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IVAN SUPEK AND THEORETICAL PHYSICS IN ZAGREB

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Talk at the Symposium

Professor Supek is father of our contemporary theoretical physics in Zagreb. It all started through the activity of Professor Supek, who founded the Seminar for Theoretical Physics in 1947 at the Faculty of Science (Prirodoslovno-matematički fakultet, PMF), which itself was founded in 1946.

Professor Supek was the best available person for that job. He studied in Zagreb, under Professors L. Stjepanek, V. Varićak and S. Hondl, and obtained his B. Sc. degree in 1939. Then he began studying physics and philosophy at European universities, which resulted in his Ph. D. in 1940 from the Leipzig University, where his work was supervised by Professor W. Heisenberg and Professor F. Hund. There he was also a member of Heisenberg's seminar, becoming eventually his assistant. In his research he was very much involved in problems of solid state physics, notably the electron-phonon interaction in connection with phosphorescence.

Together with H. Euler and W. Heisenberg himself, he also worked on problems in QED and on the theoretical description of cascades. He was dealing with the foremost theoretical physics problems at that time, being one of the first to realize the importance of the electron-phonon interaction. His good war record gave him reasonable standing with political authorities, although he was no longer party member.

After his return to Zagreb, in the period 1945 – 46 Supek was employed as Professor of physics at the School of Medicine. He became professor of theoretical physics in 1946 soon as the newly formed School of Science (Prirodoslovno-matematički fakultet, PMF) was opened by cloning it from the older School of Arts (Filozofski fakultet) which contained sciences and mathematics as a subgroup. At that time the chair for theoretical physics was empty. The former professor, L. Stjepanek (who was not active during the war), retired in 1946, without leaving a successor. He had been the head of the Theoretical Physics Seminar (chair) (Seminar (Zavod) za teoretsku fiziku) since 1920, together with Professor V. Vrkljan. Professor Vrkljan was the head of chair for Classical Mechanics and Applied Mathematics. He was active in modern theoretical physics, meaning relativity, in quantum mechanics and Dirac's equation. Through some imbroglio with students, which contained strong political undertones so important in those years, Vrkljan retired. (In order to give him some moral statisfaction, in 1950 his colleagues, at the instigation of Prof. Supek, made him a corresponding member of the Academy of Sciences and Arts in 1950 (contemporary acronym being JAZU). When the new PMF was formed, Supek was made the head of both chairs. The only other scientist was assistant Z. Janković at the Chair for Classical Mechanics, etc., who was then preparing his Ph. D. thesis. (Janković became a distinguished professor, who headed this chair until his untimely death).

In 1947 Professor Supek started a process that changed this very unsatisfactory situation by activating the Seminar for Theoretical Physics, which met regularily every Wednesday, finishing with a tea party. The core, which were Supek (member of the Academy (JAZU) since 1948) and Janković, was soon reinforced by an outstanding mathematician, D. Blanuša. (As well as in pure mathematics he was also interested in applications and problems connected with special and general relativity.) However, the main strength to the Seminar came from young students, some of whom came over from the School of Engineering (Tehnički fakultet). They became founders of various branches of our theoretical physics, starting the growth which eventually resulted in about 50 internationally established theoreticians in elementary particle physics, nuclear physics, solid state physics and classical theoretical physics. It is fit to say a few words about Supek's pupils, whose education is his outstanding contribution to the development of Croatian science.

The Seminar was concerned with the same problems as those investigated in Heisenberg's seminar in Leipzig. Various lines of research were divided among students, very often determining their future scientific orientation. Important members of the first generation were (in alphabetical order) Gaja Alaga, Ivo Babić-Gjalski, Vladimir Glaser and Borivoj Jakšić.

Babić-Gjalski, a very talented descendant of a famous 19th-century Croatian novelist (Ksaver Šandor Gjalski) of whom much was expected, died prematurely in a mountaineering accident in 1951. With his impeccable social manners and sunny nature he was an important cohesion force in the Seminar. Supek suggested him the research on the correspondence between classical and quantum electrodynamics. Together with Professor Supek he published *Korespondencija klasične i kvantne elektrodinamike* (RAD 296 (JAZU) 23 (1953)). They also extended the semiclassial Weizsäcker-Williams approach, developed for soft photons in QED, to meson physics.

Alaga was a Croatian from Vojvodina, from a landowning family. Alaga started working on nuclear structure and nuclear β-decay. In 1949 he was expelled for a time from the University in one of the purges, being suspect as a son of the "kulak"-

father. Alaga was a member of the first group that visited the Bohr Institute in Copenhagen (the others were Z. Janković and S. Kurepa). There he started his brilliant career in theoretical physics by writing a joint paper with the future Nobel-prize winners A. Bohr and B. Mottelson. Alaga's selection rules are still referred to in nuclear physics and he was the author of the most quoted paper among those produced by the Zagreb theory group. He died as the head of the Theoretical Physics Department.

Glaser was probably the most talented member of the Seminar, exceeding in mathematical brilliance, which made him later, when he was on the CERN staff, an undisputed authority for mathematical problems. Among CERN mathematical physicists he was known as the "pope", stressing his mathematical infallibility. Supek directed him towards QED and problems connected with field-theory normalization. He was sent to Goettingen to spend some time in Heisenberg's group. After his return to Zagreb he published (1955) the book *Kovarijantna kvantna elektrodinamika (Covariant QED)*, which still provides a useful reading with many interesting insights. He also collaborated with Lehman, Szymanzik and Zimmerman, helping further development of (for some time) the famous LSZ formalism. While in Zagreb, he found his much appreciated exact solution of the two-dimensional Thirring model field theory. He left Zagreb for good in the late fifties, and died while serving as a distinguished staff-member at CERN.

Jakšić was introduced by Supek to meson physics and sent to work under Rosenfeld in Manchester. Later he became the head of the Theory Group at the Ruđer Bošković Institute, gathering many talented young people in the field of theoretical physics, and finding them suitable fellowships abroad. He was expert in mathematical problems, especially nonrelativistic scattering. Together with Glaser he produced a noted work on electromagnetic form factors, which contained many relations which were used by later researchers. He left Zagreb in the sixties.

Supek's Seminar was later jointed by K. Ljolje and A. Grossmann, who grew to be theoretical physicists. Other members, K. Ilakovac, M. Petravić, M. Cerineo, B. Leontić and V. Knapp, were directed and persuaded to become experimental physicists, all being given foreign fellowships. This was dictated by an urgent need to develop experimental research in Zagreb, connected with the newly built Ruđer Bošković Institute. Same was the fate of even newer Seminar members N. Cindro and I. Šlaus. Most of these scientists were, and still are, the backbone of the experimental physics in Zagreb.

One of the Seminar members, M. Randić, was offered, by Supek, a fellowship under the condition to specialize in theoretical chemistry. He is now a well-known authority in that field. Although he left Zagreb a long time ago, his occassional visits are useful to the Zagreb theoretical chemistry group.

Supek also contributed to the education of undergraduates by writing the first Croatian theoretical physics textbook *Teorijska fizika i struktura materije* (1949). This book is important for our science and our culture in general, as it is the first book on quantum mechanics ever published in Croatia. Since then it has had many editions being enlarged and modernized by his numerous former students (G. Alaga,

N. Bilić, B. Jakšić, M. Martinis, M. Randić, V. Šips, M. Šunjić, D. Tadić and M. Tomaš).

Supek's own research stayed in solid state physics. With K. Ljolje, another Seminar member, he published *Utjecaj termičkog titranja kristalne rešetke na elektrone u pobuđenim stanjima metala i fotoluminiscencije metala* (1953). After obtaining his Ph. D. under Supek, Ljolje went to Sarajevo, where he is now a leading University professor.

Supek also published another pioneer paper in the Croatian language *Korespondencija klasične i kvantne elektrodinamike* (with Babić-Gjalski 1953), which is connected with Supek's early publication *Kvantiziranje elektromagnetskog polja* (Glasnik matematičko-fizički i astronomski 4 (1949)) (*Quantization of the Electromagnetic Field*). These are the first papers on quantum field theory ever published in Zagreb.

The latest scientific papers by Supek reflect the rapid development and sophistication of theoretical physics in Zagreb. By now he has educated a group of theoretical physicists, who are or were members of the international scientific community, producing papers for the leading international scientific journals. In his papers *Elektrische Leitfähigkeit der Metalle bei tiefen Temperaturen* (Z. Phys. 149 (1957) 324 and *Electrical Conductivity of Metals at Low Temperatures* (Nuovo Cimento 12 (1959) 290), Supek attacked the same problems on which he had worked during his years in Leipzig. His pupils Glaser and Jakšić published an elegant mathematical formulation (Glasnik mat.-fiz. i astr.) of Supek's ideas on low-temperature conductivity. In this way Zagreb developed theoretical research of international standing in nuclear physics, quantum field theory, particle physics and solid state physics. That was soon backed by experimental work.

Thanks to Supek's efforts, systematic modern physics research became an important part of Zagreb science, in less than 10 years.