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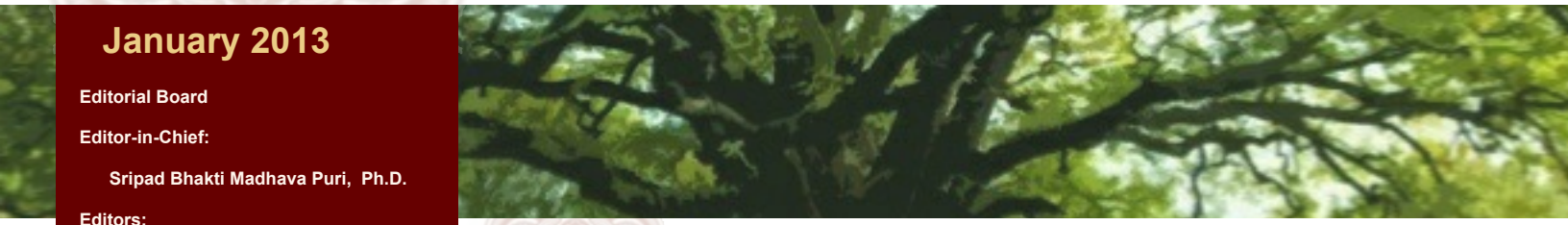

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Worlds in Collision: The Stability of the Solar System

Bhakti Madhava Puri, Ph.D.

The Revolutionary Science of Spiritual Cosmology

Sir Isaac Newton (1642–1727) discovered a problem in theoretical physics that is still unresolved to this day. He recognized that the periodic forces of gravity produced by the planets of the solar system degrade their orbits over long time spans, to produce either collisions of planets, ejections of planets into interstellar space, or incineration in the Sun. Although the calculated effects may be small for a given instant of time, over millions of years those small effects accumulate to produce problems of instability of the solar system. Fully aware of this situation, he therefore wrote,

> ". . . the Planets move one and the same way in Orbs concentrick, some inconsiderable Irregularities excepted, which may have arisen from the mutual Actions of Comets and Planets upon one another, and which will be apt to increase, till this System wants a Reformation."

Due to the fact that the various planets in the solar system gravitationally interact with one another and thus perturb the orbital paths they follow, Newton realized that the system was ultimately unstable and thus divine intervention was needed to restore the balance in the planetary orbits that we observe today. In an original letter to Richard Bentley on December 10, 1692, Newton wrote (in Olde English):

> ". . .the motions which the Planets now have could not spring from any naturall cause alone but were imprest by an intelligent Agent. ffor since Comets descend into the region of our Planets & here move all manne{r} of ways going sometimes the same way with the Planets sometimes the contrary way & sometimes in cross ways in planes inclined to the plane of the Ecliptick at all kinds of angles: its plaine that there is no naturall cause which could determin all the Planets both primary & secondary to move the same way & in the same plane without any considerable variation. This must have been the effect of Counsel. Nor is there any natural cause which could give the Planets those just degrees of velocity in proportion to their distances from the Sun & other central bodies about which they move & to the quantity of matter conteined in those bodies, which were requisite to make them move in concentrick orbs about those bodies. Had the Planets been as swift as Comets in proportion to their distances from the Sun (as they would have been, had their motions been caused by their gravity, whereby the matter at the first formation of the Planets might fall from the remotest regions towards the Sun) they would not move in concentric orbs but in such excentric ones as the Comets move in. Were all the Planets as swift as Mercury or as slow as Saturn or his Satellites, or were their several velocities otherwise much greater or less then they are (as they might have been had they arose from any other cause then their gravity) or had their distances from the centers about which they move been greater or less then they are with the same velocities; or had the quantity of matter in the Sun or in Saturn Jupiter & the earth & by consequence their gravitating power been greater or

> less then it is: the primary Planets could not have revolved about the Sun nor the secondary ones about Saturn Jupiter & the earth in concentrick circles as they do, but would have moved in Hyperbolas or Parabolas or in Ellipses very excentric. To make this systeme therefore with all its motions, required a Cause which understood & compared together the quantities of matter in the several bodies of the Sun & Planets & the gravitating powers resulting from thence, the several distances of the primary Planets from the Sun & secondary ones from Saturn Iupiter & the earth, & the velocities with which these Planets could revolve at those distances about those quantities of matter in the central bodies. And to compare & adjust all these things together in so great a variety of bodies argues that cause to be not blind & fortuitous, but very well skilled in Mechanicks & Geometry."

The great philosopher-mathematician, Gottfried Leibniz, criticized Newton's subjection of God to such menial tasks as directing the planets. For Newton, the laws governing material nature were a manifestation or reflection of the rationality of the Creator, not that God personally acted within Nature. The gravitational laws he discovered were a feeble proof of the rationality of the cosmos, but never meant to be a complete comprehension of the supreme intelligence of God. In other words, his idea was not to separate God from His creation as the Deists later concluded, in which the universe would work mechanically according to certain laws. Rather, the idea of a clockwork universe was something Newton eschewed and refuted, although this fact is rarely admitted in teaching physical science. He considered the whole of the universe in space to be what he called the sensorium of God. Thus for Newton the universe was not mechanical and certainly not pantheistic or identical with God, but it was the subservient domain over which God was the Lord (Gr. *Pantokrator*).

Einstein held similar views to Newton in this case. He was also not a pantheist, but a panentheist. As Einstein saw it,

> "Every one who is seriously involved in the pursuit of science becomes convinced that a spirit is manifest in the laws of the Universe — a spirit vastly superior to that of man, and one in the face of which we with our modest powers must feel humble."

And,

> "The human mind is not capable of grasping the Universe. We are like a little child entering a huge library. The walls are covered to the ceilings with books in many different tongues. The child knows that someone must have written these books. It does not know who or how. It does not understand the languages in which they are written. But the child notes a definite plan in the arrangement of the books— a mysterious order which it does not comprehend, but only dimly suspects."

Despite Newton's fear that his laws would be misinterpreted by the mechanists, a century later, what Newton understood as the rationality of God reflected in the law-like nature of the universe, became for Pierre Simon Laplace (1749–1827) the ultimate intelligibility of the universe for Man. Thus he wrote in his treatise, *Celestial Mechanics*:

> "An intelligence knowing all the forces acting in nature at a given instant, as well as the momentary positions of all things in the universe, would be able to comprehend in one single formula the motions of the largest bodies as well as the lightest atoms in the world, provided that its intellect were sufficiently powerful to subject all data to analysis; to it nothing would be uncertain, the future as well as the past would be present to its eyes. The perfection that the human mind has been able to give to astronomy affords but a feeble outline of such an intelligence."

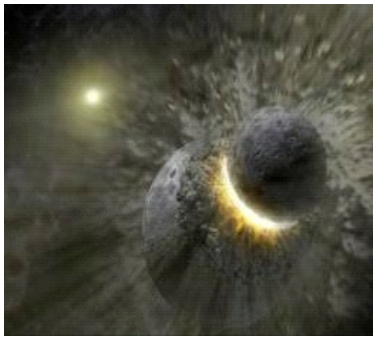
He was quite convinced that the universe was governed by intelligible laws that an ultimate intelligence could fashion. This represented the extreme limit of determinism that took hold of science, but which modern theories of quantum physics have overthrown. We find a long list of notable mathematicians, astronomers, and physicists who held on to the mechanistic dream and attempted to solve the problem of the solar system's stability, including Carl Friedrich Gauss, Andrei Kolmogorov, Joseph Lagrange, Jürgen Moser[1], Henri Poincaré, Siméon Poisson, Malhotra[2] and many others. Yet the problem remains unresolved to this day. Several "proofs" of stability have been touted based on specific approximations, but none of them are accurate over the age of our solar system and thus fail to justify its stability. In the process this has led to the discovery of many new mathematical methods to deal with this problem, including perturbation theory, non-linear dynamics and chaos theory.

The Large Hadron Collider (LHC) must guide protons over a hundred million revolutions or more, presenting a problem similar to the long term behavior of the solar system. The discovery of other planetary systems in the universe means that they also have to face the same requirement of stability over billions of years. Even the theory of evolution has now come under the domain of chaos theory:

> "It is impossible to predict how a given species will respond to environmental change . . . the neat concept of adaptation to the environment driven by natural selection, as envisaged by Darwin in *On the Origin of Species* and now a central feature of the theory of evolution, is too simplistic. Instead, evolution is chaotic."[3]

What this signifies is that the whole problem of determinism exists not only at the subatomic quantum level, but also at the macroscopic cosmic level, and thus has become a central problem in numerous fields of modern scientific study. Thus the days of a purely deterministic science are over. Although chaos theory assumes the necessity of deterministic laws, those laws are not sufficient to explain or predict complex phenomena in the world. Errors in initial values or truncation errors in computations are inescapable, due to the inherent limitations of our numerical methods, accuracy of measurements and

computing ability. The small errors they each entail produce catastrophic effects in the long run. This has forced scientists to re-think their whole conception of science in order to be able to practically deal with what are in fact complex systems of reality that are not reducible to a small set of a simple laws.



Computer simulations of the solar system can be followed for a few billion years, with accurate data on planetary masses, orbits, and interplanetary forces, as well as forces from passing stars, Galactic tidal fields, comets, asteroids, moons/satellites, etc. One of the problems here arises from truncation errors due to the inherent limitations of computational machines and our numerical methods of dealing with computed values. This adds up to a considerable problem of accuracy over billions of computational cycles. The other problem has to do with processing time, which is somewhat alleviated by the increased performance speed of modern computers, and the possibility of shared distributive computing over thousands of other computers. This would seem to solve the time problem, but the calculations have shown that small changes in initial parameters that determine the masses, positions, etc. of the planets lead to catastrophic exponential divergences from stability. We simply do not have the means necessary to accurately determine those initial values precisely.

Mathematically, those systems in which small changes in initial conditions produce large catastrophic behavior overall are called chaotic systems. What this means practically is that the orbits of the planets in our solar system in the long range are as unpredictable as long range weather forecasting. As astronomer Jacques Laskar writes, ". . . it becomes essentially impossible to predict the motion of the planets with precision beyond one hundred million years."[4,5] This is considerably less than the astronomer's belief in the billions of years that the solar system has existed.

The neat deterministic universe Laplace imagined is today replaced by a ruthlessly realistic chaotic picture that gives no assurance that the planets may not collide in the distant future. The deeply held conviction that the universe can be understood by a handful of physical laws is one of modern science's most comforting and abiding delusions. This belief in a strictly deterministic, law-governed universe, forms the very ground of the mechanistic world view of Nature and Life that still dominates much of contemporary scientific thinking. But the fundamental unpredictability of subatomic measurements that Heisenberg's principle established must exist inextricably in the largest dimensions of the universe as well. These quantitative limits to scientific knowledge are insignificant compared to its qualitative limits, since modern empirical science has not even developed the concepts needed to explain the dimension of cognition, emotion and volition (thinking, feeling, and willing) that characterize the aspects of reality that are so essential to life. Does this mean that the ultimate truth forever lies beyond the bounds of science? Or do the limitations of science only prove what we already believe to be a spiritual truth that will always surpass its reach?

It is easy to understand how the simple mechanical view of the universe has been imbibed by the young and the uninformed or misinformed public, including even scientists who are not directly involved in astronomy. The general picture of the solar system that appears in many books on astronomy and in public planetariums is one of regular circular or elliptical orbits which the Earth follows around the Sun. One year corresponds to one circulation around the Sun and a return to a point from which it started. However, the actual situation is far more complicated. The Earth never returns to any point which it already covered. The movement is so complex that even the elliptical orbit is also revolving around the Sun, the plane of revolution is always changing, the axis around which the Earth rotates is also changing, and the Sun is not stationary.[6]

The Sun is presently moving with respect to neighboring stars at about 43,000 miles per hour (70,000 km/hr) roughly in the direction of the bright star Vega in the constellation of Lyra. In its journey around the Milky Way galaxy, the Sun has to move 483,000 miles per hour (792,000 km/hr). This means that the planets also have to move at that speed to keep up with the Sun, forming spirals, not orbits, in the Milky Way. And we should be mindful that all the speeds given here are not constant, so they are averages. The complexity of the calculations is thus enormous.

Sir James Lighthill, President of the International Union of Theoretical and Applied Mechanics, who held and demonstrated a rigid belief in the mechanical laws of Newton throughout his career, made this remarkable apology[7] in 1986,

> "We are all deeply conscious today that the enthusiasm of our forebears for the marvelous achievements of Newtonian mechanics led them to make generalizations in this area of predictability which, indeed, we may have generally tended to believe before 1960, but which we now recognize were false. We collectively wish to apologize for having misled the general educated public by spreading ideas about the determinism of systems satisfying Newton's laws of motion that, after 1960, were to be proved incorrect.

> "I feel fully justified, therefore, in repeating that systems subject to the laws of Newtonian dynamics include a substantial proportion of systems that are chaotic; and that, for these latter systems, there is no predictability beyond a finite predictability horizon. We are able to come to this conclusion without ever having to mention quantum mechanics or Heisenberg's uncertainty principle. A fundamental uncertainty about the future is there, indeed, even on the supposedly solid basis of the good old laws of motion of Newton, which effectively are the laws of motion satisfied by all macroscopic systems. I have ventured to feel that this conclusion would be of interest to a Discussion

> Meeting on Predictability in Science and Society. For example, there might be some other discipline where practitioners could be inclined to blame failures of prediction on not having formulated the right differential equations or on not employing a big enough computer to solve them precisely or on not using accurate initial conditions; yet we in mechanics know that, in many cases where the equations governing a system are known exactly and are solved precisely, nevertheless, however accurately the initial conditions may be observed, prediction is still impossible beyond a certain predictability horizon."

The idea of the clockwork universe has thus been overthrown. Even *Wikipedia* summarizes the current situation,[8]

> "The best current evidence seems to be that even for classical systems, the argument for a clockwork universe as a strict consequence of Newtonian dynamics is no longer logically valid. Since both complexity and errors accumulate over time, perhaps exponentially, we cannot be certain of determinism even for short times, or even in principle, or even for classical systems. Basically, nature seems to draw a curtain on predictions of mechanical motion in a clockwork universe that is forever beyond our ability to penetrate."

Theories of natural science consist of testable laws based on regularities that can be expressed mathematically. It is the regularities that make repeatable experiments and precise predictions possible. However, if the world does not consist of mechanically repeatable regularities, but of unique, contingent, singular events, then each event can only be understood in its historical context and has meaning only as part of a whole, inviting the need for theological integration and interpretation.[9] Indeed the very subtle and complex, non-mechanical and carefully coordinated movements of the members of the cosmos over eons of time take on the appearance of providentially attended systems, much like living organisms.

We can only conclude that a principle beyond mere mechanical physical laws is at work in the creation, maintenance, and destruction that are inherent to the nature of the ever-changing face of the phenomenal world. The modern scientific mind chafes at the idea of accepting that a divine inscrutable influence (*acintya shakti*) governs the whole cosmos and supports its existence. Yet we see that the most advanced scientific knowledge ultimately rests in a blind faith in its own ability to explain reality. It is in faith that science and religion inevitably collide, and it is in faith that they ultimately meet. All knowledge is based on faith, be it in axioms or doctrines, assumptions or revelations. But they are also harmonized at this same meeting point, if we understand them as being complementary ways of confirming the same divine truth that is transcendental to finite means of knowledge.

Classical, relativistic, and quantum mechanical calculations all have their respective domains of validity without contradicting each other. And the domain of one does not necessarily apply also distinct disciplines that attempt to represent reality, but by their respective methods that are peculiar to each. As such, they must overlap one another because they express the same reality from different perspectives – different angles of vision. It is only the attitude of the exclusive dominance of one field over another that obscures the actual harmonious understanding that they provide.

The search for Truth is called philosophy, while the search for Certainty is known as science. The search for Beauty is expressed in art, and the search for he highest fulfillment of Love is what religion offers us. These are not separate Non-Overlapping Magesteria (NOMA), as the famous evolutionist, Stephen Gould identified them. They are the aspirations of everyone, and certainly do not occupy mutually exclusive endeavors in our lives. Historically, the satisfaction of these aspirations has found their fulfillment in the greatest conception of all - the all-comprehensive idea of the Personality of Godhead. This primeval knowledge, known even to the most ancient of human civilizations, still finds itself at home in the cutting edge of modern of scientific thought.[10]

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