

## MEMORIES OF LES HOUCHES

**Claude Cohen-Tannoudji** – You asked me to bring up a few memories of the Les Houches Summer School. I have a huge admiration for the place, which I discovered back in 1955! I first went there as a second-year student at the École Normale, then several times as a student, then as scientific organizer in 1964 and subsequently, three or four times as lecturer. Over that long stretch of time - sixty years! - the school changed significantly. Initially, it was a school for very young students. In July 1955, I was twenty-two and hadn't even begun my Master's research in Kastler's lab when I was invited to apply to Les Houches. I was accepted, and discovered that we would work hard for two full months, with courses every day - an extremely serious curriculum. There were some exceptional teachers, such as Julian Schwinger who was one of the founders of quantum electrodynamics.

Pauli, the great Pauli, once gave a talk that no-one understood, whereas Schwinger was much clearer! We were all very impressed to see Pauli, the Exclusion Principle and all that... As he prepared his talk he moved, swinging back and forth, he reminded me of the Orthodox Jews praying at the Wailing Wall, just like that! And nobody knew what he was doing, and then he gave his course, he came up to the blackboard - he was quite fat - and nobody could see what he was writing, he hid it! At the end there was a question session; Messiah was there and asked a polite question, and Pauli answered: "What a silly question..."

Schwinger had a habit of working very late, until two or three in the morning. He would prepare his stuff, go to bed and sleep late. So we would schedule his lecture around eleven or in the afternoon. But in Les Houches, there are cows! "Those bells annoy me!" He was furious with the cows! "They ruin my sleep!"

There was, I remember, Uhlenbeck, a great specialist of statistical mechanics, there was also Ramsey, Norman Ramsey, we took all those lessons. Schwinger gave a full month-long course, I think, every day; it was a very, very advanced course in Quantum Mechanics, and there was an extraordinary atmosphere... There wasn't much comfort at the time, we stayed in small chalets, the lecture hall was a wooden thing, it was all very primitive, but the atmosphere was really extraordinary! Because we were all together for two whole months, we had time to discuss and to pursue. So I have wonderful memories of those moments. And I learned a lot at Les Houches - most importantly as a young student in France where there was no course in Quantum Mechanics at the time, no modern physics course... Finding yourself in the midst of the world's greatest researchers in your field - that urged you to go on, to work harder, to learn more. Moreover, it's a mixed crowd, half French, half foreigners, so that

you experienced the international character of Science. And since most courses were in English, it was good language training as well...

At the end of the session, we had a sort of exam, in a way. The lecturers would put up a number of topics on the blackboard, and we would choose one we liked, and then we had two or three free days - in the library, discussing with anyone - and after all those discussions and readings and rummaging through our courses, we would write up a short paper, two or three pages, on the chosen topic. I had chosen a topic given by Ramsey, a rather esoteric one, proving the existence of octupole magnetic moments! Dipole moments and quadrupole moments are known, but octupole moments are just a wee bit more special! I had worked, discussed, written up a little report, and got an answer six months later with comments. And he had given me an A-minus, perhaps an A! *I have read with pleasure the excellent exam of Monsieur Claude Cohen-Ta... Monsieur Claude Cohen-Tannoudji! If this exam had been submitted to me here (in the States), I would have given it the grade of at least A minus... And probably A... Which is the highest of the grades A, B, C, D, E, which we normally use... Norman Ramsey...* There was also an oral exam given by Claude Bloch from Saclay on Quantum Mechanics, I had done my best, but didn't know Quantum Mechanics very well at the time! He wrote: « Has good knowledge of Quantum Mechanics, but the exposition should have been better organized, underlining the important points ». Ramsey's comments were more positive...

I went back, in a totally different way, in 1964. I had finished my PhD Thesis in December 1962. And in 63, the first Conference on Quantum Electronics and Quantum Optics took place in Paris! That's when the first talks on lasers, which were pretty complex, rather complicated, were given... People tended to think that these were something of an oddity, that they wouldn't be of much use... But there were some people who were very involved, such as Bloembergen, or Glauber - Glauber was there... He made quite an impression on me, because he had given papers on coherence in optics, on coherent states, on correlation functions, and I had told him, "It would be the right time to give a series of lectures on that, it would be very interesting", and to my great satisfaction, he accepted! And Cécile DeWitt, who was Director of Les Houches school, said "it's a very good idea", and she asked me to organize the two-month scientific session with André Blandin, a classmate from the École Normale, who was a condensed-matter physicist, so we organized a pretty exceptional session. There was Norman Kroll, giving a course on quantum theory of radiation that was truly fundamental, Glauber on optical coherence and photon statistics, introducing coherent states and quantum correlation functions that are now absolutely basic for all quantum optics studies. That was an extraordinary course, referenced I don't know how many times, anybody doing optics refers to this course! Here's a paper I wrote on the occasion of Roy Glauber's 90th birthday... May I read it to you? Here: *Dear Roy, we met for the*

*first time in Paris in 1963, more than fifty years ago, at a meeting of quantum electronics I was starting to organize Les Houches Summer School, which was planned for July and August 1964... The lectures that you gave at Les Houches during the summer of 1964 were a memorable event. Your talent to explain the quantum nature of optical detection signals fascinated everybody. Willis Lamb was also attending the lecture and the questions that he was asking after each lecture were extremely stimulating. I really think that this course which you gave in 1964 was the starting point of quantum optics. I heard - I wasn't there, Alain Aspect read my note - , I heard that Roy Glauber was absolutely moved and delighted with it... There was Brossel, who gave a course on optical pumping and I had written part of it, two or three out of the ten courses he gave, there was Willis Lamb, also a great man - the Lamb shift is a most important topic in quantum electrodynamics - who had developed a theory of optical masers, at the time they were called optical masers, they weren't called lasers yet! He had given a course in which the problem was treated in fully classical terms. And it was all very pleasant because everybody attended other people's courses! And Glauber and Lamb argued, because Lamb wanted to do everything classically while Glauber was a quantum fan, so the arguments between them were fascinating. In addition, Kastler was so enthralled by Les Houches that he had bought a little chalet on the mountain facing the school, at Coupeau, so we would all go up to have tea at Coupeau! And he would come down to attend the courses! All the courses every year, because he loved it, and he would interrupt and there would be a three-way discussion, it was fabulous for the students... There was Ali Javan, who built the first optical laser... Nicolaas Bloembergen, a great specialist in non-linear optics, who gave an impressive course, ten or twelve lessons on non-linear optics, the Raman effect, all that stuff, there was Pierre Aigrain, who designed solid state lasers, and Jacques Winter. So it was an absolutely superb session that really gave a great start to the field of quantum optics!*

I returned a number of times as lecturer, to give a series of courses. I must say that the school's style changed over time. Early on, it was for younger students, the first session I'd been to was like that and the session we'd organized with Blandin was also for students, a bit more mature, but it was still made up of basic courses, it lasted two months. But then there was a shift in the French University curriculum with the introduction of what we called the DEA (master's level) introducing a large number of basic courses in quantum and statistical mechanics, and optics, so that it was no longer necessary to do the same at Les Houches. Thus instead of two-month sessions, there were one-month sessions devoted to a specific research topic. It was far more specialized... I came back in 1975, for a session organized by Roger Balian, Serge Haroche and Sylvain Liberman, on the frontiers of laser spectroscopy. I returned in 82, for a session organized by Gilbert Grynberg and Raymond Stora, "Introduction to quantum electrodynamics" as seen, not by particle

physicists but by atomic physicists... At that same session, I also gave a course with Jacques Dupont-Roc on "Approach via a fictitious  $g-2$  hamiltonian", one of the basic effects in quantum electrodynamics... And finally I came back in 1990, for a session organized by Jean Dalibard, Jean-Michel Raimond and Jean Zinn-Justin, on "Fundamental Systems in quantum optics"... and there was a course on atomic motion in a laser beam... Already a bit of laser cooling and trapping...

Thus if I'm to start from my own experience, I'd say that the institution has been an excellent idea, a marvelous idea due to Cécile DeWitt; an idea that was naturally modified over time because educational systems change, but whose spirit is essential: bring people together, both at teacher level and student level for a month or two, have them share meals, discuss, share a marvelous landscape - Mont-Blanc, the Alps - while discussing physics; coming back to problems that remain obscure, discussing further... That is absolutely exceptional. That, I believe, is a very important method, and it has also given teachers from all over the world a chance to meet students in a friendly setting, for positive and fruitful discussions potentially leading to invitations to come prepare a PhD with them. There have been many collaborations initiated in this way, lasting for decades! Hence, I believe that it has been a wonderful thing, and may well explain why physics has been strong in France.

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