METAL-VAPOR LASERS AND THEIR APPLICATIONS (CHRONICLE OF 1998)

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It was the 12th time when the specialists in metal-vapor lasers (MVL) gathered to take part in the Symposium held by the Rostov State University. That time the Symposium took place in 20 km from Novorossiisk, on the Black Sea coast, near the village of Dyurso (information about the previous symposium of 1996 can be found in *Atmospheric and Oceanic Optics* **11**, Nos. 2–3, 1998). The late September — the peak of the mellow season — is the traditional time for those Symposiums. However, the participants had not much leisure time. Fifty nine reports from scientific groups of Rostov-na-Donu, Moscow, St. Petersburg, Ekaterinburg, Novorossiisk, Fryazino, Novosibirsk, Tomsk, Obninsk, and Raduzhnyi were delivered.

Chairman, Professor M.F. Sem opened the Symposium. He characterized briefly a progress in MVLs for two years elapsed after the previous Symposium. The first session started from the report made by Professor V.E. Privalov (Baltic State Technical University, St. Petersburg). In his report named "Computer Atlas of Iodine Absorption Lines (B–X Band) and Its Application to Metal-Vapor Lasers,B Professor Privalov recalled three definitions of the unit of length – meter – since 1799 till 1983, described the evolution of the meter by its way to the natural primary standard, and told about five now-used reference wavelengths, four of which were stabilized by the saturated absorption in iodine, although the real today's and especially tomorrow's need was an availability of tens or even hundreds of them only in the visible spectral region. It was shown, using particular examples, that just MVLs were capable to satisfy that need. Parameters of the Atlas of iodine absorption lines were briefly presented: almost million lines in the spectral region (0.4–0.83 μm) accurate to the eighth decimal place. The Atlas could be stored on two standard 3.5″ floppy diskettes.

The review "Metal-Vapor Lasers. Potential for Increase of EfficiencyB was presented by A.A. Isaev (Institute of Physics RAS, Moscow). He analyzed the reasons limiting the efficiency and came up with his idea on its increase up to 10%. He pointed out that the highest (by now) efficiency was achieved in experiments performed by foreign scientists (Little, Sabotinov). That report provoked numerous questions, which then were transformed into a discussion. In particular, A.N. Soldatov (the Tomsk State University) noted that the physical efficiency of 9% was achieved in the 80s, and the real efficiency of 3% was achieved in the 70s in the experiments conducted by Tomsk scientists (Soldatov, Fedorov, Bokhan, et al.).

Nuclear pumping of MVLs was widely discussed at the previous Symposium. Five reports dedicated to this topic were submitted to this Symposium as well. However, most authors of these reports could not participate the Symposium because of financial problems. The only delivered report was "Use of a Microsecond Electronic Beam for Experimental Modeling of Nuclear Pumping of He–Cd LaserB by Yu.N. Novoselov and V.V. Uvarin.

The scientists from Rostov G.D. Chebotarev, A.V. Vasil'chenko, and E.L. Latush presented the report "Study of Pulsed Metal-Vapor Lasers with Cathaphorestic Flow of Active Atoms.B G.D. Chebotarev reported on the experiments with He–Cd and He–Sr lasers. The authors showed that the cathaphoresis ran more vigorously in tubes of small diameter (3–6 mm). A high rate of flow provided for homogeneity of the laser active medium (the Cd–vapor laser emission at 0.5337 and 0.5378 μm with pulse repetition rate from 5 to 10 kHz and the output power of 2 mW; the Sr–vapor laser emission at 0.4395 μm with the pulse repetition rate of 25 to 50 kHz, and the mean output power up to 500 mW).

The report made by A.A. Isaev (authors K.I. Semskov, A.A. Isaev, S.V. Markova, and G.G. Petrash; Institute of Physics RAS, Moscow) was devoted to influence of negative ions on kinetics of discharge and excitation in pulsed metal–vapor lasers. An interesting hypothesis was developed in this report about an influence of negative HBr ions generated in the discharge of CuBr and CuHyBrID lasers on lasing parameters.

In the report "Comparative Characteristics of Cu and CuBr Lasers at a High Pulse Repetition Rates (above 100 kHz)B (G.S. Evtushenko, V.B. Sukhanov, V.F. Fedorov, and D.V. Shiyanov; Institute of Atmospheric Optics SB RAS, Tomsk) made by G.S. Evtushenko, it was shown that the maximum pulse repetition rate, which could be achieved for the CuBr lasers, was higher than that for copper–vapor lasers. The maximum obtained value of the pulse repetition rate was 300 kHz, but it was said to be not a limiting value.

The report "Lidar System with a Copper–Vapor Laser for Monitoring of Atmospheric Pollution with HydrocarbonsB (R.N. Verem'ev, E.I. Voronin, V.G. Shemanin; Novorossiisk Affiliate of the Kuban State Technical University) was made by V.G. Shemanin. That report dealt with calculation of parameters for a lidar operating at the fundamental wavelength (0.510 μm) and the second harmonic of the yellow line of the copper–vapor laser (0.289 μm) designed for monitoring the methane and benzene concentrations in the atmosphere. A possibility to detect pollutants at a distance up to 5 km was demonstrated.

M.A. Kazaryan (Institute of Physics RAS, Moscow) delivered two reports on the first day of the Symposium. A possibility of using copper ions in a gas flow to obtain UV lasing near 0.25 μm was treated in the first report (V.V. Buchanov and M.A. Kazaryan, "Theoretical Study of UV Generation Characteristics with Cu Ions in a FlowB). The calculations indicated that the lasing with good output parameters (power density up to 5 W/cm^2 at the efficiency of several per cents) could be obtained in such a system. In the next report named "Effect of Laser Acceleration of Scatterers in the Problem of Multiple Scattering of Radiation in a Randomly Inhomogeneous MediumB (S.E. Skipetrov, V.V. Chesnokov,

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S.D. Zakharov, M.A. Kazaryan, N.P. Korotkov, and V.A. Shcheglov), multiple scattering by accelerated micron-size particles was considered.

N.A. Lyabin, the representative of the State Scientific and Production Enterprise "IstokB (Fryazino) presented three reports. The first report "Industrial Designs of Copper–Vapor LasersB (M.S. Domanov, N.A. Lyabin, M.E. Koroleva, and S.A. Ugol'nikov) comprehensively considered the technical and operational characteristics of industrially produced lasers with mean output power from 1 to 100 W and service life up to 1000 hours. It was noted that the sales volume of the lasers increased by more than five times since 1994 and now it was more than 100 units a year. Most lasers were sold abroad, where the production of sealed-off active elements for MVLs was only under development. Some results of MVL applications were presented in two next reports "Modified Copper–Vapor and Gold–Vapor LasersB (N.A. Lyabin and A.D. Chursin) and BApplication of Copper–Vapor Lasers to Processing of Microelectronic ItemsB (L.L. Betina, V.M. Zharikov, and N.A. Lyabin).

The report "High–Power UV and VUV Radiation Sources Based on the Copper–Vapor LaserB (A.A. Isaev, Yu.S. Leonov, A.I. Mokshunov), made by A.A. Isaev, called the specialists' attention to a possibility to obtain shortwave radiation using a high-power copper–vapor laser (mean output power of 100 W). Having focused a laser beam with the power density of 10^{12} W/cm^2 strictly on a target (or on plasma), the X-ray emission of 1% efficiency or UV and VUV emission of 10% efficiency could be obtained.

In the report "Modeling of Processes of Population Inversion Generation at Ionic Transitions in Two- and Three-Component MixturesB (N.V. Burdastykh, G.A.Kalinchenko, and I.G. Ivanov) presented by I.G. Ivanov, the results on simultaneous lasing at krypton (0.469 μm) and mercury lines (0.615 and 0.794 μm) in the He–Kr–Hg mixture were demonstrated.

M.M. Malikov and V.T. Karpukhin (Institute of High Temperatures RAS, Moscow) in the report "Nonlinear Transformation of the Copper–Vapor Laser Frequency in Focused and Parallel BeamsB showed that the parallel beam proved to be twice as efficient as the focused one as applied to transformation of MVL frequency, at least when using the DKDP crystal. In answering questions, M.M. Malikov noticed that the results might be different when using the VVO crystal.

A.N. Soldatov delivered the joined report by researches from the Tomsk State University. This report summarized the results of many-year study and development of metal–vapor laser for different practical applications, first of all, to medicine. He noted that Tomsk scientists were the pioneers in obtaining a lot of results: in the MVL pulse repetition rate, specific lasing power per unit volume of a laser medium, lasing efficiency. Considering medical applications of the copper–vapor laser, A.N. Soldatov pointed out that the copper–vapor laser radiation relieved aftereffects of surgical operations, slowed down the tumor growth and metastasis processes in oncological therapy.

Tomsk scientists presented three more reports: "Peculiarities of the Optogalvanic Effect in Pulsed Metal–Vapor LasersB (V.E. Prokop'ev, N.A. Yudin, and V.M. Klimkin); "Laser Phase–Contrast Projection MicroscopeB (V.E. Prokop'ev, N.V. Vasil'ev, V.B. Sukhanov, and V.F. Fedorov); and "Photodynamic Diagnostics and Therapy of Urinary Bladder Cancer with the Help of ALAB (V.E. Prokop'ev and S.P. Selivanov). The last report, in which V.E. Prokop'ev compared the developed laser method with traditional ones and shared their experience of laser system application in an operating-room attracted the greatest interest of the audience.

In the report "Processes of Recharge of Helium Molecular Ions on Sr Atoms in the Recombination Sr-Vapor Laser MediumB (E.L. Latush, G.D. Chebotarev, and V.I. Kanavalov, Rostov State University) presented by E.L. Latush, it was noted that an increase in pressure in the HeSr laser increased the output power. Conversion of atomic He ions into molecular ones with the following recharge played an important part in that process. The method to measure the recharge cross section was proposed, and that value was found to be $1.6 \cdot 10^{-14}$ cm^2.

A lot of reports at the Symposium were dedicated to imaging systems: "Application of Pulsed Metal–Vapor Lasers to Forming a Color TV Image on a Large–Size ScreenB (M.A. Kazaryan, S.V. Kruzhalov, Yu.M. Mokrushin, and V.A. Parfenov; Institute of Physics RAS, Moscow); "New Projection TV System with a Copper–Vapor AmplifierB (K.I. Zemskov; Institute of Physics RAS, Moscow); "Laser Setup for Formation of Large–Scale Graphical Images by the Vector MethodB (V.V. Vainer, S.P. Zinchenko, I.G. Ivanov, and S.V. Orlov; the Rostov State University). Different aspects of MVL application were considered in a greater detail at the round-table session, which terminated the Symposium. Professor M.F. Sem opened the round-table session. He recalled the basic results of MVL study and development since 1965. His particular attention was paid to numerous applications of MVLs (medicine, isotope separation, spectroscopy, microelectronics, atmospheric sensing, hydrooptics, brightness amplifiers, and projection systems). V.E. Privalov, M.A. Kazaryan, A.N. Soldatov, A.A. Isaev, and E.L. Latush were involved in the following discussion, which allowed more detailed consideration of MVL application problems.

In conclusion, the participants of the round-table session were informed about the conferences on the lasers and their applications planned to be held in 1999 in St. Petersburg and Tomsk. The detailed information about these conferences is now available on request. Contact persons: V.E. Privalov: phone(fax): (812) 555–7647, e–mail: root@ssav.spb.su and G.S. Evtushenko: phone: (3822) 25–99–89, e–mail: qel@asd.tomsk.su, http://symp.iao ru. Besides, the new book *Lasers at Self-Restricted Transitions of Metal Atoms* by V.M. Batenin, V.V. Buchanov, M.A. Kazaryan, I.I. Klimovskii, and E.I. Molodykh was announced.

All participants of the Symposium expressed the common wish for the next Symposium to be held in September of 2000 with wider representation of young scientists and post-graduate students.