Reflections

Elementary Particle Physics – Then and Now

The 1951 Indian Science Congress Presidential address (reproduced in the following pages) by Bhabha can broadly be divided into two parts. In the first, Bhabha talks about the development of modern science, the importance of experiments in arriving at the laws of nature and the question of a final fundamental theory. In the second part, he describes the status of 'Elementary Particle Physics' at that time.It may therefore be worthwhile to briefly describe the present situation regarding 'Elementary Particle Physics'.

In early 1951, one already knew about ten different (so called)elementary particles. Soon hundreds more were discovered. This created a crisis since scientists and philosophers have always been fascinated by the idea that the number of basic constituents of nature should be few. Fortunately this crisis was resolved to some extent in the following decades. The modern picture of the basic constituents and their interactions is described by the so called 'Standard Model'. There are four basic forces in nature which in the order of decreasing strength are (i) strong interactions (ii) electromagnetic interactions (iii) weak interactions (iv) gravitational interaction. As for the basic constituents, there are six varieties (flavours) of quarks (u,d,s,c,b,t) each coming in three colours; and six leptons (e, μ, τ, ν_e, ν_μ, ν_τ), plus their anti-particles. Besides, there are twelve gauge bosons, comprising the photon, eight gluons and W^+, W^-, Z^0. According to the standard model, all quarks and leptons are point objects, with leptons (including the electron) experiencing no strong interactions. On the other hand, the quarks and gluons are coloured objects and are permanently confined inside hadrons and cannot exist as free particles. Further, the electromagnetic and the weak interactions are unified into a single force called the electroweak force.This is reminiscent of the unification of electricity and magnetism by Maxwell.

The standard model, though so successful in explaining all the available experimental data, is unable to answer several basic questions including the mechanism for generating the masses for quarks, leptons and massive gauge bosons. Besides, the unification is only partial in this model.In recent years, a 'truly unified' theory called superstring theory has been proposed to unify all the four basic interactions. According to this theory, the basic constituents of nature are not point objects but strings of length 10^{-33} cm. The quarks, leptons and the gauge bosons are merely the different modes of vibration of such strings. The modern unification ideas have brought closer the seemingly contrasting worlds of the very small and the very large. In particular, these ideas hold the promise to explain how the universe evolved after the bigbang, as well as the bigbang singularity itself.

One disturbing aspect of recent theoretical activities is that they are highly speculative, with no experimental data to back them up. It is good to remember Bhabha's views on this issue. As he rightly emphasises, there may be many logically consistent theories which may nevertheless have nothing to do with the actual structure of the physical world.

Are we close to an ultimate theory of everything (TOE) or as others would like to say, a truly unified theory (TUT) ? Again, let us recall what Bhabha says on this matter. According to him, however great the successes of a theory, unless the success is total and complete, it is always possible that something very important may have slipped through the net.

Finally, it is good to remember the words of Bhabha that only science and technology can solve the immense problems facing India. It may be noted here that Bhabha has included both science and technology. This is very important because in this era of 'liberalisation' we think that we only need technology and not science. It would be a grave mistake if we continue to neglect science at the cost of technology. A way must be found so that both can go hand in hand. Only then can this country realise her full potential.

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