ON CHARGE TRANSPORT IN THE TERMINATOR'S VICINITY: Román Alvarez,
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A mechanism for charge transport across the lunar terminator was proposed (1) such that a lunar surface element approaching it should change its electric potential from the (positive) value on the sunlit hemisphere to the (negative) value on the dark hemisphere or vice versa. Such a change in electric potential would involve a change in surface charge density in the element of area, which in turn would define a non-zero current density value. The electric current would produce a magnetic field; such a magnetic field would appear only in the terminator's vicinity and would thus consist of periodic, magnetic spikes for an observer on the lunar surface. The possibility was advanced that such magnetic spikes acting during geologic times could be at least partially responsible for the weak surface magnetism observed in some lunar regions.

Despite the fact that the phenomenon of electric levitation had already been discussed (2) and the hypothesis advanced that lunar horizon glow was due to light scattering from electrically levitated particles positioned at 20 to 30 cm above the lunar surface (3), there was no direct evidence that horizontal charge transport was actually taking place on a large scale at the lunar surface. Horizontal charge motion would yield, of course, a much more efficient way of magnetizing surface materials than vertical charge motion (e.g., particle levitation). Recently, however, a transport mechanism of charged dust particles has been found by direct measurements on the lunar surface of the Lunar Ejecta and Meteorites (LEAM) experiment (4, 5). Berg et al. (5) have reached the conclusion that the bulk of events detected by the LEAM experiment are not hypervelocity cosmic dust particles, as expected, but rather highly charged, slowly moving lunar surface fines.

The above results constitute the first corroboration of our hypothesis (1) that charge motion at the lunar surface should occur preferentially around the terminator, in such a way as to adjust the surface charge density to the changing values of potential. Furthermore, we predicted that currents at the terminator would flow from the same hemisphere to the opposite, regardless of whether the observer was at the sunrise or sunset terminator; correspondingly, Berg et al. (4) find a strong suggestion in their measurements, that the particles being registered are moving westward during sunrise (i.e., away from the sun) and eastward during sunset (i.e., away from the sun), which is equivalent to our statement.

The new evidence warrants reconsideration of our initial hypotheses even though such results are preliminary and do not yet allow for proper evaluation of the efficiency of the magnetizing mechanism associated with the charge motion. As a first instance consider the observation from the results in (4) that the event rates are of different magnitude for the sunrise and sunset terminators, with the former being 5 to 6 times more intense than the latter; such a result is of direct relevance to the proposed magnetization mechanism. In the initial hypothesis the magnitude of charge transport was implicitly considered to be equal at sunrise and sunset, and should result in a tendency of the surface material to be magnetized either in the north or the south direction (i.e., these two directions would be those of the inducing field.
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at the sunset and sunrise terminators respectively. The asymmetry in the reported measurements implies that magnetization should be stronger for the southern direction considering that the sunrise positive current is greater than the corresponding current at sunset (i.e., the magnetic spikes would not be of the same magnitude and magnetic orientation in one direction should prevail over the opposite direction).

A second piece of evidence from (4) is the fact that particles arriving into the eastern sensor start increasing markedly from 7 hours to as much as 40 hours before sunrise. Assuming that the distribution of events (per 3-hour period and integrated over 22 lunations) shown in (5) is in direct relation to the particle energy distribution, the first events occurring before sunrise will be the most energetic (i.e., those with the largest range). The kinetic energy $\frac{mv^2}{2}$ of the particle of mass $m$ and initial velocity $v_0$ can be calculated for the most energetic particles by requiring that their initial speed is slightly less than the escape velocity of the moon (i.e., $v_0 = 2.4$ Km/sec); if the speed is equal to or greater than the escape velocity the LEAM would obviously not detect the particle.

Let us assume a particle of mass $10^{-12}$ grams for the average particle intercepted by LEAM (5) and assign to it a speed of $2.0$ Km/sec: its corresponding kinetic energy would be of $2 \times 10^{-2}$ ergs or $1.3 \times 10^{10}$ eV. Such a kinetic energy can be attained at varying accelerating potentials $V$, depending on the net charge $q$ of the grain. An upper limit on $q$ can be obtained through the levitation condition $qE = mg$, where $E$ is the electric field established by the lunar surface (typically $E = 60$ v/m), $m$ is the mass of the grain and $g$ is the lunar gravity. A value of $2.7 \times 10^{-10}$ coul is obtained, or $1.7 \times 10^9$ electrons charges. However, such a figure for $q$ is extremely large since it amounts to almost one ionization per molecule in the grain; considering the density $\rho = 2.33$ g/cm$^3$ for SiO$_2$, the volume of the $10^{-12}$ g grain is $4 \times 10^{-13}$ cm$^3$ and taking the molar volume for SiO$_2$ as 25 cm$^3$ there are $9.6 \times 10^9$ molecules/grain. A $10^{-12}$g particle already levitating in the above field requires a voltage of 7.3 volts to reach the kinetic energy of $1.3 \times 10^{10}$ eV. The less net charge on the grain the larger the accelerating potentials required to reach the same kinetic energy. Figure 1 shows the accelerating potential as a function of $q$ on the grain, necessary to reach the above kinetic energy ($E_0$); the limits for $q$ have been established considering ionization ratios (i.e., ionizations per molecule) of 1:1 to 1:10$^5$. In this manner one can establish limits for $q$ and $V$ on the basis of additional considerations. An ionization ratio of 1:1 cannot be reached in the grain because surface fields would exceed $10^9$ v/m, giving rise to field emission from the grain. On the other hand, accelerating potentials in excess of 100 KV are very unlikely in the lunar surface. $E_0$ in Figure 1 thus represents the limits for charge and accelerating potential for the most energetic particles detected by LEAM. Particles closer to the terminator shall give rise to a family of curves parallel to $E_0$; $E_1$, $E_2$ and $E_3$ corresponds to smaller energies $10^{-1}$, $10^{-2}$, and $10^{-3}$ times $E_0$.
REFERENCES


Fig.1.