My Time with Sir Rudolf Peierls

Professor Peierls took up the Wykeham Professorship at Oxford in October 1963. I started as his research assistant in the Department of Theoretical Physics at the beginning of November the same year. I had just finished my PhD with Mel Preston, a former student of Peierls at Birmingham. Theoretical Physics, which Peierls headed, was a large department housed at 12-14 Parks Road. It had many faculty members, graduate students, post-doctoral fellows, and visiting foreign professors. The faculty included R H Dalitz, the Royal Society professor lured from Chicago, Roger Elliott, D ter Haar, David Brink, L Castillejo, amongst others. In addition to his administrative duties, Peierls lectured on nuclear theory, supervised students, and actively participated in seminars and colloquia. The latter took place at the Clarendon laboratory nearby, where the experimentalists worked. In addition, nuclear physics was also housed at 9 Keble Road. We all took afternoon tea at the Clarendon, thereby bringing some cohesion amongst the diverse groups. At this time, Divakaran and Rajasekaran were both at Oxford finishing their doctoral work with Dalitz. K Chandrakar (plasma physics) and E S Rajagopal (low-temperature physics) were at the Clarendon.

As will be clear from Professor Baskaran's article, Peierls was a versatile physicist, having made fundamental contributions in condensed matter physics, statistical mechanics, quantum field theory and nuclear physics. I think it is fair to say that in the mid-sixties his focus was mostly in nuclear theory, in addition to his work in the Pugwash movement on nuclear disarmament. I should perhaps give a brief account of some of his contributions to nuclear physics. Peierls became interested in this area while he was at Manchester in 1933–34, when Bethe spent a year at the same place. Bethe and Peierls were great friends, and Bethe stayed in Peierl's house during this year. It was an exciting time for nuclear physics, Chadwick having discovered the neutron just a year back. When Bethe and Peierls visited Cambridge, Chadwick told them about the experiment on the photo-disintegration of the deuteron that he was doing with Goldhaber. The deuteron is a loosely bound nucleus consisting of a proton and a neutron, and is broken up by incident gamma rays of low energy. Chadwick dared the two friends to explain his experimental results. It was already known that the nuclear force is of short range, although its functional form, or other details were not known. Bethe and Peierls realized, on their train journey back from Cambridge to Manchester, that since the range of the nuclear force is very short compared to the size of the deuteron, a zero-range approximation should suffice. With this the experimental result. This kind of 'shape-independent' approximation is also very successful in explaining the behaviour of ultracold atoms today. When they applied the same idea to low energy elastic neutron-proton scattering, however, their results failed. This was not because of the zero-range approximation, but because at that time the spin-dependence of the nuclear force was not known.

Peierls joined Birmingham as Professor of Mathematical Physics in 1936, and shaped it into one of the finest centres of theoretical physics in the world. When he joined Birmingham, he had two doctoral students working with him in nuclear physics, P L Kapur, and Fred Hoyle. Peierls was very interested in the compound nucleus model of Bohr. Because of the short range of the nuclear force, an incoming incident neutron can only interact with the target nucleus when it is sufficiently close. Once captured within this distance, a compound nucleus is formed. The excess energy of the incident particle is quickly redistributed through a few collisions in this mix. Once this first stage of the reaction is over, it takes a relatively long time, through many collisions, for one of the particles to acquire enough energy to be emitted again. This second stage of the reaction depends on the energy and the angular momentum of the ejected particle, but not on the previous history of formation. The cross-section of the reaction may be expressed in terms of resonances of the compound nucleus and their widths. Kapur and Peierls wrote a major paper on this subject in 1938. With Niels Bohr and Placzek, Peierls wrote another basic paper on the compound nucleus model. The experiment with slow neutrons on uranium by Hahn and Strassmann in Germany was interpreted as fission by Lisa Meitner and Frisch. This naturally led Peierls to investigate the critical condition for neutron multiplication in a solo paper in 1939. Frisch came to Birmingham in the summer of 1939, and the two of them calculated how much mass of ^{235}U would be needed to make a sphere of critical size. They found, to their surprise, that only a kilogram of it would do to create a nuclear bomb. Very afraid that the Germans might discover this too, and act on it, they wrote a memorandum to the British Admiralty. The rest is history. Peierls left for Oxford in 1963.

I now come back to the sixties. Peierls at this time was interested in the nature of the nuclear force, and its application to *ab initio* nuclear structure calculation. Shortly before, he had written two influential papers (one with Yoccoz and the other with Thouless) on how to incorporate collective motion of the nucleus (like rotation and translation) with the motion of the interacting nucleons (neutrons and protons). The force between two nucleons, following Yukawa, may be generated through the exchange of (virtual) bosons. These are the pion, and heavier resonances like the ρ and ω mesons. In such exchanges, momentum is conserved, while the meson created with borrowed energy has to be absorbed within a time dictated by the uncertainty principle. It was realized that the recoil of the nucleons due to the heavier mesons may introduce nonlocality in the nuclear potential. The potential between the two nucleons may then depend not only on their relative distance, but also on their relative momentum. This may have, he suggested, diamagnetic effects on the magnetic moments, for example. It could also affect the cross-section of photo-disintegration that we mentioned before. In the first year of my stay, I did these calculations. The diamagnetic effect could explain some discrepancies with experiment, but so could some other more conventional explanations. This work, jointly with P van Leeuwen, was published without Peierls as a co-author. It was typical of him (and other professors of that era) to suggest an idea, follow up its progress regularly, but not include his name in the paper. In the second year, along with Tomusiak, we did rather involved calculations of the energy of a nucleus using some techniques that Peierls suggested. This work was largely done by Tomusiak, with myself and Peierls as co-authors.

This article would be incomplete without mentioning the human caring side of Professor and Mrs Peierls. I arrived in Oxford with my young wife from India on a cold night in early November, 1963. We did not know where to go, and the taxi from the station deposited us in a very expensive hotel. When I called Professor Peierls at his home the next morning (I think it was a Saturday), he expressed concern at the expense I was incurring. He himself came to pick us up that morning after we had checked out, and took us to some modest temporary quarters. When he had applied for a British (DSIR) grant for hiring me, he was unaware that I was getting married. This resulted in the grant being rather small. To compensate, Professor Peierls arranged that I could tutor some undergraduates in the department, and get paid on a *pro rata* basis. The teaching faculty was given lunch (with wine) once a week, and I was included because of my occasional tutoring. Mrs Peierls knew that we were left out of college social activities because of not belonging to one, and to make up she invited us regularly to their home for dinner. Physics discussions at the dinner table were forbidden by Mrs Peierls, no matter how distinguished the dinner guests. The dinner guests would help with the dish washing. At these parties, my main claim to fame was cracking hard Brazilian nuts with my teeth. At Christmas departmental parties, she would show me off as the Indian nut cracker! When my wife became pregnent, Mrs Peierls took her under her wings and helped in many ways. When the baby was due, she forbade me to come to the department. She also forbade our friends to crowd our home to see the newborn, afraid that this may tire us!

Professor Peierls reserved the mornings for administrative work, but was always accessible for discussions with students or post-docs in the afternoons, if not taken up by one of the many distinguished visitors. His office had a big black board, but I do not recall any book shelves there. In any discussion, he would go to the board and make his point from first principles. He was a very courteous person, particularly patient with younger people. When Tomusiak and I gave a joint seminar on some work we had done, Castillejo asked difficult questions. Professor Peierls came to our rescue, even though he had not collaborated on this part of the work.

We learnt from Professor Peierls that it pays to be interested in all of physics, and not just ones' sub-speciality. By example, he also taught us humility and courtesy, and not to take oneself too seriously. At the end of my stay at Oxford, when I told him that I was going to McMaster, and that they would pay my fare and half of my wife's, he chuckled and asked which half was I taking!

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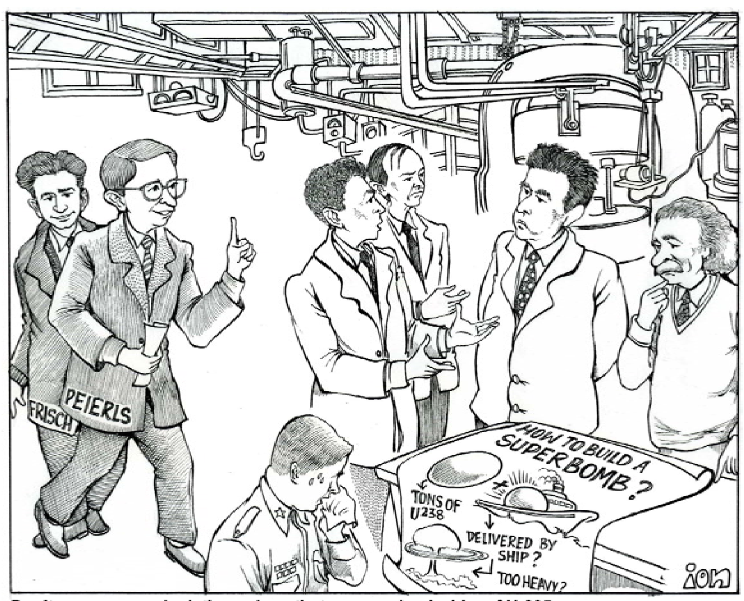
R K Bhaduri
Professor Emeritus, Department of Physics and Astronomy,
McMaster University, Hamilton, ON, Canada
Email: bhaduri@physics.mcmaster.ca



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