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Extended Abstract OpenAccess

Multi - MW laser for new applications

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Introduction

In the beginning of 1973 in the USSR the study of possibility of LJE designing was conducted. The reflector, located in the tail of the rocket prototype, concentrated the obtained radiation in air and ensured micro-burst that the reactive thrust was created. The successful results of different models of the reflectors tests, which were at the same time the laser light receivers, had been obtained. One should note that all experiments pointed out above were conducted with the use of electric discharge CO2- lasers with power up to 10 kW, while for the injection into orbit of different highly and technologically effective equipment (global network connections, Internet, photo-monitoring of Earth surface, debris cleaning) the radiated power substantially higher is required, something about few MW. Thus, for example, for SC launching with the weight 1000 kg the laser with power not less than 20 MW is necessary.

Laser jet engine development

The laser for this application at present time can be the gas-dynamic laser (GDL) only, since only in this case the laser technology in the significant measure intersects the rocket technology, which in 50 years moved sufficiently well in the creation of super-power gas generators and it makes it possible to pose similar problems. Furthermore, the laser must work in P-P regime with the high frequency of the repetition of short pulses for the exception of the process of laser emission screening entering by the plasma, which appears with the engine work, and so for an increase in the work effectiveness [3]. In the opinion of specialists - classical missileman - LJE can find an effective use in creation of cheap single-stage means of nano- and micro-satellites launch with mass in the gap 5- 50 kg, which according to the opinion of experts tomorrow will compose the fundamental basis of commercial launch program. In the first stage of flight SC at the heights up to 30 km as the working medium in the engine the usage of atmospheric air is intended, and then to inject satellite into orbit the onboard reserve of the special fuel - ablating substance- in the quantities not exceeding 15-20% of the SC started weight is needed.

The experience of powerful lasers creation is accumulated in the A. M. Prokhorov General Physics Institute of RAS and other organizations of Russia. During last few years very successful experimental studies of P-P regime in the powerful and well developed continuous laser systems were conducted. This makes it possible to approach the experimental realization of super-power P-P laser source on the basis of gas-dynamic principle and LJE in the composition of light carrier with control system. The forthcoming complex of works must become major step toward the future starting of super-lightweight SC into low near Earth orbit. The realization of project will make it possible to create highly economical LJE of reusable starting for the removal of the payloads of wide designation into space. The key advantage of new approach is connected with the fact that the source of kinetic energy and payload are untied in the space and launching weight SC can be lowered to the payload weight only. An even greater K. E. Tsiolkovskii foretold, that the starting SC of future will be achieved with the aid of the electromagnetic waves directed from the external energy source, laser at that time was not known to the World at all. The great interest of scientists and specialists, as they confirmed few last symposium in this field of research, was connected with the

successful solution in our country of the problem of powerful lasers creation with high repetition rate (50-100 kHz) of pulses of short duration (150-250 ns).

This is what recently wrote “the father of laser reactive motion” Arthur Kantrowits: “Dear Victor, thanks for the pleasure given to read your articles from the last symposium on the motion with the aid of laser energy which are now accessible for the scientific community. I already thought above your works and I count that these remarkable ideas on the quasi-stationary wave, about the light-detonation waves, about the matrix of reflectors those introduced into your new examination are very important for the development of theory and technology of motion with the aid of the light. With great admiration I do control the development of the laser starting in the world and in Russia in particular. I hope that after your publications the significant activity in the field of laser engine creation and its applications will be stimulated. It would be very interestingly and further hear about the progress in this hot field of research. Thanks for your energetic contribution.

To the present time two directions, in which the possibility of applying the laser emission in the aerospace tasks is investigated: launching to the space orbit light SC, reduction of aerodynamic drag of the flying bodies, which move in the atmosphere with the high speed were formed. In the problem of developing LJE the generated by P-P laser emission is focused by reflector near the rear end of SC and the periodically repetitive laser sparks are created. Sparks generate shock waves, which transfer the part of their mechanical pulse to the reflector, located near the tail of the rocket. As the characteristic of the previous years the gas-discharge laser systems had demonstrated the pulse repetition frequency, which was limited by the time of gas exchange in the discharge zone in the range of 100 - 300 Hz. For achievement high average power - 10 MW for this rate of operation it should be necessary to use laser pulses with the energy about 100 kJ. With the reduced air pressure, for example for the height more than 15 km, long living plasma sphere, created by each pulse, occupies practically entire volume of reflector, which leads to the screening of the subsequent pulses into the course ~ of 10 ms.

Technical difficulty of that method of energy extraction for the laser is also a very strong impact loads with such a high energy of pulses. The use of high energy pulses with the small repetition frequency and, consequently, with the very high peak power is limited also by optical breakdown as on the route, so on the surface of reflector. The method proposed by us is the way of overcoming all that difficulties on the indicated basis: usage of laser emission with short duration of pulse and high pulse repetition frequency and mechanism of generated by OPD shock waves resonant association. Under that conditions of LJE energy of laser pulse with the short duration (100ns.) effectively (95%) can be absorbed and converted (~ 30%) into shock waves. In addition to this it is shown that the specific thrust can be increased several times due to the artificial transformation of radial component of shock waves into the longitudinal one. There are many other advantages of high repetition rate P-P lasers should be mentioned here as well.

They are:

Much higher efficiency of energy extraction from a media and conversion into laser light, which is important for high aperture lasers scale up;

Plasma screening effect decreasing due to the decreasing of laser pulses duration and increasing of number of pulses up to a few tens of kHz;

Decreasing of laser beam thermal defocusing due to the optimal temporal structure of laser radiation;

Localization of energy deposition in space and time and elimination of stressed state of solids under laser action due to replacement of melting by ablation;

Possibility of unrolled 3d geometry of breakdowns in space due to a very high repetition rate generation of laser pulses,

creation of optical, acoustical and electromagnetic fields far away of laser source;

Much longer distances of optical breakdown conditions for the same optical systems.

High conductivity channel and new applications

The displacement of the optical focusing system in the media and interaction of P-P laser radiation with energy in the focus of optical system sufficient for the breakdown ensures the formation of the continuous current-conducting channel in the air medium due to its ionization, in this case. As calculations show, the frequency band of laser pulses ensures the continuity of the formed current-conducting channel in the appropriate speed range of the moving focusing system, which can be realized in this particular medium. Actually, each pulse of the laser, with the help of focusing system can create a certain extensive region of plasma, which applies to the relatively small section of space in the trajectory of the displacements of that focusing system. If the repetition rate of pulses will follow each other with small frequency the displacements of the plasma regions after focusing system will be something more similar to the dotted line. However, with higher frequency, for example more than 10 kHz, and optimum for the medium speed the displacements of ionization regions will no longer have breaks and the formed by this process conducting channel will be continuous.