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Condensation and Water Drops Formation due to Endothermic Reaction by Laser Pulse through Natural Lighting Phenomena in the atmosphere

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Abstract*: After lightning, precipitation formed, these lightning phenomena occur in the atmosphere by high power laser pulse. After striking the laser pulse, condensation and water drop formation take place in the atmosphere. It is well known that, for water drop formation, condensation must occurred (condensation is the basic need for water drops formation).Condensation means, heat energy subtraction. Heat energy subtraction take place by only endothermic reaction in the atmosphere. Recently M. Petrarca et al and other scientist also proved that, condensation in air could be induced by laser pulse. NO and ozone found after inducing laser pulse is evidence of endothermic reaction. Lightning or laser shot creates high temp breaking bonds of Nitrogen (N_2) and Oxygen (O_2) to formed excited N* and O* consequently NO & Ozone formation. At that time endothermic process starts. In these endothermic reactions heat energy get absorbed from surrounding atmospheric water vapor, catalyzing condensation and water drop formation by dissociation in the atmosphere. Also other processes responsible for condensation and water drop formation are dissociation, ionization and natural seeding process creates (CCN) which may be useful for Artificial Rainmaking in the atmosphere.*

Artificial rainmaking can be done by initiating endothermic reactions in the cloud, with sufficiently high humidity, using a high power laser pulse. The advantage of this method is, it is environmentally clean, economical, can be turned on and off at will, and can be precisely positioned. It will be movable system on mobile platform.

1. INTRODUCTION

Rain plays an important role in world economy by influencing the agriculture yield. But rain is a natural phenomenon, and it does not fall as and when man needs it. Researchers are trying to create artificial rain for the past many years.

Current Technology for Artificial making is through cloud seeding: -

In 1946 Langmuir produced clouds in a chamber by cooling air with dry ice and gave the idea that nucleation of water would take place by adding some foreign materials as seeds inside the chamber. This idea is being used for more than 60 years for artificial rain creation by spraying chemicals like silver iodide, calcium chloride and sodium chloride to cold wet air from balloon or aircraft. But the success rate of this method is low. Because in seeding condensation does not take place. ***Condensation is the basic need for water drop formation.*** Seeding process was used only for cold rainy clouds but our process will be used for warm white cloud. In our process, condescension is by endothermic reactions. We have proved this in our Laboratory. Seeding process is expensive and harmful to mankind because it brings harmful chemicals on earth along with rain.

Practical Evidences for condensation by high power Laser ;- 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, 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_2 and O_2 molecules because air contains 77% N_2 and 23% O_2, 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.

In the laboratory, we did an experiment in a chamber where lightning was created by a high voltage electric spark. We noticed formation of water droplets on the surface of the chamber. The results have been published *(Chopkar and Chakrabarty 2008, Chopkar et al. 2010)*.

Rohwetter et al. (2010) have shown that ionized filaments (like a cable) generated by ultra-short wave (Visible, Infra Red region) laser pulses are able to induce water-cloud condensation in the sub-saturated atmosphere in the altitude region between 45 and 75m resulting in rain.

Yoshihara et al. (2007) have shown that the pulsed UV-laser irradiation of ambient air induces the formation of water droplets or small ice particles in the laboratory. They also observed that the atomic oxygen which is formed in this process quickly reacts with oxygen molecules to form ozone. In their experiment ozone is formed due to endothermic process by which condensation takes place and CN (condensation nuclei) is formed which produces water droplets or ice crystals.

Recently M. Petrarca et al. (2011) proved that, condensation in air can be induced by laser pulse. NO and ozone found after inducing high energy laser pulse is evidence of endothermic reaction.

It may be mentioned here that a group at Indian Institute of Tropical Meteorology, Pune who is experimenting with lidar, has also observed that a few drops of water fall after the laser beam is shot in the atmosphere.

Teams of scientists from Switzerland and Germany have been trying to create artificial rain by using laser. In 2011, they succeeded to produce tiny water particles in moderately humid air. But the droplets were about a hundred times too small to fall as raindrop; instead, they remained suspended in the air. But the team believes that it is feasible to get larger droplets. In the 2011 experiment, they used a 100 terawatt (1tw=10^{12} watts) laser and a mobile laser of size of a shipping container of 5 terawatts. Their conclusions were:

1. If the power of laser is increased to petawatt (10^{15} watts) or exawatt(10^{18} watts) level it is possible to create larger water droplets. These powerful lasers are commercially available.
2. The team did the experiment in less humid air. If the experiment is done in high humid air like monsoon, there is high possibility of forming big raindrops.
3. If the experiment is done by the side of a mountain then air will go up along the mountain side and get cooled and there is possibility of forming big raindrops.
4. There has to be arrangement of fast sweeping of the beam to cover more area.

In 2012 this group has found that at high temperature condensation takes place and water droplet, NO and O_3 are formed after laser beam shooting.

2. NATURAL EVIDENCES

On several occasions it has been found that precipitation follows after lightning. *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. *Battan* (1981) has observed very rapid growth of precipitation particles/ice crystals caused by electrical forces following a lightning discharge. In many cases the on-set of strong electrification follows the appearance of heavy precipitation within the cloud in the form of hail stones (*Wallance* and *Hobbs*, 1977). The correlation between lightning and precipitation is as follows: heavy gushes of rain or hail often reach the ground in 2-3 min. after the lightning flash and it is evidenced that lightning is the cause rather than the result of the rapid intensification of the precipitation (*Mason*, 1975). It is further speculated that the rapid intensification of the precipitation from about 1mm/h to 50mm/h in this 2-3 min period is brought about by a greatly accelerated rate of coalescence of water drops under the influence of electrical forces by a mechanism that is obscure and has no convincing experimental or theoretical base (*Mason*, 1971). From the above work it is clear that precipitation is formed after lightning.

In lightning, temperature rises as high as (30,000K) in fraction of a second. At this high temperature both dissociation and ionization of N_2 and O_2 as shown in reactions (1), (2), (3) and (4) take place as fallow. 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 cool the medium. The mechanism is occurrence of endothermic reactions (5) and (6) which cool the atmosphere. This cooling will create CCN (clouds condensation nuclei) in cloud and produce tiny water droplets in the atmosphere. These tiny water droplets then will act as natural seed for the formation of rain drops in the atmosphere (*Drake* 2006).

3. THEORY

The artificial rain can be initiated by endothermic reactions in the cloud using a high power laser pulse. The advantage of this method is, it is environmentally clean, economical, can be turned on and off at will, and can be precisely positioned.

When a laser pulse of wavelength, λ and energy, $h\nu$ ($\nu = 1/\lambda$ and h is Planck's constant) is shot in the atmosphere, depending on the value of its energy, it can dissociate (break the bonds of) Nitrogen (N_2) and Oxygen (O_2) (which are the two major gases in the atmosphere) and ionize them as follows:

Dissociate:

$$\mathbf{N_2 + h\nu \rightarrow N^* + N} \quad \textbf{(1)}$$

$$\mathbf{O_2 + h\nu \rightarrow O^* + O} \quad \textbf{(2)}$$

Ionize:

$$\mathbf{N_2 + h\nu \rightarrow N_2^+ + e^-} \quad \textbf{(3)}$$

$$\mathbf{O_2 + h\nu \rightarrow O_2^+ + e^-} \quad \textbf{(4)}$$

Energy required to dissociate 1 molecule of N_2 and 1 molecule of $O_2 = 2.25 \times 10^{-18}$ Joule.

Energy required to ionize 1 molecule of N_2 and 1 molecule of $O_2 = 4.44 \times 10^{-18}$ Joule.

Hence 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. Therefore, when a laser pulse is shot in the atmosphere, it will first dissociate N_2 and O_2 and if energy still remains then it will ionize them.

After bond breaking (dissociation, reactions 1 and 2), two atoms of N_2 (N^*, N) and two atoms of O_2 (O^*, O) are formed. Among them atoms N^* and O^* are in excited state and hence are unstable. They immediately react with some gases to come to ground state and form stable NO and O_3 as follows:

$$\mathbf{N^* + O_2 + \Delta\ H\ 43.2\ kcal/mol) \rightarrow NO + O} \quad \textbf{(5)}$$

$$\mathbf{O^* + O_2 + N_2 + \Delta\ H\ (67.6\ kcal/mol) \rightarrow O_3 + N_2} \quad \textbf{(6)}$$

Both reactions (5) and (6) are endothermic and absorb a large amount of heat (43.2 + 67.6 = 110.8 kcal/mol) from the surrounding air. As a result, the air becomes cooled below the condensation temperature and fine water particles are formed, cloud seeding takes place and it rains. Recently Kasparian group has detected formation of NO and O_3 after laser beam shooting.

There is another possibility. In reactions (3) and (4), positive ions, N_2^+ and O_2^+ and electrons, e^- is formed. Positive ions, N_2^+ and O_2^+ will quickly react with water molecules and form big ions like $H^+(H_2O)_n$ etc and electrons, e^- will quickly react with many gases to form big negative ions like $NO_3^-(H_2O)_n$ etc. The value of "n" could be as large as 25. These big positive and negative ions may act as seed and create rain.

4. METHODOLOGY

To trigger artificial rainfall, model system can be used is shown in Figure 2. This system has a transmission unit which sends two laser pulses in the direction of the cloud as shown in Figure 1. The transmitter could be a 100 terrawatts femtosecond Ti: sapphire pulse laser. Its fundamental

wavelength could be ~800nm. The pulse will have energy 2-5J, duration 25fs and repetition frequency 10Hz. The laser pulse has to propagate with almost high peak intensity over a distance of ~500m. This nonlinear phenomenon is caused by the subtle interplay between self-focusing induced by optical Kerr effect and the defocusing by the self-generated plasma. We will send two Laser simultaneously, towards parcel clouds in the atmosphere. One, main high power laser diameter 50mm, and second, cover low intensity Laser, diameter 80mm. Energy of high power laser could not loss in travelling up to 500m distance.

The system is controlled by a Micro Controller (remote unit), which consists of data acquisition and processing system. The peripherals of the system include fast transient digitizer and computer controlled stepper motors (SM-1 and SM-2). The laser beam energy will be adjusted by SM-2. The system will be operated by a MV power supply. The transmission unit will be designed as mentioned above.

Figure 1. *Demonstration in the Atmosphere*

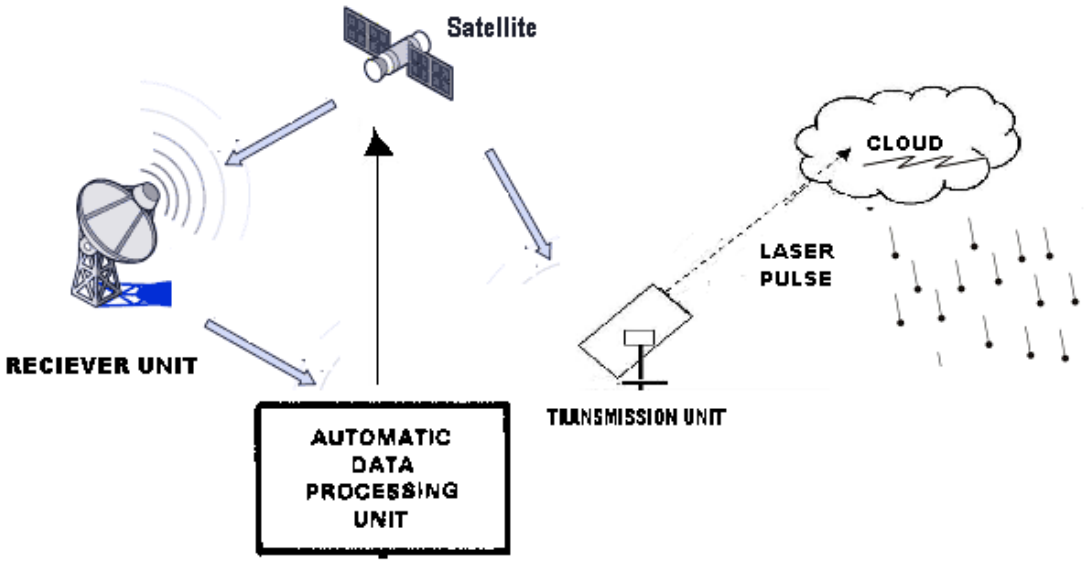

Figure 3. *Artificial rainmaking by laser pulse through satellite system*

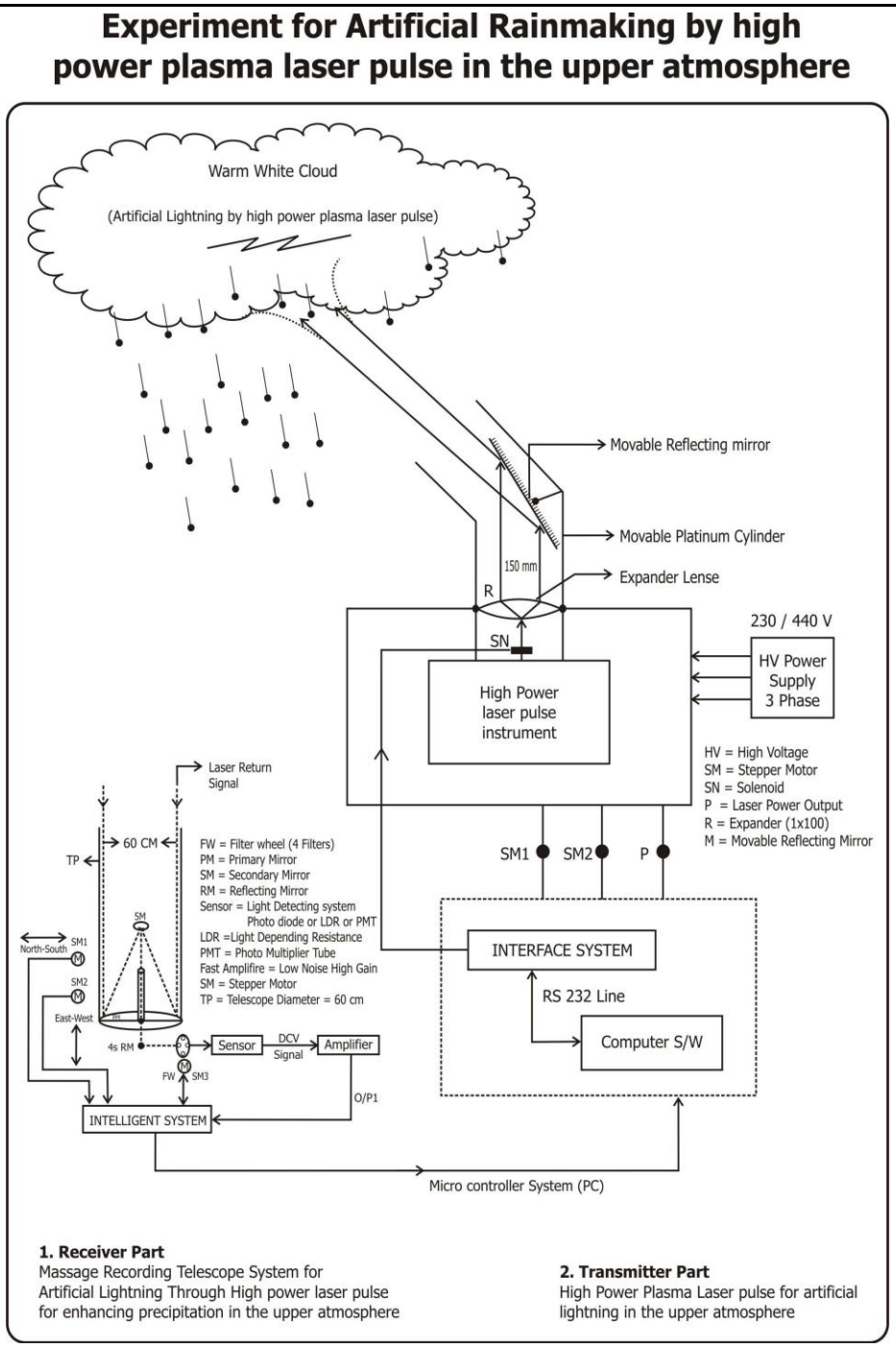

Figure 2. *Experiment Setup*

5. ARTIFICIAL RAIN MAKING SYSTEM DESIGN EXPERIMENT

1. Recording of atmospheric parameters

Measurement of atmospheric parameters like percentage of humidity, temperature, pressure and wind velocity at different height before and after sending the laser pulse will be done by launching appropriate instrument at those heights in helium balloons.

We will record Humidity, Wind Velocity, Liquid water content, Temperature and Pressure, etc all atmospheric parameters by sending a laser beam of particular wavelength and then we will vary the wavelength of laser beam and record the same parameters so that we will get the data for ready reference for artificial rain making at that particular place.

2. Observation of cloud condensation and precipitation formation

We will record videos and pictures of cloud condensation and precipitation by cameras before, during and after laser induced precipitation.

3. Measuring liquid water content in the cloud

Liquid water content in the clouds will be measured by sending quad-opter at various height (remote controlled from the ground). These quad-opter will be fitted with various light weight sensors.

4. Laser experiment

After recording atmospheric parameters and water content of the clouds on any given day at a particular date, time and location; we will start our experiment by sending different wavelength of lasers and recording the resulting precipitation using rain gauge.

In this way we will record the above various parameters by passing a laser beam of particular wavelength and then we will vary the wavelength of laser beam and will record the average rain fall at different rain gauge stations so that we can get the optimum value of wavelength and intensity of the laser beam which will give the maximum average rain fall.

5. Analysis

At any given level of humidity range, we will have the data of laser intensity (wavelength) versus % of water drop formation.

After calculating optimum laser intensity at a given humidity range, we will analyze the relationship between humidity range and optimal wavelength to cause precipitation at that humidity range. This reading will help us design the final laser induced rain making system optimized to cause maximum possible rainfall at a given level of humidity.

6. DISCUSSION

It is obvious that, many scientists observed condensation in air due to incidence of laser pulse. For condensation endothermic reaction is necessarily happen. This endothermic reaction in the atmosphere can be done by dissociation of gas molecules due to laser energy. Ionization can be the source of endothermic reaction, if laser intensity is more. The same result can be obtained by using low power laser pulse with dissociation of molecules instead of ionization. Recently M. Petrarca et al also proved that, condensation in air can be induced by High power Laser. But who removes the heat? That means after high energy Laser, some mechanism occurs which cool the medium. The mechanism is occurrence of endothermic reactions (5) and (6) which cool the atmosphere.

7. CONCLUSION

1. Now it is clear that the water drops formed after lightning is due to condensation by endothermic reaction and seeding by photochemical ionization process. These natural lighting phenomena can be used for artificial rainmaking by using high power laser system in the atmosphere.
2. If the power of laser is increased to petawatt (10^{15} watts) or exawatt (10^{18} watts) level it is possible to create larger water droplets. These powerful lasers are commercially available.
3. The team did the experiment in less humid air. If the experiment is done in high humid air like monsoon, there is high possibility of forming big raindrops.
4. And also if the practical experiment is done in hilly areas where clouds are near to ground level, high power of laser system can easily reach the parcel clouds, which will create artificial lightning in the atmospheric clouds and there is possibility of forming big raindrops.
5. After fixing a laser beam of optimum wavelength giving maximum rain fall, it will activate the water droplets in the parcel cloud in the upper atmosphere as natural seeding process to form another set of rain drops. These new raindrops will again act as natural seeding. In this way, chain process occurs to give maximum artificial rainfall, which will be commercially used for domestic and industrial proposes.

6. If materializes, our future plan is to fixed data in the computer software and providing same to satellite (Fig.3) for causing maximum rain fall at any place, at any time, as per our human need, for green revolution, in the whole world.

8. ENCOURAGEMENT

Above research work is necessary for green revolution in whole world. But due to lack of funds we are not able to move further, if any organization/government can fund this research, we would be happy to work with them.

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