New Advances in Physics, Vol. 12, No. 2, December 2018, pp. 119-128

A Personal Account of Abdus Salam

K. R. Sreenivasan*

Professor Abdus Salam, the founding director of my institution, the International Centre for Theoretical Physics, now named after him, received the Physics Nobel Prize in 1979 for his work on electroweak unification of forces. This year is the 10^{th} anniversary of his death, and I have the honor to say the following few words about him to commemorate the occasion. While everything I say is factual, at least to the best of my knowledge, the interpretations reflect my personal opinions which have many limitations of their own. The best thing I can say upfront is to admit that I am aware of those limitations.

I. ABDUS SALAM IN HIS OWN WORDS

It is best to let Salam speak in his own words on how he evolved into a great physicist from modest beginnings. I reproduce below a brief article that was culled a few years ago from some of Salam's writings [1]. The article also speaks directly to his vivacious and engaging personality.

> "I was born in the country town of Jhang, then part of British India, now Pakistan, in 1926. My father was a teacher and educational official in the Department of Education and my mother was a housewife. I had six brothers and one sister. My family was by no means rich. My father took a vast amount of interest in my school work. He had great ambitions for me. I was destined for the Indian Civil Service, entry to which was by competitive examination. However, this was not to be—as events in my life took a different turn.
>
> "When I was at school in about 1936 I remember the teacher giving us a lecture on the basic forces in Nature. He began with gravity. Of course we had all heard of gravity. Then he went on to say "Electricity. Now there is a force called electricity, but it doesn't live in our town Jhang, it lives in the capital town of Lahore, 100 miles to the east". He had just heard of the nuclear force and said "that only exists in Europe". This is to demonstrate what it was like to be taught in a developing country.

* Abdus Salam Research Professor, Director, ICTP, Trieste, Italy

"When I was 14, I won a scholarship to Government College, Lahore, with the highest marks ever recorded. I recall that when I cycled home from Lahore, the whole town turned out to welcome me. I wrote my first research paper when I was about sixteen years of age. It was published in a mathematics journal but I wasn't actually hooked on research till I went to Cambridge University.

"I was very fortunate to get a scholarship to go to Cambridge. The famous Indian Civil Service examinations had been suspended because of the war and there was a fund of money that had been collected by the Prime Minister of Punjab. This money had been intended for use during the war, but there was some of it left unused and five scholarships were created for study abroad. It was 1946 and I managed to get a place in one of the boats that were full with British families who were leaving before Indian Independence. If I had not gone that year, I wouldn't have been able to go to Cambridge; in the following year there was the partition between India and Pakistan and the scholarships simply disappeared.

"At Cambridge, I achieved a First in the Mathematics Tripos in two years. I still had a third year free in the sense that I had the scholarship and the choice of whether to go on with higher mathematics—that's part III of the mathematics tripos—or to do the physics tripos. On the advice of my tutor, Fred Hoyle, who said "If you want to become a physicist, even a theoretical physicist, you must do the experimental course at the Cavendish. Otherwise, you will never be able to look an experimental physicist in the eye", I joined the Cavendish Laboratory where Rutherford had carried out his experiments on the structure of the atom. The Cavendish was an outstanding laboratory for experimental work and a focus for physicists around the world. However, I had very little patience with experimental equipment. To be a good experimenter you must have patience towards things which are not always in your control. I think a theoretician has got to be patient too, but that is with something of his own creation, his own constructs, his own stupidities.

"The very first experiment I was asked to do was to measure the difference in wave length of the two sodium D lines, the most prominent lines in the sodium spectrum. I reckoned that if I drew a straight line on the graph paper then its intercept would give me the required quantity I wanted to measure. Mathematically, a straight line is defined by two points and if you take one other reading then mathematically that should be enough since you then have three points on that line, two to define the straight line and the third one to confirm it. I spent three days in setting up that equipment. After that I took three readings and took them to be marked. In those days the marking of experimental work in the class counted towards your final examination. Sir Denys Wilkinson was one of the men who supervised our experimental work, and I took it to him. He looked at my straight line, and asked "What's your background?" I said "Mathematics". He said "Ah, I thought so. You realise that instead of three readings you should have taken one thousand readings and drawn a straight line through them". I had by that time dismantled my stuff and didn't want to go back. So I tried very hard to avoid Denys Wilkinson during the rest of the year. I still remember when the results came out in 1949. I was looking at the results sheets hung in the Cavendish and Wilkinson came up behind me. He looked at me and said "What sort of class have you got?" and I very modestly said "Well, I've got a first class". He turned full circle on his heel, three hundred and sixty degrees, turned completely round, and said "Shows you how wrong you can be about people".

"I went back to Lahore in 1951 and taught there at the University. But as a physicist, I was completely isolated. It was very difficult to get the journals and keep in touch with my subject. I had to leave my country to remain a physicist. Now, it is the lack of this contact with others that is the biggest curse of being a scientist in a developing country. You simply do not have the funds, the opportunities, which those from richer countries enjoy as a matter of course. There are not the communities of people thinking and working in the same fields. This is what we have tried to cure by bringing people together at the International Centre for Theoretical Physics which I founded in Trieste in 1964. The Centre provides the possibility for scientists to remain in their own country for the bulk of the time, but come to the Centre to carry out research for three months or so. They meet people working in the same subject, learn new ideas and can return to their own country charged with a mission to change the image of science and technology in their own country.

"I returned to Cambridge in 1954 as a lecturer and Fellow of St. John's College. Three years later, I accepted a professorship at Imperial College, London, where I succeeded in establishing one of the best theoretical physics groups in the world.

"The pinnacle of my physics career came in 1979 when I shared the Nobel Physics Prize with Sheldon Glashow and Steven Weinberg for our unification of electromagnetism and the weak nuclear force in the 'electroweak' (a word which I invented in 1978) theory, one of the major achievements of twentieth century physics. This theory had made predictions that could be verified by experiment. The most revealing of these was that a new particle exists at extreme energies. To test this theory we had to convince the experimental physicists working on the great particle accelerators to build new equipment: To create, in principle, conditions that would be similar to those first few moments in the birth of the universe. In 1983 the final confirmation was obtained with the discovery that the predicted particles—the intermediate vector bosons—did exist. Called W^+, W^- and Z^o, these hypothetical particles were seen for a few fleeting moments under the cosmic conditions of the CERN accelerator. This temporary existence was enough to demonstrate that the unification theory was an accurate description of the fundamental nature of matter. This experimental verification led to the award of the Nobel Prize to Carlo Rubbia and Simon van der Meer in 1984."

I might add the following postscript: Salam held his professorial position at the Imperial College from 1957 until 1993 with distinction. From 1964 until 1993, he was concurrently the Director of the International Centre for Theoretical Physics (ICTP), where he provided both the physical drive and the lofty vision. For a period of time, he played various advisory roles for the government of Pakistan. Salam fell prey to a rare type of Parkinson disease around 1985 but exerted himself greatly to carry on his responsibilities for several more years. Those who knew him remember them as difficult years. He passed away at his home in Oxford on 21 November 1996.

II. BRIEF REMARKS ON SALAM'S SCIENCE

Salam's place in physics is described in several places [2], but it is useful to understand it in his own words. In an undated popular talk given sometime after 1979, Salam described his work as a major milestone in the quest for unification of forces of nature. He first described Newton's role in the unification of celestial and terrestrial gravitation—an idea that is now commonplace, but undoubtedly revolutionary at the time. Then came Einstein's theory of relativity that defined gravitation through the curvature of the space-time manifold. Space and time were never again to be considered in separate terms.

On another branch of unification, Faraday realized that electricity and magnetism were two aspects of the same physical phenomenon, and Maxwell wrote down his beautiful equations describing the theory of electromagnetic radiation.

The next set of forces deals with nuclear structure. The weak force is the second weakest after gravity, responsible for radioactive decay and neutrino interactions. Enrico Fermi understood the basics of weak interactions while studying the decay of radiation. The weak force occurs in the decay of nuclear particles requiring, as learnt later, a change of a quark of one flavor to another. The theory that describes the unified electromagnetic and weak interactions is the *Standard Electroweak theory, which, in large part, is the work of Sheldon Glashow, Abdus Salam himself and Steven Weinberg, for which they shared the 1979 Nobel Prize.*

The *strong force is* short-ranged, acting over ranges of order 10^{-13} cm and is responsible for holding together the nuclei of atoms. It is important for both nuclear fission and fusion. Despite existing gaps, there is strong evidence to suggest that a theory that unifies strong forces with electroweak forces is required to make sense of the Universe. Salam played an important role in the development of this part of physics as well.

The quest for unifying all forces including gravity has been the focus of attention in high-energy physics, and one sustained effort is the string theory in its several manifestations. It has come under attack recently for not having yet produced tangible physical results but there is little doubt that it has been a very stimulating construct that may ultimately begin to answer important physics questions.

Within this grand construct Salam placed himself in an important position—and rightly so. He had several abiding technical interests such as renormalizability, non-Abelian gauge theories and chirality. The importance of the Standard Model, which he helped shape, was realized more completely when Gerard t'Hooft proved its renormalizability in 1972 and the experimental confirmation came about in 1983 at CERN.

Physics has moved on. The recent major experimental developments in cosmology have introduced remarkable changes in the outlook of the Standard Model of quarks and lepton, and have deeply modified the views prevailing at the time of Abdus Salam. Even a normally conservative person today would say that we are witnessing a turning point. Recent experimental findings, which have led to the 2006 Nobel Prize to John Mather and George Smoot for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation, have introduced an entirely new view of the constituents of the universe. It appears that the overwhelming majority of our scientific and technological knowledge has been confined so far to about 5% of the universe related to ordinary matter—both inanimate and living. Determining the nature of the missing 95% of the Universe is amongst the most important problems in modern cosmology and particle physics—something that was unforeseen in Salam's time.

Changes in physics have come from another direction as well. Conviction is growing that reductionism, the cornerstone of much of the 20th century physics, has serious limitations of principle despite its enormous successes; that a deductive link does not exist between the finest constituents of matter and phenomena that occur on the human scale; that one needs an equally deep understanding of the so-called emergent phenomena regulated by higher organizing principles; that these organizing principles are equally deep in both content and structure. Perhaps it is too much to say that physics at the turn of the 21st century is undergoing a crisis similar to that at the turn of the last, but there is no doubt that the subject is changing its landscape.

III.SALAM'S CONCERN FOR SCIENCE IN DEVELOPING COUNTRIES

There is a second aspect of Salam's work that merits equal attention: his concern for scientists from poor countries—or developing countries as they are euphemistically called today. Towards the end of one of his lectures [3], Salam remarked as follows:

> "Unquestionably, there has been no one like Einstein in physics of this century, but one has to reflect on how easily Einstein might have been lost, particularly if he had been born in a developing country….
>
> "Would an Einstein—with his total commitment to science for its own sake—fare well in the climate of today, even in a developed country, [in an environment that looks constantly for] social relevance, immediate applicability and cost-benefit analysis in supporting scientific research…."

One of Salam's passions was that the best and the brightest in developing countries do not get lost because of lack of opportunities. Continuing from his description [1], we have the following text:

> "I spoke earlier of the difficulties of doing science in developing countries. I would like to conclude with an appeal. Funds allotted for science in developing countries are small, and the scientific communities sub-critical. Developing countries must realize that the scientific men and women are a precious asset. They must be given opportunities, responsibilities for the scientific and technological developments in their countries. Quite often, the small numbers that exist are underutilized. The goal must be to increase their numbers because a world divided between the haves and have-nots in science and technology cannot endure in equilibrium. It is our duty to redress this inequity."

It was this passion that was instrumental in establishing ICTP as a center of learning where such opportunities might be provided for scientists from developing countries. Salam's specialization in high energy physics meant that the Centre was oriented initially towards that area of physics, but he never lost track of other branches of theoretical physics. The Centre now not only encompasses several different branches of theoretical physics such as condensed matter physics, statistical physics, applied physics, geophysics, climate variability, but also mathematics. It is a lively place where ideas cutting across different branches of physical and mathematical sciences coexist, and has grown well past the confines of theoretical physics as it is generally understood. It is a hallmark of international cooperation in science working under a tripartite agreement among the United Nations Educational, Scientific and Cultural Organization (UNECO), the International Atomic Energy Agency (IAEA) and the Government of Italy (which funds a major share of ICTP).

Salam was well aware that physics is incomplete without an experimental component, and took interest in the experimental work of young scientists. In particular, one finds the following comments in a report that he prepared for the ad-hoc committee evaluating ICTP in 1983:

> "There is a pressing request from experimental physicists coming to the Centre to find here at least some of the experimental facilities which are not available in their home countries. Two kinds of laboratories have been therefore proposed… (a) Training and Demonstration Laboratories … in which scientists could spend a training period …and (b) Permanent Research Laboratories…where high-level, modern research can be performed …"

Thus, beginning around 1980, there has always been some experimental work at ICTP underlying his belief that physics is the result of a fruitful interplay between experiment and theory (one has to include computer simulations these days). This has resulted in the creation of both types of labs mentioned above, and have included, at one time or another, microprocessors, aeronomy, distributed instrumentation networks, information and communication technology, optics and lasers, fluid dynamics, synchrotron radiation, high-Tc superconductors, materials science, accelerator physics, and so forth. Much of the experimental work has been done in cooperation with other local institutions in Trieste such as International Centre for Science and Technology, International Centre for Genetic Engineering and Biotechnology, the Synchrotron Laboratory Elettra, and Italian Institute for Nuclear Physics (INFN), and other institutions in Italy and elsewhere (such as the International Centre for Scientific Culture—World Laboratory in Geneva), as well as CERN. The best example of the interaction between theory and experiment is Salam's theoretical predictions and the experimental discovery at CERN, which led to the Nobel Prize for Carlo Rubbia and Simon van der Meer in 1984.

IV. SALAM'S BROADER CONCERNS

It is sometimes said that every great man has had at least one great idea. Salam may be said to have had two: the electroweak theory and the ICTP. As a physicist and as a human being concerned about poor countries and with scientists from there, Salam was simply admirable. He is one of my heroes, and I am honored to hold a professorship in his name.

Salam was, above all, a complex person with diverse ideas and drives. I am therefore particularly unsympathetic to efforts that attempt to fit him into shapeless putty and forget the rich tapestry that made him the unique person that he was. In this spirit, I should point out at least one dimension of Salam to which I myself cannot relate—as indeed several others in his time did not. This concerns his pronouncements on a wide range of subjects, such as the history of science across cultures and ages. There was often more rhetoric than substance in them, and generalizations more sweeping than to which he was entitled on the strength of cursory sources that seemed to have been consulted.

It is even more difficult to appreciate his latter-day preoccupation with Islam, his penchant to proclaim religiosity, and the drive to proclaim that he was a believer and a practicing Muslim—sometimes attempting to establish that he was better at it than others. These extraordinary circumstances, probably in part the result of the religious persecution that he indirectly and directly faced, did not prevent him from being excommunicated eventually: I have in possession a letter in which he remarks on this fate with great sadness. It was also clear that he met insurmountable hurdles posed by his country when he made concerted efforts to become the Director-General of UNESCO. That his health deteriorated soon after this failed attempt is perhaps no coincidence, though it is hard to prove the connection. That no one in the Pakistani power structure felt free to attend his burial, and that his remains lie buried in a grave of no consequence are sad facts that one cannot but reflect upon glumly. I have been told that Salam was never allowed to make his Hajj [4] and that, in an incongruous and meaningless attempt to exclude him from Islam even in his death, the words on his grave "there lies the first Muslim Nobel laureate" have apparently been altered [5] to "there lies the first Nobel laureate".

Somewhere in the kind of end that befell a great and passionate man lurks a lesson. Perhaps religion and science cannot be mixed intimately, though one can live them simultaneously and successfully in one's life without making a hard sell of either. If Salam's message was that science does not negate spiritual outlook, it is indeed a valuable point to drive home—especially in our era in which considerable concern exists that scientific outlook is somehow a negation of spirituality. If his thesis was that religion is not blind faith, it underscores an eternal view. But the coexistence of science and religion can be imbued only through example that sanctions no aberrant proclamations. One of the most profound statements I know is that it is hard to tell apart, through causal encounters, a deeply spiritual person from one who is not.

V. FINAL REMARKS

One of Salam's well known quotes, adopted as one of ICTP's driving mottos, is that "Scientific thought is the common heritage of mankind". In the scientific legacy of our species, many countries and cultures have indeed made crucial contributions—some, no doubt, more than the others. This subject is worthy of deep study and cannot be reduced to clichés. Salam's core concern was that science had become the province of the West in recent three or so centuries, and that the situation needed to be altered if the world as a whole were to share the benefits of science. He particularly bemoaned the fact that science in Islamic countries had fallen into dark times, and, both privately and publicly, cajoled Muslim scientists to change the situation in all possible forms. Unfortunately, his considerations on this score remain valid, by and large, even today.

One should, however, not forget the reasons why the West has been able to gain the ascendancy in science and technology. The West is not innocent in how it has appropriated a good part of the world's wealth and resources; indeed, there is no doubt that this propensity has played a major role in its recent rise to power and plenty. In so far as it concerns science, however, this pre-eminence lies in its ready acceptance of factual evidence, wherever it may have come from and wherever it may lead to; the courage to make risky hypotheses but the willingness and discipline to subject them to the rigor of experimental verification; a strong focus that does not permit solace to be found in subjective experiences or in the authority of a text. It is not as if the West of yesteryears, or of today for that matter, is flawless in its pursuit of truth—one only has to recall the fate that befell Galileo and the modern-day rise of creationism. Even so, the underlying qualities remain as stated in so far as it concerns the best science that we have inherited. It is the willingness—indeed eagerness—to challenge and be challenged that allows us humans to comprehend the universe and our place in it.

If the rest of the world catches up on these traits, Salam's dream in its best sense will have come true. The institution that he created, namely the ICTP, and those of us who have followed his footsteps and tried to fill his large shoes, will be proud to be part of his grand dream.

References

[1] From "One Hundred Reasons to be a Scientist," published by the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy. A copy of this book for a nominal cost, as well as items [3]-[5], can be obtained by writing to ICTP library at library@ictp.it.

[2] See, e.g., "Selected Papers of Abdus Salam", World Scientific, edited by A. Ali, S. Isham, T. Kibble and Riazuddin (1994).

[3] Speech given at UNESCO by A. Salam on 9 May 1979, commemorating the 100th Anniversary of A. Einstein.

[4] F. Hussain, "Salam, Saudi Arabia and Pakistan," can be found at the website *http://bznotes.wordpress.com/2006/06/23/salam-saudi-arabia-and-pakistan-%E2%80%93-a-disgrace-by-faheem-hussain/*.

[5] N. Subramanian, "The scientist that Pakistan chose to forget," The Hindu, November 31, 2006, can be found at the website *http://www.hinduonnet.com/2006/11/30/stories/2006113004621000.htm*