

## Reminiscences of My Journey Through a “Nobel” Lab

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It was the Christmas of 1972 when I received an exciting offer - the possibility of working with Richard Ernst of Switzerland. I had just returned to India from U.S.A. after completing three years of Post-doctoral work after a Ph.D. in 1969 from the Indian Institute of Technology, Kanpur. I was looking for openings and immediately grabbed it. An old friend from Kanpur days, who was already working in E.T.H., met me at Zürich airport (Feb., 1973) and we immediately launched into the bylanes of Zürich looking for the best places to eat and drink. Ernst, a junior faculty member in the Physical Chemistry Laboratory of E.T.H., was occupying a small office at the top landing of a flight of stairs. I was the only post-doc and he had 4 Ph.D. students, one of which (Dieter Welti) was busy working through a paper I had published from Kanpur. With the help of another (Enrico Bartholdi) I soon found living quarters, a two bedroom apartment at Roetel Str., which I shared with a Swiss architect, who still is a good friend. The other lab mates were Thomas Baumann and Stefan Schäublin. Soon Alexander Wokaun and Geoffrey Bodenhausen came to do their diploma work. While Alexander stayed on to do his Ph.D., Geoffrey decided to go to England.

Lab consisted of three crammed rooms full of people and equipment half of it home made. I got involved into doing, - which in those days was somewhat of a tricky experiment - cross polarization in solids - which did not work till we moved into a more spacious laboratory in a new building, allowing more elbow space. We switched transmitters and suddenly the experiment worked. Ernst was quite pleased and gave me a small raise. Around that time a young student, Luciano Müller, joined our group for his Ph.D. and I initiated him into cross-polarization experiments. He grew a fine crystal of ferrocene and we observed oscillations in the cross-polarization dynamics which was later published in *Physical Review Letters*. Dedicated minicomputers attached to experimental set-ups were novelties those days and it was fun programming them into their little languages and then making modifi-

cations directly into machine language - you could almost see how computers worked and interpreted your commands. Using these, I did a series of pulsed cross-polarization experiments, and presented the results in a conference in England in the summer of 1974.

During February 1974, I received an urgent message from my father asking me to make a quick trip to India. I told Ernst, “I am going for two weeks”, but returned three weeks later after getting married. Ernst and all members of the group had hearty laughs at the idea of getting married to someone you have hardly seen. Visa for my wife took some bother, as Switzerland was in the midst of another of their many referendums on controlling the number of foreigners. I remember Ernst making a special trip to foreigner’s office in Zürich convincing them that it was important that I stayed in Switzerland. I had been to Ernst’s home in Winterthur for a group party, but had another exclusive one after Padma’s arrival in May 1974.

Jean Jeener of Belgium in a summer school held in Pule, Yugoslavia in 1971 had proposed an esoteric looking idea of two-dimensional NMR and, it seems, promptly forgot about it. I remember Ernst discussing with me sometimes during 1973 that he would like to continue on the theme but did not want to step-toe on Jeener if he is continuing on it - a case of high and these days rare scientific ethics. I was of the opinion that a two year period is long enough. However, Ernst is made of finer stuff. He used the idea in an experiment which is completely different from what Jeener had in mind. The story is as follows. Paul Lauterbur of USA had in 1972 described a technique of obtaining images of small objects using steady field gradients and NMR. Ernst thought of doing imaging using pulsed gradients and two-dimensional Fourier analysis. Dieter Welti wrote some subroutines and I did the experiment. I still remember the little teletype tick-ticking printing blanks, dots, numbers and a few alphabets, spitting out a crude image of two tubes of water placed in a magnet. We laughed at the experiment,

thought nothing will ever come out of it and decided that it was not worth patenting. What short-sightedness? In fact not only we but many others did not think much about the idea and the Swiss National Science Foundation turned down a proposal from Ernst for further work on NMR imaging.

We then turned all our attention to two-dimensional NMR spectroscopy. Luciano and I did the first experiment, which was a simple one, resolving a complex spectrum into components. I remember a visit to our lab by Kurt Wüthrich. On seeing the spectrum he took his head in his hands and sat down. The potential of the technique seem to have hit him. He later collaborated with Ernst in exploiting the applications of it in biomolecules and revolutionized the applications. Enrico Bartholdi worked on the theory, Walter Aue on protons and Luciano and myself on carbon-proton two-dimensional experiments. Many developments were made and a quiet revolution was taking place without our ever realizing it. Perhaps I should add, without fear of contradiction, that the work looked nothing different from extremely routine laboratory work, full of frustrations and slow progress, without any special excitement and anxiety - except for some occasional worry such as a visit by a couple, both scientists. We had observed some unexpected modulations of carbon echoes and after a lot of explaining we convinced them of our observations. As soon as they left Ernst and myself exchanged worried glances and we immediately wrote-up a short account for *Chemical Physics Letters*. Four months later Ernst received a preprint from the couple saying they have also observed the effect.

During our stay in Europe we travelled extensively. Padma insisted that I take her back to all the places I had visited before her arrival. In addition we visited many places including a skiing trip with research-mates in the Swiss Alps. Many places were visited for attending conferences. In one of these (Colloque Ampere in Heidelberg, Germany, 1976) Ernst was invited to give a plenary lecture on Two-dimensional NMR. For some reason he was not able to go and instead asked me to give the talk. It was my first major lecture and I was a bit nervous but it went off well. During this conference a boat ride down the Neckar river with many famous scientists was particularly memorable. During a conference in Kenderstag, a town in Swiss mountains, Ernst was

the expert tracking guide.

Although Ernst had told me that I could stay in his research group as long as I wanted, I had to look for a position of my own. I therefore put an ad in *Physics Today* with a box number. Ernst noticed it and remarked that this is the person he wants in his lab, but soon realized that he already had him. Ernst recommended my name to several places and I went for an exploratory lecture trip to University of Lausanne. Though a beautiful city, my lack of knowledge of French must have upset me and I showed little interest in that position (presently occupied by Geoffrey Bodenhausen). When the offer of a position came from Bangalore I accepted it without even looking at the details. We returned to India in late 1976 and I joined the Indian Institute of Science in January 1977. Two and a half years later, after the birth of our daughter, we went back to Zürich for one more year to apply two-dimensional NMR to biomolecules, in a joint project of Ernst and Wüthrich. The work carried out during that period proved to be a turning point in the application and growth of two-dimensional NMR.

Life has many turning points which are often recognized years later. It is always possible to go and work with a famous person - a nobel laureate - but to do so before he becomes famous and to take part in some of the exciting things are the more pleasant parts of life. It becomes more so when the person is a thorough gentleman and highly cultured. Ernst enjoys western classical music and is a lover of fine arts. He has a large collection of Tibetan Tankas (hand made religious scroll paintings). His wife once remarked, when they did not own a car in early seventies, that whenever they had enough money he goes out and buys a painting. I wonder what he did with the Nobel money!