In memoriam: Dmitri Ivanenko (1904 – 1994)

In honor of the 110th Year Anniversary

(G. Sardanashvily, Science Newsletter, Issue 1 (2014) 16)

Dmitri Ivanenko (29.07.1904 – 30.12.1994), professor of Moscow State University, was one of the great theoreticians of XX century, an author of the proton-neutron model of atomic nucleus (1932).

D. Ivanenko was born on July 29, 1904 in Poltava (Russian Empire), where he began his creative path as a school teacher of physics. In 1923 Ivanenko entered Petrograd University. In 1926, while still a student, he wrote first scientific works with his friends George Gamov and Lev Landau (Nobel Laureate in 1962). After graduating the university, from 1927 to 1930 D. Ivanenko was a scholarship student and a researcher scientist at the Physical Mathematical Institute of Academy of Sciences of USSR. During these years he collaborated with Vladimir Fok and Viktor Ambartsumian, later to become famous.

In 1929 – 31, Dmitri Ivanenko worked at the Kharkiv Institute of Physics and Technology, being the first director of its theoretical division; Lev Landau followed him in 1932 – 37. Paskual Jordan, Victor Wieskopf, Felix Bloch (Nobel laureate in 1952) and Paul Dirac (Nobel Laureate in 1933) visited D. Ivanenko in Kharkiv. In Kharkiv, Ivanenko organized the 1st Soviet theoretical conference (1929) and the first soviet journal "Physikalische Zeitschrift der Sowjetunion" in foreign language (1932).

After returning to Leningrad at the Ioffe Physical-Technical Institute, D. Ivanenko concentrated his interest to nuclear physics. In May 1932, Ivanenko published his famous proton-neutron model of the atomic nucleus in “Nature” [18], and two months later Werner Heisenberg (Nobel laureate in 1932) referred to his work.
Iwanenko D., The neutron hypothesis, Nature, v.129, N 3265, p.798, 1932

In August 1932, D. Ivanenko and E. Gapon proposed the pioneer nuclear shell model describing the energy level arrangement of protons and neutrons in the nucleus in terms of energy levels [22]. Later this model was developed by Eugene Paul Wigner, Maria Goeppert-Mayer and J. Hans D. Jensen who shared the 1963 Nobel Prize for their contributions.

Ivanenko’s success pushed forward the nuclear physics in the USSR. In 1933 on the initiative of Dmitri Ivanenko and Igor Kurchatov, the 1st Soviet nuclear conference was organized. Paul Dirac, Frédéric Joliot-Curie (Nobel laureate in 1935), Fransis Perrin, Ftanko Rasetti, Victor Wieskopf et al participated in this Conference.

The realization of Ivanenko’s far-reaching plans and hopes was interrupted, however. In 1935 he was arrested in connection with the Sergey Kirov affair. Exile to Tomsk followed. D. Ivanenko was a professor at Tomsk and Sverdlovsk Universitie until the beginning of the World War II. From 1943 and until the last days of his life, he was closely associated with the Physics Faculty of M.V. Lomonosov Moscow State University.
Dmitri Ivanenko made the fundamental contribution to many areas of nuclear physics, field theory and gravitation theory.

In 1928, Ivanenko and Landau developed the theory of fermions as skew-symmetric tensors in contrast with the Dirac spinor model [4]. Their theory, widely known as the Ivanenko -- Landau – Kahler theory, is not equivalent to Dirac’s one in the presence of a gravitational field, and only it describes fermions in contemporary lattice field theory.

In 1929, Ivanenko and Fock generalized the Dirac equation and described parallel displacement of spinors in a curved space-time (the famous Fock – Ivanenko coefficients) [9]. Nobel laureate Abdus Salam called it the first gauge field theory.

In 1930, Ambartsumian and Ivanenko suggested the hypothesis of creation and annihilation of massive particles which became the corner stone of contemporary quantum field theory [16].

In 1934 Dmitri Ivanenko and Igor Tamm (Nobel Laureate in 1958) suggested the first non-phenomenological theory of paired electron-neutrino nuclear forces [24]. They made the significant assumption that interaction can be undergone by an exchange of massive particles. Based on their model, Nobel laureate Hideki Yukawa developed his meson theory.

In 1938, Ivanenko proposed a non-linear generalization of Dirac's equation. Based on this generalization, W. Heisenberg and he developed the unified nonlinear field theory in 50th [69].

D. Ivanenko, P.A.M. Dirac and W. Heisenberg (Berlin, 1958)

In 1944, Dmitri Ivanenko and Isaak Pomeranchuk predicted the phenomenon of synchrotron radiation given off by relativistic electrons in a betatron [39]. This radiation was soon discovered by American experimenters D. Bluitt (1946) and H. Pollock (1947). Synchrotron radiation possesses a number of very particular properties which provide its wide applications. In particular, neutron stars also are sources of this type radiation. Classical theory of synchrotron radiation was developed by Dmitri Ivanenko in
collaboration with Arseny. Sokolov in 1948, and independently by Julian Schwinger (Nobel Laureate in 1965). For their work on synchrotron radiation, D. Ivanenko, A. Sokolov and I. Pomeranchuk were awarded the Stalin Prize in 1950.

Iwanenko D., Pomeranchuk I., On the maximal energy attainable in betatron, Physical Reviews, v.65, p.343, 1944

Two of D. Ivanenko's and A. Sokolov's monographs "Classical Field Theory" and "Quantum Field Theory" were published at the beginning of the 50th. "Classical field theory" was the first contemporary book on field theory where, for instance, the technique of generalized functions was applied. Nobel laureate Ilya Prigogine referred to it as his text-book.

In 1956, D. Ivanenko developed the theory of hypernuclei discovered by Marian Danysz and Jerzy Pniewski in 1952.

At the beginning of the 1960's, D. Ivanenko did intensive scientific and organizational work on the development and coordination of gravitation research in the USSR. In 1961,
on his initiative the 1st Soviet gravitation conference was organized. D. Ivanenko was
the organizer of Soviet Gravitation Commission, which lasted until the 1980's. He was a
member of the International gravitation Committee since its founding in 1959.

In the 70 – 80th, D. Ivanenko was concentrated on gravitation theory. He developed
different generalizations of Einstein’s General Relativity, including gravity with torsion,
the hypothesis of quark stars [63] and gauge gravitation theory [79]. In 1985, D.
Ivanenko and his collaborators published two monographs “Gravitation” and "Gauge
Gravitation Theory".

Theoretical physics in the USSR has been enormously influenced by the seminar on
theoretical physics organized by D. D. Ivanenko in 1944 that has continued to meet for
50 years under his guidance at the Physics Faculty of Moscow State University. The
distinguishing characteristic of Ivanenko’s seminar was the breadth of its grasp of the
problems of theoretical physics and its discussion of the links between its various
divisions, for example, gravitation theory and elementary particle physics. The most
prominent physicists in the world participated in the seminar: Niels and Åage Bohr, Paul
Dirac, Hideki Yukawa, Julian Schwinger, Abdus Salam, Ilya Prigogine, Samuel Ting,
Paskual Jordan, Tullio Regge, John Wheeler, Roger Penrose et al.

The scientific style of Dmitri Ivanenko was characterized by great interest in ideas of
frontiers in science where these ideas were based on strong mathematical methods or
experiment.

It should be noted that seven Nobel Laureates: P.A.M. Dirac, H. Yukawa, N.Bohr, I.
Prigogine, S. Ting, M. Gell-Mann, G. ’t Hooft wrote their famous inscriptions with a chalk
on the walls of Ivanenko’s office in Moscow State University.

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