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EDITORIAL

Physics – past perfect, future uncertain

Most physicists would be happy to make one discovery that is important enough to be taught to future generations of physics students.

— Mathew Chalmers in *Physics World* (Jan. 2005)

Physics rules supreme over the wide expanse of the cosmos (the observable universe being nearly 80 billion light years in size) to the minutest sub-nuclear species (nearly a femtometer), over time scales of the age of the universe (nearly 14 billion years) to femtosecond or even lesser intervals of time. The nature of the physical world is governed by the laws of physical interactions that have helped it to be held together.

What is physics? I am reminded of a lecture by Prof. K. S. Krishnan some 50 years ago, on 'What is electricity?' He dealt with the past centuries when giants like Isaac Newton, Helmholtz and others laid foundations of physics. Krishnan referred to Newton as a complete natural philosopher, for Newton knew everything of medicine, mathematics and natural philosophy of those days. Helmholtz was a complete physicist for he had mastered mechanics, optics, acoustics and every other aspect of physics of his times. By the time of Michael Faraday, one begins seeing specialization. By the time of Krishnan, he jocularly noted, there were specialists, some of ac electricity and some of dc electricity, some of incandescent lamps and some of florescent lamps and so on. So amidst all this, can one answer the question 'What is electricity?' In order to answer this question, Krishnan switched over to an apocryphal story. A guru posed a question 'what is *tapas*?' to his students and asked them to independently cogitate and give him their answers. The students returned the next day, jubilant that they could answer this 'simple' question. Each one gave a different answer. The last of the students broke down saying 'Sir, I do not know what is *tapas*, it is inexplicable in a word or two. I can only say "*tapas* is *tapas*" and nothing more'. The guru, overwhelmed by this answer, said that only this student had appreciated the meaning of *tapas*. So Krishnan ended his talk by saying that whereas we can talk for hours on various aspects of electricity, the most appropriate answer to the question he began with was 'electricity is electricity'. Extending what Krishnan had said that day, perhaps his answer to 'what is physics?' would have been 'physics is physics'.

To describe physics in detail is to fragmentize the subject. Physics is a great unifier. One discovers new aspects of physical reality with advances in technologies, instruments and theoretical insights. The onward march of physics leaves its footprints on everything it touches on its way, be it biology, medicine, engineering or industry. It tends to transform them so much so that sooner than later one tends to forget that physics was behind these transformations. While physicists are aware that they are agents of the transformation and hence (arguably) arrogant, they also realize that society does not always remember and acknowledge what is their due.

The UNESCO conference, in Paris in January this year, was convened to kick-start the 'World Year of Physics 2005' (also referred as the 'Einstein year' or centenary of the 'miraculous year') 'to improve public perception of physics and how physics can help solve socioeconomic problems'. At present, while there is a scramble to IT, BT, engineering and medical courses, physics is perhaps the last choice of students and parents. Physics lacks glamour and moolah although people are curious in matters celestial due to some mystique surrounding cosmology and astronomy. Physics *appears* not to be addressing socioeconomic problems. Is it true? If physicists are involved in dealing with day-to-day problems (for example, in issues related to transportation, energy, weather and so on), where have they gone wrong in giving a wrong perception to the general public? The society would invest in physics, if and only if, physics plays an important role.

The centenary of the triad of Einstein's 1905 papers has given an alibi for timely introspection, debate and stocktaking through a surge of programmes, notably public and popular lectures and conferences. According to Elizabeth Simmons (*Physics Today*, Jan. 2005, p. 42), 'popularising physics means disseminating research results to a non-expert audience… . Popularising physics is also to convey to non-physicists the inherent excitement and underlying goals of the discipline … A related aim of the outreach is to help the public appreciate the beauty and creativity of the scientific endeavour, and that physicists do not merely enumerate dry facts… .' Continuing on, Elizabeth Simmons, justifying that physicists must get involved in this publicity, says 'if we are to continue doing the research we deem intellectually important, socially relevant or personally fulfilling, we are responsible for informing our sponsors about the connection between our concerns and theirs'. This is easily said than done. Not all physicists are articulate and are at home as communicators. But it is incumbent that all physicists must 'describe implications of their research for other scientific fields and for society as a whole'. Phrases like 'one's research helps advance frontiers of knowledge' or that 'it transforms the way of living', etc. remain mere catchwords. But, all said and done, the integral of all scientific research results in pushing frontiers of knowledge and transforms the life and living style of people in general. This appreciation is very much there amongst those who are 'followers of science' or who are 'sympathizers of scientific method'. Elizabeth Simmons ends her article, cited earlier, by stating 'public awareness of physics is important for the future of the field. Those who invest efforts to produce that awareness are worthy of their colleagues' respect'.

The period 1900–1930 is considered the golden era of physics; it ushered in modern physics comprising developments in quantum physics and atomic and nuclear physics. It all began with the publication of three revolutionary papers by Einstein in 1905: one on Brownian motion that proved the existence of atoms and molecules, the second on photoelectric effect that validated quantum hypothesis and the third on special theory of relativity that transformed our notions of space–time. Perhaps no other equation has caught the imagination and wonder of common people as much as, $E = mc^2$. This simple equation is an outcome of the special theory of relativity. It is an expression of mass-energy equivalence. A realization of this equivalence was the release of nuclear energy in fission and fusion reactions.

Einstein's legacy is not just a part of history. As Mark Haw has noted (*Physics World*, Jan. 2005), Brownian motion is as relevant today as when it was discussed by Einstein: 'As physics increasingly overlaps with biology, nanotechnology and the statistics of complex phenomena, we can begin seeing how understanding Brownian fluctuations is vital to everything from cell function to traffic flow, and from models of ecologies to game theory and the stock market ...Without them, there would be no phase behavior, no protein folding, no cell–membrane function and no evolution of species... . Two centuries after Brown (and a century after Einstein) a trade-off at the heart of nature is gradually becoming clearer: there is an extraordinary balance between function and fluctuation, between hard physical rules and the subtle effects of randomness...'. So also one of the inroads that relativity has made of late is to the Global Positioning System (GPS). 'Were it not for designers factoring in relativity to GPS, the whole system would go wrong in 20 min, GPS depends on corrections to the timing signal from the effects of both special relativity and general relativity'. Similarly another work of Einstein that has made wide impact is his theory of stimulated emission; it is seen working in all places where lasers are found. Prediction of Bose–Einstein condensation, made in 1924, was realized only recently. In many ways 'Einstein was ahead of his time'. Many predictions of the general theory of relativity like existence of gravitational waves, their properties if detected or violations of the inverse-square law are subjects of current experimental investigations. So, Einstein's contributions have lasted over a century now, made him an icon and given certain criterion to assess the contributions of any scientist to the pool of scientific knowledge. A working criterion could be by noting if his/her contributions are to be found in text books, have led to a new school of thinking or have opened doors to a new line of investigations that have far reaching applications; such contributions in terms of number of publications may be a few but 'ever-lasting'. Einstein himself published hundreds of papers.

How was Einstein as a human? Much is available in books, his famous biographies and other literature. He noted sometime in 1920s, 'In the last few years I have traveled over the world. In fact, it was too much for a scholar, because a scholar like me should sit in his room and study'. His only visit to Asia was during 1922, to Japan. Einstein was known to the Japanese through their publications of articles and books, preparatory to his visit. He impressed them and was much impressed by that visit. The *AAPPS Bulletin* (April 2005 issue) has brought out English translations of three articles published in Japanese in 1922: (i) 'Impacts of Einstein's Visit on Physics in Japan' by Hiroshi Ezawa (ii) 'How I constructed the Theory of Relativity' by Albert Einstein and (iii) 'My impressions in Japan' by Albert Einstein. These are very readable articles. What impressed me most after reading these articles is the sense of history, heritage and tradition that seems to be a part of Japanese psyche. If one has to locate records to fathom our recent past, if not past history, I am somewhat skeptical if we can succeed. Many a time, either one has a no-care-after-me attitude or a sadistic pleasure in erasing/distorting the past. Although Einstein was in touch with Gandhiji, Rabindranath Tagore and Nehru and was known to Bhabha, Einstein did not visit the Indian subcontinent.

What is the status of physics in India? R. Y. Deshpande has noted [http://www.tifr.res.in/~aset/full_text/ryd_tifr.doc], 'It is said that the period 1920–1930 was the golden era of physics in India. Four important discoveries were made during those ten years. These are the Saha ionisation formula, Bose statistics, the Raman effect, and the Chandrashekhar limit. That was physics in its trueness. Yet the Indian gold appears to be less bright than the gold that was mainly coming out from Western Europe of the time. ...(There was a) rush of epoch-making contributions, far-reaching in their significance, India's participation was marginal. ...' That is a candid opinion. *Resonance* has featured seven Indian physicists so far in its portraits of famous scientists. There are none who took to research in the post-independent India, in this collection. It would be of interest to find, in future, equivalent icons.

The style of doing science has changed during the last 50–60 years. It is no longer individual-centric. Collaborations involving a few to hundred researchers are common. There is greater emphasis on large budgets, skills in management of science rather than on contributions to science per se and evolution of committees and commissions. That they achieve rather little is a cliché; Richard Feynman's talent and acumen in solving the problem of failure of O-rings in the Challenger missions, in spite of Roger commission is a model-success story. The famous Yale mathematician Serge Lang is reported to have said in an interview, 'When Richard Feynman was asked to be a member of the commission investigating the Challenger disaster, he gave us a model of scientific responsibility. He resisted attempts by (commission chairman William) Rogers to inhibit his investigation. He interviewed engineers and others at Morton Thiokol. He explained the scientific facts to the public. He bought pliers and screwdrivers and a clamp in a hardware store and showed publicly in front of video cameras how rubber O-rings lose their elasticity at low temperatures. ...He wrote about all this in his book, *What Do You Care What Other People Think?*'. In the founding of projects and thrust-areas, the casualty has been recognition of individual excellence; accountability is given the go-by quite often.

India is on several studies, projects and experiments related to physics – à la at CERN or at BNL, nanophysics, string theory, quantum computing and so on. Some projects have been under various stages for decades, while similar projects take shape elsewhere in fewer years. Speed is essential; otherwise we have to be content in that we too ran the race. 'Will this cauldron throw up some icons?', is a moot question.

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