**A Tribute to Abdus Salam**

by M.J. Duff

Some personal reminiscences by a former graduate student of the life and works of Abdus Salam. (An after-dinner talk delivered at the *Workshop on Frontiers in Field Theory, Quantum Gravity and String Theory*, Puri, India, 12-21 December 1996.)

 **When all else fails, you can always tell the truth.**

*Abdus Salam*

The death earlier this month of Abdus Salam was a great loss not only to his family and to the physics community; it was a loss to all mankind. For he was not only one of the finest physicists of the twentieth century, having unified two of the four fundamental forces in Nature, but he also dedicated his life to the betterment of science and education in the Third World and to the cause of world peace. Although he won the Nobel Prize for physics, a Nobel Peace Prize would have been entirely appropriate.

Salam was born in Jhang in what is now Pakistan in 1926 and came from what he himself described as humble beginnings. In fact, ``I am a humble man'' was something of a catchphrase for Salam and used whenever anyone tried to make physics explanations more complicated than necessary. He attended the Government College in Lahore and Panjab University before setting off for England and St. John's College, Cambridge, in 1946 where he gained a double first in Physics and Mathematics. He gained his PhD at the Cavendish Laboratory in 1952. He returned to Lahore for a couple of years but was appointed lecturer at Cambridge in 1954. Undoubtedly, the greatest influence on Salam at these early stages of his career was his mentor at St. John's, the great Paul Dirac, who remained Salam's hero throughout his life both as a great physicist and as a man who was largely disinterested in material wealth. (Salam himself never craved material riches, and was known to have paid for poor Third World students and postdocs out of his own pocket.)

At the behest of Patrick Blackett, Salam moved to Imperial College, London, in 1957 where he founded the Theoretical Physics Group. He was elected to a Fellowship of the Royal Society in 1959. He remained at Imperial as Profesor of Physics for the rest of his career and it was there that I was fortunate enough to be his PhD student from 1969 to 1972. In 1964 he established the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, where he remained until recently as its Director.

Among Salam's earlier achievements was the role played by renormalization in quantum field theory when, in particular, he amazed his Cambridge contempories with the resolution of the notoriously thorny problem of overlapping divergences. His brilliance then burst on the scene once more when he proposed the famous hypothesis that *All neutrinos are left-handed*, a hypothesis which inevitably called for a violation of parity in the weak interactions. He was always fond of recalling his visit to the formidable Wolfgang Pauli where he submitted (or should I say ``humbly'' submitted) his two-component neutrino idea. Pauli sent him packing unceremoniously with the jibe that this young man does not realize the sanctity of parity! So Salam delayed publication until after Lee and Yang had conferred the mantle of respectibility on parity violation. That taught Salam a valuable lesson and he would constantly advise his students never to listen to grand old men. (I hope this student, at least, has lived up to that advice!). It also taught him to adopt a policy of publish or perish, and his scientific output was prodigious with over 300 publications.

Of course, the work that won him the 1979 Nobel Prize that he shared with Glashow and Weinberg was for the electroweak unification which combined several of his abiding interests: renormalizability, non-abelian gauge theories and chirality. His earlier work in 1960 with Goldstone and Weinberg on spontaneous symmetry breaking and his work with John Ward in the mid 1960s on the weak interactions was no doubt also influential. One of my greatest regrets is that as a student in the Theory Group at Imperial from 1969 to 1972, a group that included not only Abdus Salam but also Tom Kibble, no-one suggested that weak interaction physics would be an interesting topic of research. In fact I did not learn about spontaneous symmetry breaking until after I got my PhD! The reason, of course, is that neither Weinberg nor Salam (nor anybody else) fully realized the importance of their model until t'Hooft proved its renormalizability in 1972 and until the discovery of neutral currents at CERN. Indeed, the Nobel Committee was uncharacteristically prescient in awarding the Prize to Glashow, Weiberg and Salam in 1979 because the W and Z bosons were not discovered experimentally at CERN until 1982. Together with Pati, Salam went on to propose that the strong nuclear force might also be included in this unification. Among the predictions of this *Grand Unified Theory* are magnetic monopoles and proton decay: phenomena which are still under intense theoretical and experimental investigation. More recently, it was Salam, together with his lifelong collaborator John Strathdee who first proposed the idea of superspace, a space with both commuting and anticommuting coordinates, which underlies all of present day research on supersymmetry.

However, it is to Abdus Salam that I owe a tremendous debt as the man who first kindled my interest in the Quantum Theory of Gravity: a subject which at the time was pursued only by mad dogs and Englishmen. (My thesis title: *Problems in the Classical and Quantum Theories of Gravitation* was greeted with hoots of derision when I announced it at the Cargese Summer School en route to my first postdoc in Trieste. The work originated with a bet between Abdus Salam and Hermann Bondi about whether you could generate the Schwarzschild solution using Feynman diagrams. You can (and I did) but I never found out if Bondi ever paid up.) It was inevitable that Salam would not rest until the fourth and most enigmatic force of gravity was unified with the other three. Such a unification was always Einstein's dream and it remains the most challenging tasks of modern theoretical physics and one which attracts the most able and active researchers, such as those here tonight.

I should mention that being a student of someone so bursting with new ideas as Salam was something of a mixed blessing: he would allocate a research problem and then disappear on his travels for weeks at a time (consequently, it was to Chris Isham that I would turn for practical help with my PhD thesis.). On his return he would ask what you were working on. When you began to explain your meagre progess he would usually say ``No, no, no. That's all old hat. What you should be working on is this'', and he would then allocate a completely new problem! After a while, we students began to wise up and would try to avoid him until we had achieved something positive. Of course the one place that could not be avoided was the men's room. So if you were unlucky, that was frequently the location of receiving your new orders.

I think it was Hans Bethe who said that there are two kinds of genius. The first group (to which I would say Steven Weinberg, for example, belongs) produce results of such devastating logic and clarity that they leave you feeling that you could have done that too (if only you were smart enough!). The second kind are the ``magicians'' whose sources of inspiration are completely baffling. Salam, I believe, belonged to this magic circle and there was always an element of eastern mysticism in his ideas that left you wondering how to fathom his genius.

Of course, these scientific achievements reflect only one side of Salam's character. He also devoted his life to the goal of international peace and cooperation, especially to the gap between the developed and developing nations. He firmly believed that this disparity will never be remedied until the Third World countries become the arbiters of their own scientific and technological destinies. Thus this means going beyond mere financial aid and the exportation of technology; it means the training of a scientific elite who are capable of discrimination in all matters scientific. He would thus vigorously defend the teaching of esoteric subjects such as theoretical elementary particle physics against critics who complained that the time and effort would be better spent on agriculture. His establishment of the ICTP in Trieste was an important first step in this direction. He served as President of the Third World Academy of Sciences, and was hotly tipped as the Director of UNESCO until ill-health forced him to withdraw his candidacy. He also acted as chief scientific advisor to the President of Pakistan. His visionary insights into the urgent need for science and technology in the Third World are set out in his book *Ideals and Realities*.

I will not list his numerous awards but would just mention the Atoms for Peace Prize (1968), the Einstein Medal (1979) and the Peace medal (1981). He holds honorary degrees from over 40 universities worldwide and he received a Knighthood for his services to British Science in 1989.

Another aspect of Salam's thinking was that he remained until the end of his life a devout Muslim. Unfortunately, this is the side of his character on which I am the least qualified to comment, except to say that he took it all very seriously. On a lighter note the evening of the Nobel ceremony was memorable in that Salam arrived attired in traditional dress: bejewelled turban, baggy pants, scimitar and those wonderful curly shoes that made him appear as though he had just stepped out of the pages of the *Arabian Nights*. The net result, of course, was that he completely upstaged Glashow and Weinberg (which I suspect may have been the main motive for the get-up)!

It is indeed a tragedy that someone so vigorous and full of life as Abdus Salam should have been struck down with such a debilitating disease. He had such a wonderful *joie de vivre* and his laughter, which most resembled a barking sea-lion, would reverberate throughout the corridors of the Imperial College Theory Group. When the deeds of great men are recalled, one often hears the cliche "He did not suffer fools gladly", but my memories of Salam at Imperial College were quite the reverse. People from all over the world would arrive and knock on his door to expound their latest theories, some of them quite bizarre. Yet Salam would treat them all with the same courtesy and respect. Perhaps it was because his own ideas always bordered on the outlandish that he was so tolerant of eccentricity in others; he could recognize pearls of wisdom where the rest of us saw only irritating grains of sand. Such an example was provided by the young military attache from the Israeli embassy in London who showed up one day with his ideas on particle physics. Salam was impressed enough to take him under his wing. The young man was Yuval Ne'eman and the result was flavor SU(3).

Let me recall just one example of a crazy Salam idea. In that period 1969-72, one of the hottest topics was the Veneziano Model and I distinctly remember Salam remarking on the apparent similarity between the mass and angular momentum relation of a Regge trajectory and that of an extreme black hole. Nowadays, of course, string theorists will juxtapose black holes and Regge slopes without batting an eyelid but to suggest that black holes could behave as elementary particles back in the late 1960's was considered preposterous by minds lesser than Salam's. (A comparison of the gyromagnetic ratios of spinning black holes and elementary string states will, in fact, be the topic of my technical talk at this conference, so in this respect Salam was 25 years ahead of his time!) As an interesting historical footnote let us recall that at the time Salam had to change the gravitational constant to match the hadronic scale, an idea which spawned his *strong gravity*; today the fashion is the reverse and we change the Regge slope to match the Planck scale!

Theoretical physicists are, by and large, an honest bunch: occasions when scientific facts are actually deliberately falsified are almost unheard of. Nevertheless, we are still human and consequently want to present our results in the best possible light when writing them up for publication. I recall a young student approaching Abdus Salam for advice on this ethical dilemma: "Professor Salam, these calculations confirm most of the arguments I have been making so far. Unfortunately, there are also these other calculations which do not quite seem to fit the picture. Should I also draw the reader's attention to these at the risk of spoiling the effect or should I wait? After all, they will probably turn out to be irrelevant." In a response which should be immortalized in *The Oxford Dictionary of Quotations*, Salam replied: "When all else fails, you can always tell the truth".

Amen.

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