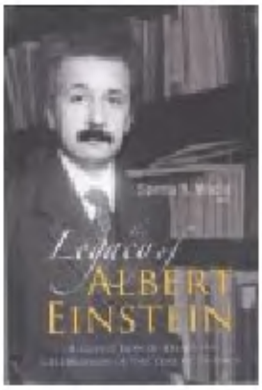


The Legacy of Albert Einstein – A Collection of Essays in Celebration of the Year of Physics. Spenta R. Wadia (ed.). World Scientific Publishing Co Pvt Ltd, 5 Tok Tuck Link, Singapore 596 224. 2007. 260 pp. Price not stated.

Albert Einstein is regarded by many as the greatest scientist of the twentieth century. His contributions to physics revolutionized the subject in a myriad ways. The year 1905 was an extraordinary one for Einstein and indeed for all of physics; it is now referred to as his *annus mirabilis*. In that year, he wrote five papers and completed his Ph D thesis. In one of these papers, he developed the special theory of relativity, starting with two rather simple-sounding requirements that all physical theories should satisfy. He then wrote a short paper deriving the relation $E = mc^2$ between the mass of an object and its energy when it is at rest; this is one of the most well-known equations ever written down. He wrote two papers on Brownian motion and random walks, which confirmed the existence of molecules and suggested experimental ways to measure their size and number per unit volume. Finally, he wrote a paper explaining the photoelectric effect by postulating that electromagnetic radiation is absorbed and emitted in quantized packets, later called photons. Einstein considered this to be his most revolutionary piece of work, for which he was awarded the Nobel Prize in 1921.

Although certain features of the special theory of relativity had been discovered earlier by Lorentz, Einstein was the first person to truly appreciate the relativity of time and the startling fact that events which appear to be simultaneous to one observer may not appear to be simultaneous to a second observer who is moving with respect to the first with a constant velocity.

Einstein then went on to develop the general theory of relativity almost singlehandedly during the period 1907–15. This resulted in a completely new understanding of gravitation, which replaced Newton's theory of gravitation developed several centuries earlier. In this theory, Einstein wrote down equations relating space–time and matter. This led to amazing concepts such as space–time being curved in the presence of matter and eventually to black holes which are such dense objects that nothing, not even electromagnetic radiation, can escape from them classically. Incidentally, the curvature of space–time plays a significant role in modern life. Due to the curvature, the rate at which a clock runs depends on the strength of the earth's gravitational potential felt by it; this has to be taken into account by the global positioning system (GPS), which is based on the atomic clocks located in satellites flying around the earth. The GPS also has to correct for the motion of the satellites using Einstein's special theory of relativity.

In 1917, Einstein applied the general theory of relativity to the universe as a whole and hypothesized a 'cosmological constant', which is currently an idea of great interest. The most recent observations of the cosmic microwave background radiation indicate that the universe is made up of about 76% dark energy, 20% dark matter and 4% ordinary matter. Of these, dark energy is the most mysterious object; it is possible that this will turn out to be just the cosmological constant introduced by Einstein.

Einstein also discovered the stimulated emission of radiation by atoms in 1916, which eventually led to the development of lasers, and Bose–Einstein condensation of certain systems at low temperatures in 1924, which arose as a consequence of a new kind of statistics discovered by Satyendra Nath Bose. Einstein was the first to apply quantum mechanics to properties of solids such as their specific heat.

Apart from his major discoveries, Einstein thought about simpler problems as well. In 1926, he wrote a clear paper on why tea leaves gather near the centre of the bottom of a tea cup after the liquid has been rotated by a spoon, and why rivers meander by preferentially eroding one of their banks more than the other.

To celebrate the centenary of the *annus mirabilis* of Einstein, UNESCO declared 2005 as the World Year of Physics. All over the world, activities were organized to draw attention to the impact of physics. The book under review is an example of such an activity. Spenta Wadia has brought together an interesting collection of essays by experts, describing different aspects of Einstein's scientific work and the developments which have occurred in some of those directions in recent years.

Some of the essays discuss attempts to unify the four different forces of nature, namely gravity, electromagnetism, strong and weak interactions. Einstein himself spent many years trying to unify gravity and electromagnetism, as discussed in the first article by David Gross. Strong and weak interactions were not well understood during Einstein's time, and he does not seem to have paid much attention to them. Although Einstein did not succeed in constructing an unified theory, some of the ideas that he considered have reappeared in current attempts at unification. One of these ideas, first proposed by Kaluza and Klein, is the possibility of there being some extra dimensions of space. The introduction of ideas from geometry into physics is one of the enduring legacies of Einstein's work, as discussed by Michael Atiyah.

The most ambitious programme for unification today is based on string theory, which has been a subject of intense study for more than twenty years. Ashoke Sen provides a glimpse into this subject. This theory has so far failed to provide a way of understanding the different forces and elementary particles in an unambiguous manner. On the other hand, it has succeeded in consistently combining quantum mechanics and gravity, which is a remarkable achievement in itself. As a result, one now has an understanding of the entropy of black holes, a concept which was developed by Stephen Hawking and which remained rather mysterious for many years. Atish Dabholkar describes some of these developments. Apart from string theory, there have been other attempts to combine quantum mechanics and gravity; these are outlined by Abhay Ashtekar. A result of these considerations is that one can now try to understand what happened at the time of the big bang or even earlier than that; questions like these would have made little sense a few decades ago.

The subject of cosmology and the current status of dark energy are covered by Jayant Narlikar and Subir Sarkar. This is a subject which is rapidly becoming more and more precise quantitatively, thanks to a number of satellite probes deployed in recent years. For instance, we now know quite accurately the rate of expansion of the universe and the amounts of its three major constituents as mentioned above. B. S. Sathyaprakash deals with the subject of gravitational waves. These are a consequence of the general theory of relativity and they were discussed by Einstein in 1916. However, they have not yet been directly observed due to the extreme weakness of the gravitational force compared with the other forces. Several detectors are currently in operation to try to observe such waves which may be generated by a pair of very compact objects, like neutron stars or black holes, circling around each other.

Amongst all the subjects studied by Einstein, Brownian motion and statistical fluctuations have probably had the widest range of applications in science and engineering. Satya Majumdar discusses a variety of such applications, including some in computer science. N. Kumar addresses the phenomenon of Bose–Einstein condensation and its recent manifestations in weakly interacting systems such as alkali atoms trapped at ultra-low temperatures. T. V. Ramakrishnan discusses a variety of systems of strongly interacting electrons, such as high-temperature superconductors, manganites and heavy fermion systems. A complete understanding of such systems constitutes one of the most important problems in modern condensed matter physics.

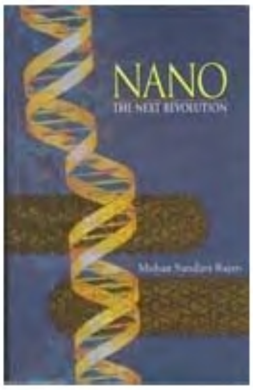
Although Einstein played a key role in the development of several aspects of quantum mechanics, he gradually developed misgivings about certain aspects of it, such as its probabilistic and non-local nature. Einstein's contributions to quantum mechanics as well as his objections to it are covered by Virendra Singh. Einstein always stated his objections with precision so that attempts to refute his arguments, by Niels Bohr and others, invariably led to a more refined understanding of the subject. Einstein's arguments helped develop concepts like entanglement, which today play a major role in areas like quantum information theory.

Apart from his scientific achievements, Einstein was also a role model as a pacifist and a democrat. Although he advocated the development of the atomic bomb by USA during the Second World War to counter fascism, Einstein began campaigning against such weapons soon after the war. Unlike many other scientists of his generation, Einstein did not hesitate to speak out on issues of public interest. T. Jayaraman covers this aspect of Einstein's life in the last chapter of the book.

I would strongly recommend this book to libraries and to individuals who have some knowledge of physics and who wish to learn about the continuing influence of Einstein on modern developments in physics.

DIPTIMAN SEN

Centre for High Energy Physics,
Indian Institute of Science,
Bangalore 560 012, India
e-mail: diptiman@cts.iisc.ernet.in



Nano: The Next Revolution. Mohan Sundara Rajan. National Book Trust, A-5 Green Park, New Delhi. 2004. 179 pp. Price: Rs 75.

The explosive growth of science at the nanoscale over the last decade has spurred research activity globally, and has promoted great expectations amongst the general public. Nanoscience and nanotechnology, unlike any other emerging field in the past, cuts across several barriers and is highly interdisciplinary in nature. Consequently, a decade ago, its societal impact could not be envisioned realistically; thereby generating an upsurge in excitement. This led to propositions, both in the scientific and popular literature, such as smart nanoscale submarines that will circulate in a person's bloodstream and cure him/her of molecular diseases, and carbon nanotube-based space elevators. Concomitantly, extreme viewpoints and doomsday scenarios were also espoused in the popular literature regarding the safety aspects of nanotechnology.

Within the scientific community, this initial surge of euphoria is now tempered and estimates of the extent of the societal impact of nanotechnology range from a technological revolution to an evolution. The possible doomsday scenario of 'grey goo' (a kind of runaway self-replication of nanoscale robots) is no longer considered a feasible proposition. Research efforts are currently underway to determine the safety aspects and health-hazard risks posed by nanostructured materials. The initial results suggest that they can be handled safely, although differently from their bulk counterparts, and do not pose extreme health-hazard risks. However, at this juncture, this tempered attitude towards nanotechnology has not percolated into the popular literature. Hence, there is a pressing need for popular literature that can provide a factual introduction to this topic and also allay some of the fears associated with the development of nanotechnology.

The book under review is an effort to fill this need. The author reportedly has experience in writing popular science books and should be commended for attempting such an arduous task. A task that involves comprehending research performed by a wide range of scientists approaching the issues with an equally wide range of perspectives, and conveying it in general and lucid terms to a lay audience. There is a range of possible approaches to write such books. One of them is an approach that is easy on the general reader, but onerous for the author. This would be an attempt to explain the basic principles involved in nanoscience, a rapidly evolving and wide-ranging field, and connect them together under a few universal themes. These should then lead to the technology and the potential societal impact of this field. The other extreme would be to attempt a chronological exposition of events and discoveries that lays the onus of analysis upon the reader. Not surprisingly, considering that there is still a dearth of scientific books written in the former approach, this book is written in the form of a chronological diary of events.

The book has ten chapters, all titled glibly. The author's endeavour to cover the entire spectrum of topics from inorganic to organic nanomaterials is laudable. The book includes details about the scientists involved in conducting the reported research and especially highlights the work done in various research labora-