CELEBRATING 50 YEARS OF THE LASER

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The laser in the USSR: the first steps

I M Belousova

<u>Abstract.</u> An account is given of how the first Soviet laser, specifically made of ruby, was developed at the Vavilov State Optical Institute and launched there in June 1961. Direct eyewitness accounts of and archival materials on this outstanding achievement are presented.

From the editorial board. The publication of the paper by Theodore Maiman on lasing in a ruby crystal [T H Maiman Nature 187 493 (1960)] became the starting gun in the race to the laser in the USSR. The most advanced groups proved to be research groups at the Lebedev Physics Institute, Academy of Sciences of the USSR (FIAN) and the Vavilov State Optical Institute (GOI), the Defense Industry Ministry. Researchers at these institutes used similar and efficient methods in optics and the spectroscopy of crystals. This fact can be easily understood if we recall that in 1930-1950, both institutes were headed by S I Vavilov-a representative of the pre-revolutionary scientific school of P N Lebedev, maintained after his death, to a great extent, by the efforts of P P Lazarev, who was the organizer and first director of the Physics Institute. He was also an immediate supervisor of Vavilov when he performed his first scientific work as a student and received his master degree. The researchers at GOI and FIAN were therefore well familiar with each other, although belonged to different departments and were engaged in this race independently. The first news and publications about successful lasing in ruby in the USSR came from FIAN. Researchers at GOI were severely restricted in their communications because their investigations were classified. However, the institutional science in the USSR was provided with considerably greater material resources, and this allowed GOI to achieve the cherished result slightly earlier. As is customary in our country (to recall, for example, the history of the atomic project), this fact has become widely known only now, when 50 years have passed. Below, we publish a note by I M Belousova, who participated in launching the first Soviet ruby laser in the summer of 1961 under the supervision of an ex-serviceman, L D Khazov. The article contains copies of the laboratory

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notebook of Khazov with sketches from the screen of an oscilloscope with a modest time resolution. The publication of this achievement was not intended.... I was invited to see the first demonstrations of lasing as a 'young talent' (this was during the second year of my work at GOI). I was deeply impressed by the demonstration and immediately began to divine the ideas of laser fusion! (But soon I encountered powerful competition and rapidly backed out, never regret-ting it later).

Later on, FIAN and GOI for a long time remained leaders and hidden rivals in the competition to achieve record energy, power, and brightness of laser radiation. Both these institutions also alternately led in the laser fusion program. By publishing this note (along with archive materials, which are being published for the first time) in this special issue of *Physics–Uspekhi* devoted to the 50th anniversary of the creation of the laser in the world and the USSR, we express our respect and gratitude to those scientists whose achievements were unknown to the wider scientific community because their studies were classified.

E B Aleksandrov

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Laser studies at the Vavilov State Optical Institute (GOI) were initiated by Academician A A Lebedev and Dr. Sc. (Phys.–Math.) M P Vanyukov in the early 1960s, immediately after the creation of the first ruby laser in the USA was reported. The development of these studies was facilitated by previous extensive investigations at GOI in the fields of spectroscopy and luminescence of crystals (D S Rozhdestvenskii, P P Feofilov, and A N Terenin) and physical optics and pulsed light sources (Lebedev, Vanyukov, and S I Levikov), and by the presence of a first-class school in the fields of optical technologies and construction (V P Linnik, E N Tsarevskii, and I A Tel'tevskii) and active media for lasers (V T Slavyanskii, A I Stozharov, and G O Karapetyan).

It is owing to this research experience that the extensive developments of solid-state lasers were initiated at GOI.

At the end of 1960, Khazov initiated a detailed analysis and assessment of laser research in Russia and abroad [1],

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First pages of L D Khazov's thesis abstract. "Ruby optical quantum oscillators are historically the first OQOs created based on the work of V A Fabrikant, C H Townes, A M Prokhorov, and N G Basov. The world's first ruby laser was created by Theodore Maiman in the USA in 1960. The author of the thesis obtained, together with I M Belousova, lasing in ruby on 12 June 1961 at the laboratory headed by Academician A A Lebedev and M P Vanyukov. It seems that it was the first operating quantum optical oscillator in the USSR fabricated from domestic materials and elements. At present, the number of solid-state OQOs based on various active media is quite large and continuously increasing. Nevertheless, ruby OQOs are still important and probably will play a considerable role in the future because high-power optical oscillators emitting at different wavelengths, in particular in the far-red region of the visible spectrum, are required for scientific studies and practical applications. In addition, any high-power OQO, including the ruby oscillator, can be used to produce oscillation at different wavelengths due to nonlinear conversion of the initial radiation (generation of harmonics, SRS, SBS, and so). Wide applications of ruby OQOs, along with other solid-state OQOs, is explained by the fact that in addition to the specific emission wavelength, ruby OQOs have high instant power, high spectral brightness, and high radiation directivity sufficient for many applications. In addition, their radiation can be visually observed, photographed using common film, and detected with quick-response vacuum photodetectors in the region of their maximal spectral sensitivity. Ruby, as an active medium, is advantageous for a number of properties, such as a narrow luminescence line (which can be further narrowed by an order of magnitude upon strong cooling)."

together with preparations of the elemental base for operating a ruby laser at GOI.

The first laser (ruby laser) in the USSR was operated by Khazov and Belousova at GOI on 2 June 1961 at Vanyukov's laboratory in the department of Academician Lebedev.

Below, pages from Khazov's notebook are presented. The page of 2 June 1961 describes our lasing experiments with a ruby crystal, in which the pump power was increased from 550 to 2200 J, corresponding to the passage from luminescence to lasing.

To confirm the presence of lasing, Khazov performed additional experiments using an oscilloscope with a better time resolution and observed the spike regime typical for lasing.

It should be pointed out that Khazov's notebook demonstrates that all the elements used in experiments were fabricated at GOI: ruby crystals were grown at the laboratory of Slavyanskii, mirrors were deposited on ruby crystal facets at the laboratory of V N Rozhdestvenskii, pump flashlamps were fabricated at the laboratory of Levikov, and ruby crystals were processed by the GOI machine shop.

Khazov's notebook is kept at the Laser Physics Institute at GOI. A reference to the creation of the ruby optical quantum oscillator (OQO) at GOI in 1961 is presented, inter alia, in the FIAN report "The use of quantum systems for the lasing, amplification, and recording of optical radiation" (N G Basov, Head, 30 December 1961, p. 7).

In the abstract of his doctoral thesis (technical sciences) [2] Khazov wrote: "The author of the thesis obtained, together with I M Belousova, lasing in ruby on 12 June 1961 at the laboratory headed by Academician A A Lebedev and M P Vanyukov. It seems that it was the first operating quantum optical oscillator in the USSR fabricated from domestic materials and elements."

The report (8 October 1963) about the research activity of Khazov kept at GOI indicates: "A mobile operating OQO was constructed and demonstrated on 27 March 1962 to the Presidium of the Central Committee of the Communist Party of the USSR headed by N S Khrushchev. The operating IT-74 model of the device has been developed. The technical documentation is sent to the LODMP, where a small-scale production is being organized."

Thus, the scientific and technical potential accumulated over many years at the State Optical Institute founded by D S Rozhdestvenskii same to fruition in the laser beam, which initiated the development of a powerful new line of optics at GOI.

Subsequently, researchers at GOI were involved in extensive studies of optical media, solid-state and gas lasers, the interaction of laser radiation with matter, and applications of lasers in industry, military devices, medicine, and science.

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