Doubt and Certainty. T. Rothman and E. C. G. Sudarshan. Perseus Books, Reading, Massachusetts 01867. 1998. 320 pp. Price: US $ 25.

'There is no limit to my divine manifestations.' 'What need is there, O Arjuna, for such detailed knowledge by you? I support this entire Universe pervading it with a single fraction of Myself.'

The Bhagavadgita – Ch. 10: 40, 42

'I am not interested in the spectrum of this or that element. I want to know how God created this universe and what were his thoughts. The rest are details.'

– Einstein

To the uninitiated, it is far from obvious that the Natural world obeys precise laws which can be stated using exquisitely beautiful mathematics. Modern science is a relatively recent discipline while, of course, the human quest for understanding is as old as the hills. Scientists, especially theoretical physicists, have often declared that the final theory is just round the corner just like politicians promising the Utopia. Consider the following statements of Laplace and Dirac:

'An intelligent being who, at a given moment, knows all the forces that cause nature to move and the positions of the objects that it is made from, if also it is powerful enough to analyse this data, would have described in the same formula the movements of the largest bodies of the universe and those of the lightest atoms. Although scientific research steadily approaches the abilities of this intelligent being, complete prediction will always remain infinitely far away.' – Laplace 1820.

'The general theory of quantum mechanics is now almost complete. The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known, and the difficulty is only that the exact application of these laws leads to equations much too complicated to be soluble.' – Dirac 1929.

With the benefit of hindsight we now know that Laplace was wrong on more than one count. Surely Newtonian dynamics fails at the atomic scale. The old theory of gravitation can hardly explain many astrophysical objects like quasars and blackholes. So the old physics failed not only at small scales but also at large scales. One has also learnt that simplicity of equations can be very deceptive as exemplified for example by the occurrence of chaos in some dynamical systems.

With Dirac, one notices modesty when he is talking about physics though not about chemistry. A very profound change also took place in the passage from classical to quantum theory, namely the conceptual framework physicists use to describe Nature, which to this date remains a matter of controversy.

In Newtonian physics, dynamics is governed by the second law. The force term can sometimes be derived from empirical observation, as in the case of gravitation. With Einstein there was the great shift in paradigm, invariance principles began to occupy the central stage. Today we know that all the forces or interactions known to us can be derived from invariance or symmetry considerations. The advent of quantum theory meant a radical change in the way dynamics is described. We no longer have simple pictures of particle trajectories as in classical physics, which Laplace thought could be described as accurately as one wished, limited only by the computational resources one had. In quantum theory we have the state vector in a Hilbert space, which is pregnant with many possibilities. Only one of these is realized in any specific experiment and there is no way by which the theorist can predict the outcome in advance, although in dealing with averages and the like, no failures of the theory have been reported.

George Sudarshan has made pioneering contributions to the theory of weak interactions and Tony Rothman has wonderful credentials as a physicist and physics writer. In their book, these authors explore several fundamental questions of science within a much wider framework which encompasses not just religion, philosophy, mysticism, etc. but also more mundane aspects of daily existence. What is it that we know for certain? Should we not doubt the tall claims of the scientists despite the unquestioned ability of science and technology to deliver many good things in life?

It is an article of faith for theoretical physicists to claim that the final theory will be a beautiful piece of mathematics. Moreover the theory would be unique, by virtue of its logical consistency and simplicity. All empirical observations either in the microscopic or the macroscopic domain, for both simple and complex systems can be obtained by deductive procedure from the final theory. Is mathematics simply a product of a human mind or is it an intrinsic part of Nature independent of humans? If nature is granular and discrete in the smallest dimensions, from where do we get our picture of smooth manifolds? Very often, one finds that in creative arts like music, painting or poetry, the admiring followers read far more meaning in the works of the author than were probably intended in the first place. In a similar vein, is the beautiful mathematics needed to write the final theory more a product of human imagination rather than something intrinsic to Nature? Putting it differently, if physics can be simulated by a Universal Quantum Turing Machine are all these beautiful properties of Nature, nothing other than human imagination?

Putting aside such doubts, even if we grant the veracity of fundamental laws, how successful are we in understanding things like the flow of time? Boltzmann, one of the great scientists of 19th century, took on himself the task of deriving the second law of thermodynamics from Newtonian dynamics, leading him to prove the famous H-theorem. The problem in accepting Boltzmann's derivation is basically this. Newton's second law which describes molecular collisions is symmetric under time reversal as typified by the example of collision of billiard balls. Using a symmetrical theory as a starting point, how can one get a result which is asymmetric at the end? Did Boltzmann perpetrate a swindle much like a magician pulling a rabbit out of the hat? Like spectators trying to figure out where the rabbit really came from, theorists have spent great efforts, trying to find where exactly is this sleight of hand in the derivation of the H-theorem by Boltzmann. Unfortunately quantum theory does not improve the matter although many theorists have tried to use irreversibility to solve another intractable problem, namely the measurement problem in quantum mechanics.

There are other manifestations of lack of symmetry in the large. For example, the predominance of biological molecules of say, the right-handed ones over their mirror symmetric partners, the left-handed ones, in some cases, and vice versa in yet some other cases. How and where do these asymmetries arise from?

There are many for whom reductionism is anathema. Even disregarding them, one might still ask how far have quantum theorists succeeded in solving problems in condensed matter, not to mention other fields like biology? A simple property like conductivity may require new paradigms when one is dealing with high temperature superconductors for example. Many contemporary brilliant minds have generated more heat than light on this subject.

Now what about realizing Einstein's ideal and dream? What is the status of the superstring theory which has been advocated by its proponents as the theory of everything? An analogy with mathematics can be useful. For a long time, mathematicians, under the baneful influence of theoretical physicists, thought that all mathematics had something to do with Nature. As Marshall Stone put it, in the 20th century they finally got rid of the theoretical physicists enabling the development of mathematics by leaps and bounds. So much so that one applied mathematician quipped that, sometimes, theorems in pure mathematics have their sole justification in the fact that the author could think of them and prove them. I think it is fair to say that string theory is in a similar happy position of allowing theorists to give free rein to their imagination unfettered by ugly experimental facts. Even more than Einstein's dream, his ideal about the role of quantum theory in describing reality has come under experimental scrutiny thanks to John Bell's pioneering work. It suffices to say that opinion about Einstein's idea of reality is divided among contemporary physicists.

There are more difficult questions. If the big bang theory is correct then did time and space have a beginning? If time had a beginning, will it have an end as well? What is the meaning of time translation invariance in such a universe if you are close to the initial singularity?

Roger Penrose has tried to argue that the human mind perhaps does not follow algorithmic procedures as in a computer program. If he is right, we must concede that either physical laws cannot describe the brain and mind or that physics itself cannot be reduced to pure computation, as some have tried to demonstrate.

So there are these great questions discussed in this book, waiting to be answered by the present and future generations of academicians. The reader should not expect a pedagogical exposition since this not the intention of the authors. To paraphrase John Bell, there is a tendency to betray the great enterprise of science and reduce it to the piddling exercise of laboratory experiments or 'researching and publishing' as one local hero put it. Every serious person, not just scientists should read this book. Contemplating the loneliness and insignificance of human beings in this vast universe can be an unsettling experience for weak minds. This book combines deep insights with wit and wisdom in every page.

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Aerosols: Generation and Role in Medicine, Industry and Environment. K. S. V. Nambi and B. K. Sapra (eds). Allied Publishers Ltd, 13/14 Asaf Ali Road, New Delhi 110 002, India. 1998. 314 pp. Price not stated.

Aerosols are fine particles dispersed in a gaseous medium. Generation and removal of these particles, their properties (size, chemistry) and their dispersion are all topics of considerable research and development both in basic and applied sciences. For example, the study and modelling of physical processes contributing to aerosol formation (e.g. evaporation, condensation, nucleation and coagulation) are all relevant not only to aerosol physics but also to understand and characterize natural phenomena such as cloud condensation, droplet formation and particle deposition. Similarly, both the beneficial and adverse effects of aerosols in industry and health have subscribed to major researches in many areas, e.g. production of fine particles of specific size and composition, techniques for coating material surfaces with individual layers of fine particles and development of filters and filtration methods for quantitative removal of particles of various size classes. Aerosols, though encompass a wide range of colloidal systems, are more synonymous with particles in the atmosphere and their studies have gained considerable momentum during the past decade or so as they affect 'our weather, our seeing and in some instances our well being and even survival'[1]. The size distribution, chemical composition and optical properties of atmospheric aerosols are all topics of detailed investigations among atmospheric scientists, climatologists, chemists and physicists, as they influence radiative forcing (hence the climate) and the quality of air we breathe. Aerosol research is thus very topical.

The book under review is the first major publication of the Indian Aerosol Science and Technology Association. This book, edited by K. S. V. Nambi and B. K. Sapra of the Bhabha Atomic Research Centre, Mumbai is targetted for 'promoting this modern science and also awareness about the many facets of aerosols'. Such a goal naturally requires the contents of the book to be broad-based reviews of current topics in aerosol research which can generate scientific interest among a wide range of readers. The book, in addition to a foreword and introduction, has 21 chapters which are divided into five sections – (i) Basic Studies, (ii) Aerosols in Medicine, (iii) Aerosols in Industry, (iv) Nuclear Aerosols, and (v) Aerosols in Environment.

The section on 'Basic Studies' has four chapters dealing with measurable effects of microgravity on aerosol formation, nucleation process in binary mixtures and growth of binary particles, coagulation and coalescence models and theoretical and experimental studies on nucleation of atmospheric aerosols. Mayya and Sapra in their chapter on models of aerosol coagulation have ventured into discussions on reversibility concepts involving thermal dissociation of nanoclusters, an idea which needs to be further explored as it may have implications to irreversible growth of particles.

The three chapters on 'Aerosols in Medicine' describe both diagnostic and therapeutic applications. Atmospheric pollution is a major cause of respiratory diseases. These pollutants enter the human body through inhalation. The