An Education

Dick Roberts

1966 was a vintage year – England won the World Cup and I met first Graham. He was a graduate student and I was a fresh post-doc, still wet behind the ears. My strongest memory was us watching Celtic win the European Cup the following summer at our house!

When I came to the Rutherford Lab. in 1970 I, like many theorists, then was into the then highly fashionable Regge phenomenology with all its poles, cuts etc. but there was Graham and Alex Love hiding in a corner looking at some unfashionable stuff called Gauge Theories. I should have known better!

When he went off to Caltech , Graham acquired the highest accolade I can imagine – we heard on the grapevine that Feynman used to drop in to Graham's office to have the 'new physics' explained to him!

It wasn't until Graham returned to Oxford that we actually did any work together. Looking at the records now I see that we did 17 papers often with other people. One day in the early 80's Graham came hotfoot back from a trip to CERN saying that these experimentalists at EMC had observed that the structure function of a nucleon in a heavy nucleus was different from that of a free nucleon. To Graham it was obvious that this was due to quarks being less confined in a nucleus. As a result of this intuition we were able (with Frank Close and Bob Jaffe) to make concrete predictions for a range of nuclei.

In the late 80's with Dave Jackson we worked on polarised proton structure functions developing a covariant parton model to derive sum rules etc. The same experimentalists at CERN had now found that the spin of the quarks didn't add up to the spin ½ of the proton. Not many people realise that the most cited paper of Graham's is in this very area. He and Guido Altarelli calculated the anomalous dimension of the first moment and showed that the gluon contribution is not suppressed by powers of α_S and thus provided a potential explanation of the puzzle.

One day exactly 20 years ago, Graham says '*These guys at CERN organised a 3-horse race where the horses ran backwards and all met at the same point!*' But only because they jumped over the same fence at $Q=M_{SUSY}$. *We are going to do much better! We shall organise a race with more than a dozen horses all running forwards and backwards – all with slightly different fences to jump and with the added complication that they all can interfere with each other's running!*' So I learnt all about running masses, running gauge couplings, running Yukawa couplings, running soft SUSY breaking terms. Everything seemed to be running! On top of that, some of the horses were 'doped' – they needed just the right injection of the top Yukawa coupling in order to get EW-symmetry breaking with the right mass of the W. Too much fine tuning of the 'dope' was deemed unacceptable on grounds of good taste or health and safety.

By demanding a limit to the amount of fine tuning we found we had painted ourselves into a corner of the $M_{½}$,M_0 plot. '*This is good news*' the maestro said - '*the relatively low masses of the sparticles means the LHC is bound to find them*!' I always believe everything Graham tells me.

To sum up – working with Graham has been enormous fun from beginning to end. Not many people can claim to have something in common with the great Feynman – but I can! We have both had a brilliant tutor. He has taught me so much in physics. Not just imparting a deeper understanding of the physics itself but how to ask the right questions in order to find exciting answers. So thank you, Graham, for an Education!.