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Laser without a Moscow Residence Permit

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Abstract- Two great physicists of our time-academicians Nikolai Basov and Alexander Prokhorov in recent interviews said that they managed to significantly advance laser physics, which they also discovered and developed. But nevertheless, it has not yet become possible to create a strategic laser weapon (LW). They passed this baton to the students. Today, assessing what was done then in the conditions of acute competition with the United States, I want to confirm the validity of what Academician Andrey Kokoshin said: "Laser technology, like space and nuclear technologies, was a powerful catalyst for the scientific and technological progress of the country." And here it is more than appropriate to recall together with the Nobel laureates another outstanding creator. This progress was made by Dmitry Ustinov, who in 1969 insisted on making an important decision to establish the NPO Astrophysics – a leading scientific center of the country focused on the development of the element base of high-power and high-energy LW and related laser technologies /1/.

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Laser without a Moscow Residence Permit

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Abstract- Two great physicists of our time-academicians Nikolai Basov and Alexander Prokhorov in recent interviews said that they managed to significantly advance laser physics, which they also discovered and developed. But nevertheless, it has not yet become possible to create a strategic laser weapon (LW). They passed this baton to the students. Today, assessing what was done then in the conditions of acute competition with the United States, I want to confirm the validity of what Academician Andrey Kokoshin said: "Laser technology, like space and nuclear technologies, was a powerful catalyst for the scientific and technological progress of the country." And here it is more than appropriate to recall together with the Nobel laureates another outstanding creator. This progress was made by Dmitry Ustinov, who in 1969 insisted on making an important decision to establish the NPO Astrophysics – a leading scientific center of the country focused on the development of the element base of high-power and high-energy LW and related laser technologies /1/.

I. Pushing off from Solid-State

The world laser science began its ascent to the strategic LW with solid-state (SS) lasers on glass and, obviously, will end up with a solid body when searching for structures with a minimum weight factor (kg/kW), which is important for mobile applications of high-energy laser systems for civil and military purposes. The active body in the first laser device of the American physicist Theodore Meymann. A ruby rod served as the device, created in 1960, and the excitation was carried out by optical pumping from a flash lamp. Everything, it would seem, is everyday and simple, like many other great things in this world. Time has passed, and now a recent DARPA report already says, and this is quite true, about a global change in the rules of the game after the widespread spread of "directed energy weapons", which will turn traditional symbols of military power into obsolete trash like cannonballs and cavalry. To assess the timing of the formation of the serious LW from the idea and the first prototype product to the final product, it should be remembered, for example, that strategic aviation has reached a very decent level in 110 years. So do you have a strategic LW there is still time for development. But in reality, its creation today is much faster, this is already clear from the dynamics of events. Solid-state technologies in the world have reached a level of maturity that allows the creation of the required tactical LW with acceptable weights and dimensions. When evaluating laser technologies, the key criterion today is the weight factor, which allows us to soberly judge the applicability of the complex as a mobile weapon.

II. Weight as a Priority

Comparison of the weighting factor for the gas-dynamic (GDL), electro-discharge, chemical lasers: oxygen-iodine (COIL) and hydrogen/ deuterium-fluoride (HF/DF),diode pumped alkaline metals vapor lasers (DPAL) with the same attitude for a new generation of ss lasers in the optical fiber and ceramics in the disc geometry tells about the unconditional priority of the latter. Achievement the increase in the value of the weight factor of 5 kg per kW allows us to confidently talk about equipping almost all aircraft, all rolling stock of the battlefield forces and sea-based means with tactical, and in the future, strategic law. For all the laser systems listed above, leaving the distance leading to effective tactical and strategic LW, the weight factor is significantly greater. A similar fate at this distance, unfortunately, is prepared for solid-state laser systems on rods and on slabs. Experimental models of LW complexes based on well-known laser systems, which the United States has already abandoned or is abandoning, have become a thing of the past, it became clear that it is impossible to get a light and compact law based on them. The weight factor of these systems is in the range of 200-400 kg /kW, which means that a complex with an output power of 100 kilowatts will weigh at least 20 tons and it can hardly be placed even in a heavy ATA transport vehicle. To achieve air supremacy, it is necessary to create and equip serial combat aircraft with light and compact tactical complexes weighing several hundred kilos. What can we say about more energy-intensive strategic missile systems with a range of more than a thousand kilometers. With all the effort and huge amounts of money invested, up to now, the strategic LW has not been created anywhere in the world. Finding a solution to this problem combines several important requirements. Thus, to the maximum compactness and minimum weight of the complex, the variability of the time structure of the radiation and the scalability of the average power up to several tens of megawatts are added. The whole world is in search of this physico-technical idea based on solid-state technology and its structural basis.

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III. Adding Modules does not Lead to Progress

Here it is necessary to dwell in more detail on the already created ss disk laser technology. This idea of the academician Basov is already 55 years old, but it is his principle of building powerful LC that is dominating today and in the future. With the same very advantageous factor of less than 5 kg / kW as for fiber technology, this design principle allows the implementation of a high-energy high-frequency pulse-periodic (P-P) mode, so as the aperture of the disk laser that exists today with a diameter of about 1.5 centimeters, which is much larger than the diameter of the active body of the fiber laser. To increase the average power of the system, several disks are added in an optical sequence ZIG-ZAG, the average power of such a module today is already 50 kilowatts. Modules, as in the case of fiber systems, can be built in parallel and the power is added to the target. Based on the above figures, it can be seen that a one-hundred-kilowatt laser will weigh less than 500 kilograms! The spectral addition of the modules ' radiation leads to an increase in the pulse energy in a high-frequency periodic sequence, which qualitatively changes the interaction mechanism. However, it should be noted that to perform the tasks.

The Armed Forces of the Russian Federation need LW complexes of much greater average power. Fiber laser technology is limited to the tactical level of medium power, and created in the United States with the help of the complex with a power of 300 kilowatts of spectral addition has convincingly proved this. At the same time, the disk technology that exists today, even with a module of 75 kilowatts (Lockheed Martin plans to increase this due to the quality of reflective coatings), will reach the power level of the entire system of about 10 megawatts, whether he can. It is impossible to combine the power of more than a hundred modules into a single beam of a mobile complex. It is appropriate to recall the well-known in the history of solid-state laser creativity experimental models of complexes created in the USSR, "Omega" (96 modules) and "Tandem" (60 modules) from the point of view of the feasibility of their tactical and technical parameters and reliability. It is obvious that a different constructive construction of the ss LW complex is necessary, which would allow further effective scaling of its average power while maintaining the minimum weight factor characteristic of a modern solid-state LW.

IV. Arrow and Shield Dispute

In the article "Laser spears for the defense of Russia" /2/ the discussion of the proposed new approach to the creation of a ss monomodule disk laser with a large diameter of the working fluid has begun. The article aroused great interest among laser specialists in the country, a series of meetings has already been held with a detailed discussion of the new opportunities provided by the developed technology of advanced laser systems. Emerging technologies pose new questions to the developers of defeat systems, and this in turn calls to life the improvement of already created technologies. Which once again poses difficult challenges for the creators of weapons. Such a step in solving the problems of destruction is the creation of a scalable laser source with a monomodular disk geometry, which solves two problems inherited from Academician Basov: the effective cooling of the body of a large-diameter disk and the suppression of the amplification of spontaneous emission (ASE) along its diameter. So, it is clear that mobile LW can be obtained only on the basis of new technical and technological solutions. But strategic.

There is no law yet, and in the near future a way out of the ideological impasse can only be found based on ss technology. The entire scientific world is in search of this constructive basis. We have the idea of creating it, it is analyzed in detail, numerically modeled, tested on models and is waiting for its implementation. On this basis, the entire line of light and compact LW can be obtained from hundreds of watts to many tens of megawatts.

Let me remind you that in the US, by the end of 2022, the aircraft will be equipped with a tactical LW. At significant altitudes, where MANPADS do not reach the aircraft carrier, there is no large scattering and absorption, and the range of destruction for the LW with a capacity of 100-150 kilowatts, they increase to several tens of kilometers in power mode (violation of the integrity of the structure). In functional mode (in the US, this mode is called "smart interaction») the distance of the lesion increases significantly, but there is no complete certainty about the reality of the effect of the lesion.

Further. On the basis of fiber lasers with the spectral addition of radiation from single sources in the United States, LW complexes with an average power of 30, 60, 100 kilowatts have been consistently created. The weight of the complex based on a fiber laser is brought to the level of 5 kg / kW. It is shown that with further scaling, the TTK can be reduced to 2 kg / kW, in the US, the development of an already created prototype of a laser system of 300 kilowatts and a total weight of only 600 kilograms is underway. The illusory nature of further increasing the power of such a LW in the chosen design is convincingly shown. Obviously, we need a different scheme of the ss LW complex, which allows us to would further scale its average power while maintaining the achieved weight factor. This is particularly important when equipping spacecraft with lasers, a similar task is already on the agenda in the US. According to the strategic defense plans (the fight

against hypersonic missiles) and the accumulated experience of operating already created LW on an outdated physical and technical basis, the need for creating complexes is confirmed. A LW with an output power of several tens of megawatts. A partial return to the SDI program has already been announced by the US Joint Chiefs of Staff. High-energy fiber lasers, due to physical limitations, cannot be high-frequency P-P at a large average output power due to the destruction of the fiber. The spectral composition of the radiation of these compact and light LW complexes, even in the continuous generation mode, is limited by the tactical level of average power. This is the whole limitation of fiber technology, not only the strategic level of power, but also many new exposure modes and effective applications of high-frequency P-P radiation from high-energy lasers is impossible for them.

The existing world-wide ss laser technology based on disk geometry, developed by Academician Basov at the FIAN, as well as fiber laser technology, does not allow us to solve the problem of further scaling the average power of LW complexes to strategic characteristics. The only promising and effective at the moment constructive approach to the creation of the entire line of ss LW complexes from the tactical to the strategic levels is the monomodule technology proposed in Russia (GPI RAS). It is obvious that the new aviation complex LW SHiELD created by the Americans will not only be able to defend against a missile attack, but will also become a serious threat to the objects of military equipment (OME) and enemy aircraft. Laser radiation is significantly absorbed and scattered in the desert conditions in the Middle East, where they conducted tests of tactical LW systems to combat drones. It is known that under these conditions, the beam power drops three times at every mile of the distance. And this really complicates the use of LW in conditions of high dust and humidity. But none of this is true. It follows the conclusion of some experts that the law is ineffective in principle. It is necessary to increase the capacity of the complexes and create a higher level of average power, go to other time modes of generated radiation. There are other military tasks besides destroying drones. This is the use of LW in the upper atmosphere and in space. At altitudes of seven to nine kilometers, the environment is more transparent and the target ranges for destroying OME even for a power level of 100-150 kilowatts can be many tens of kilometers. And if we are talking about the megawatt level, then it is already historical works experts from the USA and the USSR experimentally proved the reality of the range of active operation of "laser monsters" in 100 kilometers. Another thing is that all this is again a tactical range and it is necessary to continue to increase the average power of the LW to achieve a strategic level of range 1000 or more kilometers with a significant reduction in their weight and size. It is already clear that the chemical, gas, and metal vapour-based LW, with their enormous size, have left this strategic road. Now among scientists and designers, understanding dominates the fact that only the solid-state basis of the active element of the LW complex, fiber and disk geometries determine the future of the LW for almost all branches of the armed forces. The question of the range of destruction of OME in space will rest only on the optical quality of the generated radiation. But apart from the quality of the beam, there is another problem – the multi-megawatt LW complex must be put into space. For this purpose, in the US, the emphasis is on creating a solid-state technology that allows you to provide a weight factor of 2 kg/kW and even lower. And there are still great difficulties here.

V. There is a Solution, But...

A few words about the problem of protection from laser radiation. Yes, on the football field, the goalkeeper can easily cover himself with a glove from an annoying fan with a laser pointer. But with a laser power 30 kilowatts this trick will not pass. Drones in the Middle Eastern sky were burning at a distance of 1.5-2 kilometers. But these were toys in comparison with modern multi-ton drones made of titanium and aluminum alloys. Here, even 100 kilowatts of continuous radiation at tactical distances in the power mode of destruction may not be enough. But in the functional high-frequency I-P mode, it will be more than enough. This is a mode in which the laser energy is released as a sequence of short pulses with a high repetition rate. At the same time, the peak power of individual pulses is hundreds or thousands of times higher than the average power of the same LW in the normal continuous generation mode. Leading experts in the field of creating high-power high-frequency P-P lasers and the authors of the patent they are employees of the GPI RAS, who worked under the leadership of Academician Prokhorov. The same team proposed and experimentally tested a laser engine based on the mechanism of a high-frequency optical pulsating discharge and obtained record-breaking characteristics of the engine thrust. Using a high-frequency IPP laser, an intense and frequency-varying sound in the far zone is obtained, containing up to 20 % of the laser energy, a conducting channel with a minimum resistivity is experimentally implemented, the possibility of its scaling to significant distances and the reality of such a highly conducting channel, including in a vacuum, are shown. These new-old technologies-P-P mode with a high pulse repetition rate (more than 10 kHz) and a monomodule disk-are perfectly combined in a single laser complex. In particular, we, in addition to the experimental demonstration of the mode at level 10 kilowatts and cutting of metals, glass and composites, theoretically shown to be highly effective for the destruction of space

debris, cutting the ice of the Arctic Ocean and much more. Thus, the increase in the level of laser output energy and the use of new time modes of radiation generation allow us to confidently look at the problem of overcoming protection from laser radiation. Once again, we note that the simple summation of radiation on the target (purely geometric from various sources) is inefficient for a number of reasons. The most, if not the only, promising approach for solid-state technology is to obtain a single laser beam of radiation in a single resonator with a single large-diameter disk element. It is with this approach developed by us that it is possible to solve the problem of scaling the average power of the LW complex to many tens of megawatts. And this is the goal to which LW creators all over the world have been striving and are striving. Only in this case can the most complex problems of the Russian Aerospace Forces be solved, which are now being brought to the fore due to the strategic plans of the US, which continue to strive for world domination.

VI. Conclusion

I will repeat once again what I already said in the article " Laser spear for Russia" /2/ unfortunately, the country has created a monopoly on the development of high-energy tactical LW, there are no serious advances in the development of solid-state technology yet. In the US, more than a dozen enterprises have already been created to solve the problem of tactical and strategic LW and its element base for all branches of the armed forces, including space. Therefore, the policy of concentrating material resources in one laser center located at a distance from the qualified personnel of the capital seems erroneous. In a similar situation scientists in Moscow and St. Petersburg are deprived of the opportunity to effectively participate in the creation of new samples of high-energy LW. And the creation of a new galaxy of engineering and technical craftsmen is a long process, and there is no time for their training. The placement of laser centers and their branches on this topic is advisable in these cities or in their suburbs. Despite the prohibitions established by the international community, LW by the efforts of the US, it will be launched into space after equipping the aircraft with tactical LW. In accordance with the doctrine of the National Space Policy of the US, the right of Americans to extend their sovereignty to outer space is proclaimed. An important place among the possible types of effective means of fighting in space and in the air is given by American strategists to space-based air defense systems, with special attention being paid to the destruction of hypersonic missiles. The strategic level of power will be provided only by the monomodule disk geometry of the active element of the LW complex. Exactly this way the project, initiated jointly with academicians N. Basov and A. Prokhorov, has been promoted by us for many years. To ensure it, it is necessary to urgently create a target organization and urgently, even ahead of the creation of the element base of such solid-state monomodule disk drives.

References Références Referencias

1. Russian newspaper VPK № 16,879.
2. Russian newspaper VPK № 11,874.