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## AN ANTHOLOGY OF THE DISTINGUISHED ACHIEVEMENTS IN SCIENCE AND TECHNIQUE. PART 35: NOBEL PRIZE LAUREATES IN PHYSICS FOR 1990-1994

*Purpose. Implementation of brief analytical review of the distinguished scientific achievements of the world scientists-physicists, awarded the Nobel Prize in physics for period 1990-1994. Methodology. Scientific methods of collection, analysis and analytical treatment of scientific and technical information of world level in area physics of elementary particles, physics of high energies, of astrophysics, of modern theoretical and experimental physics. Results. The brief analytical review of the scientific openings and distinguished achievements of scientists-physicists is resulted in area of modern physical and technical problems which were marked the Nobel Prize in physics for period 1990-1994. Originality. Systematization is executed with exposition in the short concentrated form of the known scientific and technical materials, devoted pioneer researches results on dispersion of relativism electrons on protons (neutrons), to opening of likenesses of physics of hard matter and physics of the condensed state of matter, creation of revolutionary detector of elementary particles, to opening of new pulsars and new possibilities in the study of gravitation, to creation of neutron spectroscopy and method of neutron diffraction. Practical value. Popularization and deepening of scientific and technical knowledges for students, engineer and technical specialists and research workers in area of modern theoretical and experimental physics, extending their scientific range of interests and cooperant further development of scientific and technical progress in human society. References 25, figures 12.*

*Key words: modern physics, achievements, dispersion of relativism electrons on heavy particles, physics of hard matter and condensed state, multielectrode detector of elementary particles, new pulsars and gravitation, neutron spectroscopy and diffraction, review.*

*Приведен краткий аналитический обзор выдающихся научных достижений ученых мира, отмеченных Нобелевской премией по физике за период 1990-1994 гг. В число таких достижений вошли результаты пионерских исследований по рассеянию релятивистских электронов на протонах и нейтронах, открытие сходств физики твердой материи и физики конденсированного состояния вещества, создание революционного детектора элементарных частиц, открытие новых пульсаров и новые возможности в изучении гравитации, создание нейтронной спектроскопии и метода нейтронной дифракции. Библи. 25, рис. 12.*

*Ключевые слова: современная физика, достижения, рассеяние релятивистских электронов на тяжелых частицах, физика твердой материи и конденсированного состояния, мультиэлектродный детектор элементарных частиц, новые пульсары и гравитация, нейтронная спектроскопия и дифракция, обзор.*

**Introduction.** The world-renowned Swedish engineer, inventor of explosives and businessman Alfred Nobel (1833-1896) bequeathed to the respective fund 31.5 million SEK (at the time of about 5 million USD) [1] for the monetary rewards of the future Nobel Prize winners perpetrators of outstanding discoveries in physics and chemistry, and have achieved outstanding results in the field of physiology (medicine), literature and peace among peoples. We note that, personally handed the outstanding German experimental physicist Wilhelm Conrad Roentgen (1845-1923) «for the discovery of X-rays» [2] for 1901 the first Nobel Prize in Physics was, but gold medals (Fig. 1) and diploma embodiment, similar to that shown in Fig. 2, and relied check in the amount of 150 thousand SEK [3].



Fig. 1. Constant view of obverse and reverse of the gold medal of winners of the Nobel Prize in Physics [2, 3]

Over time, the amount of monetary award to the group of authors (no more than three co-authors) of this prestigious international award was increased and in 2011 was already 10 million SEK (1.3 million USD) [2, 3].

Taking into account the importance of the scientific results of Nobel Laureates, professional scientific interest of the author – electrophysicist and scientific and technical profile of our Journal, we will try, by five short essays in its five issues to present the principal outstanding achievements in science and technology by only Nobel Prize Laureates in Physics for the current period 1990-2015.

**1. The scattering of electrons on the elementary particles and the quark model in particle physics.** In 1990, «for pioneering studies of deep inelastic scattering of electrons on protons and coupled neutrons, which are essential for the development of the quark model in particle physics» American experimental physicists Jerome Isaac Friedman (Fig. 3) and Henry Way Kendall (Fig. 4) and Canadian-American experimental physicist Richard Edward Taylor (Fig. 5) have been awarded the most important in science Nobel Prize in physics [2, 6-8].



Fig. 2. Exterior of the Nobel Diploma of Prize Laureates in Physics for 1903 the prominent French experimental physicists Pierre and Marie Curie [4, 5]

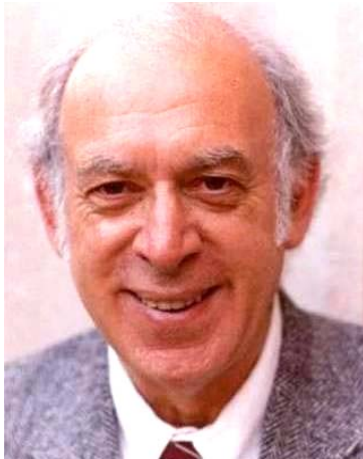


Fig. 3. Prominent American experimental physicist Jerome Isaac Friedman, born in 1930, Nobel Prize Laureate in physics for 1990

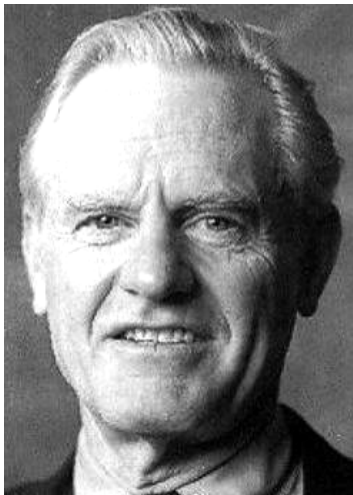


Fig. 4. Prominent American experimental physicist Henry Way Kendall (1926-1999), Nobel Prize Laureate in physics for 1990



Fig. 5. Prominent Canadian-American experimental physicist Richard Edward Taylor born in 1929, Nobel Prize Laureate in physics for 1990

In the period 1967-1973 J.A. Friedman [6] together with his colleagues H.W. Kendall [7] and R.E. Taylor [8] conducted a complex of important in the field of high energy physics experimental studies on the newly launched into operation (in 1967) the world's largest Stanford electron linear accelerator on energy to 21 GeV at the length of his accelerator vacuum tube of 2 miles (about 3200 m) [2, 5]. The aim of this work was to determine the characteristics of the scattering of electrons accelerated to relativistic speeds beginning with protons in the future related to the breeder. It was assumed that electrons accelerated in the accelerator of charged particles to speeds close to the speed of light in a vacuum, «will» through or the «jump» the said elementary particles [6]. However, in practice it turned out that most of these electrons «bounced» from protons at different angles. And so that these nuclear physicists evolved the belief that the accelerated electrons consist of smaller elementary particles, whereas conventionally called «quarks»[6]. According to modern concepts under the «quark» in the elementary particle physics meant a hypothetical elementary particles with fractional electric charge ( $1/3$  and  $2/3$  of the electron charge  $e_0=1.602 \cdot 10^{-19}$  K) of which may consist of elementary particles (e.g., hadrons, including such heavy particles like baryons with half-integer spin, which the weight of no less than the mass of the proton), involved in strong interactions [9, 10]. As a result of processing results performed pioneering experiments and classifications found particles of the nuclear physicists presented the international scientific community a set of «quark», named [6]: up, down, charm, strange, truth and beauty. Received by them on the Stanford electron linear accelerator experimental data were extremely important for the development of modern physics, the quark structure of elementary particles [2, 6-8].

**2. Opening many similarities of physics of solid matter and the physics of condensed matter.** In 1991, the Nobel Prize in Physics was awarded the French physicist Pierre-Gilles de Gennes (Fig. 6) «for discovering that methods developed for studying order in phenomena in simple systems can be generalized to liquid

*crystals and polymers*» [2, 11]. According to the data given in [11], P.-G. de Gennes in 1968 switched to the study of liquid crystals. Over time, he became a leading physicist in the field of polymer and colloidal systems. In 1977 he published the monograph «The Physics of Liquid Crystals» which is to this day a basic tool in this research field. [11] He is one of the founders of the physics of liquid crystals. Its share had the honor to become a pioneer in the field of physics of soft materials - polymers, surfactants, liquid crystals and colloidal systems. It is with P.-G. de Gennes was opened physico-chemical structure (ferroelectric smectic), marked the beginning of the production of liquid crystal displays for computers, TV-sets and mobile phones [11-13]. For a number of fundamental developments in the field of physics they called him «Newton of our time» [2, 11].

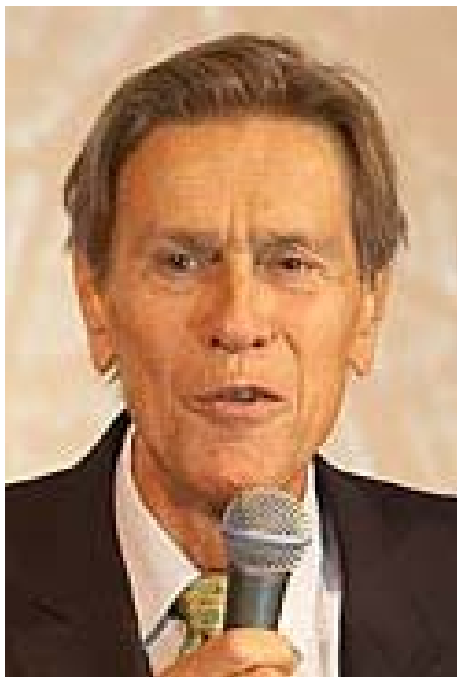


Fig. 6. Prominent French physicist Pierre-Gilles de Gennes (1932-2007), Nobel Prize Laureate in physics for 1991

After receiving the Nobel Prize P.-G. de Gennes became Director of the «École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris» ( ESPCI). [11] At this highest administrative and academic position he remained until 2002. A lot of time and energy he devoted to educational institutions of France, while sharing with the students and the students of his scientific knowledge.

**3. The invention of proportional chamber and particle detectors.** In 1992, «*for the discovery and creation of particle detectors, in particular the multiwire proportional chamber*» French experimental physicist Georges Charpak (Fig. 7) was awarded the Nobel Prize in physics [14].

Our next winner of the Nobel Prize G. Charpak had difficult for his generation and at the same time bright human destiny. He was born in the Polish village of Dąbrowica (now the city of Dubrovitsa, Ukraine) in a Jewish family of Polish origin. In 1931 his family moved to Paris.



Fig. 7. Prominent Polish-French experimental physicist Georges Charpak (1924-2010), Nobel Prize Laureate in physics for 1992.

During World War II he participated in the resistance movement, fighting against Nazi Germany. In the period of 1944-1945 in difficult conditions he was in a Nazi concentration camp Dachau near Munich [15]. In 1945, after his release, he joined the Parisian École des Mines – one of the most prestigious engineering schools in France (since 1946 he was naturalized French citizen). After receiving the Bachelor degree in 1948, G. Charpak started to work at the National Center for Scientific Research, and later in a scientific laboratory at the «Collège de France» of outstanding nuclear physicist, Nobel Prize Laureate in Chemistry for 1935 (together with his wife Irene Curie - the sister of Eve Curie [4] «*for discovery of artificial radioactivity and synthesis of new radioactive elements*») Frederic Joliot-Curie [2, 5] (1900-1958). In 1954 he defended his Doctoral Thesis on the results of his work in this laboratory in the field of nuclear physics [15]. In 1959, G. Charpak became a member of the research team at the European Center for Nuclear Research (CERN, Geneva, Switzerland). In this scientific center G. Charpak in 1968 and made his important scientific discovery – he created a multielectrode proportional chamber («Charpak chamber») for the detection of elementary particles [16]. Connection of this camera (this detector) with a computer, according to the inventor of this original physical-technical device, increased the speed of gathering information about the test particles millions of times [16]. At present, none of the experiment in the field of high energy physics is possible without such «Charpak detector». This invention was of revolutionary character in the field of elementary particle physics [2, 16].

**4. The discovery of new pulsars, and new possibilities for the study of gravitation.** In 1993, «*for the discovery of a new type of pulsar which gave new possibilities for the study of gravitation*» American physicists-astronomers Russell Alan Hulse (Fig. 8) and Joseph Hooton Taylor Jr. (Fig. 9) received the Nobel Prize in physics [17, 18] . Their astronomical discoveries related to the discovery of the universe of double pulsar

PSR B1913+16 R.A. Hulse and J.H. Taylor Jr. made in 1974 carrying out joint astronomy observations on the unique US radio telescope «Arecibo» (Fig. 10), established in Central America (Puerto Rico) having a perforated aluminum parabolic reflector with a diameter of 305 m [17-19].



Fig. 8. Prominent American physicist-astronomer Russell Alan Hulse, born in 1950, Nobel Prize Laureate in physics for 1993



Fig. 9. Prominent American physicist-astronomer Joseph Hooton Taylor Jr., born in 1941, Nobel Prize Laureate in physics for 1993

Recall that under the «pulsars» (this term is from the English word «pulsars» - «pulsed radiation sources» [9]) refers to cosmic sources coming to Earth radio, optical, X-ray and gamma radiation. In radio pulsars, which are rapidly rotating neutron stars, radio pulse periods enclosed in the range (0.03-4) s [9]. In X-ray pulsars which are binary stars where the first neutron star material flows from the second ordinary star, periods of pulses ranging from a few seconds to tens [9]. The first pulsars were discovered in 1967 (such as a radio pulsar CP 1919 with a period of pulsation of its directional radiation in 1.33 s) by astronomers at Cambridge University

(England) Anthony Hewish (born in 1924) with the assistance of his colleague Jocelyn Bell [20]. For this discovery E. Hewish was awarded the 1974 Nobel Prize in physics [2]. In 1991 R.A. Hulse and J.H. Taylor Jr. after 17 years of his careful astrophysical study of said continuously varying in sizes double pulsar, by measuring the declining orbit of the pair of amazing stars found confirmation of general relativity [2, 18]. In addition, in the course of this study the type of the binary pulsar PSR B1913+16, astronomers, these scientists were able to show that they have studied star system may emit gravitational waves [18, 20].



Fig. 10. General view of the unique radio telescope in Arecibo (set in a natural rock basin) managed by Cornell University and a member of the US National Centre for Astronomy and Ionosphere [20]

**5. Creation of neutron spectroscopy and neutron diffraction method.** The Nobel Prize in physics for 1994 was awarded to the Canadian experimental physicist Bertram Neville Brockhouse (Fig. 11) «for the creation of neutron spectroscopy» jointly and in equal shares with American experimental physicist Clifford Glenwood Shull (Fig. 12) «for the creation of the method of neutron diffraction» [21, 22]. Thorny scientific way for the native of a poor family B.N. Brockhouse has served as a volunteer in the Navy in Canada the entire period of the Second World War, it began with his admission in 1945 with the assistance of the Department of Veterans Support to the University of British Columbia [21]. In 1950, B.N. Brockhouse defended his Doctoral Thesis and begins to work in a scientific laboratory Chalk River engaged in the acquisition and use of nuclear energy. In 1955, B.N. Brockhouse together with its employees specializing in the field of neutron physics developed and produced a three-axis neutron spectrometer [21, 23]. After 10 years of fruitful work in the field of nuclear physics, he heads the Department of neutron physics in this large Canadian institution.

Talented Canadian physicist B.N. Brockhouse actually created a new trend in the field of neutron physics associated with the measurement of spectra of fast and slow neutrons and other elementary particles, including the quasi-particles (photons) [21, 23].

C.G. Shull after studying at the US Carnegie Institute of Technology in 1937 was connected to the

work of the research group at the Faculty of Physics, New York University in the field of nuclear physics [22]. Before he and his colleagues were given the task to create a high-voltage generator according to the known scheme Cockcroft-Walton [5] to accelerate deuterons D (nuclei of hydrogen isotopes - deuterium  ${}^2\text{H}$ ) to energy of 200 keV [22]. He participated in the first tests of the generator and the implementation with the help of the form of nuclear experiments D-D - reactions [24]. In 1941, C.G. Shull received the degree of Doctor of Philosophy. From 1946 he switches to the nuclear issue and moved to a secret area near the Tennessee River (United States) to work at the famous Oak Ridge National Laboratory [5, 22]. There he teamed up with the American physicist Ernest Vollan who died in 1984 and is therefore not share inherited C.G. Shull honor of presenting him in 1994 Nobel Prize, creates a simple two-axis spectrometer for neutron diffraction patterns of crystals and other materials [25].



Fig. 11. Prominent Canadian physicist Bertram Neville Brockhouse (1918-2003), Nobel Prize Laureate in physics for 1994



Fig. 12. Prominent American experimental physicist Clifford Glenwood Shull (1915-2001), Nobel Prize Laureate in physics for 1994

C.G. Shull is successfully studying neutron coherent scattering of many chemical elements from the periodic system of elements of D.I. Mendeleev [25]. He explores the dynamic diffraction and neutron waves spread in a variety of crystals. As a result of many years of fruitful work, C.G. Shull actually becomes the founder of structural neutron physics [2, 25]. It is considered to suppose that a time period that has elapsed since the creation in the field of neutron physics of neutron diffraction method to presenting the considered high scientific awards to C.G. Shull together with B.N. Brockhouse is yet the largest in the history of the Nobel Prizes [24].

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