LECTURER — TEACHER — MENTOR: WHAT I HAVE LEARNED FROM PROFESSOR KACPER ZALEWSKI*

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Lecturer

In the early 1970s, when I started my studies at the Jagiellonian University, the theoretical physics course included four series of lectures being mandatory for all physics students. These lectures were: theoretical mechanics in the third semester, quantum mechanics in the fourth and fifth semesters, classical electrodynamics in the fifth semester, and thermodynamics along with statistical physics in the sixth semester. It was the Faculty tradition that the above-mentioned courses were conducted by the same group of professors: theoretical mechanics by Professor Zygmunt Chyliński, quantum mechanics and electrodynamics alternately by Professors Jerzy Rayski and Bronisław Średniawa, and thermodynamics by Professor Kacper Zalewski. The starting point was the course of theoretical mechanics which, according to the traditional pattern, included lectures focused on basic elements and methods of classical mechanics completed with classes devoted to training in solving problems. Lectures were given by Professor Chyliński while younger assistants conducted classes. The course ended with written and oral exams which both served as a rigorous filter for those wishing to continue their studies and to become physicists. Within the Faculty community, Professor Chyliński was regarded as a charismatic lecturer and true expert in the intricacies of classical mechanics. He was also known as an extremely tough examiner. His unconventional questions circulated among the students as a legend and to answer them demanded not only detailed knowledge of the classical mechanics formalism but also its deep understanding.

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According to the opinion frequently heard in the Faculty and confirmed by the year after year experience, passing the exam meant overcoming halfway, if not more, of the winding road leading to be awarded the diploma. The courses and exams in quantum mechanics and electrodynamics were considered not so cumbersome, less demanding and easier to pass. However, after tackling them, there remained one more hurdle closing the sixth semester and preceding the choice of specialization. It was the course of thermodynamics and statistical physics. The course was conducted by Professor Kacper Zalewski and its exceptional feature and novelty was that the Professor not only was giving lectures but also personally led the classes. It gave the Professor a unique possibility to get to know students, their commitment to the studies, and to recognize students' strengths and weaknesses, as well as gaps in education. The Professor perfectly knew that, and thus the exam and classes preceding it were a real test of knowledge. An unwritten rule routinely practiced during the classes linked with theoretical subjects was that each session began with the so-called "kartkówka", a 10-minutes short test within which students were obliged to solve problems similar to those given as homework. Students' works were evaluated and graded from 0 to 10 points. The criterion that guaranteed passing the classes and to be admitted to the exam was to get an average of at least 7 points during the whole semester. Those who did not achieve this level were required to take a qualifying test. We were used to this, but the fact that the lecturer, examiner, classes leader, and grader of the mentioned tests was the same person kept us awake at night. It was obvious that the Professor would know everything about each of us and to perform well on the exam meant that one had to work very hard. Simultaneously, we were aware that the subject was difficult, and that Professor's demands were high. The lectures were based on Professor's «Lectures on Phenomenological Thermodynamics and Statistical Physics», a pocket-sized, very condensed book whose essential part consisted of over 200 problems summarizing individual chapters. The ability to solve problems and to discuss obtained solutions were crucial — the Professor emphasized it using as a motto the quote from Robert A. Millikan: *I still consider problem-solving to be the essence of successfully learning physics, while attempts to encompass the entire material in a series of lectures, as is often done, are a foolish anachronism — a relic from the times before the invention of the printing press.* Thus, as confirmed by our elder colleagues, it was really the ability to solve problems which confirmed the knowledge and preparation for the exam. Equally important was understanding of their physical meaning as one can find in the remark which the Professor wrote in Introduction to «Lectures on Phenomenological Thermodynamics and Statistical Physics»: *Some of the problems presented are quite difficult and require extensive physical discussion. Nevertheless, I de-*

liberately do not provide the answers, so as not to prejudge the scope and outcome of the discussion on the solutions. Having all this in mind we were ready to face Professor Zalewski. Perhaps some of us even began solving the problems following the first chapters of Professor's book, especially because these are relatively simple. However, as far as I remember, it was not very common. There were a lot of exams closing the fifth semester, they were difficult and the majority of us put the matter of thermodynamics course "on hold" when suddenly we received the news — there would be no thermodynamics course with Professor Zalewski; the reason was that the Professor was going abroad, namely to CERN, for an extended period and his teaching obligations would be taken over by Professor Andrzej Staruszkiewicz. That time I felt a sense of relief but now, after many interactions with the Professor, I regret that I missed his lectures as a student. This regret comes back and strikes me particularly in moments when I feel a lack of knowledge concerning the statistical physics.

Teacher

As it was just mentioned I did not meet Professor Zalewski as a student, but as the saying goes *what is delayed is not lost.* After graduating and one year employment in the Institute of Physics of the Jagiellonian University as a younger assistant, I began my doctoral studies in the same Institute. There were nine of us enrolled for the first year: five candidates who planned to write the thesis in theoretical physics and four persons working in experimental physics. Our duties in the Institute were different from those required from contemporary Ph.D. students. On the one hand, we were treated as younger employees required to fullfil the standard duties of academic teachers, in particular conducting regular teaching activities, while on the other hand, we had to realize a training program addressed for doctoral candidates — a year-long course in advanced quantum mechanics, colloquially referred to as the "fourth quantum". The course was taught by Professor Zalewski who, analogously to the situation with thermodynamics, simultaneously lectured, led the classes and was the examiner. We were afraid, but much less than three and a half years earlier. We considered ourselves quite well prepared for the quantum mechanics course and our optimistic belief was based on the fact that besides of general courses included in the second and third year programme, we attended specialistic courses during the fourth year of studies, *e.g.* in theoretical specialisation — it was relativistic quantum mechanics and introduction to quantum field theory. However, we still felt some anxiety. It seems to me that it stemmed mainly from the desire not to embarrass ourselves in front of the Professor. We were doctoral candidates; each of us was accountable to our supervisor and did not want to be the subject of comments from colleagues and students in case of making

a fool of oneself in front of the Professor. I remember the "fourth quantum" course as an intellectual adventure which opened my eyes to quantum physics. It took a lot of effort, both in understanding the lectures as well as in studying notes taken during the lectures and, finally, in solving the homework problems assigned week after week. The latter was laborious even if done in close cooperation of the whole group. Meetings whose purpose was solving homework problems usually lasted for hours but they did teach me cooperation and common work. Working together, we were able to study much more carefully lecture notes which served us as a primary source of information. Access to the literature was very limited. Slides, prepared in advance and available online, did not exist at all. Professor Zalewski used only chalk and the blackboard, and if he used any notes, they were written on a folded in four sheets of A5 paper which he pulled out of his pocket, gave it a glance, and put them back in his pocket. We never managed to access the content of those notes, just as we could not decipher the symbols used by the Professor to denote our successes and failures recorded in his little notebook. As I mentioned, Professor's lectures opened my, and not only mine, eyes to the meaning of quantum mechanics, its beauty and richness of applications. Our previous contacts with quantum mechanics arose from general courses held during the second and the third years which were conducted in a very traditional manner — the dominant subject was solving the Schrödinger equation for standard examples either tedious calculations based on using special functions about which we knew very little. At that time, of mid 70s, available textbooks, to mention Professor Średniawa's academic script and classical Davydov's and Landau/Lifshitz' books as well as a collection of problems by Flügge and Marshall were rather discouraging a deeper interest in quantum mechanics, even though the achievements of quantum physics just began to enter public awareness and daily life. My and my colleagues' perspectives on quantum mechanics changed somewhat with specialistic courses which we attended during the fourth year and during preparation for work on our theses. I was particularly interested in mathematical problems of the quantum field theory which at that time I considered to be close to an "ultimate theory" solving the most significant problems in physics. Fascinated by quantum field theory, I left quantum mechanics a little bit "aside" which caused that my knowledge of quantum mechanics for a long time remained rather superficial. I was made aware of this by the "fourth quantum" course. The Professor made us familiar with the modern approach to teaching quantum mechanics and illustrated it on examples and problems solvable using physically-based construction instead of complicated calculations and sophisticated mathematics. The same concerned assigned "homework" problems. The Professor knew that we solved them together but examining somebody in front of the blackboard almost always was able

to identify the individual contribution of the person just being called to the blackboard. Observing puzzled expressions on the faces of the listeners, the Professor usually reacted with the question, *Do you understand that?* and in the case of silence, quietly started to explain the problem once more. Time has erased details, but I remember that the Professor dedicated a lot of time to the symmetry theory neglected in the basic course illustrating it with the examples of rotation group and quantum theory of angular momentum, theory of scattering matrix and quantum mechanics of many-body systems. I especially remember the lectures devoted to the BCS model. I liked them very much, and by a twist of fate, the Professor asked me about BCS during the final exam. I passed the exam but I think that not only due to good luck. Preparing for this exam like for no other, I learned a lot. I am aware that this happened because I had good luck which gave me the chance to meet a Teacher who introduced me to better understanding quantum mechanics.

Mentor

After obtaining my doctorate, I was employed at the Institute of Nuclear Physics. Parallel to my responsibilities assigned to the position of a younger research scientist, I was drawn by my boss Professor Edward Kapuścik into activities of the Doctoral Studies that were launched in the Institute in 1984. Twenty years later, in 2004, major changes came to the Institute — it became the institute of the Polish Academy of Sciences and, as such, had to adapt to the legal regulations in force in the Academy units. Changes affected also the Doctoral Studies, whose activity began to be subject to the supervision of the Institute's Scientific Council taken over by the Committee of the Scientific Council for Doctoral Studies chaired by Professor Zalewski. The Professor also took over the course of quantum mechanics, mandatory for first-year doctoral students. Many years have passed since my "fourth quantum". During this time, the Professor continued to deliver lectures for doctoral students at the Jagiellonian University, which, as far as I know, closely resembled the lectures I attended. Based on a part of this lecture, the book entitled «Lectures on the Rotation Group» was published (PWN Warsaw 1987, Volume 12 of the Library of Physics). The Professor conducted also the so-called "small lecture on quantum mechanics" addressed to physics students and aimed at preparing listeners for introductions to atomic physics, solid-state physics, nuclear physics, and particle physics (https://th.if.uj.edu.pl/~zalewski/notatki.pdf). The "small lecture" served also as an introduction to the more advanced course which became the source of the book «Lectures on Nonrelativistic Quantum Mechanics» (Scientific Publisher PWN, 1997) whose fragments resemble the "fourth quantum" and which served as a textbook for doctoral students at IFJ PAN for 15 years. Conducting the quantum mechanics lecture for our

doctoral students was quite a challenge, primarily due to the vast diversity of starting points. The interdisciplinary nature of the research held in the Institute and the large variety of topics of realized doctoral theses meant that among students enrolled in doctoral studies were both individuals who had previously successfully completed quite advanced quantum physics courses and those who had studied subjects having little in common with quantum physics and for whom the course conducted by Professor Zalewski was their first encounter with quantum mechanics at a level different from poorly executed popularization. Additionally, the situation was often complicated by glaring gaps in mathematics. Professor Zalewski always investigated his prospective students in order to gather detailed information about their history of contacts with quantum mechanics. To overcome potential problems with mathematics, I was usually tasked with conducting "remedial classes" in complex analysis and linear algebra. Only after completion of this "training", usually in mid-October, Professor began the classes. According to his usual manner, the Professor conducted lectures and classes which were scheduled for four hours each Wednesday in a logical sequence: two hours for classes and solving problems related to the previous lecture, and after that, two hours for the new lecture. The material selected by the Professor (and required for the exam) outlined for two semesters included chosen problems of non-relativistic quantum mechanics in the autumn semester, while the spring semester was dedicated to the introduction to relativistic quantum mechanics. Regular classes were concluded with a series of consultation meetings preceding the final exam. The exam was oral, but with a significant novelty: it was absolutely mandatory that the supervisor had to participate in the exam; without supervisor's presence, the Professor did not begin the exam. I, as a representative of the Doctoral School authorities, was also required to be present at the exam. I am convinced that during approximately 45-minute exam both the advisors and I could learn a lot about the candidates. Professor's experience allowed him to identify accurately students' strengths and weaknesses, and provide the supervisor with some guidance on how to continue working with the doctoral student. Simultaneously, I could estimate the prospects for the further progress of the doctoral project. I know that for many advisors this exam was an experience comparable to their own exams; for me, it was a lesson of how much one can learn, and in so short time, about a candidate for a doctorate. I admired the Professor for his calmness, tolerance, and understanding for students who, in their nervousness, forgot even basic knowledge. Passing the exam was crucial for completing the first year of doctoral studies, but it was neither the only nor the last assessment that doctoral students were subjected to. The regulations of the Doctoral Studies imposed the obligation of an annual evaluation of students' progress next given for approval by

the Scientific Council. The evaluation was based on the report submitted to the aforementioned Committee of the Scientific Council for Doctoral Studies whose task was defining evaluation criteria and conducting the assessment. It should come as no surprise that these criteria were developed by the Professor who introduced in them a pivotal element of the evaluation pattern being the statement that the assessment pertains to the doctoral student–advisor pair. I do not know if we would have been able to implement this rule if it had not been Professor's idea. Similarly, the seemingly complicated symbolism of the assessment scheme, in reality, it ordered quite well-splitted responsibilities between doctoral students and their advisors. The concepts of assessment introduced by the Professor, particularly those concerning the evaluation of the student–advisor pair and the principles of considering achievements survived the government regulations on doctoral education effective from 2019. Nowadays, we apply them in Kraków Interdisciplinary Doctoral School led by the Institute. However, the most important Professor's contribution to the education of doctoral students at the IFJ PAN, the contribution that makes Professor Zalewski the Mentor to several generations of physicists, is his contribution to teaching quantum mechanics. Over the 15 years during which the Professor lectured quantum mechanics at the Institute about 180 people passed through his lectures, classes, and examinations. 170 of them successfully defended their theses and were awarded a doctoral degree. Among the latter, 26 researchers continue their scientific careers at the Institute, 11 obtained habilitation, and step by step approach the title of professor. Perhaps not all of them have «Lectures on Nonrelativistic Quantum Mechanics» on a bookshelf filled with favourite and most important books, but certainly when someone mentions a red-covered book having in the title two Polish words "mechanika kwantowa" all of them will immediately associate it with Professor's textbook on which they spent not one, not two, but many hours.