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ONE HUNDREDTH BIRTHDAY OF STANISŁAW ULAM

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"Mathematics is a very concise way of formulating all rational thoughts"
S. Ulam

This year marks the centenary of birth of Stanisław Marcin Ulam, an extremely talented and creative mathematician, the author of original theories that affected several areas of the discipline and of its spectacular implementations. To commemorate Professor Ulam's 100th birthday and to pay tribute to his great achievements it has been decided by the organizers of the international conference MSA 2009 that a substantial part of the meeting will be devoted to the areas to which he contributed the most significantly – i. e. mathematical statistics, the Monte Carlo method and the use of computers in statistics.

Stanisław M. Ulam was born on April 13, 1909 in Lvov in the family of Polish Jews who had emigrated from Venice three generations before. Jozef Ulam – Stanisław's father, was a barrister. When the World War I broke out the Ulam family moved to Vienne.

After the war, in 1919 Stanisław started his education in the Polish secondary school in Lvov. At that time the theory of relativity by Einstein was being discussed in detail. Ulam resolved to understand the theory and its consequences which, to a large extent, he managed to do. During his school years he got interested and started to examine the problem of odd perfect numbers i.e. numbers which are the sum of all their factors except for the number itself.

In 1927 he enrolled at the Technical University of Lvov where he was attracted by the lectures on the theory of sets given by professor Kazimierz Kuratowski.

Professor Kuratowski also took interest in his new student and the two spent a lot of time together. Ulam solved the first of the problems in the theory of sets assigned to him by the professor, and by doing so he discovered independently the technique of graphs whose existence he had not been aware of. This allowed Kuratowski to confirm his deep belief in Ulam's talent.

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It is worth mentioning that Lvov was at the time the place where eminent professors such as Kazimierz Kuratowski, Stanisław Mazur and Stefan Banach lectured at Lvov University and Lvov Technical University. They introduced Ulam to the arcane of the mathematical way of thinking and discovering process. He used to spend hours with them in the Scottish Café poring over a sheet of paper with just one symbol or function on it. They stared at it as if it was a crystal ball, which allowed concentration, and exchanged opinions and suggestions on the problem. One of those sessions spent in the Scottish Café together with Banach and Mazur lasted for about 17 hours with just a few short breaks taken for meals.

Many years later, when he was writing about the Lvov School of Mathematics, Ulam characterized it as dealing with "the heart of the matters" which constitute mathematics. He also recalled his Lvov milieu and the years spent there with feelings of warmth and gratitude.

At the age of 18 Ulam wrote his first paper and published it in Fundamenta Mathematicae in 1929. He presented some of his findings at the congress of mathematicians in Vilnus in 1931. A year later he participated in the congress in Zurich which helped him to build a firm belief in the power of Polish mathematics and his personal ability to find new ways of solving problems.

In 1932 Stanislaw Ulam obtained a master's degree in the set theory, and in 1933 he defended his doctoral dissertation written under the supervision of Kazimierz Kuratowski at the General Faculty of Lvov Technical University and published it in the Polish periodical Fundamenta Mathematicae (Ulam1930, 1933).

His papers, which he published since he was 18, were often written in joint authorship with: K. Borsuk (1931, 1933), K. Kuratowski (1932, 1933), Z. Łomnicki (1934), S. Banach (1947), S. Mazur (1932); (see K. Kuratowski (1973), Mycielski (1990).

In 1935 Ulam went to Princeton in the USA at the invitation of one of the greatest mathematicians of the previous century John von Neumann. Between the years 1936–1940 he was a member of the "Society Fellows" at Harvard University where he became the lecturer in 1940. In the years 1941–1943 he was a professor at the University of Wisconsin in Madison. For over three decades (1944–1967) he worked for Los Alamos National Laboratory in New Mexico, where he arrived at the invitation of his friend John von Neumann and his co-workers. In Los Alamos he became a member of Edward Teller's team working on the "superbomb" project whose head was Robert Oppenheimer.

In the years 1965–1967 he was a professor at the University of Colorado in Boulder.

Having obtained his first problem in Los Alamos in 1944, Ulam worked together with Cornelis Everett and managed to prove that the implementation of the "superbomb" project was unfeasible.

It is worth mentioning here that Ulam and Everett did all their calculations with the use of slide rules and old-fashioned, manually operated office

calculators. A few months later, using one of the first electronic computers, von Neumann confirmed that Teller's project of the "superbomb" was impossible.

Another problem related to the bomb was solved by Ulam in cooperation with Fermi in 1950 and it was done also with the use of slide rules and office calculators. As the two projects proposed by Teller proved to be wrong, Ulam put forward in 1951 a new project of hydrogen bomb which he called "Teller-Ulam device". The above facts reveal that Ulam had some innovative ideas about the bomb.

He also proposed to apply fast computers for solving different problems with the use of random numbers and the Monte Carlo method. Ulam suggested that the probability of obtaining different results should be determined by a computer simulation. The Monte Carlo method allows to program computer in such a way that each step of a particular game is taken according to a well-known probability, and we can determine the accuracy of the final result depending on the number of games in a sample.

The works of Stanisław Ulam cover many areas of mathematics and the related fields e.g. theories of: graphs, numbers, sets, transformations, groups, ergodic and measure, as well as topology, geometric topology, algebra, the Monte Carlo method, theory of combinations, mathematical statistics, branching processes, computers and computing, biomathematics and astronomy (cf. Oktaba, 2000). Ulam was the first one to define the infinite game in the Scottish Book. Everett and Ulam dealt with processes of Galton-Watson type, and their works discuss probability related to cascades of elementary particles induced by impact of very energetic particles or by atom disintegration. Their basic findings concerned the size of population of different particles neurons and uranium nucleus and proportions between population sizes. They used the classic Frobenius-Perron theorem on power of matrix with non-negative terms.

The subject matter of Ulam's and Stein's work is connected with the classic work of Wolterra on periodicity of population sizes of various species of fish in ponds.

While experimenting with the computer E. Fermi, J. Pasta and S. Ulam discovered that a vibrating cord, whose classic equation was disturbed by a non-linear term almost returns to its initial position much earlier than it would follow from statistical considerations.

In the works of Neumann, Richtmyer and Ulam (1947) and Metropolis and Ulam (1949) we can find an application of computers for statistical examination of means with the use of random sampling.

Ulam was interested in the theory of games and genetic distances within species. He perceived the world from the naturalist's point of view and was of the opinion that works of mathematicians enable a closer examination of the world of nature. Physics, biology and mathematical problems were important as long as they were related to achievements of mathematicians.

Throughout his life he published 161 studies, a number of abstracts, research announcements and summaries.

In joint authorship with M. Kac (1968) he wrote a study for Encyclopaedia Britannica entitled "Mathematics and Logic: Retrospects and Prospect". (cf. Wiadomości Matematyczne, 1993).

One of the fathers of the theory of chaos and mathematical physicist–Mitchell Feigenbaum, who was half-Polish and just like Stanislaw Ulam and Marek Kac came from Krzemieniec, was also very much interested in the secrets of nature. The term "mathematical physics" is used here to mean applying and constructing mathematics within the context of physical reality.

While Kac was the pioneer of developing the mathematical theory of probability and its applications mostly in statistical physics, Ulam's name is closely connected with the Monte Carlo method of numerical simulations.

As it was mentioned above, Ulam was an extremely versatile man equally interested in mathematics, astronomy, physics or the theory of relativity. Nowadays, an ever-increasing specialization in the field of mathematics is observed. In the field of physics the problems are defined in a much more precise manner and experiments in physics lead to formulating numerous problems and theories. In the case of mathematics, experiments can be of purely mental or theoretical nature. These days mathematicians have a wonderful, new invention at their disposal–the computer. Since the very beginning of his work in Los Alamos Ulam was connected with computers. At some point he came to the conclusion that the Monte Carlo method was not a great intellectual achievement, yet it was a very useful tool.

It is worth mentioning that the book entitled "*The Scottish Book : Mathematics from the Scottish Café"* came out in print on the basis of the manuscript received from Hugo Steinhaus and translated by Ulam. It encompasses circa 190 problems in their original form written in "The Scottish Book" by Banach, Mazur, Ulam and others, and supplemented with a commentary on advances in solving them. Ulam held those extremely inspiring conversations with Stefan Banach, Kazimierz Kuratowski, Stanisław Mazur and Hugo Steinhaus in cafés of Lvov.

Stanisław Ulam was closely connected with Los Alamos National Laboratory for over 30 years of his life. In the period 1957–1967 he was one of the two scientific advisers of Morris Bradbury–the director of Los Alamos National Laboratory. He became a member of the scientific committee of NASA and US Air Force. He was one of those who proposed starting work on sending the man on the moon to J. Wiesnerow – the scientific adviser to President John F. Kennedy (cf. Kobos A.M., 1999).

Stanisław Marcin Ulam died of heart attack in Santa Fe on May 13, 1984. His wife Francoise Ulam buried his ashes in the Montmartre Cemetery in Paris.

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