrogen and helium. With the onset of electromagnetic field, the hydrogen and helium atoms/molecules got formed, their aggregation finally lead to the

formation of stars and galaxies over a period of few billion years. The emergence of weak nuclear field led to the termination of stable limit of elements around lead, as unstable higher elements led to decays to immediate lower stable elements, limiting the stable elements to lead. Such is the evolution of the Universe that we have been observing since the birth of first humans some tens of thousands years back. It has been a remarkable logical design. Physics is interested in evolving the disciplinary laws that govern such an evolutionary pattern and then explain the various processes and phenomena taking place in the visible universe of ours. It does not want to concern itself with why's of creation, including what existed prior to the creation of the universe.

Classical physics explained the motions of material particles through mechanics and kinetic theory. Optics took care of the nature and behaviour pattern of different radiations. Atomic and molecular Physics helped us understand the interactions at the level of atoms/molecules, as Chemistry got concerned with reactions between the varieties of molecules to constitute the form of matter existing in nature. Other sub-disciplines arose soon to describe the variety of solids we have both in crystalline and amorphous forms, as studied in solid-state physics. Soon, we discovered semi-conductors in between metals and insulators, specially silicon and germanium. The latter exhibit remarkable electronic properties that permits switching between two distinct states, as also an easy flow of electric current in controllable conditions leading to devices called diodes and transistors. An electronic revolution took place that has affected the technological state we are living in today. Earlier, optics provided the means to develop some gas lasers as sources of intense monochromatic radiations. The emergence of semi-conductor electronics followed up with development of solid state lasers with much higher intensity and better monochromatic properties as well as covered a wide spectral range from far ultra violet to far infra-red frequencies. Another interesting development with great future lies in the field of nanoparticle materials. Their novel structures provide great potential in modifying the known properties of ordinary materials if these are transformed into products built with their nano-structured analogues. The latter has already achieved great success through enhanced efficacy of drugs. If metals and insulating materials are made with their nano-structured analogs, they are expected to show unique tribological properties. The picture for nano-structured semiconductors (inorganic and organic) may result in another revolution in electronic devices and lasers.

Classical physics limitations soon emerged leading to the birth of quantum mechanics. It mainly led to a better understanding of the micro-world of atoms/nuclei and particles, the ultimate constituents of matter/radiation. It helped evolve a picture that permitted the concept of quanta of energy through the Planck's constant, h and helped consolidate the wave and particle nature of radiations as synonymous to a better understanding of particle and wave motions. We now that these are mere complimentary in nature and stand consolidated quantum mechanically, in contrast with the distinct behaviour in classical physics.

Certain physical constants appeared on the scene in the form of electronic charge and mass, the velocity of light and the Planck's constant, h (the quanta of radiation energy). The magnitude of the latter being very small, its effectiveness decides whether one can work with classical physics or resort to quantum mechanics. Obviously, the micro-world required the latter while the former was found relevant to the macro-world of existence. The Planck's constant determines the correspondence between the two through its significance in understanding a phenomenon. On account of inherent uncertainties associated with quantum mechanics, classical physics however continues to provide the pictorial understanding for any process/phenomenon.

The concepts of space and time are seen to be of fundamental nature in the growth of entire physics. Quantum physics provided the conjugation of space with momentum and time with energy of a physical system. It is an important development as it indicates that the corresponding uncertainties are related to the Planck's constant. If either space or time exhibit any non-homogeneity, the situation can lead to the creation of mass or energy. Such an implication is significant in the early universe of the first half a billion years since birth, a period of extreme physical conditions. The same may not be open to the physics we have developed in the past few hundred years when the universe acquired more or less a steady state.

A few words about gravity as an interaction field appear to be in order. Attempts to unify the various interactions into the concept of a Unified field have succeeded, barring gravity. The concept of quantum nature of gravity has been introduced in order to understand the extreme high density of matter/radiation contained in stellar objects called Black holes. Is gravity acquiring closeness with quantum physics? What is it that makes gravity special? We have not yet understood the reasons behind the extremely fast evolution of the initial universe from a point to its original size, before the accelerated expansion took over. May be, the nature of gravity following the Big bang was extremely repulsive in nature to start with. Such a nature has been established for the strong nuclear field which is highly repulsive at distances of size of the nucleon and becomes attractive at nuclear distances. The nature so demands in order to prevent the collapse of the nucleus! The same may well be the case with gravity too! Nature controls Physics and not vice-versa. The simulations of conditions at the time of birth and the quick evolution of early universe will be extremely difficult to implement in a laboratory on earth, as is being attempted in High energy Ion Beams Collider labs. across the world. It may well be advisable to attempt instead conducting more accurate and precise space experiments in order to understand more and more of what transpired cosmologically in the early universe – a challenge too!

Some speculations and perspectives in regard to such a problem appear in order. We may not treat constancy of field strengths and or that of the physical constants to be a holy picture close to the birth of the Universe. After all we have developed our Physics only during the past 500 odd years! Physics of the early universe may require some radically different approach conceptually!

EXPECTATIONS:

Physics seems to deal only with better and better relative truths about the processes/phenomena it chooses to deal with. We hardly expect to arrive at any finality of understanding. For Physics to grow, let us leave the psychology of absoluteness/perfectness and instead adopt ways and means that are free from bias and consider 'freedom of thought' supreme. With such an open approach, we can hope to develop new concepts/ideas to approach the unsolved problems, e.g., constancy of strengths of the force/fields, constancy of velocity of light, charge and mass of electron and other basic particles, etc. In addition, mystery surrounds the constituents of dark matter and the basic nature of dark energy. A program of outer space experimentation of cosmological nature, with greater precision and accuracy, may help unravel such mysteries and remove distractions that may come our way.

To bring in couple of mundane but unique developments that may become possible, one may hope to develop human apparel with appropriate refractive index that makes the wearer disappear (Star Track TV serials). Another aspect concerns the speed limitation to c, the

velocity of light. This limitation prevents a human to explore the universe ever. Let us recollect that it arises because of the homogeneous nature of space. If a space vehicle has the technology to condense space in front and expand space behind, it may well exceed this limit in such an inhomogeneous environment that gets created thus.

What limitations we may face in Physics that defy an answer? What existed prior to the Big Bang finds us clueless presently. The only solution lies with permanent existence of the universe. However such a picture does not match the observed anisotropy of background microwave radiations that followed the sudden creation of the universe. The latter measurements strengthen the Big bang approach, as probed by Hubble Space Telescope. Nature of dark matter may require mastering the art of detecting neutral and or heavy particles (Higgs bosons and the like) unknown thus far. We may prepare ourselves to sense particles of an entirely new family of primordial matter! Limits of technological growth and the capacity of the human mind will come to extreme testing in the years to come. As what gets born also dies, we run a race to solve the mysteries before the human race becomes extinct!

OVERALL COMMENTS:

What physics can not hope to do? Some expectations outlined above may never get fulfilled. Then, there are things in the universe that currently exhibit no apparent physical basis. These will remain beyond the scope of physics. Physics is just one of the professional activity for the humans and gets bound by its methodology. The human mind also requires to expand (1), as it controls the way we conceptualize a set of observed facts into an acceptable theory. It is thus a struggle where we compete against the super-mind of the creator, a task that does appear to lie beyond physics.
It does appear relevant to find some strong bridges between physical and life sciences, with physics providing not only the tools but also the means to interpret the phenomena in life sciences. The nature of human mind requires better understanding as we need to expand it in raising both its capacity and capability, to unravel the mysteries of nature. What is the nature of life force and how it uses the complex DNA like molecular structures to run our body like structures? It may well require a super mind like that of the creator, if there is one! Perhaps the secret lies in the emotional component that has been ignored in physics, in preference to the rational component of the mind. Individual biological cell is capable of acting independently as well as collectively in a live body. How each cell communicates with the entirety of the environment is indeed a difficult task to unravel? A recent report (2) indicates the success of a nano-structured dye, as capable of measuring the electrical field strength within a cell, acting as a nano-voltmeter. Further such developments may enliven the role of physics in life sciences!

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The author feels indebted to the ‘silence’ component of the mind!

REFERENCES:

1. Relevance of Consciousness in Sciences: Eternal India (New Delhi), July 2009, pp. 133-139.
2. http://www.dailygalaxy.com/2009/01/human-cells ; dated 1/30/2009.