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SUPER LONG CONDUCTIVE CHANNEL PRODUCTION BY IMPULSAR

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Key words: conductive channel, energy transmission, beamed energy propulsion.

ABSTRACT

The attempts to create a super long conductive channels were taken in order to study the upper atmosphere and to settle special tasks, related to solar energy transmission, accumulated by orbital solar stations. There upon the program of creation of "Impulsar" represents a great interest, as this program in a combination with high-voltage high repetition rate electrical source can be useful to solve the above mentioned problems. The principle of conductive channel production can be shortly described as follows. The "Impulsar"- laser jet engine vehicle - propulsion take place under the influence of powerful high repetition rate pulse-periodic laser radiation. In the experiments the CO_2- laser and solid state Nd: YAG laser systems had been used. Active impulse appears thanks to air breakdown (< 30 km) or to the breakdown of ablated material on the board (> 30 km), placed in the vicinity of the focusing mirror-acceptor of the breakdown waves. With each pulse of powerful laser the device rises up, leaving a bright and dense trace of products with high degree of ionization and metallization by conductive nano-particles due to ablation. Conductive dust plasma properties investigation in our experiments was produced by two very effective approaches: high power laser controlled ablation and by explosion of wire. Experimental and theoretical results of conductive canal modeling will be presented. The estimations show that with already experimentally demonstrated figures of specific thrust impulse the lower layers of the Ionosphere can be reached in several ten seconds that is enough to keep the high level of channel conductivity and stability with the help of high repetition rate high voltage generator. Some possible applications for new technology are highlighted.

I. "IONOSPHERE-EARTH" AND "CLOUDS–EARTH" CONDENSERS AS THE SOURCES OF ENERGY

There are no any other forms of energy moreabundant than the sun irradiating energy. Sunlight bathes us in far more energy than we could ever need - if we could just catch enough. The sunshine on the solid part of the Earth is about 120 PW and total value for the globe 274 PW. Power density of solar energy on the orbit of Earth is very constant and equal to 1.37 kW/m^2. The total power needs of the humans on Earth is about 16 TW. In the year 2020 it is expected to grow up to about 20 TW. At the same time well developed countries plan for 2010 budget calls for doubling the country's renewable energy capacity in three years. What is going on in our days in the area of renewable energy production in the World. "Nevada Solar One" based on oil heating technology, for example, has demonstrated 21% of sun's rays into electricity. Layering compounds technology based on GaInP/GaInAs (PV) - 40.8%, but the cost of that super modern technology is huge - 10000 USD/cm^2 or even more than that. At the same time standard PV panel technology efficiency is high as 23%. 100 × 100-mile square of PV (3/10 of USA surface on the globe) could electrify the entire country, but the cost of that technical operation as well looks awfully. Much smaller solar PV panel can be deployed in space behind the dense shield of air, but to get this energy on the ground we need an effective way of transformation that energy into microwave, electron beam, laser light or any other type of conductive canal for low loses delivery.

Laser power beaming was envisioned by NASA as a stepping stone to further industrialization of space. In the 1980s, researchers worked on the potential use of lasers for space-to-space power beaming, focusing primarily on the development of a solar-powered laser. In 1989 it was suggested that power could also be usefully beamed by laser from Earth to space. In 1991 the Space Laser Energy project had begun, which included the study of laser power beaming for supplying power to a lunar base. That program was a two-year research effort, but the cost of taking the concept to operational status was too high, and the official project ended in 1993 before reaching a space-based demonstration.

In 1988 the use of an Earth-based laser to power an electric thruster for space propulsion was proposed with technical details worked out in 1989. The proposed solution using

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diamond solar cells operating at 600 degrees to convert ultraviolet laser light, a technology that has yet to be demonstrated even in the laboratory.

Well known the energy distribution of a different production sources for 2006 looks like the following: renewable for the world – 343 B kWh, nuclear and other – 932 B kWh, fossil – 2780 B kWh. But for 2030 the same distribution looks very much different: renewable for the world – 864 B kWh, nuclear and other – 926 B kWh and fossil – 3358 B kWh. All that really means that we are in the very beginning of the solar energy production process. Why we cannot think about huge energy of clouds and Ionosphere as a sources of energy, concentrated in the natural condensers around our planet?

During the last few years in the literature there were published very much reliable data and results of study of so-called "jets" and "sprites" - discharges in the huge condenser "Ionosphere – Earth" [9]. The volume of each category makes up to 10 thousand cubic kilometers. The discharge usually arises over an ocean surface. There are cases of elevated discharges. The volume of a transferable energy to the Earth can be up to several hundred megajoules. A series of many discharges in the range of few minutes can be registered very often. Such events can be seen in the area of equator zone $\pm$ 30 degrees. There are 280 lightning discharges per year in average take place for one km^2 of Earth surface, over three million lightning strikes every day around the world. There are 10^{10} thunderbolts per year, or 1000 thunderbolts per second take place at the Earth.

Another significant sources of energy are the condensers "Cloud – Earth" and "Cloud – Cloud". The greatest frequency is in tropical and sub-tropical regions of the Globe, and topping the list are: El Bagre, in Colombia (270 days per year with lightning); Tororo in Uganda (274 days); and Bogor in Java, Indonesia (283 days). The most extraordinary electrical storm is found in Venezuela, at the mouth of the Catatumbo river, where it empties into Lake Maracaibo. It can be seen during 180 nights of the year for as long as 10 hours per night and is comprised almost exclusively of eerily silent cloud-to-cloud lightning, arcing through the atmosphere at altitudes of 5-10 kilometers. The sky is illuminated by these flashes as often as 280 times per hour, amounting to over one million electrical discharges per year with the intensity up to 400,000 amps each. The flashes are visible up to 100 kilometers away and have been used as a natural lighthouse for many centuries, which is also known as the "Maracaibo Beacon". The confluence of cold winds pouring from the Andes and hot, humid air rising from Maracaibo's marshlands is thought to be a major contributory factor to this unique display. Electrization of gases ascending from the marshes, particularly methane from decaying vegetable matter, by mixing with descending stream of cold Andes is the physical mechanism of this natural factory. Each lightning bolt could light all the bulbs in South America. Now, if only mankind could find a way to harness all that significant amount of power by efficient delivery to the ground.

Studying of the given phenomena represents considerable interest from many points of view. The essence of the observable abnormal phenomena consists of electromechanical transformation of energy surpluses of natural electricity into mechanical and thermal energy of cyclones, typhoons and other natural cataclysms. The ionosphere can keep only certain quantity of energy. Otherwise, it dumps surpluses of an electricity through atmosphere or transforms them to the energy of storms, including even a storms inside the Earth. Electric breakdown of such scale of energy can be considered as the trigger hook conducting to liberation of huge energy stored before. Using the part of natural electricity for useful purposes it is possible to get the way to operate planet weather. It could be possible at the same time to try to cause breakdowns of the Ionosphere artificially and dump of operated water deposits in the necessary points of the globe. It is very interesting to find the way of regulation for the climate of our planet (very important after the summer event in the Europe this year) and to prevent or to reduce amplitudes of magnetic storms, earthquakes, hurricanes with the help of high repetition rate lasers technology. The quantity of Atmosphere electricity is closely connected with the important components of a natural complex of the planet, in a part: deducing out of operation systems of electronic maintenance, influence on astronautics and aircraft, perfection of methods of long - distance detection of objects, problems of electromagnetic influence over ecological systems and measuring devices, attempts to correct the climatic conditions on the Earth.

II. LIGHTNING PROTECTION APPROACHES

Powerful lasers are capable to create the spending canals of big length which are settling down on any distances from a radiator. At relatively small energies of single impulses the lengths of canals make about hundreds of meters. Since 1970 the successful attempts of their usage were undertaken for solution of problems of interception of lightning and blocking of overload waves on electric lines [1, 2, 4]. The traditional lightning protection systems being used currently are not always in a position to ensure the desired level of efficiency. This stimulates the quest for new approaches to solve this problem. Laser protection against lightning is one of the most prospective trends that are being developed actively at present. While using this approach, it is assumed that the lightning discharge canal being developed is guided towards the conventional rod of the metal lightning rod along the plasma canal formed as a result of the laser induced breakdown of the Atmosphere. This method is based on the concept of an active lightning rod, when a laser beam can be used for "triggering" and guiding a positive ascending leader from the tip of a lightning rod to a negatively charged thunderstorm cloud. It is expected that in contrast to the traditional approach, the use of laser spark will make it possible to control efficiently the very process of protection from lightning, ensure the selectivity of lightning capture, and provide safety of tall objects and large areas. Conductive canal in this case is about 20-25 m long and main advantage of the approach is due to immediate appearance of laser produced prolongation of the lightning rod. But maximum length of the laser produced breakdown in the air was registered on the level of 100 m and limited by optical method and technology of laser energy delivery into the long range focal point. Where is the way to get conductive canal of much longer length?

The same goal to produce long conductive canal has ongoing French-German program “Teramobile” [8], based on femto-second multi-photon lasers technology. The task is to get a very long canal with very low level of electrical resistivity in comparison with canals produced by infrared laser radiation breakdown. The ionisation of air produced by ultra - intense and ultra - short pulse can be put to use to canal bolts of lightning. As a “Teramobile” burst propagates it creates a sort of straight filament of ionised air, which should conduct electricity. If the laser were directed toward a dark and threatening thunderhead, it would trigger a lightning bolt that could be safely ushered away from doing harm. This capacity has already been demonstrated over a distance of a few meters only with a laboratory version of lightning, and tests on a more natural scale are limited by very high filaments resistivity. So, what do they do with a mobile Terawatt laser, if it is not good enough for the lightning control purposes? One can use it very effectively to study the propagation of intense laser light in the atmosphere, detect pollution, and control the parameters of fast objects in the space. Ultra - high intensity brings its own special qualities; it modifies significantly the index of refraction while it induces a focusing of the light beam along its path, the effect of the latter being to produce a self - guiding laser burst which can travel hundreds of meters. Another effect is that the luminous spectrum widens to yield a white laser whose light is composed of a wide range of wavelengths, which are important for a wide spectrum of applications.

III. “IMPULSAR” AS A BACKGROUND FOR NEW TECHNOLOGY

There upon the well known program of creation of “Impulsar” represents a great interest, as this program in a combination with high-voltage high-frequency source can be useful in the solution of above mentioned problems [3]. The principle of “Impulsar” operation can be shortly described as follows. Jet draught of the offered device is made under influence of powerful high frequency pulse-periodic laser radiation. In the experiments the CO_2 laser or solid-state Nd: YAG laser systems were used. Active impulse appears thanks to air breakdown (< 30 km) or to the breakdown of low-ionisable material vapour saturated by nano-particles of conductive material (dust plasma), placed in the vicinity of the focusing mirror - acceptor of the breakdown waves. With each pulse of powerful laser the device rises up, leaving a bright and dense trace of products with high degree of ionization and metallization by nana-particles after ablation. The theoretical estimations and experimental tests show that with already experimentally demonstrated figures of specific thrust impulse the lower layers of the Ionosphere can be reached in several ten seconds that is enough to keep the high level of canal conductivity with the help of high frequency high voltage generator [7].

The space around globe represents a series of megavolt class condensers created by Earth surface, the cloudy cover, various layers of Ionosphere and radiating belts. With the help of supported by high - voltage source of trajectory trace of “Impulsar” it is possible to create a conductive canal of required length and direction. In process of the optical vehicle lifting and conductive canal following it, the breakdown characteristics of the interval with decreasing for 5 orders of magnitude (90 km) density considerably reduce, than the process must be prolonged by expanding of micro-discharges net and develop as self-supported process in the external field of all studied interval. It is important to notice, that presence of such an orbital scale canal development technology allows us also to perform a number of important experiments from the Earth surface as well as from space.

IV. DUST PLASMA CONDUCTIVITY MODELING

The electrical breakdown of dust plasma produced by laser radiation in the vicinity of surface of graphite, textolite (glass fabric material which is impregnated with furil, epoxy, polyester, silicone-organic or other resins), vinyl (plastic material, which unlike other plastics, can easily be recycled) ferrite (iron or iron alloys with a body centred cubic crystal structure) and permalloy (nickel - iron magnetic alloy) (Fig. 1).

Generically, it refers to an alloy with about 20% iron and 80% nickel content) targets were investigated. The breakdown threshold values in dependence on material of the target have been measured. The high power phosphate glass laser with asymmetric resonator with 100% reflecting back side mirror and the ring shaped output mirror was used [5, 6].

Our experimental phosphate glass laser (Fig. 2) had been operated in the modified spiking mode. It generated the radiation with $\lambda = 1.054$ μm. Temporal structure of radiation represents the series of flashes with envelope duration in the gap 0.6 - 1 ms and total energy of pulses up to 30 J. Laser radiation has been detected as a series of high-contrast pulses traveling with the average frequency in the gap 100 - 200 kHz, and duration of each pulse about 150 – 200 ns. The peak power of pulses was about 100 – 500 kW each.

The similar parameters of the electrical breakdown have been investigated for the clouds of dust plasma formed by electric explosion of a 100 μm nichrome (nickel - chromium) wire up to ~0.5 m long and explosion of a 90 μm copper wire up to ~1.9 m long at a voltage not higher than 11 kV [6] (Fig. 3).

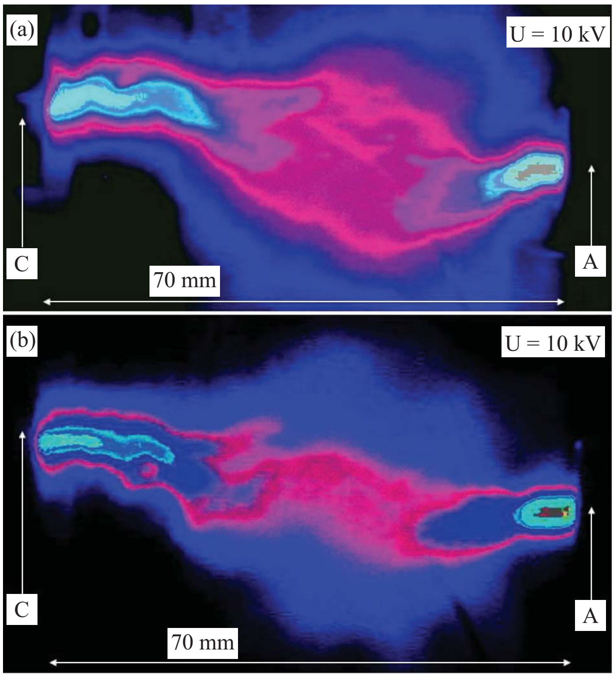

Fig. 1. Dust plasma electrical breakdown produced by laser (on a graphite target).

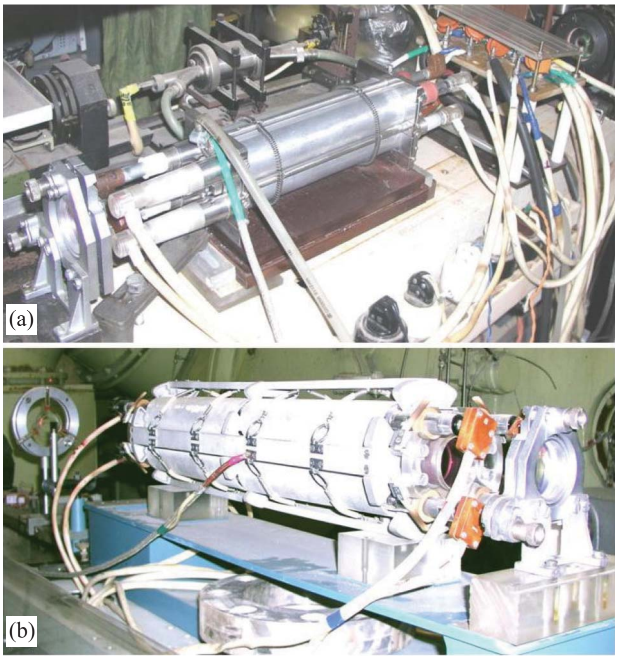

Fig. 2. Phosphate glass laser operated in the modified spiking mode.

The values of dust plasma conductivity on it's decay stage had been measured. The preliminary results of measurements are:

1. The dust particles size for graphite, textalite and permalloy produced by laser ablation was in the gap 0.01 – 0.5 μm). Charging voltage for condenser was on the level of U = 10 kV and energy storaged in the condenser was about E = 100 J; For the laser ablation dust plasma the best results are: specific resistance ~10 Ω/m; specific voltage of the gap breaking ~300 V/cm;
2. For the case of wire explosion the corresponding values are as follows: minimum specific resistance ~5 Ω/m is implemented at the maximum introduced specific energy: ~200 J/m; specific voltage of the gap breaking ~53 V/cm;
3. Another approaches:
   - for canal produced by breakdown of CO_2 pulsed laser with conical optics: specific resistance ~100 Ω/cm; specific voltage of the gap breaking ~80 V/cm;
   - for canal based on filaments produced by FS laser: specific resistance ~0.4 mΩ/m; specific voltage of the gap breaking ~6.6 kV/cm;
4. For the "Impulsar" modeling test with power of CO_2 laser about – 1 kW with RR = 30 kHz, the gap value – L = 1.5 m, capacitor charging voltage – U = 7.5 kV and storaged energy E = 100 J the specific resistance value ~10 Ω/m and specific voltage of the gap breaking ~50 V/cm.

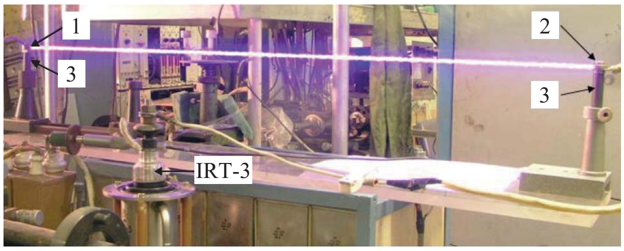

Fig. 3. Controlled electrical breakdown of dust plasma produced by copper wire ~1 m long explosion.

This means, that 7 MV, without taking in to account very strong natural field strength in the gap, is necessary for realization of conducting canal with total length more than 1 km. The level of energy necessary for conductive canal creation for the same conditions is about 300 kJ. Resistance value is very much dependable on the cross-section of dust particles sheaf, concentration and size of particles, repetition rate of laser pulses, average power of laser, humidity of the air and many other parameters, which more or less are involved in to the process under consideration. It must be stated here that our new approach looks as a very promising one for hot and cold dust plasma investigations in the future.

V. OTHER APPLICATIONS

Ball and bead lightning investigation is the most interesting application for the super - long conductive canal technology based on "Impulsar" due to the intriguing possibility for investigator to set up the stationary laboratory with variable boundary conditions for effective tests. It would appear after investigations to be done that natural ball lightning may be not one phenomenon but many, each with similar appearance but with different mechanisms of origin, different stability criteria, and somewhat different properties dependent upon the atmosphere and the environment present at the time of the event or test. Consideration of a large set of available data on such an objects during last few years led us to the conclusion that by “Impulsar” approach we can get a very powerful tool for investigation in the future of ball and bead lightning nature and to find a wide spectrum of new applications, like space debris elimination, super hard and fragile materials precise cutting in a cold state and so on.

VI. CONCLUSION

1. Powerful lasers are capable to create the conducting canals of the big length which are settling down on any distances from a radiator. At relatively small energies of single impulses the lengths of canals make about hundred meters. Since 1970 the successful attempts of their usage were undertaken for solution of problems of interception of lightning and blocking of overload waves on electric lines. Laser protection against lightning is one of the most prospective trends that are being developed actively in the past. It is assumed that the lightning discharge canal being developed is guided towards the conventional metal lightning rod along the plasma canal formed as a result of the laser induced breakdown of the air;
2. Dust plasma conductivity modeling has demonstrated that high average power high repetition rate laser producing dust plasma sheaves perfectly contacted each other is a powerful tool for super - long canal production in the space. Next step of investigations is related to the same set of parameters measurements in vacuum. Successful technology development of high repetition rate pulse – periodic powerful lasers, as well as “Impulsar” technology let us to foresee the possibility of conductive channels of several ten kilometers length realization for the purpose of energy transfer for considerable distances, creation of new perspectives for mastering space, new spacecraft energy sources adoption and settling of other several important problems like ball bead lightning investigation. The usage of presented in the paper technology and settling on its base the problems of renewable energy of Atmosphere and Ionosphere electricity as well should contribute to significant improvement of global ecology of the planet.

VII. ACKNOWLEDGMENTS

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