Abdus Salam

In his celebrated three-volume *Lectures on Physics*, Richard Feynman introduces the subject of electromagnetic radiation with these words:

> "The most dramatic moments in the development of physics are those in which great syntheses take place, when phenomena which previously had appeared to be different are suddenly discovered to be but different aspects of the same thing. The history of physics is the history of such syntheses, and the basis of the success of physical science is mainly that we are able to synthesize."

The first such synthesis – the most dramatic and the greatest leap of imagination ever taken by the human intellect – occurred in 1665 when Isaac Newton discovered his law of universal gravitation, and showed that terrestrial and celestial motions are governed by the same laws. Two centuries later, around 1865, James Clerk Maxwell succeeded in uniting electric and magnetic phenomena into a comprehensive *electromagnetic theory*, and deduced that light consists of electromagnetic waves. And then, another century later during the 1960's, three physicists – Sheldon Lee Glashow, Abdus Salam and Steven Weinberg – achieved the third great synthesis, that of electromagnetism with the so-called weak nuclear force responsible for beta decay. They were awarded the Nobel Prize for physics in 1979 "for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including inter alia the prediction of the weak neutral current."

While Newton's and Maxwell's achievements belong to the world of classical physics, this most recent synthesis is totally within the quantum domain.

Salam was born in January 1926 in Jhang, a small town in the erstwhile West Punjab of undivided India, into a family of modest means. His father rose from being a school teacher to head clerkship in a Government Office; and the entire family of parents, seven sons and two daughters lived in a one-room tenement. At school in Jhang, Salam was taught that gravitation and capillarity were the fundamental forces in nature – and while electricity could be found in Lahore, the nuclear force was only in far-away Europe! (At this point one cannot help recalling that Glashow and Weinberg were contemporaries in the Bronx High School in New York, an institution with a good reputation in those days).

Starting from such humble beginnings, and fulfilling his father's hopes and dreams, Salam went on to college in Jhang, and then obtained his M.A in mathematics at Punjab University in Lahore, performing brilliantly at every stage. In 1946, just before partition, he won a scholarship to study at Cambridge in England. Here he came into close contact with the legendary Paul Dirac, who became Salam's (and so many others') hero for the rest of his life. His thesis adviser was Nicholas Kemmer, and his collaborator of that period – Paul Mathews – became his best friend in life. For his Ph D, awarded in 1952, Salam solved an outstanding and very technical problem in the renormalization theory of quantum

electrodynamics, that of handling the so-called 'overlapping divergences'. This work was of such a class that it already gained him an international reputation.

Salam returned to Pakistan in 1951 as Head of the Mathematics Department of his old college in Lahore. However there was no encouragement to pursue creative research and no peers to talk to . Then, in 1953, the anti-Ahmadiyyah riots – Salam was a devout Muslim and belonged to this sect – took place. This, and the indifference of the bureaucracy, compelled Salam to leave Pakistan for good in 1954; he spent the rest of his creative life in the West. For three years he stayed at Cambridge. Then in 1957 he moved to Imperial College in London as Professor of Physics, and put together an outstanding group working on problems of quantum field theory and elementary particle physics. In 1964 he founded the International Centre for Theoretical Physics at Trieste in Italy, and then divided his time between England and Italy. He retained links with Pakistan for some years, as a member of the Atomic Energy Commission and as Chief Scientific Adviser to the President.

After his landmark contribution to the renormalization theory of quantum electrodynamics, Salam extended these methods to the meson theory of nuclear forces. At the time of the parity revolution around 1956-57, he was among the first to conceive of a natural explanation for the lack of mirror reflection symmetry in nature, namely that it was due to the neutrino being a left handed or chiral particle. (The other genius to hit upon this particular idea was Lev Landau). However the senior physicist Wolfgang Pauli criticised Salam's ideas so strongly that the latter withdrew his paper before publication! Prior to this, in 1954, Salam's student Ronald Shaw at Cambridge had discovered the basic structure of non-abelian gauge field theories, a highly nontrivial generalization of Maxwell's electromagnetism. Independently and at the same time, Yang and Mills also constructed this class of theories, now known by their names. As we know today, this is the leitmotif of all the fundamental interactions in nature. In the early 1960's Yuval Ne'eman, another student of Salam, discovered the SU(3) symmetry of elementary particles at the same time as Murray Gell-Mann. All these instances show Salam as a world leader in elementary particle physics at that time.

In his work on the electro-weak unification, Salam brought together two key ingredients – nonabelian gauge symmetry and spontaneous symmetry breaking – to each of which he had earlier made crucial contributions. Later he turned his attention to the notoriously difficult problem of including gravity, and also built up the basic mathematical language for dealing with supersymmetry. Till his last years when a crippling illness overtook and finally claimed him in November 1996, Salam remained a source of inspiration and creativity to many.

Salam visited India several times. His Centre at Trieste was created to save Third World scientists from the isolation and deprivation that he had faced in his youth. And he understood deeply and identified with the problems of growing science in the developing world. For all this, as much as for his great achievements in physics, Salam will always be remembered with admiration and gratitude.

N Mukunda