Physics – Uspekhi **50** (7) 763 – 765 (2007)

PERSONALIA

PACS number: **01.60.+q**

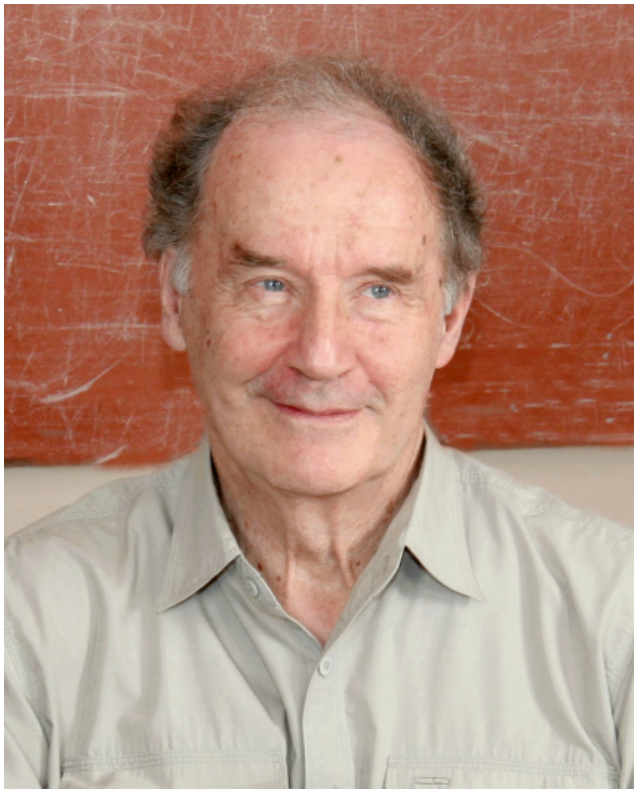
Vladimir Ivanovich Ritus (on his eightieth birthday)

DOI: 10.1070/PU2007v050n07ABEH003474

Vladimir Ivanovich Ritus, Corresponding Member of the Russian Academy of Sciences, an outstanding Russian physicist whose name is closely connected with progress in modern quantum electrodynamics as the nonlinear theory of electromagnetic interaction celebrated his 80th birthday on 23 May 2007.

Vladimir Ivanovich was born in Moscow. His parents, both researchers at the Timiryazev Academy of Agriculture, worked in plant-growing and entomology. V I Ritus's path to theoretical physics was far from straightforward and rather tortuous. By the time he graduated brilliantly from his first year at the Moscow Aviation Institute (MAI) — this was in 1945 — the field of heroics moved from aviation to nuclear physics and V I Ritus decided to sacrifice one year to make his knowledge more fundamental, and to transfer to Moscow State University (MGU). The Chancellor of MGU at the time had shortsightedly decided that wasting valuable human resource in this way was unacceptable and banned Ritus's transfer "because he was doing well at MAI" (!?) — until certain pressure was exerted on him. Ultimately, Vladimir Ivanovich wrote his graduation thesis at the P N Lebedev Physical Institute of the USSR Academy of Sciences (FIAN) as an experimenter in I M Frank's laboratory. In the course of this graduation project he designed a coincidence circuit of scintillation counters and measured the angular correlation of cascade gamma quanta of some radioactive nuclei.

V I Ritus's work at FIAN on his thesis during his postgraduate course (he was enrolled in January 1951) was interrupted by being assigned, on the strength of M A Markov's recommendation, to what was known at the time as the First Main Directorate of the USSR Council of Ministers, later rechristened the Ministry of Medium Machine Building (Sredmash) — a powerful state body placed above any other in the name of implementing the Soviet Government-sponsored program of thermonuclear weapons design. Working in the highly classified town of Sarov, then denoted by euphemism 'object' [in fact, in the theoretical department formed by I E Tamm within the Design Bureau No. 11 (KB-11)], V I Ritus took part directly in the work of creating the RDS-6S thermonuclear device, known as 'sloika' (a layer cake), and drew up under Andrei D Sakharov's guidance mathematical task orders for L D Landau's and A N Tikhonov's groups which computed energy release from sloika. Vladimir Ivanovich studied the efficiency of fission of ^{238}U nuclei by neutrons from dd- and dt-reactions, computed the neutron ranges in lithium deuteride, and evaluated the energy release from sloika for various concentrations of ^{6}Li and tritium. The successful test of the Soviet hydrogen bomb on August 12, 1953 that, according to G M Malenkov's declaration, marked the end of the American monopoly on this sort of weapon, was commemorated for V I Ritus by receiving a Class III Stalin Prize. To V I Ritus belongs the suggestion of double implosion made in 1954 in the wake of the 'third idea' (as Sakharov put it) that assumed the use of the pressure of radiation and was realized in higher-power devices of subsequent generations: RDS-37 and others. In this, however, V I Ritus played no part and was even kept completely ignorant of the fate of his suggestion (until very recently). In the spring of 1955, I E Tamm succeeded at last in returning V I Ritus, who had continued to work in Sarov under the veil of extraordinary secrecy, to academic research — but this time, and now irreversibly, as a theoretical physicist in the Theoretical Department of FIAN.



Vladimir Ivanovich Ritus

The first stage of this life, new to V I Ritus, was inspired by Fermi's experiments on interaction between π-mesons and nucleons, in which the resonance nature of a scattering cross section was discovered. Vladimir Ivanovich studied the photoproduction of π-mesons and scattering of photons by nucleons, taking into account the excited states of nucleons. The angular polynomials-matrices he introduced became an efficient tool when considering polarization effects in nuclear reactions. V I Ritus's thesis for Candidate of Physicomathematical Sciences presented a theory of reactions involving polarized particles; it was submitted and defended in 1959 but published only in 1971, by which time its results were already

Uspekhi Fizicheskikh Nauk **177** (7) 801 – 802 (2007)
Translated by V I Kisin

in general use and incorporated into monographs written by other people.

This was when the legend of his infallibility when conducting complicated and cumbersome computations, by now quite well established, just started to take root; its protagonist did nothing that would sully this reputation, neither then nor later. Science is unaware of any errors ever made by Ritus!

The 1960s is the period when an exceptionally fruitful creative fellowship formed between V I Ritus and Anatoly Il'ich Nikishov, that was rarely interrupted in the following years; together they carried out calculations dealing with the most important quantum-electrodynamical processes in high-intensity external fields, which earned them the I E Tamm Award of the USSR Academy of Sciences (1983), and worked on other research projects.

Vladimir Ivanovich Ritus earned his reputation in physics through his work in high-intensity-field quantum electrodynamics. These results were partly incorporated in his thesis for Doctorate of Physicomathematical Sciences submitted and defended in 1969 and also published in the famous Volume 111 of the *FIAN Proceedings* for 1979. This volume, plus Volume 168, which appeared in 1986 and contained subsequent results, became must-have handbooks that were usually extremely dog-eared and worn to tatters by not only those who, like V I Ritus himself, remained faithful to quantum electrodynamics as the frontline reliable quantum-field theory, but also by those who did computations of processes in intense fields due both to weak and quantum-chromodynamical interactions, and nuclear decay processes. In fact, Vladimir Ivanovich himself in his paper pioneered the application of appropriate methods to neutrino astrophysics, now widely used, when he found that the probabilities of photoproduction of neutrino pairs on electrons are essential for studying energy balance in stars and supernova explosions.

Quantum electrodynamics (QED) established itself brilliantly in the 1950s as a perfect theory, owing to impeccable agreement with experimental data. Measurements of the Lamb shift, a phenomenon occurring in the strong field of the nucleus, played an important role in this. Other issues became pressing later: is there a limit to QED applicability in the range of strong fields and short distances to field sources, how can the nonlinear nature of QED be established experimentally, i.e., how can the interaction between electromagnetic fields, the property that distinguishes quantum electrodynamics from the classical one, be detected?

The most important quantity responsible for the nonlinearity of the QED is the effective Lagrangian found as a function of constant electric and magnetic fields. Extending the classical works of W Heisenberg and H Euler, V Fock, J Schwinger, V I Ritus found this function with principally important two-loop accuracy (two is the number of electron loops in the Feynman diagram). In addition, he and S L Lebedev studied the radiative corrections to the probability of pair creation by the electric field, which contained in the resulting expressions: this is the most significant process pointing to the instability of a vacuum in this field. V I Ritus was able to show in a spectacular manner that the asymptotics of the effective two-loop Lagrangian have the same logarithmic form in the high-field limit as the asymptotics of the conventional (with no external field) polarization operator in the same two-loop approximation in the high-momentum range. This result established a relation between the QED of a high-intensity field and quantum electrodynamics at short distances, and also gave foundation to the notion that the well-known internal contradiction of the QED connected with the asymptotics at high momenta is also transferred to the high-field range. The values are unreasonably high in both cases, so the prevailing view is that other, nonelectromagnetic interactions will come into play long before the theoretical limit of QED applicability is reached.

This does not make less important the need to check QED in the range of high fields by measuring nonlinear effects which were assumed to become appreciable at intensities of the electric or magnetic fields on the order of 4.4×10^{13} CGSE. These values are also very high but they become realistic in astrophysical environments, or may be reduced due to resonance effects. V I Ritus and A I Nikishov made the key observation that the effective parameters that introduce nonlinearity into the interaction are also, in addition to field strength invariants, mixed invariants that contain both the field and the 4-momenta, i.e. the invariants characterizing the particles taking part in the process or the variability of the external field. Therefore, insufficiently high field strength can be compensated for by high particle energy or by varying the external field frequency. This factor allowed conducting the first observations, once laser intensities increased sufficiently at the end of the 1990s, of nonlinear electrodynamic effects (photon emission by electrons and creation of an electron–positron pair by a photon in the intense laser field, with up to four quanta borrowed from it) in accordance with the calculations made long before this by V I Ritus and A I Nikishov.

This key observation also signify that when the mixed invariants are high, while field invariants are sufficiently low, the latter can be neglected; this implies in turn that a particle in its co-moving frame of reference senses the external field as if it had zero invariants — that is, as if it was a so-called crossed field whose electric and magnetic fields are mutually orthogonal and equal in magnitude. It is clear that calculations are much more simplified in a crossed field and can be taken considerably further. This explains V I Ritus's special interest in quantum processes in crossed fields. Its most impressive manifestation was the calculation carried out by V I Ritus together with V O Papanyan of the polarization tensor of rank three — the interaction vertex of three photons (including — for the first time in the world — off-mass-shell photons) which yields the contribution to the Lagrangian of its interaction (in fact, self-action) that is cubic in alternating electromagnetic field and is responsible for the nonlinear optical process of a photon splitting into two or of two photons merging into one in the external field (this process is forbidden in the absence of an external field or medium).

Nor did V I Ritus shun studies of quantum processes directly in constant electromagnetic fields of the general type. This work involved the calculation of the electron mass operator, including two-loop corrections to it (the latter was done together with D A Morozov), which resulted in finding the shift and splitting (in spin degree of freedom) of electron mass, and in finding the anomalous magnetic moment and induced electric moment as functions of the field and momentum. The discovery by V I Ritus of the complete set of matrix functions that are eigenfunctions (with matrix-valued eigenvalues) for the Dirac operator with the external

field and diagonalizing the exact mass operator was like a side product of this analysis. The resulting expansion proved to be of much use in a wider class of problems and is frequently applied (it is known under the name 'the Ritus E_p-functions method').

What is amazing in V I Ritus's work is the way he manages never to lose sight of the crystal-clear physical meaning (and to always do it in a superelegant manner) of what occurs in the course of very cumbersome transformations (or 'rebottling', as he likes to put it) and how he is on a first name basis with the 'centaurs' generated on the way. One of the manifestations of this art was an interesting physical interpretation of renormalization of the electron mass in the course of calculations of the two-loop Lagrangian.

We have not mentioned here many other outstanding achievements of the protagonist of this jubilee. The reader can look up some of them, e.g., in the article published in *Physics – Uspekhi* ten years ago on the occasion of V I Ritus's seventieth birthday (Vol. 40, p. 545).

In recent years, V I Ritus has fallen in love with an idea which, on the one hand, is in the mainstream of current developments that arose following the success of the string theory (when correspondence is established between phenomena that unfold in configurational spaces of unequal dimensions) but, on the other hand, is a natural application of the experience accumulated by V I Ritus and an implementation of what he favors most in science. He demonstrated a symmetry between pair production by an accelerated pointlike mirror in two-dimensional spacetime and the emission of photons by a pointlike electric charge in the ordinary four-dimensional world. The relevant spectra coincide not just functionally but exactly too if, in correspondence with the pointlike nature of the sources, the fine-structure constant is assumed to be bare and have the value equal to $1/4\pi$ [see V I Ritus in *Zh. Eksp. Teor. Fiz.* **129** 664 (2006)]. This intriguing result that explains the weakness of the electromagnetic interaction for any momentum transfer is waiting for more profound analysis, expansion, and interpretation.

V I Ritus, already in possession of a State Prize and an I E Tamm Prize of the USSR Academy of Sciences, was also awarded the Order of Honor. He is a member of the Bureau of the Physical Sciences Division of the Russian Academy of Sciences, a member of the editorial board of the journal *Physics Uspekhi*, and a member of the Learned Councils of FIAN, OTF FIAN, and ITEP.

His friends, colleagues, and disciples wish Vladimir Ivanovich Ritus good health, a never failing creative drive, and much success — first and foremost in the field to which he has now chosen to devote his efforts.

B M Bolotovsky, M A Vasil'ev, B L Voronov,
V L Ginzburg, A V Gurevich, N S Kardashev,
A A Komar, L V Keldysh, A I Nikishov,
M A Solov'ev, I V Tyutin, A E Shabad