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JOHN VON NEUMANN – A BIOGRAPHICAL SKETCH

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"The galaxy of scientific minds, that worked on the liberation of nuclear power, were really visitors from Mars. They found it difficult to speak English without an alien accent, which would give them away, and therefore chose to pretend to be Hungarian, whose inability to speak any languages but Hungarian without a foreign accent is well known. It would be hard to check the above statement, because Hungary is so far away."

(Fritz Houtermans, Physicist)

John von Neumann was born on 28 December 1903 in Hungary. He was a pupil of the Lutheran Gymnasium (secondary school) of Budapest. Other students of the same school included Eugene Wigner, the Nobel-Prize-winning physicist, Antal Doráti, the famous conductor, Oszkár Glatz, a well-known painter as well as Janos Harsanyi, the Nobel-laureate economist.

His multiple talent showed already at an early age in various ways. His math teacher, László Rátz, called the attention of his parents and of the famous Hungarian mathematician József Kürschak to the exceptional mathematical talent of his pupil. As a result, outstanding mathematicians including Gábor Szegő and Mihály Fekete started to tutor him individually. Before he reached the age of 19 he already published his first study in mathematics (in 1922, co-authored by his tutor, Mihály Fekete).

His father insisted that at the university he should study a profession "more rewarding" than mathematics. At the suggestion of Theodore von Karman, another famous Hungarian and a friend of his fathers, it was decided that he should study chemistry at the Eidgenössische Technische Hochschule (ETH, Zürich, Switzerland). To prepare for the graduate entrance exam he started his math, physics and chemistry studies in Pázmány Péter University of Sciences (Budapest, 1921–25) and Friedrich Wilhelm University (Berlin, 1921–23), where he attended Einstein's physics seminars among other courses. He started his studies in the ETH in 1923, in 1925 von Neumann received his M.Sc. in chemical engineering in Zürich

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and in 1926 his Doctorate in mathematics at Pázmány Péter University of Sciences in Budapest.

In 1926–27, von Neumann received a Rockefeller Foundation scholarship and spent a year in Göttingen as an assistant to David Hilbert, the "King of the European Mathematicians". It was in Göttingen where "… John von Neumann had given quantum mechanics a form acceptable to mathematicians, as Euclid did for geometry" (E. Teller, quoted by Gy. Marx, 1994), a mathematical foundation (the statistical interpretation) of quantum mechanics.

As a consequence of his rapidly growing reputation as a brilliant mathematician and physicist he was invited to several universities. For example, in 1927 he became a Privatdozent in Berlin, and visited Hamburg quite often. He was invited to visit Princeton University first in 1929, where he was appointed a visiting professor, and later a permanent professor of mathematics (between 1931 and 1933).

It was, however, not until the Nazi take-over in 1933 that he accepted a permanent position in the USA, where he became a Professor of Mathematics in the newly established famous Institute for Advanced Study (IAS) at Princeton.

Von Karman, the old friend of the family, reactivated again in the mid-1930s. He constructed the first supersonic wind tunnel on the Aberdeen Proving Ground (Maryland, USA), and invited von Neumann to work with him as a part-time consultant. This is how he started to study explosions and shock wave propagation, which – according to his colleague and close friend, Stanislaw Ulam – made him aware of the mysteries underlying non-linear partial differential equations.

In the mid-1930s von Neumann also became deeply involved with the problems of supersonic and turbulent flows of fluids. The special knowledge he acquired in these areas gained great importance during World War II, by the time of which he had become one of the leading experts on shock and detonation waves. He inevitably became involved in the Ballistic Research Laboratory of the Office of Scientific Research and Development (OSDD) of the US Government, as well as in the Manhattan Project that created the first atomic bomb. Von Neumann worked together with Seth Neddermeyer, Edward Teller and James L. Tuck on the problem of how to generate a spherical shock wave that would push simultaneously on all points of the nuclear mass (implosion). Tuck and von Neumann invented an ingenious new type of high explosive lens that could be used to make such a spherical wave.

Von Neumann was also a participant of several other important World War II projects. For example, he worked with Maurice Shapiro on the question how underwater explosions could be used against an enemy harbour. One idea was to produce huge water waves (a kind of "tsunami") in order to destroy ships. The Bikini bomb tests served as the basis of the experimental studies for producing such artificial waves. Another idea was to crush submarines by deep nuclear explosions (the Wigwam Project). It was these problems that made von Neumann realise the importance of computers, since there were no pure analytical solutions to the emerging non-linear problems.

As General Eisenhower was elected President of the United States, John von Neumann became one of the most influential scientists in Washington. He was a member of the General Advisory Committee of the US Atomic Energy Commission (1952–54) and of the Technical Advisory Panel on Atomic Energy (1953–57). In 1955, he was nominated to the post of the US Atomic Energy Commissioner. He died in Washington D.C. on 8 February 1957.

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Major scientific contributions of John von Neumann included important works in fields other than pure mathematics. We list only some of his most important contribution below.

Theory of Games: Von Neumann was the first to prove the existence of equilibrium for two-person zero-sum games (1928, *Math. Annals*) based on his famous minimax theorem and the generalisation of Brouwer's fixed-point theorem. Also, in his path-breaking book on game theory (written together with Oskar Morgenstern, published in 1944 by Princeton University Press) he explored the intrinsic relations between games and economic behaviour. (See Forgó's paper in this issue for details.)

Theory of Economic Equilibrium and Growth: Using similar mathematical structures and techniques he formulated a multi-sectoral model of balanced economic growth, and employed Brouwer's fixed-point theorem in the proof of existence of a competitive general equilibrium for the first time. He used an explicit and full-duality approach and the linear activity description of technological choice in his model. (See Zalai's paper in this issue for details.)

Theory of Automata: Mathematicians Emil L. Post and Alan Turing did not build actual devices but only paper constructs. Their aim was to investigate a fundamental problem in formal logic. Turing showed that any particular automaton can be described by a finite set of instructions and that when this is fed into his universal automaton the latter will imitate the special one. Von Neumann was enormously intrigued with these ideas and he started working in two directions from 1947 on. First, he wanted to find out how complex a device or construct needed to be in order to become self-reproductive. Second, he also wanted to investigate the problem of how to organise devices that need to be made from potentially malfunctioning parts.

Computers: Von Neumann became involved in developing computers in 1944 and his first important achievement was the improvement of ENIAC (Electronic Numerical Integrator and Computer). "Sometime in the summer of 1944 ... I was waiting for a train to Philadelphia on the railroad platform in Aberdeen when along came von Neumann. ... The conversation soon turned to my work. When it became clear to von Neumann that I was concerned with the development of an electronic computer capable of 333 multiplications per second, the whole atmosphere of our conversation changed from one of relaxed good humour to one more like the oral examination for the doctor's degree in mathematics. Soon thereafter the two of us went to Philadelphia so that von Neumann could see the ENIAC. At this period the two accumulator tests were well underway" (Goldstine, 1973).

In 1947 von Neumann realised that the lack of a centralised control organ for the ENIAC was not an incurable deficiency. He suggested that the whole machine be programmed into a somewhat primitive stored programme computer. He turned the task over to Adele Goldstine, who worked out such a system and passed it along to Richard Clippinger, the head of Computing Laboratory at the Ballistic Research Laboratories at the time. He and his associates put the final touches on the idea by making certain amendments to it and made the new system run on the ENIAC in September 1948.

Let us quote Goldstine again: "(von Neumann) … proposed to use one or two of ENIAC function tables as the place to store the orders describing a problem and to wire up the ENIAC once and for all to understand this orders. With a few other tricks, it was possible to use various devices in the ENIAC to control the execution of the orders" (Goldstine, 1973). Von Neumann's contribution changed ENIAC from an electronic calculator to a primitive stored programme computer.

In June 1946 the University of Pennsylvania turned off and conferred ENIAC to the US government, which was then moved to Aberdeen and started up again in July 1947. The ENIAC became a most useful instrument operating until 2 October 1955.

The next step was the Electronic Discrete Variable Computer (EDVAC). The report entitled *First Draft of a Report on the EDVAC by John von Neumann*, prepared in 1945, discussed among other things the flexibility of the use of the EDVAC, storage capacity, computing speed, sorting speed, the coding of problems and circuit design. This paper was the first complete description of a stored programme computer. The Moore School of the University of Pennsylvania put EDVAC together with some difficulties, handed it over to the Ballistic Research Laboratories, and in 1950 it was also moved to Aberdeen.

Subsequently, in 1946, Eckert and Mauchly formed their own company (Electronic Control Co.) and von Neumann, Adele and Hermann Goldstine, Alice and Arthur Burks and others went to Princeton and constructed the IAS computer. The

Electronic Computer Project of the Institute for Advanced Study was undoubtedly the single most influential undertaking in the history of the computer during that period. It included a number of path-breaking innovations leading to the creation of the first computer built upon the same principles all modern computers follow. This was, for example, the first piece of IT equipment based upon von Neumann's idea of using the binary system instead of sticking to the longstanding tradition of building digital machines in the decimal system.

The new computer had also a relatively huge capacity of storage with a hierarchy of memories. The innermost (primary) memory had a capacity "of about 4000 numbers of 40 binary digits each", a secondary one was "of much larger capacity on some medium such as magnetic wire, or tape", and a tertiary one on paper tape or punch cards. This latter unit was also used for programme storage, which was another important innovation.

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