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ELECTROSTATIC MODELLING OF THE LUNAR SOIL - HOW ELECTROSTATIC PROCESSES IN THE LUNAR DUST MAY GENERATE THE ION-CLOUD LEVITATING ABOVE THE SURFACE ON THE MOON - EXPERIMENTS IN A MODEL INSTRUMENT

TIVADAR. FÖLDI[1], SZANISZLÓ BÉRCZI[2]

[1] FOELDIX, H-1117 Budapest, Irinyi J. u. 36/B. Hungary,
[2] Department of General Physics, Cosmic Materials Space Research Group, Eötvös University
H-1117 Budapest, Pázmány Péter sétány 1/C, Hungary
e-mail: berczisszani@ludens.elte.hu

ABSTRACT

According to the measurements of Surveyor landers and Apollo 17 LEAM experiments a levitating lunar dust cloud appears above the lunar surface. We studied the united acts by UV radiation and solar wind from the Sun and the micrometeorite bombardment processes which we suggest generate through electrostatic processes an ion-cloud above any dusty (i.e. lunar) planetary surface. This levitating ion-cloud form a quasiatmosphere where charged dust particles can take part in different processes. We studied such electrostatic mechanisms of lunar (and planetary) dust in an instrumental experimental arrangement of FOELDIX-1. In these studies we concluded that dust particles can agglutinate by the alternating process of receiving and loosing charge. We found that during a longer interval in this process the electrostatically charged dust particles may produce larger and larger grains. The agglutinating grains also attract and include H_2O molecules. As a consequence of these recognitions we suggest that considering longer time intervals there is a trend on any dusty planetary surface for composite agglutinated particles to be dragged by the solar radiation pressure toward the poles. In the vicinity of poles larger agglutinated particles are discharged, fall down and accumulate on the surface. The summary of the application of our model is the suggestion of accumulation of H_2O molecules in the fine dust of the polar regions of planetary surfaces, especially on the Moon.

INTRODUCTION

Storm Electricity

In the late 1930s there were an instrument and experiments inside the clouds (In Germany). The instrument was carried up to the atmosphere by balloons. In the measurements a recording cylinder writing equipment showed that the direction of the electric field was alternately changing polarity, when the uplifting balloon crossed the cloud. This measurement sketched a picture that the shower cloud consists of layers with alternating electric field charge. (Later this experiment was carried out in a finer equipment in the United States.)

In the early 1940s Simson measured and modelled the water droplet processes (disruption, charging, coagualtion) in storm electricity ionization processes in terrestrial clouds. A water droplet collects small charges in the column where it crosses during its falling. The additive summation of the charges results in gradually greater and greater charge on the surface of the droplets. Finally sparks discharge droplets with oppositely charges. But the ion-channel between these oppositely charged droplets remains open for a short time. Finally lightning uses these earlier channels to form a larger and longer ionization channel pathway toward the ground.

Finally, in their measurements Americans found that there is a 50 V/m field strength in the atmosphere. They also made hurricane modelling, but no engineering consequences were utilized. In these experiments and in electrostatic modelling they did not mixed the gas, the dust and the vapor effects together with aerosol pollution. (It is important to mention that vapour-water droplet-ice system was investigated because of the dangerous precipitations, too).

Early atmospheric electricity experiments in Hungary

Historical retrospective: Before the First World War (1908-1909) there were atmospheric electricity experiments on the Adratic Sea, made on the St. Stephen flagship of the Austro-Hungarian Monarchy Navy. The experimental arrangement consisted of an antenna and a capacitive voltage electrometer. The antenna was electrically separated from the board by a ceramic insulator, as reported by a navy newspaper.

In 1958-1961 Simonyi (Budapest Technology University, Department of Theoretical Electricity) initiated 4 types of complex experiments on atmospheric electricity in order to find relations between atmospheric electricity and human physiological processes. The experiments, carried out by Földi, were the following: 1) electric field measurements by a field-mill type experiment (Földi et al, 2001), 2) ion-density measurements by capacitive way, 3) insulated capacitive antenna (+ electrometer) measurements by using a radioactive isotope on the top of the antenna, 4) insulated capacitive antenna (with DC amplifier) measurements by using an electrometer-tube with great resistance. When the instruments were built the measurements and registration of the data were carried out for a half year continuously on the Budapest Technology University, in the tower of the Building of Agriculture. The relations between atmospheric electricity and human physiological processes were not found at that time, but the system of measurements were reproduced and developed.

Molecular water on surface in vacuum: the role of the mixed system

In the electron tubes production of Tungsram Factory, in 1935, Bródy and Palócz discovered that on the inner surface of the electron tube, even in the case of hypervacuum, a monomolecular water molecule layer can be found. This molecular water layer considerably destroyed the efficiency of electron tubes and diminished the lifetime of the cathode and affected the electron emission of the cathode. In 1957, Isreal in the Potsdam Atmospheric Research Institute found that the water molecules, which belong to the small negative ions, have far longer lifetime (even with order of magnitudes longer) then that of the small positive ions. If in the near vicinity of a surface there exists a space charge of electron cloud, then the water molecules, (occurring in this cloud) will act as if they were negitvely charged. These water molecules preserve their charge even if the negative space charge ceases. (The average velocity of electrons is far larger then the coexisting water molecules).

ELECTROSTATIC PROCESSES IN THE LUNAR DUST AND FORMATION OF LEVITATING ION-CLOUD ABOVE THE LUNAR SURFACE

Micrometeorite bombardment is a continuous source of dust production on the Moon. The distribution of dust particles from impact may cover the size range from 200 micrometers to the molecular region. The ultraviolet radiation of the Sun, (depending on the escape energy for electrons) causes strong electron emission from the lunar surface. Most of the emitted electrons escape the lunar surface therefore the lunar surface becomes charged up positively (which retards the electron escape and which may produce a negative field charge similarly to that of virtual cathode in the electron tube).

Above the negative space charge field of the electron cloud a layer of positively charged dust cloud forms in the lunar vacuum. That dust cloud consists of ions (ion-cloud) coagulated from smaller dust particles, which have great mass and low velocity. During solar radiation (on the lunar day) these larger particles are alternately charged up and discharged. In the intervals when they are positively charged, they levitate in the near vicinity of the surface (between a few decimeters and 1 meter from the lunar surface). This cloud has been measured by the Surveyor landers and by the Apollo 17 LEAM experiments (Criswell, 1972; Berg et al., 1973; Horányi et al.; 1998) (Fig. 1).

With negatively charged water molecule-ions these coagulated particles can gradually grow larger and they oscillate in the near vicinity of the surface. We modelled this process in the FOELDIX-1. instrument. In the following cartoon we show the main characteristics of the lunar quasiatmosphere, where we can find all the various types of particles referred in the coagulation experiments of the next section (Fig. 2).

EXPERIMENTAL COAGULATION OF DUST PARTICLES

We studied the production of cosmic dust in an electrostatic experiment (Földi et al, 1999). In this work we studied the possibility of the experimental production of extrafine dust fraction. We used a chamber with 2000 X 1000 X 250 millimeters volume. There were atmospheric pressure and laboratory temperatures. Two systems of electrodes were arranged in this space. One operated on + 15 kV and the other on - 15 kV potential. The electrodes were 800 mms long, their diameter was 10 mms. In a distance of 45 mm from each electrodes a 0.1 mm diameter special nickel wire was placed. The large electrodes with opposite potential were arranged in a comb like pattern (Földi et al, 1999).

We used a power supply which can be varied between 8 kV to 15 kV potential. If the system is opened to the free air, the air molecules begin to move through the instrument, by getting constant velocity of 1 meter/secundum along the alternating electrodes.

In the experiments the instrument was in a columnal arrangement, open up and down: on the bottom of the tube liquid stirol was placed. The wapor of stirol - together with the air - streamed into the space of the instrument. The stirol molecules polimerized to resin particles, as a result of their going through the alternating potential of electrodes. The coagulated particles have a spherulitic form. Getting through 20 electrodes, the final mass of the coagulated particles was 540.000. times that of the initial molecular mass.

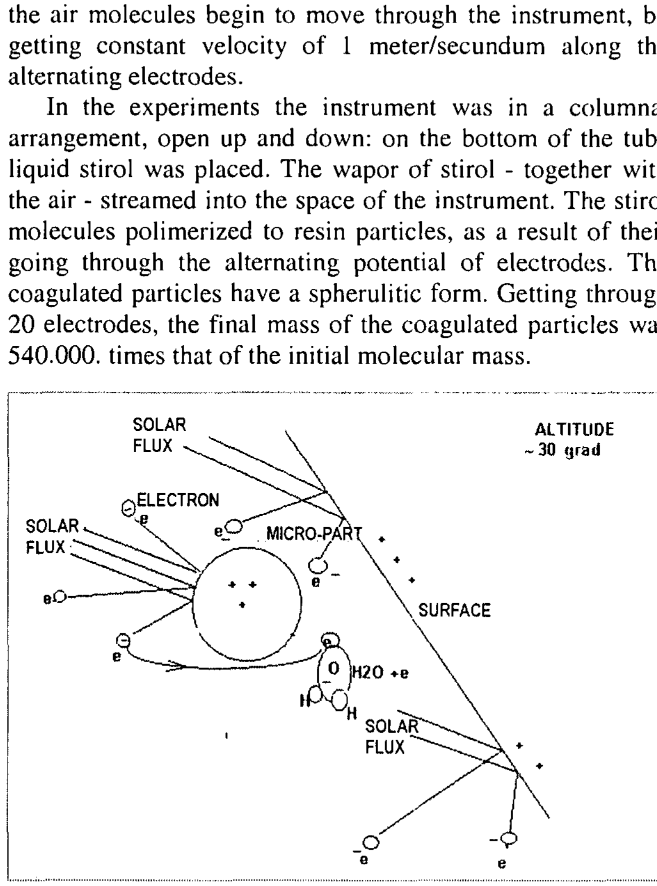


Fig. 1. The uprising of a microparticle from the lunar surface by the effect of the solar UV irradiation

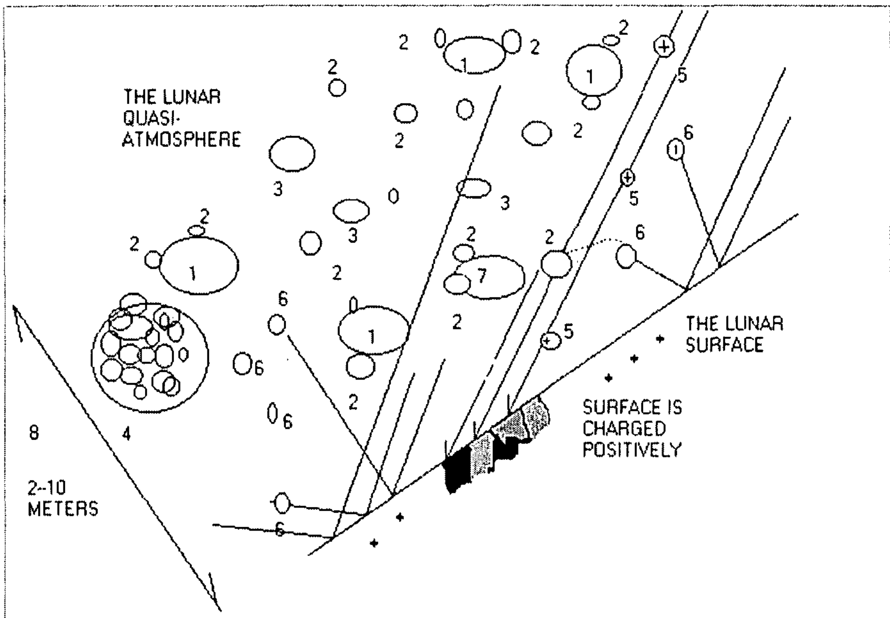
DUST COAGULATION WITH INCLUDED WATER MOLECULES

Now we use the recognition found in electron-tube industry that water molecules may retain one negative electric charge (Tungsram Factory, Budapest, 1935; Bródy and Palócz, 1953). On the inner surface of the electron tube, in hypervacuum, a monomolecular water molecule layer was found. This molecular water layer was negatively charged while the glass surface wall was positively charged. As later found (Israel, 1957) the negatively charged water molecules have very a long lifetime and they do not recombine. This lifetime is an order of magnitudes longer, then that of the small positive ions. Such charged water molecules can survive even the cosmic travel time from the Earth's upper atmosphere to the surface of the Moon.

THE SOURCE OF LUNAR WATER MOLECULES

During full Moon the tail of the Earth (magnetic and radiation belts of the Earth) sweep over the Moon. Terrestrial magnetosphere tubes retain the escape of charged particles rom this tube, because for the ionized particles the "wall" of terrestrial magnetosphere tail behaves as a eflecting wall. Together with ionized particles the water molecules, which have one negative electric charge (adhered to the water molecule) are also eflected on this tube wall. The eflecting force from the wall is: v X B (where v is velocity, B is magnetic nduction) the electrostatic accelerating force is e X E (where e is the electron charge unit, E is electric field strength in V/m) the acceleration by E is F_E Electric Force per molecular mass.

Reaching the lunar surface the negatively charged water particle meets the positively charged (from UV radiation) dust particles. With charged dust particles water molecule forms a complex coagulated particle. At the same time, in the near vicinity of the lunar surface there exists a space charge of electron cloud, which recharge and so neutralize the coagulated particle. But this coagulated particle will not remain neutral for a long time, and it becomes charged again by the space charge of electron cloud. This periodic charging up and discharge 1) enlarges the coagulated particle, and 2) levitates the particle, which will be the object of a transporting mechanism moving it toward the lunar pole. The step-by-step drag by the solar radiation pressure toward the poles, where agglutinated particles become discharged, results in their fall-down, and accumulation on the surface.



1 – OXYGEN, 2 – HYDROGEN, 3 – DUST PARTICLE, 4 – COAGULATED PARTICLE (THIS PARTICLE INCLUDES WATER MOLECULES), 5 – SOLAR WIND PROTON, 6 – ELECTRON EMITTED BY SOLAR UV RADIATION, 7 – WATER MOLECULE, 8 – THE HEIGHT OF THE LUNAR QUASIATMOSPHERE, WHERE COLLISIONS ARE FREQUENTLY OCCURRING, THERMAL PARAMETERS (ESTIMATED VALUES): 1: 600 K, 2: 5000 K, 3: 400 K, 4: 300 K, 5: 6000 K, 6: 12000 K.

Fig. 2. The lunar quasiatmosphere has many constituents which alternate between charged up and electrically neutral states

DRAG OF COAGULATED DUST PARTICLES TOWARD THE POLES

Let us follow the way of a coagulated particle. Start the observation at the 45 degrees latitude. Three main forces act on this particle: gravity, solar wind pressure and electrostatic force. The gravity force, determined by particle mass and G specific gravity, remains constant (a good approximation). The solar wind pressure force is determined by the effective cross section (surface given by the diameter of coagulated particle): solar wind force is also constant in absolute value, but its components projected to the gravitational force, changes according to the cosine function with latitude. The electrostatic force is determined by the field strength coming from the surface charge of the planetary body multiplied by the charge of the coagulated particle. This force is oscillating depending on the absorption of negative or positive ions. As a result of the combined action of the three forces the coagulated particle periodically sinks or rises to the surface. But because the components of the solar wind force gradually changes with latitude, *the tangential component of the solar wind pressure force* (changing with sinus function of the latitude) *will drift the particle toward the poles between two* (rising and sinking) *oscillations.* When the particle approaches the polar region the local vertical component of this force becomes zero (cos 90^o =0) while the tangential component becomes almost one (sin 90^o=1). Therefore, if the coagulated particle reached the pole, it will remain in the vicinity of the pole (there is no force to move it out from this region).

CONSEQUENCES OF THE MODEL

On the surface of the dusty planetary body the size distribution of the dust particles in the vicinity of the equator will not exhibit a gaussian because the fine fraction of the dust slowly moves toward the poles.

In the vicinity of a new great impact crater the dust produced by sublimation from the plasma originally have a gaussian size distribution. After some time elapsed the size distribution will loose the fine fraction because of the drift toward the poles. We suggest that the age of the crater can be estimated on the extent of lacking fine fraction drifted.

The coagulated particles - together with the accompanying water component, - will accumulate in the vicinity of those craters (in the planetary polar regions) which are always in shadow.

CONCLUSIONS

On the basis of Surveyor and Apollo observations and theoretical considerations we defined a mechanism how lunar (and dusty planetary) quasiatmospheres may form. This quasiatmosphere mainly consists of charged dust particles. On the basis of our experimental experiences on coagulation in an electrostatic tube, we proposed a mechanism acting in the lunar quasiatmosphere. There the coagulation of electrostatically charged dust particles may produce larger and larger grains. These grains attract H_2O molecules on dusty planetary surfaces and continue in growing during time. The coagulated particles will be dragged by the solar radiation pressure toward the poles where they are discharged, fall down and accumulate on the surface. This electrostatic mechanism accumulates H_2O molecules on polar regions of dusty planetary surfaces in craters which are always in shadow.

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