



# “Novel Technology for Artificial Rainmaking by Using High Power Laser Which Initiates Endothermic Reactions, as in Natural Lightning Phenomenon, Onboard Aircraft 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 result “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, completely utilized for breaking the bonds of  $N_2$  and  $O_2$  [1]. 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. 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 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. “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. We propose laser system of specification is  $10^{12}$ watt, 800nm, 500mJ, 120fs and 10Hz. for this research project. It should work when more than 65% humidity is available 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.

**Keywords:** Lightning; Laser makes rain; Dissociation process; Endothermic reactions; Condensation; Precipitation; Raindrops; rainmaking; Natural seeding; Rainfall.

## 1. 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. (Please visit our web site [www.irrindia.org](http://www.irrindia.org) or search on Google web as “Artificial rainmaking by endothermic reactions” to know more details about this novel technology.

### 1.1. 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 occurred around the ice glass. So, *IRRA Scientist Group, propose laser system of specification is  $10^{12}$ watt, 800nm, 500mJ, 120fs and 10Hz, for this research project, to create artificial lightning which initiation endothermic reactions, in a way of Natural Lightning Phenomena for artificial rainmaking, in the atmosphere. As a result, these reactions will produce, temperature falls, condensation takes place, seeding and rain 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”, evidences as follow.*

## 2. Natural Evidences for Rainmaking by Lightning Phenomena

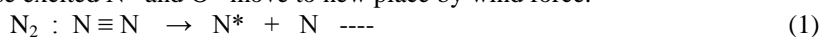
Researchers have been trying to create artificial rain since 1946 (details of literature can be found in our website). They show that, “After lightning. Golde [2], from a number of radar observations has reported that intense

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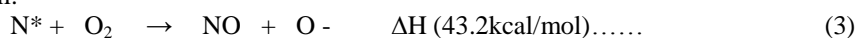
precipitation is not even present in the clouds before the first discharge but it develops abruptly in the same region after discharge from which the lightning flashes originate". This is a well known process in the atmosphere, after lightning, precipitation is formed and heavy rainfall occurs. But the 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 (~30,000K) in fraction of a second. At this high temperature both dissociation and ionization of N<sub>2</sub> and O<sub>2</sub> 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 (~30,000K) attains a temperature of -10K? Who removes the heat? That means after lightning, some mechanism occurs which cools the medium. The mechanism is occurrence of endothermic reactions (3) and (4) which cools the atmosphere.

### 2.1. Novel Technology for Rainmaking

As mentioned above, lightning creates very high temp. At this temperature, bonds of N<sub>2</sub> and O<sub>2</sub> break to form excited N\* and O\* (reactions 1 and 2). Total heat energy of lightning, completely utilized for breaking the bonds of N<sub>2</sub> and O<sub>2</sub> [1]. 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 O<sub>3</sub>. 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.



NO and O<sub>3</sub> which leads to the formation of Nitric acid, NO<sub>3</sub>(H<sub>2</sub>O)<sub>n</sub>, H(H<sub>2</sub>O)<sub>n</sub> etc. compounds that bind water molecules together to create water droplets with big rain drops, which is act as natural seeding process to enhancing rainfall in the atmosphere.

### 2.2. Practical Evidences for Rainmaking by Laser Technology

The occurrence of above reactions is confirmed from laboratory experiment. Also production of O<sub>3</sub> and NO has been observed in the laboratory by Petit et al. 2010. They say that laser photons photo-dissociate atmospheric compounds to produce O<sub>3</sub> and NO. Increase of O<sub>3</sub> 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. [3]. 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 [1, 4]. Our research result on Lightning Phenomena for enhancing precipitation in the atmosphere has also been published by American Meteorological Society in Meteorological & Geo-astronomical 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 when and where it is needed (Source: Inside Science TV). As in nature, artificial lightning can be created by plasma laser pulse for making artificial rain.

Carls and Brock [5], 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, he 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 N<sub>2</sub> and O<sub>2</sub> molecules (Air contains 74 % N<sub>2</sub> and 23% O<sub>2</sub>, exist) which is responsible for endothermic reaction and condensation takes place. Our simulation substantiates the theory that shock heating of air can be at least partly responsible for aerosol-enhanced breakdown.

High power Laser shoots in the Laboratory Cloud chamber, results comes out, "Laser induce condensation and water drops formation" also NO & O<sub>3</sub> formation has been measure after high power Laser shooting in the laboratory cloud chamber, also percentage of NO & O<sub>3</sub> has been increase after lightning in the atmosphere, which is responsible for two endothermic reactions as above. These two endothermic reactions are the most challenging to scientifically enhance & responsible for condensation and water droplets formation in the Laboratory Cloud chamber as well as in the atmosphere. It is most useful for artificial rainmaking in the atmosphere.

When high power Laser will be shoots in the atmosphere. High power Laser induces condensation & tiny water droplets formation as in the Laboratory cloud chamber. These tiny water droplets, comes to-gather and formed big rain drops, by wind force as acceleration and turbulence process in the atmosphere, which is enough to fall down as rain droplets, as in lightning phenomena. These rain drops or tiny water particles, act as natural seeding process to formed new sets of rain drops, chain process occur, which is enough to rainfall in the atmosphere.

So, IRRA Scientist Group, propose laser system of specification is  $10^{12}$  watt, 800nm, 500mJ, 120fs and 10Hz for this research project. "To create artificial lightning by laser system, which initiation endothermic reaction, in a way of Natural Lightning Phenomena for artificial rainmaking, in the atmosphere".

### 3. Methodology for Rainmaking

A laser pulse is 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 femtosecond-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:

- 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 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 200 km<sup>2</sup> 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 market.
- Acceleration and turbulence created by the aircraft in the atmosphere creates small water drops which collide with each other and form big rain drops.

Three aircrafts equipped with laser system will be used in this operation. Each aircraft will release three to six laser beams in the atmospheric clouds. They will cover more than 200Km<sup>2</sup> area.

Distance between two flying aircraft will be ~300 m horizontally and 300 m vertically. Speed of aircraft will be 100km/h. In each aircraft there should be instrument by which we can measure the atmospheric parameters. For the sake of demonstration model of three aircrafts is shown in Fig.1.

#### 3.1. Design of Aircraft with Laser System

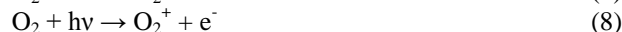
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### 4. Discussion

When a laser pulse of sufficient energy is shot in the atmosphere, it will dissociate N<sub>2</sub> and O<sub>2</sub> and excited species N\* and O\* will be formed:



These excited species, as shown above, are very unstable and quickly convert into NO and O<sub>3</sub> 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 will ionize N<sub>2</sub> and O<sub>2</sub>:



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 (German-French) group says that it is the ionized species, N<sub>2</sub><sup>+</sup> and O<sub>2</sub><sup>+</sup> which produce rain. But there is no report of any increase of N<sub>2</sub><sup>+</sup> and O<sub>2</sub><sup>+</sup> in the laboratory. Also these two species are of micro size which cannot act as seeding agent. Production of O<sub>3</sub> and NO has also been observed by Kasparian group in laser filamentation experiment. But N<sub>2</sub><sup>+</sup> and O<sub>2</sub><sup>+</sup> radicals are not measured / observed in laser filamentation experiment. Experiment of Kasparian group shows condensation and water drop formation and they say in their ionization theory that N<sub>2</sub><sup>+</sup> and O<sub>2</sub><sup>+</sup> act as seeding agent. Kasparian, *et al.* [6] "Mechanism of laser-induced condensation, the technique involves photo dissociation, in which photons break down atmospheric compounds in the atmosphere. This process produce 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; 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 absorbed by dissociation, then the remaining energy (temperature) needed for ionization of  $N_2$  and  $O_2$  cannot be delivered by the laser pulse. 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.* [7], 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  $O_2$  and  $N_2$  (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. TM group suggested increase of laser power to petawatt ( $10^{15}$  watt) or exawatt ( $10^{18}$  watt) to create large water droplets. We 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  $N_2$  and  $O_2$  containing  $(\sim 0.5/2.25^{-18}) \sim 10^{17}$  molecules which is much higher than the density in the atmosphere. We use terawatt mobile laser system of specification 800nm, 500mJ, 120fs and 10Hz for creating artificial rain from normal cloud heights.

## 5. 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. This will produce artificial rain. This novel technology is fully acted as natural as lightning phenomena, so it's none pollute system. In this method, there are condensation and natural seeding process occurs. In this process, cloud formation by condensation take place in the atmosphere. 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 any time. It is very useful for human being, particularly for farmers. Also, this method can cover more than 200  $km^2$  rainfall area at a time Chopkar, *et al.* [8]. 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.

*As per above discussion and IRRA Scientist Group, conclude that One or two, high power laser cannot enough to create, artificial rainmaking, in large atmosphere. So, IRRA Scientist Group, will be used multiple Laser system by Aircraft, as per available laser technology, appropriate laser technology for this purpose is yet to be developed. We will release more and more, high power laser, as lightning in the atmosphere. Aircraft and high power Laser System are easily available in market. Design of model are ready available with IRRA Scientist Group. Our academy is interested to further develop this technique for Green revolution in the whole world for all human being. If any organization / Govt., takes up this project then IRRA Scientist Group, would be happy to work with them. . If our findings could be used to help scientists and engineers create new alternative method for artificial rainmaking, the resulting techniques could be of inestimable value. IRRA Scientist Group, are ready for scientific discussion.*

## 6. Figures

**Fig-1.** Position of three Air Craft in flight mode



Fig-2. Position of laser system in aircraft

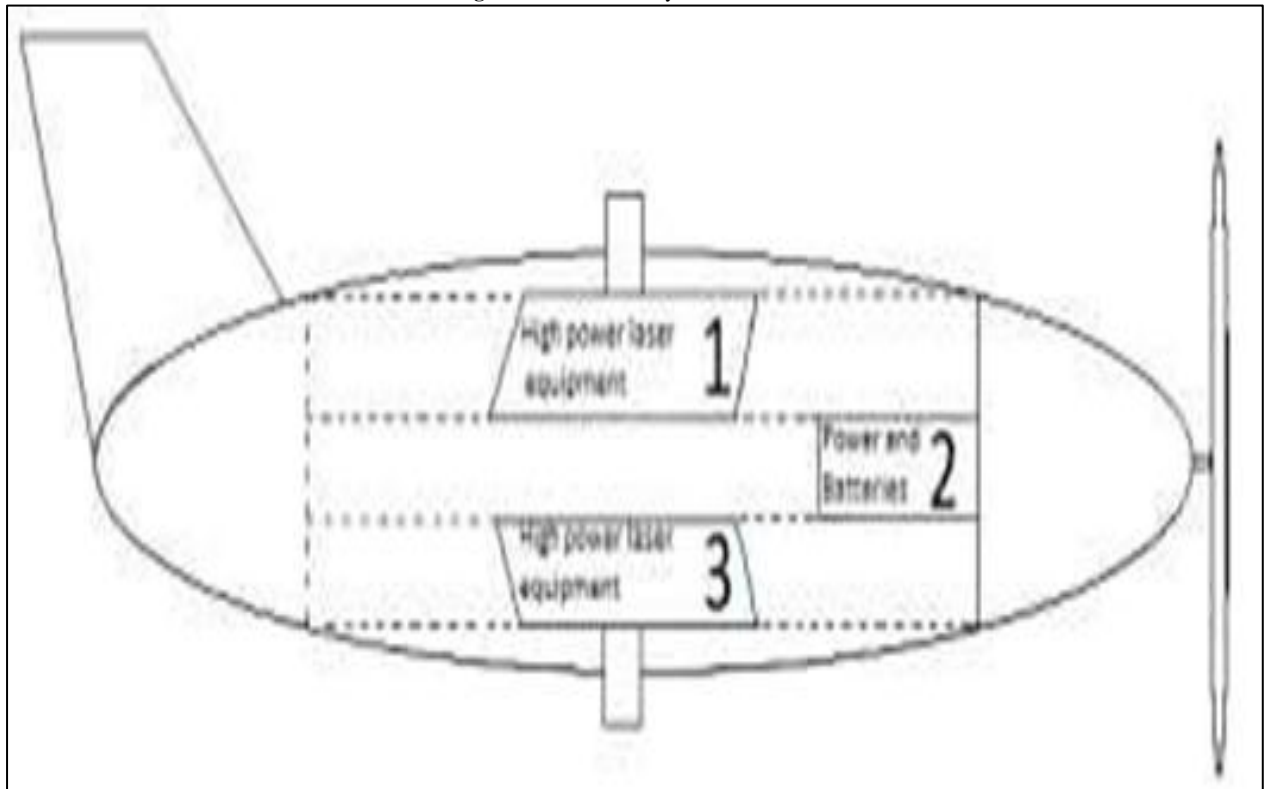
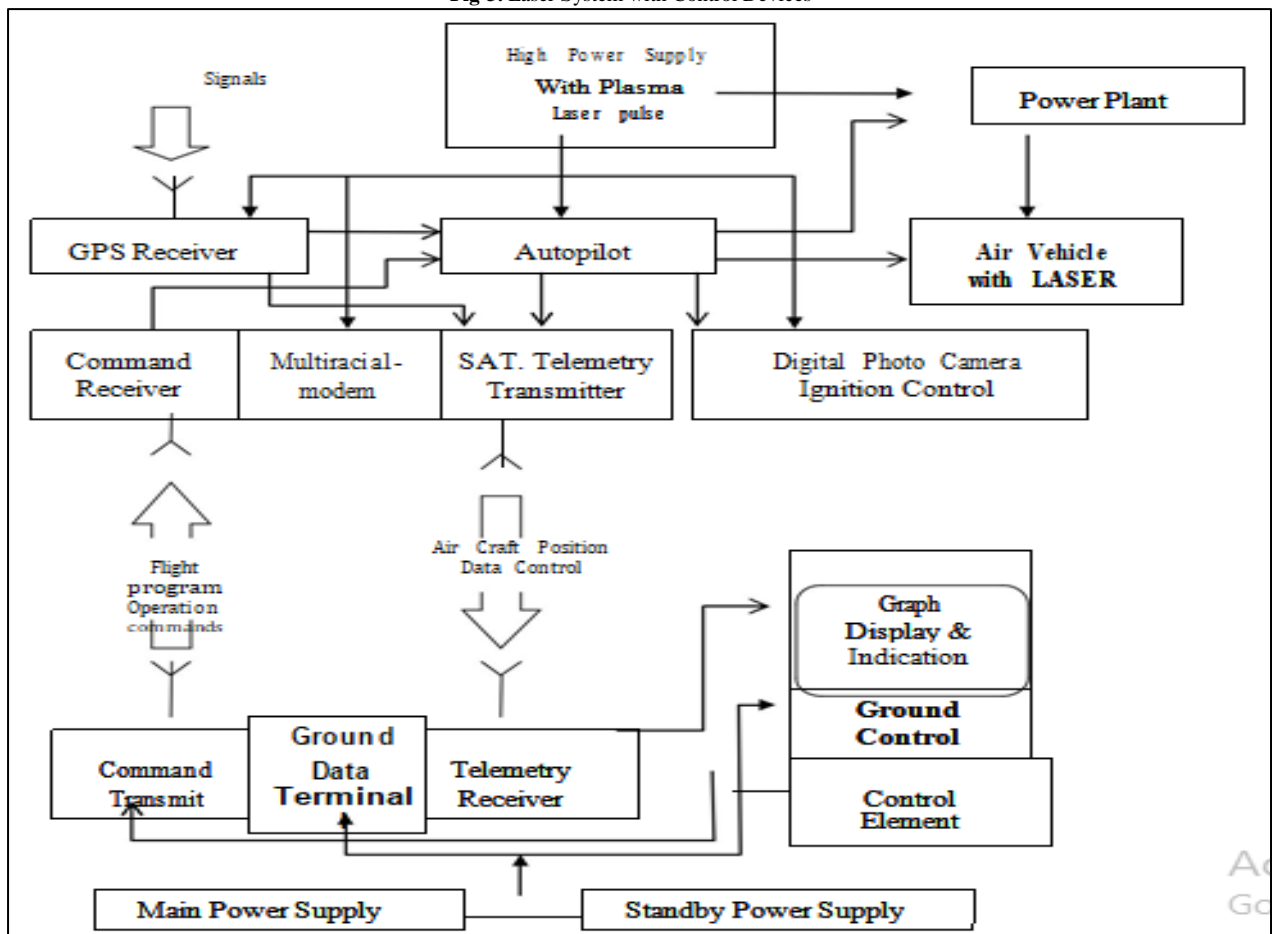


Fig-3. Laser System with Control Devices



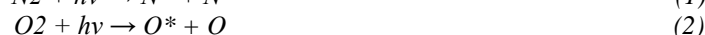
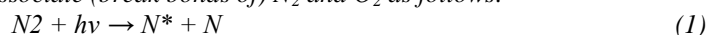
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## Appendix

The energy of a laser beam of wavelength  $\lambda$  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:



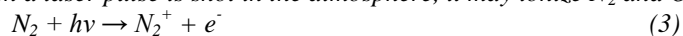
Bond energy of  $N_2 = 226$  kcal/mole.

1 cal = 4.184 Joule, Avogadro number =  $6 \times 10^{23}$

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 =  $2.49 \times 10^{-18}$  Joule

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

So the total energy required to ionize 1 molecule of  $N_2$  and 1 molecule of  $O_2$  is  $2.49 \times 10^{-18}$  Joule +  $1.95 \times 10^{-18}$  Joule =  $4.44 \times 10^{-18}$  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.