

**Artificial rainmaking system in a way of natural phenomena**S. K. Chopkar¹ and D. K. Chakrabarty²¹Atmospheric Rainmaking Research Society, Chimur, Chandrapur Dist., Maharashtra- 442903, India.²Centre for Environment Survey, Vidyanagar Society 29/251, Ahmedabad- 380015, India.
dkchakrabarty@rediffmail.com; skc.arr@rediffmail.com

Abstract: An experiment conducted in the laboratory is described in this paper which demonstrates the cooling effect caused via two endothermic reactions as a results of atmospheric air exposure to lightning. Based on the experimental evidences, a proposal has been made to create artificial rain by triggering the lightning in the atmosphere by sending a high power laser beam.

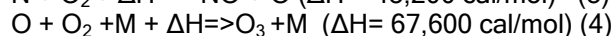
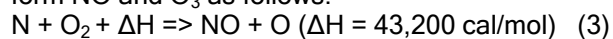
Keyword: Artificial rain, precipitation, laser beam.

Introduction

Lightning creates high temperature ~ 30000 °C in a fraction of second (Newcott, 1993). At this temperature, bonds of molecular nitrogen and oxygen break into active N* and active O*:



These active N* and O* shift from a place of high temperature to other places by wind and react to form NO and O₃ as follows:



The occurrence of above two reactios and formation of NO and O₃ are confirmed in a laboratory experiment (Sander *et al.*, 2003). Both reactions (3) and (4) are endothermic and abstract a large amount of heat energy from the surrounding atmosphere. As a result, the atmosphere is cooled below the condensation temperature of water vapour. This cooling may create CCN in cloud parcel and produce small water droplets. These small droplets then could multiply into a large number of water droplets resulting in artificial rain. An experiment conducted in the laboratory demonstrated the mechanism of cooling effected via the two endothermic reactions. Based on this phenomenon, a proposal is made here to create artificial rain in the atmosphere by triggering the lightning with the help of high power laser gun.

Rains play a great role in national economy by influencing agriculture yields. But rain is a natural phenomenon and it does not fall as and when man needs it and hence man has been trying to create artificial rain for several years. At present, the process which is used for creating artificial rain is seeding. In this process chemicals such as silver iodide, calcium chloride or sodium chloride are used. They are spread from the aircraft in the cold cloud region. This creates rain. This process has been tried in South Africa, Thailand, Japan, Mexico

and some states of India. But this process is very expensive and occasionally it fails.

Lightning creates tremendous amount of electrical energy. This energy could be harnessed. But people are more worried about the damage caused by lightning. Therefore researchers have been working to devise a method to trigger lightning and guide the discharge to harmless spots. It has been reported that discharge of lightning can be done at a fixed spot by a laser system (Uchida *et al.*, 1999). We propose to use this technique to create artificial rain. Our proposal is based on the success of an experiment conducted in the laboratory. The experiment described here demonstrates that cooling is produced in the atmosphere by endothermic reactions leading to precipitation and then rain. Our technique, if successful in open system, could make artificial rain in a very low price.

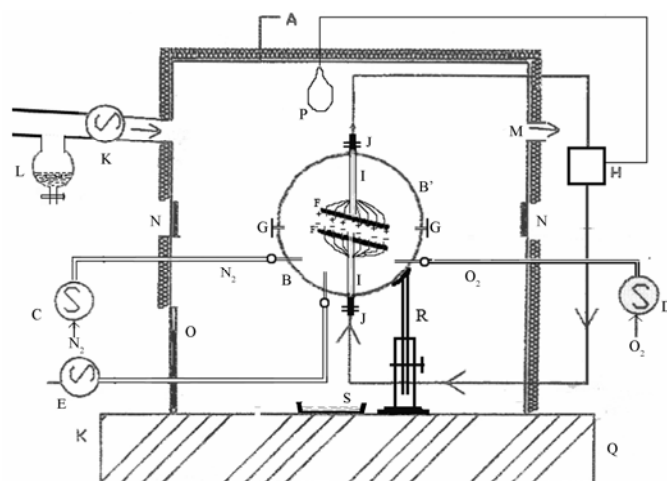
An experiment performed in the laboratory to show the effect of endothermic reactions

A simple experiment performed in the laboratory has been shown in Fig. 1. Here A is an iron chamber of size 10'×10'×10' (actually this a water tank purchased from the market). This was covered with insulating material. Inside this chamber a spherical glass chamber (B) of diameter 3' was mounted. Actually this chamber is made up of two hemispheres B and B' joined by rubber packing GG. Steam was introduced in this chamber through a hole of diameter 4" by controlled system K. N is a glass window for inspection from outside. O is a door of size 3'×3' to enter inside the chamber for inspection. At the centre of the glass chamber two parallel plates, F and F' made up of non-conducting material carbon of size 1' 6"×1', are mounted. On each of these plates 12 tungsten nails of diameter 0.3" and length 1" are fitted. All the nails in one plate are electrically connected. The distance between these two plates can be varied by screw adjustment (JJ) from outside. These two plates are connected to the opposite terminals of H, a 220V DC power supply. A switch is used to make the supply on or off. Pure nitrogen and pure oxygen are introduced in the glass chamber through ports C and D. K is a vacuum system to evacuate the glass chamber B. We did the experiment in three steps:

In the first step, glass chamber was evacuated to some extent. Then 3.5 parts of nitrogen and 1 part of oxygen by volume was introduced in the

glass chamber B. Then steam was injected into the chamber A. DC voltage was applied between two plates F and F' by switching the power supply 'on'. The distance between F and F' was varied till there was a spark (or artificial lightning). After few seconds, power supply was switched off. It was observed that on the surface of glass chamber B

Fig. 1. Block diagram of the laboratory experiment to show the effect of endothermic reactions.



- A IRON CHAMBER
- B&B' TWO HEMISPHERICAL GLASS CHAMBERS
- C NITROGEN GAS SUPPLY WITH CONTROLLED SYSTEM
- D OXYGEN GAS SUPPLY WITH CONTROLLED SYSTEM
- E VACUUM CONTROLLED SYSTEM
- F&F' TWO NON CONDUCTIVE PLATES WITH TUNGSTEN NAILS
- G HEMISPHERICAL PARTS OF B & B' JOINED WITH RUBBER PACKING
- H HIGH VOLTAGE POWER SUPPLY
- I STEEL PIPE TO HOLD PLATES F & F'
- J SCREW TO VARY DISTANCE BETWEEN F & F'
- K STEAM SUPPLY WITH CONTROLLED SYSTEM
- L CONDENSED WATER REMOVAL VESSEL
- M STEAM OUTLET
- N GLASS WINDOW FOR INSPECTION FROM OUTSIDE OF CHAMBER A
- O DOOR TO ENTER CHAMBER A
- P ELECTRIC BULB
- Q PLATFORM ON WHICH CHAMBER A IS MOUNTED
- R STAND ON WHICH B IS MOUNTED
- S WATER COLLECTION POT

steam had condensed and formed drops of water.

In step 2, above experiment was repeated by injecting N_2 and O_2 in B and passing steam in A, but power supply was switched off. This time no condensation of steam was seen on B.

In step 3, supply of N_2 and O_2 was stopped but the supply of steam was on. DC voltage was applied between F and F' and the distance between them was varied till spark or artificial lightning was produced. This time a few drops of water were seen on the surface of B.

In step 1, spark broke N_2 and O_2 to excited N and excited O, then NO and O_3 were formed by endothermic reactions; the chamber was cooled, steam condensed and drops of water were formed. In step 2, since there was no spark, there was no formation of excited N and excited O; no

endothermic reactions and hence no substantial cooling, though the surface temperature of B was lower than that of steam. Now in glass chamber there was only air of chamber capacity having natural ratio of 78% nitrogen and 21% oxygen. Since, volume of air was limited to chamber volume this time, very less tiny water droplets was observed on the surface of the glass chamber. This may be due to the limited nitrogen and oxygen content of the chamber by which endothermic reaction could not have sustained for longer time, so it could not create sufficient cooling and hence yielded very less water droplets in the chamber.

This experiment suggests that water droplets are formed by condensation by means of endothermic reaction at the instance of the artificial lightning created in the glass chamber. It was also noticed that after spark, the nails fitted on F and F' become black immediately. This is because the chamber B was very much cooled due to endothermic reactions. Taking an analogy with black smith, when a piece of iron is heated over a furnace and taken out of the furnace, it remains red hot for a couple of minutes. This is because there are no endothermic reactions to cool the surrounding; whereas in step 1 in chamber B, it is very cold due to endothermic reactions. Similarly in arc welding it can be noticed that the points of arc become black as soon as flame is extinguished. It may be worth to mention here that Shoenbein in 1840 showed that O_3 is produced when O_2 is passed between two electrodes having electrical discharge and that is how he discovered O_3 .

Theoretical consideration

In an earlier work, one of us (Chopkar, 1993) has shown that the heat energy produced in a thunder storm is more than 4.2×10^4 kcal and the total energy needed to break the bonds of N_2 and O_2 is 4.16×10^4 kcal. Hence lightning is capable of breaking the bonds of N_2 and O_2 to produce N^* and O^* . Also shown in that work that these active species are unstable and further react to form stable molecules of NO and O_3 . These reactions are endothermic and the heat absorbed from the surrounding is 8.37×10^3 kcal. To reach the dew point, 1.58×10^3 kcal energy is to be abstracted from the atmosphere. This value (1.58×10^3 kcal) is much less than 8.37×10^3 kcal and hence super cooling is produced in the atmosphere by endothermic reactions to form water droplet. These steps are schematically shown in Fig. 2.

Precipitation associated with lightning

It is clear from the above discussion and the experiment performed by us that spark can produce cooling by edothermic reactions. It has



also been reported (Golde, 1977; Uman, 1987) that after lightning precipitation is formed. After precipitation there may or may not be heavy rains. It is not necessary that always lightning will precede rain, as during monsoon period, there is rain without lightning. But it has been observed that if it rains after lightning, burst of rain occurs. An important point on which so far no satisfactory understanding has reached is as follows: In lightning a temperature as high as $\sim 30000^{\circ}\text{C}$ is produced. But for the formation of precipitation a temperature as low as $\sim -10^{\circ}\text{C}$ is needed. How a region which is at a temperature of $\sim 30000^{\circ}\text{C}$ attains a temperature of $\sim -10^{\circ}\text{C}$ so fast? Who removes the heat produced in lightning? On that matter there are three theories. They are: (i) Reynold's effect, (ii) Ion capture theory and (iii) Breaking drop theory. But these theories are not tenable. They are applicable before lightning. Because lightning creates a large amount of heat. This heat energy will evaporate precipitation which is formed before lightning. Still precipitation occurs. That means after lightning some process develops which is responsible for that precipitation. Our explanation is that endothermic reactions 3 and 4 take away the heat and produce cooling. Higher the temperature, more number of N^* and O^* will be formed and more cooling and more rain will be produced. If temperature is not very high, less number of N^* and O^* will be formed and that may not lead to precipitation. Our experiment in the laboratory corroborates this theory.

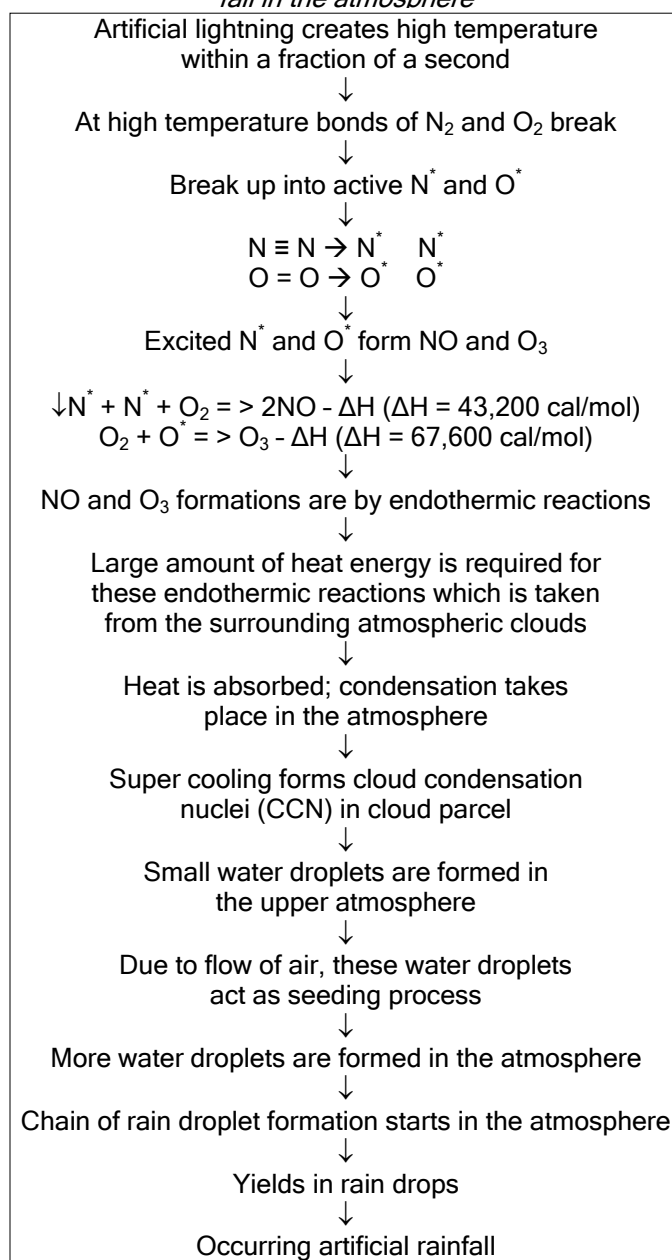
A new technology for creating artificial rain

Lightning creates electrical energy tremendously. This energy could be harnessed. But people are scared about the damage caused by lightning. Therefore researchers have been working to devise a method to trigger lightning and guide the discharge to harmless spots. It has been shown that discharge of lightning can be done at a fixed spot by a laser system. Uchida *et al.* (1999) at the University of New Mexico has explained the process: "The idea is that the laser light creates a conducting path between the cloud and the ground, triggering the lightning discharge." Groups in Japan, Russia and the U.S. are using different laser wavelengths and powers to create conductive paths between ground and thunderclouds. Uchida's group has used a combination of three lidars. We also propose to use lidar which will create high temperature. This high temperature can break the bonds of N_2 and O_2 and produce N^* and O^* subsequently. This will be followed by endothermic reactions resulting in artificial rain.

It may be mentioned here that a group at IITM, Pune which applied lidar has observed that a few drops of water fall after the laser beam has been directed in the atmosphere. Lightning discharge may also occur in the atmosphere by the laser energy. The type of lidar we would use is described below.

The system that can be used for triggering lightning in the atmosphere is a high power plasma laser pulse. The block diagram of the system is given in Fig 3. It has a transmitter and a receiver. We have shown a Micro Controller which consists

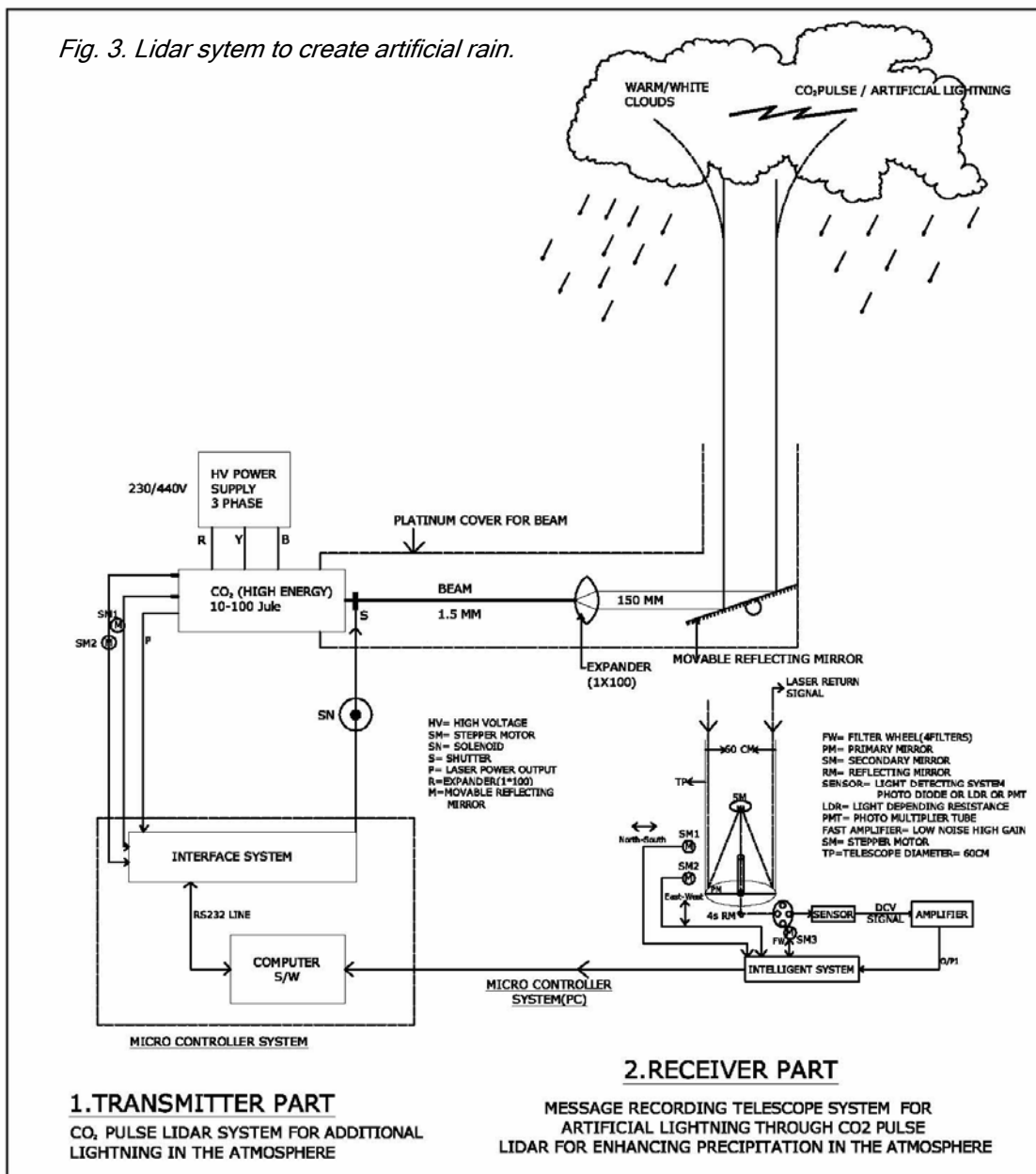
Fig.2. Schematic flow chart showing natural lightning endothermic phenomenon for occurring artificial rain fall in the atmosphere



of data acquisition and processing system. The peripherals of the system include fast transient digitizer, computer controlled stepper motors (SM-1 and SM-2). The laser beam energy will be adjusted by SM-2. The lidar system will be operated on high voltage by using the 220/440 V 3-phase power supply. The energy of the laser will be 10-100 Joules per pulse. The pulse repetition rate will be 1-100Hz. A beam expander can be used. The beam will be of 15cm arc. A movable mirror will reflect the beam in the atmosphere. Kasparian *et al.*, (2000) and Braun *et al.*, (1995) claim that high-power femtosecond laser pulses can produce self-guided light filaments in air, which

can release condensation nuclei for the formation of rain drops.

In the receiver side we can use a Cassegrain telescope of 60cm diameter which can be controlled by an intelligent system of micro controlled local unit. The telescope can be adjusted in North-South and East-West direction by SM-1 and SM-2 respectively. In acquired mode of the laser system signal as well as background noise values pass through selected filter of wavelength filter wheel (FW). This signal is converted into an electrical signal (which will be directly proportional to concentration of water vapor) by a sensor (photodiode or LDR or PMT) of high gain low noise.





The weak signal will be again amplified with the help of high gain low noise fast amplifier. The output signal will be communicated to micro controller of the system. This acquired data will be stored in required format in the system memory for later processes of the data. Provision will be made to put the whole system on mobile platform to use at different sites.

Scope

Laboratory experimental results reveal that sparks can produce excited species and in turn can produce cooling after endothermic reactions. The experiment described above to create artificial rain is centered on these facts. Since the cost of the whole experiment is expected to be about Rs. 1.67 cr, financial assistance is needed to take the work farther. However the idea has been patented both nationally and internationally (Indian Patent No. 355/MUM/2006 and International Patent Publication No. WO 2008/062441 A2).

Acknowledgement

We express sincere thanks to several scientists of Physical Research Laboratory, Ahmedabad for useful discussion. We also thank Prof. B. Padmanabha Murthy and Dr. Anwar Hussain of J. N. University, New Delhi, Mr. Thakur Prasad of Regional Meteorology Centre, Colaba, Mumbai, Prof. Tillu and Prof. Korgaokar of Pune University, Pune, Dr. G. S. Katlyar of Bombay University, Mumbai, Dr. G. L. Aggarwal of National Environmental Engineering Research Institute,

Nagpur, Dr. A. K. Kamra and Mr. Sunil Sonbhawne of IITM, Pune and Prof. Bijesh Kumar and Prof. Pratima Sen of Ahilya Devi Holkar Visha Vidyalaya, Indore.

References

1. Braun A, Korn G, Liu X, Du D, Squier J and Mourou G (1995) Self channelling of high peak power femtosecond lasers of pulse in air. *Opt. Lett.* 20, 73.
2. Chopkar SK (1993) Effect of endothermic reactions associated with lightning on atmospheric chemistry, *Indian J. Radio Space Physics.* 22, 128-131.
3. Golde RH (1977) Lightning. vol. 1, Physics of Lightning, Academic Press, London.
4. Kasparian J, Sauerbrey R and Chin SL (2000) The critical laser intensity of self-guided light filaments in air. *Appl. Phys.* B71, 877-879.
5. Newcott WR (1993) Lightning - nature's high voltage spectacle. *National Geographic.* 184 (1), 80-103.
6. Sander SP *et al.* (2003) Chemical kinetics and photo-chemical data for use in atmospheric studies, JPL Publication, 02-25 (USA).
7. Uchida S *et al.* (1999) Laser-triggered lightning in field experiments. *J. Opt. Tech.* 66(3), 199-202.
8. Uman MA (1987) The Lightning Discharge. *Intnl. Geophysics Series*, vol. 39, Academic Press, London.