Deep Inelastic and Parton Model

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In the 1960's, an electron accelerator of energy around 20 Gev was being built near the Stanford University campus. The unique feature of this machine is that it is a linear machine. Up to until then the accelerators built are all circular in shape in order to make good use of the electromagnetic fields in the acceralation and to save the space for the machine. Also we know that charge particles in cicular motion will give out radiations in which the energies of the radiation is inversly proportional to the 4th power of the mass. Thus for electron with its small mass will lose a large amount of energy in in circular machine.(This problem is later solved in the storage ring machine where energies is replenished during the storage stage.) That is the reason to construct a linear machine to reduce the energy loss due to radiation.

The machine constructed in Stanford is about 2 miles long. Certainly this machine costs lots of money to build. But this project was approved before the Vietnam war and American economy was relatively prosperous then. The reason that the machine is chosen to locate in California had to do with the powerful senator Williams Knowland from California according to the grapevine. In addition, a much smaller electron machine with energy 190 Mev was already built on the Standford campus by Robert Hoftstadter to do elastic electron proton and electron nuclei scattering.

With this new electron machine, named SLAC (short for Stanfor Linear Accerlerator Center) comes with much higher energies than previously avaliable, the question is what physics we want to study. One of the advantage working with electron beam is that we do not have the complication due to strong interaction which we do not kown very much up to that time. Physicists are not very optimistic about what are the new things might turn up. Of course we can look at what happened at lower energies for guidence. It is known at that time that in the elastic electron proton scattering the cross section drop off very steeply as the momentum transfer q^2 increases. In other words, the cross section becomes smaller and smaller as q^2 increases. This was attributed to the fact that the proton has structure inside and q^2 dependence is due to the shape of the distribution of the constituents inside the proton.The fact that cross section becomes smaller and smaller as q^2 increases can be roughly understood as large q^2 corresponds to a large kick and proton due to its structure with internal constituents has a tendercy to break apart. This will makes it harder to remain as proton and elastic cross section decrease as q^2increases.

A simple and naive extrapolation to higher energies and higher momentum transfer will mean that the cross section will be smaller and smaller and eventually will be hard to measure. But when the new machine was turned on, one of the first experiments was to study what happens when the proton was given a large kick by the electron. The expectation was that there might be a small probability that what inside the proton might reveal itself whatever it is. It turns out that as the machine was turned on experiments carried out in late 60's, a sizable cross section was found and is much larger that the extrapolation from the elastic cross section at low energies. When the data was shown to Bjorken, a very prominent theorist at SLAC, he came up with some explanation in terms of something he called "almost equal-time commutator". But no body understand very well the physics behind this and it was hard to do anything with it.

Sometimes later Feynman showed up in SLAC for some other things and people in theory group discuss these new data on electron proton scattering with him in the seminar room. Feynman was also puzzled by this sizable cross section. Manny Paschos (a post-doc in the theory group) drove Feynman back to hotel in Palo Alto and picked him up the next morning. By that time Feynman had came up with an explanation. He suggested that inside the proton there are some constituents which interact with electron with no structure and gives rise to this sizable cross section. The next day Manny Paschos tried to explain Feynman's idea to other people. But not many people comprehends Feynman's explanation. A day or two later Bjorken came back from a trip and grasp the idea right away. This is how Bjorken and Paschos paper on electron proton scattering was formulated and description is quite phenomenological. Independently, Drell, Levy and Yan wrote a couple of papers using more field theoretical approach. This constituent inside the proton is later called "Parton", meaning a part of proton.

At the bginning no body expect this simple, naive model can survive for so many years. Later, it gives rise to the concept of asymptotic freedom and leads to the development of QCD, a theory for the strong interaction.