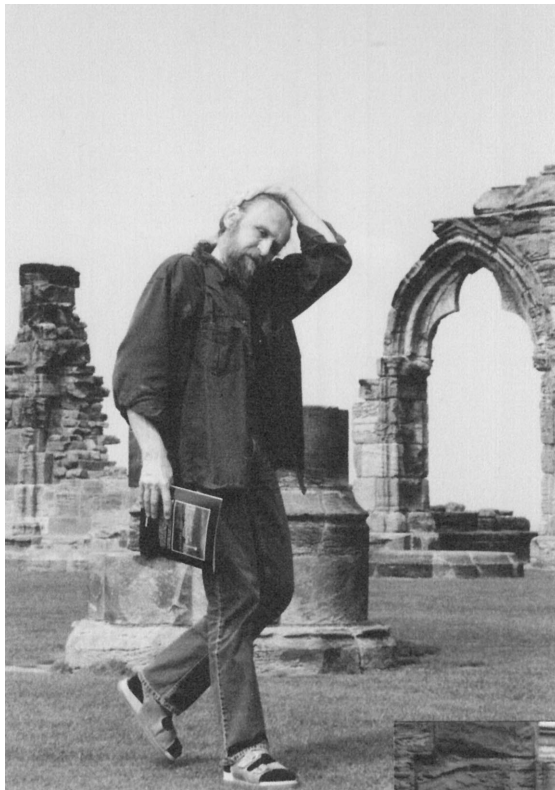


Sławomir Bugajski 1941–2003



The scientific life of Sławomir Bugajski spanned three decades, with a forced digression of almost 8 years engaged in the dramatic political developments in Poland during the 1980s. Bugajski focused his research interests on the mathematical, conceptual, and logical foundations of quantum mechanics. This led him later to search for radical extensions of ordinary quantum mechanics, first in the direction of a nonlinear theory and subsequently in the form of a general fuzzy probability theory.

The first five papers were written jointly with his first wife Krystyna Bugajska and dealt with the axiomatic basis of quantum mechanics. Applying the quantum logic approach they postulate various equivalent formulations of the projection. Their conclusion “Thus, in the authors’ opinion, the hilbertian apparatus for quantum mechanics requires no justification and ‘non-revolutionary’ generalizations of quantum mechanics are impossible.” It appears that this statement contained the seed and driving force for the whole later scientific work of Bugajski.

As a young postdoc an Alexander von Humboldt Fellowship enabled him to spend extended periods at the Universities of Munich, Cologne and Berlin, establishing fruitful, long-term research exchanges with the groups of G. Süßmann, P. Mittelstaedt, and K.E. Hellwig. The present authors regard themselves as privileged to have been able to enjoy years of collaboration with Sławek, with countless intensive and inspiring discussions.

The second set of problems that occupied Bugajski’s mind was the probability structure of quantum mechanics, joint probabilities of incompatible quantities, probability measures on effects and operations, and the interpretation of quantum probabilities. In a series of papers from the late 1970s to the early 1980s Bugajski studied the logical structures arising from quantum theory in its standard and operational forms. He showed that the so-called extraction method leads in a unique and natural way to the inner language and the inner logic of a given physical theory. The incompleteness of the nonclassical inner language obtained from operational quantum mechanics suggested to Bugajski an extension of operational quantum mechanics to a nonlinear theory.

Bugajski’s sense of devotion and revolutionary spirit were not restricted to science but were equally manifest in his engagement for the wider society, especially the country and people of Poland. The course of political events forced him to give up science to fight for democracy and the liberation of Poland from communism. Bugajski was deeply involved in the Solidarity trade-union movement from its rise in August 1980. The date of 13 December 1981 was a turning point: for the majority of people, the declaration of state of war and the banning of the Solidarity trade union with the accompanying mass arrests and large scale repression marked the end of their dreams of a free and democratic Poland. For Sławek it was a new challenge and the beginning of the true fight for freedom. Already in December 1981 Bugajski participated in the preparation of a declaration opposing the regime of General Jaruzelski, and he assisted in the creation of an underground journal in a steel mill in Nowa Huta. His early and spontaneous underground operations were stopped by his arrest and internment on May 13, 1982. He was released in July and immediately afterwards fired from his university position. Since then Sławek continued his underground activities, suffering harsh persecution from official authority—numerous arrests, house searches, and an “unofficial” work ban, making it impossible for Sławek to take up even simple jobs as a stoker or countryside teacher.

The impossibility of continuing scientific work was a great shock to Bugajski, causing him to destroy all his research notes and writings. He committed all his efforts to fighting for freedom. The Polish Internal Security Service did not know the true role or scale of the operations of Sławek Bugajski at that time. Together with his second wife, Barbara Kowalczyk, he created the Silesian branch of the most uncompromising anticommunist organization of the time, Fighting Solidarity, which had to operate in full secrecy as its goal was nothing less than freeing Poland from communism and Soviet domination. Sławek managed not only the operations of Fighting Solidarity in Silesia, but he also founded and was a main writer for two illegal underground journals: *PiK* (Katowice Underground Bulletin) and *WiS* (Freedom and Solidarity). To secure their family's living Sławek and Barbara started to produce hand-crafted and painted dresses, an enterprise that flourished very well and showed an artistic side of Sławek's personality.

When the opportunity of returning to the world of physics emerged finally in 1990, Sławek took it immediately. He wrote to one of us "It was very surprising for me that during those eight years so small progress was made in the foundations of quantum mechanics. Naturally, there are changes, but not so big as one could expect—some fields grow, some wither. However, there is no revolution."

In the 1990s Bugajski focused his attention on the features of statistical theories that rest on the convex structure of their sets of states. He found it useful in studying both structural properties and conceptual issues of quantum mechanics. However, he did not stop at that: he aimed for a deeper and more radical generalization of the theory. The states of classical statistical mechanics are known to form a simplex (i.e., mixtures have a unique decomposition into pure states) while quantum states do not (as quantum mixed states have many different decompositions into pure states). Sławek explored the representation of quantum mixed states as equivalence classes of some simplex, considered as the set of states of a new statistical theory that would thus inherit a classical aspect. This perspective has something in common with the old idea of hidden variable theories but it gives up the requirement of restoring a deterministic background.

In a series of papers Bugajski created a remarkable generalization of classical probability theory that he called "fuzzy" or sometimes "operational" probability theory. This generalization adopts a set of states with the classical structure of a simplex, but the set of observables is enlarged to include nondeterministic, or fuzzy, random variables: in this way, classical and quantum random variables are represented on an equal footing in a unified framework. Bugajski's idea was that fuzzy probability theory should be able to give an adequate account of both classical and quantum probabilities; moreover, he believed that this extended frame could be of universal use, even beyond the borders of physics. He paid special attention to the possible occurrence, in this frame, of the *Bell phenomenon*: a pattern that generalizes the violation of Bell inequalities and exhibits their mathematical and physical roots. In his last published papers he worked on the notion

of correlation between observables and discussed in particular the separation between correlations of a classical nature and nonclassical correlations associated with nondeterministic observables. The latter are shown to encompass the quantum idea of entanglement.

In the final years Sławek advanced original ideas on quantum computation theory, pointing at promising aspects that might emerge from the use of fuzzy probability theory. He outlined new ways of modelling the transfer of information from the quantum to the classical level and of describing mesoscopic and compound systems; a novel approach towards understanding the quantum computation process as a stochastic process, and new numerical measures of complexity based on his notion of net entropies.

Bugajski's professional life was active and prolific till the end. He acted as Councillor for the International Quantum Structures Association. He organized several conferences and schools; the last one, of which this volume contains the proceedings, clearly carried his mark: it was devoted to "Quantum Composite Systems," a topic close to Sławek's heart over the last years when he worked hard to forge links between the scientific communities of quantum foundations and quantum information. This was part of Bugajski's vision and effort to reaffirm the vital roles that the pure sciences of physics and mathematics have to play in securing the technological foundations for our modern society.

Sławomir Bugajski was one of the special men and women who make a lasting impression on anyone who encounters them, a man whose existence has made the world a better place to live in for many of us, by what he did and what he represented. The younger generation of scientists in Poland hold him in regard as a hero and legend. After the peaceful revolution that brought democracy to Poland, and thus after his return to physics, he gave moral and emotional support, in his characteristic modest and selfless manner, to the impressive and consuming work of his wife Barbara (once herself a working physicist) of building a modern social services system for the city and district of Katowice.

His passing means a great loss to our community. We will miss his deep eyes, knowing smile, and powerful-gentle presence. Sławek embraced life in its entirety: he was full of love and care for those closest to him, a true friend to those of us who were so fortunate to belong to his circle of companions, an active world citizen and Polish patriot, and, finally, a radical thinker and creative scientist. His great human personality came into full relief in the face of severe adversities and deep personal tragedy, notably during the years of his underground freedom fight. In a message sent to one of us on 15 November 2002, when he was already diagnosed with an illness that left no hope, he wrote "I do not know the reason, but all my life I considered myself hard like a rock. So, it is natural that I do not panic in the present situation." In the same days he was planning to contribute a paper to honor the birthday of a colleague. To his last days, his concern was to help those close

to him accept the hard reality of death; on 5 December 2002 he wrote “So, do not worry about me, please. Anyway, *sapiens mortem non timet.*”

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