Modern atomism

This is in response to the book review by Ramakrishnan[1] in *Current Science*.

My involvement with this volume on Modern Atomism began after D. P. Chattopadhyaya wrote to me a letter regarding the theme of the volume. He had earlier contacted B. V. Sreekantan, who is well known for his work in cosmic rays and gamma-ray astronomy before writing to me. Much to my pleasant and agreeable surprise Chattopadyaya, in the very first letter inviting me to put together the articles for this volume, mentioned particle physics, gravitation, cosmology, Maxwell's electromagnetic field, etc. as the subject matter. He added two specific requests. One was to include an article or two relating physics to chemistry and biology; the other was to highlight the work of scientists from our part of the world who have contributed significantly to the subject matter of this volume. I had discussed the details of this volume in many meetings with several members of the Centre for Study in Civilizations (CSC), New Delhi and editors of the other volumes of CSC on philosophy, sciences, public affairs, etc. were present. All the articles were read by other colleagues in India and suggestions for change were incorporated.

The central theme of this volume is the link between the physics of the small and the large, that is, elementary particle physics and cosmology. The cosmic microwave background radiation (CMBR) was discovered in 1965, and was quickly recognized as a relic of the hot big bang when the universe had started. On the other hand, the year 1967 marks the beginning of the Standard Model of elementary physics. By 1973, we had a unification of electromagnetic, weak and strong interactions. As a result of these developments, we now have a good understanding of the evolution of the universe from the Hadron era (when the universe had cooled sufficiently for quarks to combine to form protons and neutrons) till the present. To progress further we require the quantum theory of gravity, and need to understand dark matter and dark energy. These details are stated in my preface and discussed in the several meetings mentioned above.

Now in particle physics experiments, a result requires large and expensive machines like the Large Hadron Collider (LHC). Therefore, international collaboration is a must. Sunanda Banerjee was a member of the Indian part of the international team that discovered the Higgs boson in 2012. His article 'Collaboration in experimental research' describes the Higgs discovery in detail, among other things. The reviewer complains that 'there is not much of mention of Higgs' and in the same breath declares the article of Banerjee 'do(es) not seem to be connected with the stated theme of this volume'. Apart from Palash Pal's article, the one by Ramachandran and myself describes Higgs theory using the relativistic version of the Ginsburg Landau theory of superconductivity, but the reviewer complains that the idea of broken symmetry is not discussed. There are two articles in this volume, one on hot big bang cosmology, and the other on CMBR and inflation which extensively use COBE and Planck Satellite (launched in 2009) data; yet the reviewer mentions that the satellite-based astronomy article is out of place. Moreover, he has not only ignored all articles on gravitation and cosmology, but declares them as 'review articles on subatomic physics till the last quarter of the 20th century'.

The reviewer's statements like 'twentieth century science experienced the reality of atoms —', a little later 'consequences of atoms which are quantum reality—', 'one can "see" atoms. Their sizes were measured in many ways', etc. are strange to read indeed. Barring some hold-outs like Mach and Ostwald, atoms were very real for physicists and chemists of the 19th century. Surely, kinetic theory is valid within its domain of applicability, as is the whole of classical physics until it is pushed to its limits. It was Rutherford's discovery that the positive charge inside an atom is concentrated at the centre that made it impossible for atoms to exist in classical physics. While quantum mechanics provides stability to the atom, it is important to realize that quantum theory radically changes our view of nature. A system has a precise defined property a priori before any measurement is carried out in classical physics, but not so in quantum theory. Reality, observables and measurements are difficult concepts in quantum mechanics. The debate of Einstein, Heisenberg and Bohr about what is an observable is discussed in this volume. There are many articles in the volume which describe with care, how the properties of elementary particles are determined, ranging from the tiny neutrino to the top quark.

Quantum theory is not just about the microscopic world. We need it to understand many astronomical objects like the white dwarf. However, CMBR which pervades the universe is the most spectacular manifestation of quantum theory on a large scale. The most distinctive feature of quantum theory is the superposition principle. This latter, as pointed out by Schrödinger, when applied to a macroscopic object like a cat, leads to an absurd situation. The question then arises: if quantum theory applies to the entire universe, how is it that we can ignore the quantum aspects of many objects we deal with every day? Detailed discussions of the quantum to classical limit, the measurement problem and the intrinsic nonlocal nature of quantum theory are presented in this volume. Topics like quantum computing which exploit the superposition principle, quantum information theory which depends on nonlocality of quantum theory, quantum cryptology, quantum lithography, quantum imaging, etc. have no direct bearing on the fundamental issues which are the main concern of this volume. The central theme and spirit of this volume can be understood from a quote by Einstein:

> 'I want to know how God created this world. I'm not interested in this or that phenomenon, the spectrum of this or that element. I want to know His thoughts, the rest are details.'

About the reviewer's remark 'I missed the name of E. C. G. Sudarshan –'. His name, work, journal references, etc. can be found in Lokanathan's two articles, and chiral invariance is described in other articles. There is no biographical note on George because he was happily with us till very recently. Nowhere in this volume is it said that the Raman effect is fundamental for establishing quantum theory. On the other hand, it remains for nine decades now since its discovery, a versatile tool for studying various structures. In fact, the 'Higgs particle' in the BCS superconductor, with a mass twice the gap energy as predicted by Nambu, was found using Raman scattering. The mass of the Higgs in the Standard Model, however, does not satisfy such a relation. In biology, it is well known that the Ramachandran map is important for studying biomolecules. The list of scientists and their contributions to the theme of the articles in this volume appear in my preface. There is nothing Indian about the Raman effect or Raychaudhury equation themselves. What is important is their contributions to scientific knowledge. There is nothing atavistic or chauvinistic in the choice of any of the ten scientists mentioned in this volume.

Now about reviewer's remark, '… Annie Besant and George Leadbetter had claimed that proton consists of three quarks nearly half century before the experimental discovery…' without any reference to source material. A search reveals that Annie Besant and Charles (not George) Leadbetter wrote about their clairvoyant findings in the last decade of the 19th and first decade of the 20th century. Now from the articles by S. Lokanathan one can easily find that the proton was discovered in 1911, neutron in 1932, and later pion and strange particles in 1947. Despite the many puzzles about these particles, physicists did not find any need for a quark model. The discovery of plethora of resonant states of the proton and strange particles was made possible by building high-energy accelerators which then forced physicists to reluctantly invent the quark model in 1964. But the quark model was not taken seriously by everyone till Feynman came up with his parton model in 1969, triggering intense research leading to the theory of gluons and quarks (QCD) in 1973. The proton is actually a super position of indefinite number of quarks and gluons. The three quarks of 1964 are constituent quarks or quasiparticles. If one can believe that Besant and Leadbetter came up with the quark model using their yogic clairvoyant microscope, we can close all labs and get rid of the expendable theorists. The story of Kekule's dreams is well known. However, Kekule was a reputed chemist and the problem of understanding the structure of benzene was well laid out years before he had his dream. On the other hand, Besant and Leadbetter were theosophists. Swami Vivekananda's travel with Jamshedji Tata in 1893 and Sister Nivedita's assistance to Tata in preparing a blue print for the first Indian Science Institute are well known. Vivekananda attended the Paris Exposition 1900, held to celebrate the achievements of the past century and to accelerate development into the next. To Vivekananda's deep distress, he found that there was just one Indian scientist, J. C. Bose, among the large number of famous European scientists. During this Paris visit, Vivekananda sent a passionate appeal to Indian youth to shed their superstitions and take to the study of science. Vivekananda disliked theosophy and strongly disapproved closed minds.

1. Ramakrishnan, T. V., *Curr. Sci.*, 2018, **115**, 1810.

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