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Corresponding member of Czechoslovak Academy of Sciences Antonín Špaček. (11.10.1911-24.10.1961)

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CORRESPONDING MEMBER OF CZECHOSLOVAK ACADEMY OF SCIENCES ANTONÍN ŠPAČEK

(* 11. 10. 1911, † 24. 10. 1961)

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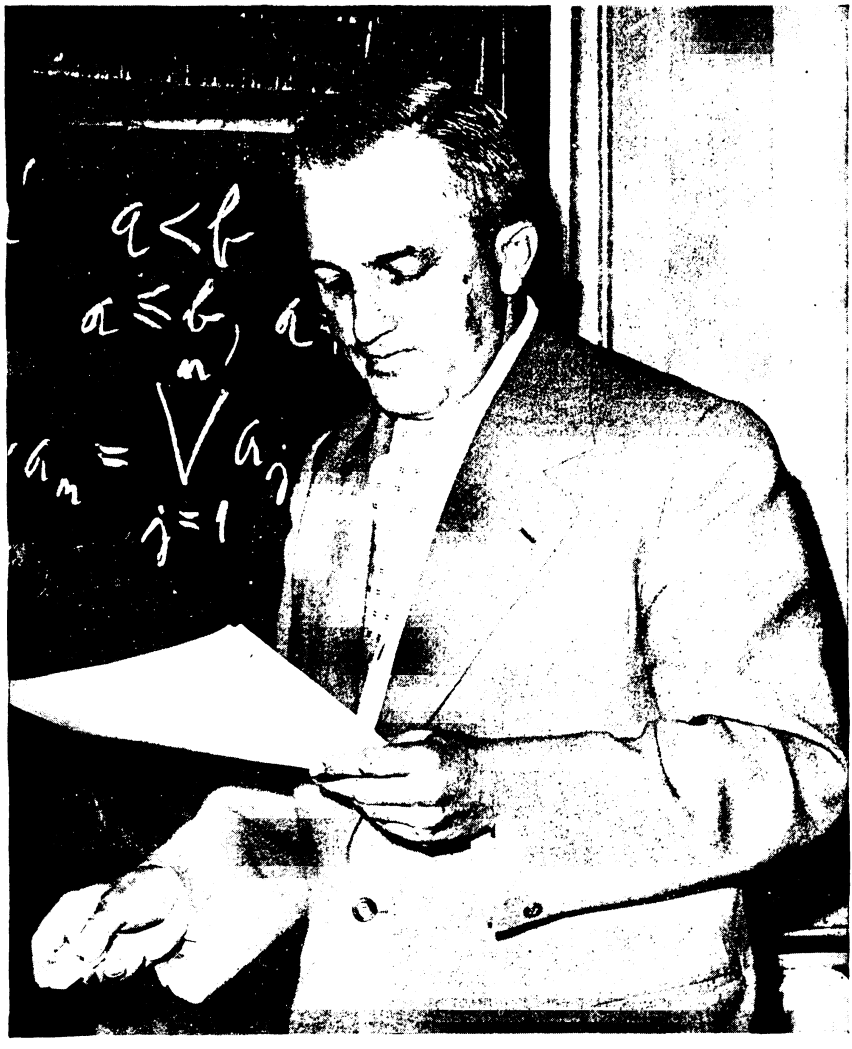
ANTONÍN ŠPAČEK, RNDr, corresponding member of the Czechoslovak Academy of Sciences, vice-director of the Institute of Information Theory and Automation, Czechoslovak Academy of Sciences, died in Prague after a serious illness on October 24, 1961. A perfidious disease tragically ended his life shortly after the President of the Republic had awarded him the Order of Labour on his 50th birthday for outstanding services to science.

In Antonín Špaček we have lost a foremost research worker whose scientific work in the field of the modern probability theory has been widely acclaimed and appreciated both at home and abroad. He stood at the head of the scientific group he had formed, which dealt with recent probability problems, particularly in the theory of random processes, the information theory and the statistical decision theory. He initiated international cooperation in these fields and for this purpose organized in Czechoslovakia conferences devoted to these subjects, in which many important foreign scientists participated. The scientific results of these conferences, published in book form in foreign languages, honourably represent Czechoslovak science on an international level and remain a permanent monument to Špaček's creative work. Špaček also made an important contribution to radioelectronics, publishing several papers and registering a number of important patents. Under his leadership a special electronics laboratory came into being, in which equipment for modelling random processes necessary for the application of theoretical results is designed on the basis of Špaček's ideas. One such instrument, suggested by Špaček, was awarded a Grand Prize at the World Exhibition in Brussels.

The breadth and depth of Antonín Špaček's scientific work, together with his modesty and further excellent personal qualities, made him an outstanding personality of Czechoslovak science. His life was an example of tireless creative work, abruptly ended by premature death.



Corresp. Member of Cz. A. Sc. ANTONÍN ŠPAČEK

Antonín Špaček was born in Bratislava on October 11, 1911. His father, who came from Bohemia, was employed at that time in a metal-products factory in Petržalka near Bratislava. Špaček went to secondary school in Plzeň, where he matriculated in 1932. After completing his military service in the spring of 1934 he started work at the *West Bohemian Kaolin Works* in Horní Bříza near Plzeň. A year later he registered at Charles University in Prague, where he studied mathematics and physics at the Science Faculty from 1935 until the universities were closed by the occupants. During the war Špaček remained employed at the West Bohemian Kaolin Works. The war had not yet ended when he wrote his doctor's thesis in mathematics, which he submitted after the war under the title: "On the Complete Extension of Metric Spaces with Respect to a Given Set of Metrics"; he was declared a Doctor of Natural Sciences in February 1946.

Apart from mathematics A. Špaček was especially interested in radioelectronics. This was apparent as early as the thirties when, shortly after matriculating, he applied for a patent in August 1932 for a "A Design of an Amplifier". Špaček was of course interested in all engineering problems; for example in the ceramic factory, in which he was employed, he used his wide mathematical knowledge to solve some problems occurring in the production of fireproof materials. His interest in radio-engineering led him in 1946 to *Tesla*, national corporation, where he began to work in the research department on broad-band amplifiers. As one of the first in Czechoslovakia he also dealt with the applications of matrices to the solution of electric circuits; in 1948 he published two papers on this subject (see papers [1], [2], in appended list).

At the time when Špaček went to Tesla, our radio-engineering industry started to develop and a basis was created for Czechoslovakia's research in this sphere. Here Špaček did a great amount of work: he was soon quite at home in radioelectronic problems and used his mathematical analyses to help make the solved problems accessible to his colleagues. Such cooperation gave rise to a series of new and important results (non-inductive resistor for measuring instruments equipment for compensating the influence of insufficiently filtered anode current etc.). Špaček paid special attention to questions of frequency modulation, the solution of which became the basis of several important patents. An analysis of frequency modulation gave rise in particular to his original solution of a phase modulator which is still used today.

In connection with questions of the radio-engineering industry Špaček was interested in methods of statistical quality control. He was convinced of the importance of such methods and approximately in the first half of 1948 he started work along these lines, building up a group to deal with such questions. After the reorganization of Tesla in 1949 Špaček's group was transferred to *Tesla-Elektronik* and set up as an independent mathematical department with Špaček as head.

Špaček followed two aims in developing *statistical methods for application* in production: to obtain new original theoretical results and to use them in production in the different factories. The introduction of statistical methods into production required cooperation in the factories themselves and Špaček personally participated.

For the introduction of such methods which were relatively new in our country, the preparation of various aids was necessary; Špaček performed and led work on the computation of tables and the drawing up of graphs. Most of this work remained unpublished.

Špaček's attention at that time was not concentrated only on methods of statistical quality control. He also studied new disciplines in greater detail, such as the *theory of statistical decision functions* and the *theory of strategic games*, and his creative attitude to this subject led to new theoretical results. From 1950 to 1951 Špaček concentrated on the very important field of the general probability theory – the *theory of stochastic processes*. Even then as one of the first in Czechoslovakia, he was clearly aware of the importance of the theory of stochastic processes and probability methods in general for investigating questions of communication and information in the broadest sense. Such progressive aims, at that time professed by only a few leading scientists in the world, are today revolutionary in modern engineering.

At that time Tesla-Elektronik was reorganized and the mathematical department formed by Špaček went to the new *Research Institute of Communication Engineering of A. S. Popov*. Špaček began to work on new problems formulated by himself in the theory of random processes and statistical decision theory. In 1952–54 he worked out papers of fundamental importance which became the basis for further scientific research by his colleagues. He thus created new disciplines for which he coined the terms *probabilistic functional analysis* and the *theory of experience in statistical decisions*. It was only after Špaček's pioneering work in this field that the modern branches of the theory of probability began to develop in this country. This was also helped by Špaček's lectures on random processes, statistical decision functions and other related subjects at Charles University in Prague.

At the beginning of 1955 Špaček's whole group moved to the *Institute of Radio Engineering and Electronics* just set up by the Czechosloval Academy of Sciences. Špaček, who confirmed the correctness of his ideas in discussions with outstanding foreign scientists at conferences in Prague, Berlin and Wroclaw, directed his colleagues to problems of probabilistic analysis and theory of experience and set the goal for the near future: to organize in Czechoslovakia an international conference at which his scientific group would be represented as a team working in one direction. The first conference devoted to the information theory, statistical decision functions and random processes, which Špaček organized, took place at the end of November 1956 in Liblice with the participation of outstanding scientists from the Soviet Union, the people's democracies and the West. The conference gave a clear picture of the general aims of the scientific group formed and led by Špaček, and confirmed the correctness of such aims. The recognition of the scientific importance of the independent Czechoslovak line of scientific research, built up by Špaček, was, of course, a great encouragement of further work. In 1957 the foreign-language proceedings of the original papers submitted to the conference were published, Špaček having played an important role in their preparation. In the period following the conference

Špaček obtained many new results, which he published in international scientific journals and reported on at international conferences in West Germany, France and Hungary. At that time Špaček laid the foundations for the development of *probability methods in mathematical logic*; he thus extended and supplemented his previous range of specialities by questions of the relation between human thought and the function of a machine, thus forming the basis for a new discipline within the framework of probability theory.

At the beginning of 1959 Špaček's department, which had already been extended by an experimental group, became one of the three parts of the newly founded *Institute of Information Theory and Automation* of the Czechoslovak Academy of Sciences. In the new institute Špaček held the function of vice-director until his untimely death. Here he organized a second conference on the theory of information, statistical decision functions and random processes, which took place in June 1959. The second conference differed from the first in that Špaček, together with his scientific group, was already internationally well-known. This was apparent at the conference in the participation of several dozen foreign experts, among them outstanding scientists from the socialist countries and from the West. The original scientific papers delivered at this second conference appeared in print in 1960 in a foreign-language publication, double the size of the proceedings from the first conference.

After the second conference Špaček worked mainly in *mathematical logic*, on problems of probability from the point of view of decision processes. He lectured on these questions and a number of other results in France, G. F. R., U. S. A. and G. D. R. In 1961 Špaček was invited to conferences in Stockholm, Leningrad and Oberwolfach and to lecture at the university in Munich. Illness resulted in him accepting only the first invitation.

In recognition of his services to science Špaček was elected corresponding member of the Czechoslovak Academy of Sciences in the spring of 1960 and in October 1961 the President of the Republic conferred the Order of Labour on him on the occasion of his 50th birthday. This high order was handed to him in hospital shortly before his death.

The scientific papers by Antonín Špaček in the field of probability and statistical decision theory deal with a broad range of subjects. The oldest group of papers is devoted to statistical methods applied in quality control; in particular, paper [3] deals with the theory of cumulative sums of independent random variables. It solves the problem of random walk with moving boundaries of a special type, which corresponds to a sequential sampling plan, representing a certain generalization of Wald's sequential test. Papers [4] and [5] deal with a statistical sampling inspection procedure based on the percentage defective, provided that the population is normal. Paper [6] represents an application, one of the first in the world, of the theory of minimax solutions in statistical decisions to the problem of the construction of sampling inspection plans.

Paper [7] is the first by a Czechoslovak author devoted to the theory of statistical decision functions. Špaček reported on it in 1950 at a conference in Warsaw, where it deservedly excited attention.

Špaček's classical papers were published after 1954 and are all devoted to new disciplines, for which Špaček laid the foundations. They are mainly probabilistic functional analysis, the theory of experience in statistical decisions and probabilistic problems of mathematical logics. Numerically the largest group of papers is devoted to probabilistic functional analysis; they deal mostly with problems of the construction of probability measures in functional spaces. In Špaček's papers these problems are treated in many different directions:

1. *Metric spaces*: the construction of a probability measure in the space of uniformly continuous functions and in the space of functions satisfying the Lipschitz condition (papers [10], [15]); the extension of a random uniformly continuous function given on a dense set and the extension of a random function satisfying the Lipschitz condition (paper [20]).

2. *Banach spaces*: the construction of a probability measure in the space of continuous linear transformations; the inversion of random linear transformations satisfying the Lipschitz condition; the solution of random Fredholm equations (papers [11], [17]); the extension of random continuous linear transformations (paper [20]).

3. *Spaces of additive set functions*: the construction of a probability measure in the space of additive set functions; the Radon-Nikodym theorem for random measures; conditional probabilities, which are probability measures with probability 1 (papers [10], [15], [16]); the extension of a random measure (paper [20]).

4. *Random metric*: the construction of a measure in the spaces of distance functions; the separability of random metrics; the universal representation of a space with a random metric; a non-random metric as a degenerate random separable metric; the characterization of a non-random metric by means of a maximal ideal (paper [12], [21], [25]).

5. *Cartesian products*: the problem of the construction of a probability measure in the Cartesian product of general probability spaces (papers [23], [27]); the Cartesian products of random metric spaces (paper [25]).

6. *Stochastic approximations*: investigating some limiting properties of the solution of random differential equations with applications to prediction (paper [24]).

Another group of papers is formed by works devoted to problems in the theory of experience in statistical decisions. The discrete statistical decision process with independent components is dealt with in papers [13] and [19] (cf. also [9]) and the process with dependent components in paper [22]. Paper [18] is devoted to continuous decision processes.

The last group of papers deals with problems of the statistical estimation of probability in mathematical logic: an estimate of the probability of theorems in the axiomatic theory described by Boole's logic (paper [26]), an estimate of probability

in monadic logic (introduced by P. R. HALMOS) by means of a decision process (paper [29]). Paper [28], dealing with the concept of the amount of information contained in deductive theory, is also devoted to probability problems of mathematical logic.

Špaček's creative contribution in the above fields consists both in formulating the problems and in the methods which he derived to solve complex and exacting problems. One such method was the construction of a probability measure in a functional type space based on the apparently simple theorem 1 in paper [10]. The verification of the assumptions for the validity of this theorem, applied to special types of functional spaces, proved in most cases to be non-trivial and thus gave rise to a series of new problems requiring a profounder approach.

It is not possible in this brief survey of Špaček's scientific work to go into detail. As an example we give one *result of Špaček's theory of random metrics*, which is very interesting from the point of view of investigating ordinary metric spaces. This result can be roughly characterized as follows:

Let X be an arbitrary non-empty set, the power of which is equal at the most to the power of the continuum. Then for each ordinary metric ϱ, whether separable or non-separable, there exists in the set X just one maximal sigma-ideal $\mathfrak{J}$ in the sigma-algebra $\mathfrak{S}$ of the sub-sets of the set of all separable metrics, which has the property that the distance in the metric ϱ between two arbitrary points of the set X is equal to the expectation of the distance between these points in all separable metrics with respect to the degenerate probability measure on $\mathfrak{S}$ defined by the relation $\mu(E) = 0$ for $E \in \mathfrak{J}$, $\mu(E) = 1$ for $E \notin \mathfrak{J}$. Here the sigma-algebra $\mathfrak{S}$ is defined by means of the Kolmogorov sigma-algebra in the usual manner.

This result can be used for embedding an arbitrary, even non-separable, metric space, having at most the power of the continuum, into the space of all continuous functions on a closed interval, if the metric corresponding to it is replaced by a maximal sigma-ideal.

It is very easy to interpret the basic conceptions of the use of experience in statistical decision-making, since they are intuitively very clear. The point is that we have to find the optimal decision procedure on the assumption of the existence of a fixed apriori probability distribution, which, however, is not known. The basic idea is based on the fact that the given decision problem is replaced by a sequence of decision problems of the same type, while the apriori probability distribution is estimated statistically (usually with a certain delay) and the optimal decision function at each step of the sequence in question is suitably adapted to this estimate. This procedure guarantees in the limit that we arrive at the sought optimum, as though we knew the actual apriori distribution. Špaček's substantial contribution in this direction is the finding of methods to solve this mathematically very difficult problem.

The principle of the application of probability methods to probability problems in mathematical logic, which was formulated by Špaček, is based on the modelling of the heuristic method of thought by the apparatus of statistical decision functions. Such a profound idea is quite original in world literature and was formulated by

Špaček in such a way that certain forms of human thought could be expressed by an algorithm with probability 1.

In concluding this brief survey of the scientific work of Špaček it should be emphasized that all his theoretical papers originated from an analysis of concrete problems occurring in practice and led to the overcoming of fundamental difficulties preventing their solution.

In Antonín Špaček we have lost an outstanding representative of Czechoslovak science, who introduced many new ideas into the probability theory and related fields. His pioneering scientific work remains and will continue to live in the work of those who follow him. Antonín Špaček united in his work progressive political opinions with a progressive conception of science; his sensitive approach to people and his specific traits of character won him the respect and esteem of all who came in contact with him. His death is a hard blow for the whole of Czechoslovak mathematics.

LIST OF PAPERS BY ANTONÍN ŠPAČEK

1. Stabilní chod oscilátoru (Stable function of oscillator). Slaboproudý obzor, *9* (1948), No. 9, 198 – 200.
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3. Note on successive cumulative sums of independent random variables. Časopis pro pěstování matematiky a fysiky, *74* (1949), 41 – 45.
4. O použití normálního rozložení pravděpodobnosti pro přejímací kontrolu (On the use of normal probability distribution in sampling inspection). Slaboproudý obzor, *10* (1949), No. 3 – 4, 80 – 83.
5. Použití normálního rozložení pravděpodobnosti v přejímací kontrole (The use of normal probability distribution in sampling inspection). Statistický obzor, 1949.
6. Sampling plans for percent defective which minimize the maximum of a given risk function. Časopis pro pěstování matematiky a fysiky, *75* (1950), 307 – 309.
7. Note on minimax solution of statistical decision problems. Colloquium mathematicum, *2*(1951), 275 – 281.
8. Stacionární a ergodické stochastické procesy a jejich aplikace (Stationary and ergodic stochastic processes and their applications). Abstract of a communication, Conference on Applied Mathematics, Liblice, 1951. Časopis pro pěstování matematiky, *76* (1952).
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10. Regularity properties of random transforms. Czechoslovak Mathematical Journal, *5* (1955), 143 – 151.
11. Zufällige Gleichungen. Czechoslovak Mathematical Journal, *4* (1955), 462 – 466.
12. Note on K. Menger's probabilistic geometry. Czechoslovak Mathematical Journal, *6* (1956), 72 – 74.
13. Experience in statistical decision problems (together with *V. Fabian*). Czechoslovak Mathematical Journal, *6* (1956), 190 – 194.
14. Elemenly znáhodněné funkcionální analysy (Elements of randomized functional analysis).

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15. Die Regularitätseigenschaften zufälluger Transformationen. Bericht über die Tagung Wahrscheinlichkeitsrechnung und mathematische Statistik (Berlin 1954). Published in 1956, 109 – 111.
16. Zufällige Mengenfunktionen. Mathematische Nachrichten, *14* (1956), 355 – 360.
17. Sur l'inversion des transformations aléatoires presque sûrement linéaires. Acta Mathematica, *7* (1957), 355 – 358.
18. Continuous random decision processes controlled by experience (together with *M. Driml*). Transactions of the First Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, 1957, 43 – 60.
19. An elementary experience problem. Transactions of the First Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, 1957, 253 – 258.
20. Prolongement des transformations aléatoires. Transactions of the First Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, 1957, 259 – 272.
21. Sur une caractérisation algébrique des espaces métriques. Bulletin de l'Académie Polonaise des Sciences, *6* (1958), 445 – 447.
22. Processus aléatoires de décision statistique conditionnée. Le calcul des probabilités et ses applications. Colloques internationaux du centre national de la recherche scientifique, *87* (1959), 157 – 163.
23. Probability measures in infinite Cartesian products. Illinois Journal of Mathematics, *4* (1960), 210 – 220.
24. Random fixed point approximation by differentiable trajectories (together with *O. Hanš*). Transaction of the Second Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, 1960, 203 – 214.
25. Random metric spaces. Transactions of the Second Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, 1960, 627 – 638.
26. Statistical estimation of probability in Boolean logic. Transactions of the Second Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, 1960, 609 – 626.
27. Condition nécessaire et suffisante assurant le prolongement d'une mesure de probabilité dans l'espace produit. To appear in Comptes rendus de l'Académie des Sciences de Paris.
28. Information contained in concrete examples of deductive theories. To appear in Proceedings of the International Colloquium on Statistics, Tokyo, 1960.
29. Statistical estimation of semantic probability. To appear in Proceedings of the Fourth Berkeley Symposium on Statistics and Probability, 1960.
30. Jak je třeba budovat teorii automatického řízení na statistickém základě (On the use of statistical methods in the automatic control theory). To appear in Aplikace matematiky.
31. O realisaci jistého stacionárního procesu v prostoru spojitých funkcí (On the realization of a certain stationary stochastic process in the space of continuous functions)-(together with *A. Perez*). To appear in Aplikace matematiky.
32. Pravděpodobnostní metody v radiotechnice (Probability methods in radio-engineering). To appear in Aplikace matematiky.