

“INNOVATION RAIN ENHANCEMENT TECHNOLOGY BY LASER SYSTEM, PRACTICALLY PROVED IN LABORATORY CLOUD CHAMBER, ALSO IN THE ATMOSPHERE

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ABSTRACT

In the atmosphere, after lightning, precipitation is formed and heavy rainfall occurs. This is a well-known process. This natural lighting phenomenon has been practically demonstrated in the laboratory cloud chamber, as “Laser-induced condensation & water drops formation” and “Water drops formation by each and every laser shots in the cloud chamber”. In this process, lightning/laser creates high temperature which breaks the bonds of N₂ and O₂ to form excited N and excited O*. Total heat energy of lightning/laser is completely utilized for breaking the bonds of N₂ and O₂ (Chopkar, 1993). These excited N* and excited O* move to new place by wind and undergo reactions to form NO and O₃ which are endothermic reactions. Heat energy required for these reactions are taken from the surrounding atmospheric clouds. As a result of these reactions, temperature falls, condensation takes place, seeds are created and rain occurs in analogous way as rain is created in nature by lightning. In this process, white clouds convert into black rainy clouds for rainmaking in the atmosphere. This process has been practically proved in the laboratory as “Production of ozone and nitrogen oxides by laser filamentation”. It is believed that “Laser photons photo-dissociate atmospheric compounds N₂ and O₂ and form ozone (O₃) and nitrogen molecules (NO). Increase of O₃ and NO concentration after lightning has also been experimentally observed. That this lightning phenomenon created through artificial lightning by plasma laser pulse or laser system can produce rain in the atmosphere has been practically proved as “Laser-induced water condensation in air”. Scientists have succeeded in obtaining raindrops from an altitude of 45 to 75m of the atmosphere by terawatt mobile laser. IRRA Scientist Group proposes laser system of specification: 1012watt, 800nm, 500mJ, 120fs and 10Hz for this research project. It works when more than 65 % humidity is present in the atmosphere. Our findings could be used by scientists and engineers to create artificial rain as a new method. The results could be of immense benefit to human being.*

KEYWORDS: *Lightning, Laser, Dissociation, Endothermic Reactions, Condensation, Precipitation, Natural Seeding, Raindrops, Rainfall*

INTRODUCTION

We know that food, water, and air are the basic needs of all human beings. Food and water depend on rain. Rain also plays an important role in basic need for all human being by influencing the agriculture yield. But rain is a natural phenomenon and it does not fall as and when man needs it. Techniques such as spraying chemicals like silver iodide or dropping coolant

materials like dry ice exist to create artificial rain for the past many years. But technology for creating artificial rain by laser system in a way of natural lighting phenomena in the atmosphere is novel. This technology has been practically proved in the laboratory cloud chamber and also in the atmosphere.

Condensation is the Basic Need for Water Drops Formation

That condensation is the basic need for water drops formation can be understood by taking two glasses one filled with normal water and another with ice pieces. After sometime one can observe water droplets on the outer surface of the glass which contains ice but not in the other. This is due to the condensation process that occurs around the ice glass. So, IRRA Scientist Group, propose laser system for this research project, to create artificial lightning by initiation of endothermic reactions, in a way of Natural Lightning Phenomena, for artificial rainmaking. As a result of these reactions, temperature falls, condensation takes place, seeding occurs and it rains in analogous way as rain is created in nature by lightning. This process has been practically proved in the laboratory and atmosphere as “production of ozone and nitrogen oxides by laser filamentation”.

Natural Evidences for Rainmaking by Lightning Phenomena

Researchers have been trying to create artificial rain since. Golde, (1977) from a number of radar observations, has reported that intense precipitation is not even present in the clouds before the first discharge but it develops abruptly in the same region after discharge from which the lightning flashes originate. This is a well-known process in the atmosphere. After lightning, precipitation is formed and heavy rainfall occurs. But the theory of technology for creating artificial rain by laser system in a way of natural lighting phenomena in the atmosphere is novel. This will be clear from the following: In lightning, temperature rises as high as $\sim 30,000\text{K}$ in fraction of a second. At this high temperature both dissociation and ionization of N_2 and O_2 as shown below, take place. But, for the formation of precipitation, a temperature as low as -10K , is needed. How a region which rose to a temperature of $\sim 30,000\text{K}$ attains a temperature of -10K ? Who removes the heat? That means after lightning, some mechanism occurs which cools the medium. This mechanism is occurrence of endothermic reactions (3) and (4) which cools the atmosphere.

Novel Technology for Rainmaking

In the atmosphere, after lightning, precipitation is formed and heavy rainfall occurs. This is a well-known process. This natural lighting phenomenon has been practically demonstrated in the laboratory cloud chamber, as “Laser-induced condensation & water drops formation” and “Water drops formation by each and every laser shots in the cloud chamber”. In this process, lightning/laser creates high temperature which breaks the bonds of N_2 and O_2 to form excited N^* and excited O^* . Total heat energy of lightning/laser, is completely utilized for breaking the bonds of N_2 and O_2 (Chopkar, 1993). These excited N^* and excited O^* move to new place by wind and undergo reactions to form NO and O_3 which are endothermic reactions. Heat energy required for these reactions are taken from the surrounding atmospheric clouds. As a result of these reactions, temperature falls, condensation takes place, seeds are created and rain occurs in analogous way as rain is created in nature by lightning. In this process, white clouds are converted into black rainy clouds for rainmaking in the atmosphere. This process has been practically proved in the laboratory as “Production of ozone and nitrogen oxides by laser filamentation”. It is believed that laser photons photo-dissociate atmospheric compounds N_2 and O_2 and form O_3 (ozone) and (nitrogen molecules) NO . Increase of O_3 and NO concentration after lightning has also been experimentally observed. That this lightning phenomenon created through artificial lightning by plasma laser pulse or laser system can

produce rain in the atmosphere has been practically proved as “Laser-induced water condensation in air”. Scientists have succeeded in obtaining raindrops from an altitude of 45 to 75m of the atmosphere by terawatt mobile laser. IRRA Scientist Group proposes laser system for this research project. It should work when more than 65% humidity is present in the atmosphere. Our findings could be used by scientists and engineers to create new method for making artificial rain; the results could be of immense benefit to human being.

As mentioned above, lightning creates very high temperature. At this temperature, bonds of N₂ and O₂ break to form excited N* and O* (reactions 1 and 2). Total heat energy of lightning is completely utilized for breaking the bonds of N₂ and O₂ (Chopkar, 1993). These excited N* and O* move to new place by wind force.



They are very unstable and hence undergo further reactions (reactions 3 and 4) to form NO and O₃. These two reactions are endothermic and require heat to occur. This heat is abstracted from the surrounding atmospheric cloud; as a result, temperature falls, condensation takes place with CCN (clouds condensation nuclei) and water drops are formed. These water drops act as natural seeding to form another sets of rain drops. This chain process occurs in the nature with rainfall.



These Ozone and Nitrogen oxides, which lead to the formation of nitric acid particle and other Nitrogen components, bind water molecules together to create water droplets. These water molecules again act as natural seeding to form another set of rain drops. In this way chains process occurs in the atmosphere, which leads to rainfall.

Practical Evidences for Rainmaking by Laser Technology

The occurrence of above reactions is confirmed from laboratory experiment. Also production of O₃ and NO has been observed in the laboratory by Petit, et al. (2012), They say that laser photons photo-dissociate atmospheric compounds to produce O₃ and NO. Increase of O₃ and NO after lightning has also been observed in the atmosphere. Laser-induced condensation and water drops formation have also been observed in the laboratory cloud chamber by Kasparian, et al. (2012), That lightning phenomenon can be created by laser system for artificial rainmaking in the atmosphere has also been practically proved. Scientists have succeeded in obtaining raindrops from an altitude of 45 to 75 meter of the atmosphere by terawatt mobile laser. We have shown earlier how much heat energy is generated in lightning, how much heat energy is utilized for breaking the bonds of nitrogen and oxygen molecules and how much heat energy is absorbed by endothermic reactions from atmospheric clouds (Chopkar 1993; Chopkar and Chakarbarty 2008). Our research result on Lightning Phenomena for enhancing precipitation in the atmosphere has also been published by American Meteorological Society in Meteorological & Geo-astrophysical Abstracts, (vol. 44, No.10, (44.10-555), October 1993). Recently in U.S.A. at the University of Central Florida in Orlando, development of technology “laser makes rain” was supported by a \$7.5 million grant from the U.S. Department of Defense. Their findings are: (1) During a rainstorm, particles inside a cloud build up static electricity and release it as lightning and (2) tiny water droplets stick together until they are heavy enough to fall to the ground. Scientists of that department want to repeat this experiment with lasers to produce rain (Source: Inside Science TV).

Carls and Brock (1987) Did an experiment in which atmosphere was heated by a laser pulse up to 1600 to 2800 K. They observed water droplet formation in the atmosphere. They postulated that water droplets were formed by ionization process. This is partly true because they did not consider dissociation and the occurrence of endothermic reactions, which are responsible for cooling and capable of CCN formation. Again in the conclusion of the said paper, they predicted that the air is shock-heated to temperatures high enough to cause ionization. If the ionized air is subjected to more radiation, avalanche breakdown of the air can occur. This is similar to breaking of N₂ and O₂ molecules which is responsible for endothermic reaction and condensation. Our simulation substantiates the theory that shock-heating of air can be at least partly responsible for aerosol-enhanced breakdown.

METHODOLOGY FOR RAINMAKING

A laser pulse will be sent to cloud to initiate endothermic reactions which will create lightning phenomena, as in nature, mentioned above. The laser technology for this purpose, though not fully developed, yet exists. For example, a German-French group has used femto second-terawatt laser to obtain "Laser- assisted water condensations in the atmosphere". They have succeeded in obtaining raindrops from an altitude of 45 to 75m of the atmosphere. Our system could be a terawatt femtosecond Ti:sapphire pulse laser. Its fundamental wavelength could be ~800nm. The pulse will have energy ~500mJ, 120fs and repetition frequency of 10Hz. The laser pulse has to propagate with almost high peak intensity over a distance of ~1km. This laser system can be operated from ground as well as from aircraft. But there are some advantages for operating this system from the aircraft. Some of them are as follows:

a) Today's laser system cannot be used from ground level for artificial rainmaking because Laser intensity with high power cannot reach a height of ~1km in the atmosphere due to loss of energy in travelling.

- If laser system is used from ground level, then natural lightning may come to ground through laser beam and damage laser instruments and may harm to workers who are working there.
- If laser system is used from ground level, then it cannot cover large area as in aircraft system as aircraft laser can cover more than 45 km² area in one time.
- Laser system from ground level cannot move easily from one place to another place but aircraft laser system can move to any place easily.
- Aircrafts, femtosecond-terawatt laser and other equipments are easily available in the market.
- Acceleration and turbulence created by the aircraft in the atmosphere and creates small water drops which collide with each other and form big rain drops.

Design of Aircraft with Laser System

One aircraft equipped with laser system will be used in this operation is shown in Fig.1. Speed of aircraft will be the minimum. In aircraft there would be instrument by which we would measure the atmospheric parameters. The design of equipping the aircraft with the laser system is shown in Fig.2. There are three sections. Size of the room in the first and third section is 27.5x7.5x2.1m. There are 3 to 5 laser units in this section. Size of the room in the third section is 21.5x7.5x2.1m. In the second section there are high powered energy supply unit, batteries and other necessary units. Sections 1 and 3 contain laser emitting devices and section 2 contains all the electrical appliances like power generating

unit etc. as shown in Fig.3. Dimension of one Laser instrument is 2.5x1.5x1.2m and weight of one Laser instrument 70 Kg.

IRRA Scientist Group, propose laser system of following specification: 1012watt, 800nm, 500mJ, 120fs and 10Hz for the research project “To create artificial lightning by laser system which initiates endothermic reaction in a way of natural lightning phenomena for artificial rainmaking”.

DISCUSSIONS

When a laser pulse of sufficient energy is shot in the atmosphere, it dissociates N₂ and O₂ and excited species N* and O* are formed:



These excited species are very unstable and quickly convert into NO and O₃ by endothermic reactions and produce rain. Enhancement of these two species has been observed both in the laboratory as well as in the atmosphere after lightning. However, according to Kasparian group, a laser pulse shot in the atmosphere ionizes N₂ and O₂



They have observed lightning phenomenon in the laboratory cloud chamber as “Laser induced condensation and water drops formation in the laboratory cloud chamber by Femtosecond –Terawatt mobile laser system”. Kasparian (2012) group says that it is the ionized species N₂⁺ and O₂⁺ which produce rain. But these two species are of micro size which cannot act as seeding agent. Also N₂⁺ and O₂⁺ radicals are not observed by Kasparian group in laser filamentation experiment but production of O₃ and NO has been observed by them in laser filamentation experiment. Experiment of Kasparian group finds condensation and water drop formation and they say in their ionization theory that N₂⁺ and O₂⁺ act as seeding agent. They also say “Mechanism of laser-induced condensation involves photo dissociation, in which photons break down atmospheric compounds in the atmosphere. This process produces Ozone and Nitrogen oxides, which lead to the formation of Nitric acid particles that bind water molecules together to create water droplets.” But there is no seeding and condensation and water drop formation is not due to seeding. Small water drops formed by laser in the laboratory cloud chamber are due only to endothermic reactions (cooling) and this is obvious. In the atmosphere, due to acceleration and turbulence, these small size water drops coalesce and form big rain drops. These rain drops act as natural seeding process to form another sets of rain drops; this chain process continues with heavy rain fall. It has been shown in Appendix that the energy required for dissociation is almost half of that required for ionization. That means energy is first used up for dissociation, then the remaining energy (which may not be sufficient for ionization of N₂ and O₂) is delivered for ionization of N₂ and O₂. Hence dissociation takes place and not ionization. Kasparian group does not talk about dissociation. It is not only near IR laser system, Yoshihara, et al. (2007), have discussed in their paper possibility of creating artificial rain by using UV laser.

Our methodology is to send laser pulse to cloud region to break bonds of O₂ and N₂ (by reactions 1 and 2), create endothermic reactions and condensation (by reactions 3 and 4) and produce rain in the similar way as in lightning. There is attenuation of energy in operating laser from ground. Kasparian group suggests increase of laser power to petawatt

(1015watt) or exawatt (1018watt) to create large water droplets. We will operate from an aircraft in the same way as spraying chemicals from aircraft. A laser pulse of energy 500mJ is capable of dissociating a column of N₂ and O₂ containing ($\sim 0.5/2.25-18$) ~ 1017 molecules which is much higher than the density in the atmosphere.

CONCLUSIONS

Today laser has application in many fields. It is shown in this paper that using an appropriate laser system on board aircraft, endothermic reactions can be initiated in the Cloudy region of the atmosphere. IRRA Scientist Group, propose laser system of following specification: 1012watt, 800nm, 500mJ, 120fs and 10Hz for the research project "To create artificial lightning by laser system which initiates endothermic reaction in a way of natural lightning phenomena for artificial rainmaking". This will produce artificial rain. This method is economical (one time investment), harmless, eco-friendly and can be switched on and off. It can be used at any place and at any time. It is very useful for human being, particularly for farmers. Also, this method can cover more than 45 km² rainfall area at a time (Chopkar, 2012). One additional use of this method is that the excess rainfall can be stopped by releasing low intensity laser into the clouds in the atmosphere during excess rainfall which will make the excess rain clouds to evaporate and will make them disappear from the excess rainfall area. This method can also be used to control pollution in the atmosphere by spraying artificial rain on the polluted city.

If any organization takes up this project then IRRA group would be happy to work with them; project proposal, design for rainmaking technology, budget and work plan are ready with IRRA Scientist Group for demonstration in large scale in the atmosphere. If our findings could help scientists and engineers to create a new method for artificial rainmaking, the resulting technique would be of immense help to mankind.

Present method can find an important use in "rain drain". When huge clouds are present above a lake or dam, we shoot laser beam to the cloud region, then rain drains (pours) as blast of clouds with heavy rainfall over the lake or dam area. Rain drain can continue till the lake or dam is completely full or as per our requirement.

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APPENDIX

The energy of a laser beam of wavelength λ is $h\nu$ ($\nu = 1/\lambda$ and h is Planck's constant). We will shoot laser pulse in the atmosphere and dissociate (break bonds of) N_2 and O_2 as follows:



Bond energy of $N_2 = 226$ kcal/mole.

1 cal = 4.184 Joule, Avogadro number = 6×10^{23}

Therefore energy required to break 1 molecule of $N_2 = 226 \times 10^3 \times 4.184 / (6 \times 10^{23}) = 1.58 \times 10^{-18}$ Joule. Bond energy of $O_2 = 96$ kcal/mole.

Therefore energy required to break 1 molecule of $O_2 = 96 \times 10^3 \times 4.184 / (6 \times 10^{23}) = 0.67 \times 10^{-18}$ Joule.

So the total energy required for breaking 1 molecule of N_2 and 1 molecule of O_2 will be $(1.58 \times 10^{-18} + 0.67 \times 10^{-18}) = 2.25 \times 10^{-18}$ Joule. When a laser pulse is shot in the atmosphere, it may ionize N_2 and O_2 as follows:



Ionizing potential of $N_2 = 15.58$ eV = 2.49×10^{-18} Joule

Ionizing potential of $O_2 = 12.2$ eV = 1.95×10^{-18} Joule

So the total energy required to ionize 1 molecule of N_2 and 1 molecule of O_2 is 2.49×10^{-18} Joule + 1.95×10^{-18} Joule = 4.44×10^{-18} Joule. The above calculation shows that the energy required to dissociate 1 molecule of N_2 and 1 molecule of O_2 is about half of that required to ionize them.



Figure 1: Demonstration for Artificial Rainmaking by Aircraft Laser System.

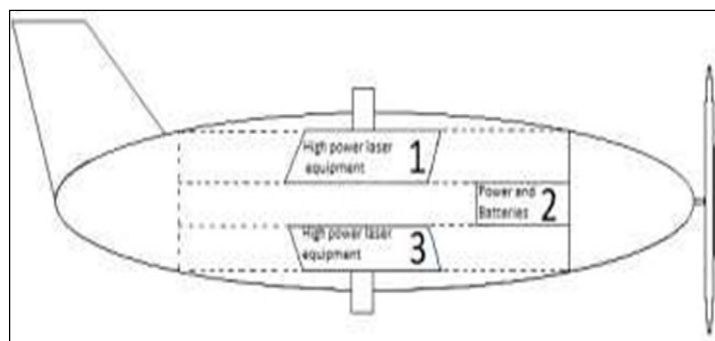


Figure 2: Position of Laser System in Aircraft.

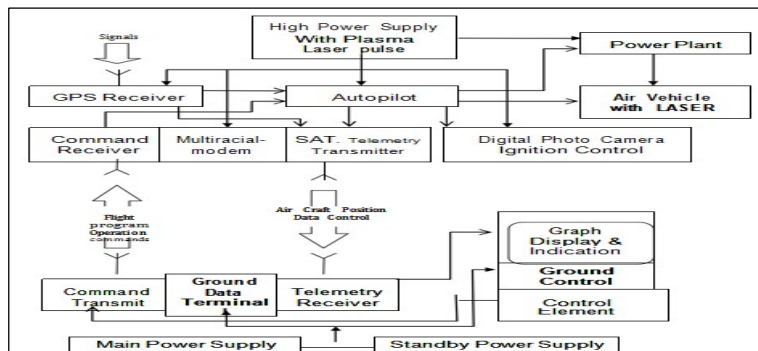


Figure 3: Key Plan for Demonstration

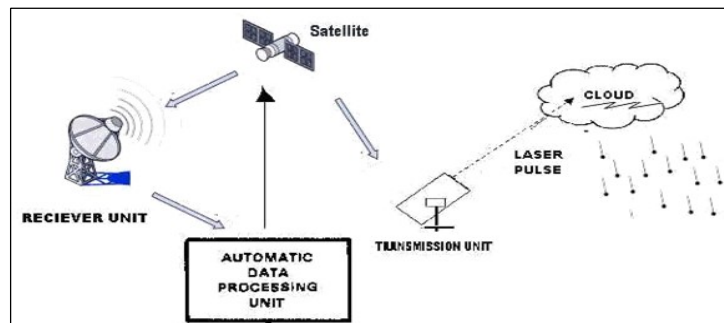


Figure 4: Future Plan for Artificial Rainmaking by Solar Plasma Laser Pulse through Transmission Unit from Ground and Control System by Satellite