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On the Ninetieth Birthday of Sergei Glebovich Rautian

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The second day of our conference (18 December) coincided with the ninetieth birthday of Sergei Glebovich Rautian (1928–2009), a world-renowned scientist; corresponding member of the Russian Academy of Sciences (RAS); foremost expert in optics, spectroscopy, laser physics and physical kinetics; and one of the founders of nonlinear laser spectroscopy. Some of his many scientific achievements are directly related to the subject matter of the conference: developed by Rautian and his pupils, probe field spectroscopy in three-level systems (in particular in lambda systems) became basic to ultrahigh-resolution spectroscopy, which in particular contains the coherent population trapping (CPT) effect, important for frequency standards based on ultracold atoms.

Rautian was born in Leningrad in physicists' family: his father, Gleb Nikolaevich Rautian, was a professor and doctor of engineering, and his mother, Lidiya Ivanovna Demkina, was a doctor of engineering. In 1952, after graduating from the Faculty of Physics, M.V. Lomonosov Moscow State University, Rautian was directed to work at the P.N. Lebedev Physical Institute (LPI), USSR Academy of Sciences. Being a pupil of Academician Landsberg, one of the fathers of Russian physics, and working several years under his guidance, Rautian adopted his teacher's approach to science, which can be briefly formulated as follows: thoroughness in addressing scientific issues, with results brought to complete clarity. The fruitfulness of this approach showed up even in his candidate of science dissertation, which was concerned with the theory of real spectroscopic instruments and a reduction to an ideal instrument, which became a classic work and is still cited today by scientists all over the world.

From the beginning of the development of lasers – new, unique devices – in the Soviet Union, laser optics and spectroscopy became the key area of research for Rautian. A diversity of novel fundamental results were obtained by Rautian (some of them, in cooperation with I.I. Sobel'man) as early as the mid-1960s, during his work at LPI. The kinetics of stimulated radiative transitions were shown to depend significantly on relaxation constants of the levels involved and the spectral composition and geometric configuration of the optical field. Besides, they take special features due to the thermal motion of gas particles and collisions. A so-called probe light field method was proposed for the first time and subsequently developed, which turned out to be an effective tool for studying the properties of a medium exposed to laser light and became one of the key methods of modern nonlinear spectroscopy. The method made it possible to demonstrate a radical modification of a small-signal absorption spectrum in the presence of high-intensity resonance light. The modification is so drastic that, in some parts of the spectrum, absorption gives way to gain and vice versa. Thus, Rautian and Sobel'man predicted 'amplification without inversion' in 1961, long before it became a 'fashionable' area of research. The Autler–Townes effect (splitting of energy levels under the effect of light) was shown to play a fundamental role in the formation of spectral properties of a medium in a high-intensity optical field. In particular, based on this finding Rautian and Sobel'man predicted a triplet structure of a resonance scattering (resonance fluorescence) spectrum in 1961, long before it was done by Mollow (after whom the triplet was named).

Rautian was one of the first who paid attention to 'sub-Doppler' capabilities of laser spectroscopy: in 1963 he demonstrated that the spectrum of spontaneous emission of atoms in thermal motion contains a sharp spectral structure of natural width on the Doppler background. This structure, and the Lamb dip, found in the same year, were the first nonlinear resonances, marking the beginning of ultrahigh-resolution sub-Doppler spectroscopy.

Rautian proposed and substantiated a method adequate to nonlinear spectroscopy issues: a quantum rate equation for the density matrix. Subsequently, it became an indispensable tool for solving problems related to interaction of laser light with gaseous media.

An appreciable contribution was made by Rautian and Sobel'man to the physics of lasers proper: they proposed how to obtain lasing in a molecule photodissociation process, which was then successfully implemented.

An unconventional outcome of Rautian's work at LPI was his doctoral dissertation, defended in 1966 and published at the Trudy FIAN journal, which became a desk companion for his many pupils and colleagues.

At the same time, his talent as a scientist and science manager became most evident during his activities in Siberia. In 1965, Rautian moved to Novosibirsk Akademgorodok, which was then being created. He brought his methods, approaches, expertise and knowledge accumulated during his work at LPI. During the nascent stage of laser physics as a science, this contributed to the development of young experts pursuing work in the novel, promising area of research. Under the effect of Rautian, the late 1960s and early 1970s were marked by explosive growth of laser physics in Novosibirsk. It was a period of great enthusiasm, active generation of new ideas and formation of a core of Rautian's Siberian school of thought. Some time after, Siberian laser physicists and their achievements became well-known and renowned in a wide range of scientists all over the world.

Between 1965 and 1971 (his first period in Siberia), Rautian and his pupils carried out a variety of pioneering studies. In particular, the probe field method was completed and used to

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analyse resonant radiative processes with allowance for the motion of particles and various relaxation processes. They predicted and investigated narrow, Doppler-free nonlinear resonances corresponding to two-photon processes in various configurations of levels (lambda system, V system, two-photon absorption and two-photon luminescence). The width and shape of nonlinear resonances were shown to depend on the mutual orientation of the wave vectors of laser fields, their polarisation and intensity and various collisions (quenching, depolarising, dephasing and velocity-changing). A slow particle effect was discovered, which reduces to the fact that nonlinear resonances are essentially free of so-called transit-time broadening, and nonlinear resonances were predicted to split as a result of the recoil effect. Hysteretic phenomena in gas lasers with a nonlinear absorbing cell were demonstrated and calculated. Unusual frequency conversion effects in resonance multiphoton processes were demonstrated experimentally and explained. Such effects are typically due to stimulated Raman scattering and multiphoton parametric processes. Most of the above results formed the basis of high- and ultra-high-resolution sub-Doppler spectroscopy and led to further great advances in many research teams all over the world.

Unforeseen circumstances of life caused Rautian to leave Novosibirsk in 1971, and he worked at the Institute of Spectroscopy, UAS, until 1976. He did not lose touch with his Siberian pupils, continuing joint research on polarisation and magneto-optical nonlinear spectroscopy. In cooperation with G.G. Petrash's laboratory (LPI), he developed theory of unstable-cavity superradiance-based lasing, which helped to make copper vapour lasers with a near diffraction-limited output beam divergence.

His second period in Novosibirsk (starting in 1977) was the longest (until 2002) and most fruitful. All that time he worked at the Institute of Automation and Electrometry, Siberian Branch, RAS. A large team of pupils, both old-time and new, assembled around him. A powerful school of thought was formed. Their most important scientific achievements were made in the following directions: polarisation spectroscopy of nonlinear difference resonances, cooperative effect in Raman scattering, polarisation contrast of nonlinear resonances, investigation of collisions by nonlinear spectroscopy methods, Coulomb broadening of nonlinear resonances in ionic spectra, targeted laser photomodification of biomolecules (RNA and DNA), the nature of frequency and angular diffusion of high-power quasi-resonance light, photostimulated alkali metal vapour condensation, giant parametric light scattering by clusters, giant nonlinear susceptibility of thin films containing J-aggregate--metallic cluster complexes, nonlinear optics of metallic fractal clusters, spectral lineshape in a polarisation cascade, light-induced drift of gases and gas kinetics in a laser field.

Rautian paid a great deal of attention to pedagogical activities since 1965. He began to prepare students majoring in optics at Novosibirsk State University. In 1977 he organised the Department of Quantum Optics, which he headed until 2002. Alumni of the Department work not only at the Novosibirsk Scientific Centre but also in other scientific centres of Siberia, in other regions of our country and abroad. The vast majority of them are renowned as top-class professionals. Under his direct mentorship, 27 candidate of science dissertations were defended. Fifteen of his pupils received doctoral degree and one became a member of RAS. Moreover, a large number of Russian scientists are proud to consider themselves as his pupils.

In 2002, Rautian returned to Moscow, to LPI. Until the last days of his life (2009), Rautian retained a high research activity: he had at least four publications in scientific journals every year.

Rautian constantly sought to transfer his characteristic approach to scientific work, based on infinite industriousness and devotion to science, to his pupils. All those who were lucky to interact with Rautian especially noted his exceptional personal qualities: culture, fidelity to his principles and amiability. Rautian was committed to high ethical standards and above all he appreciated human qualities.