THE LUNAR DUST EXOSPHERE AND CLEMENTINE LUNAR HORIZON GLOW:

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Introduction: There is a surprisingly dense cloud of dust, visible to the naked eye, above the lunar surface. This dust exosphere surrounding the moon can not, however, be attributed to ejecta from impacts by interplanetary meteoroids, for two reasons: (1) The spatial density of dust in the cloud is far too high to be caused by meteoroid impact ejecta, and (2) the rate at which dust grains were sensed at the Apollo 17 site peaks sharply at local lunar sunrise or sunset; it is unreasonable to expect such a time variation to be due to meteoroid impacts. The observational data and corresponding interpretations are summarized below.

Surveyor LHG Observations: A narrow glow was observed to extend above and along the sunset lunar horizon by the Surveyor 1, 5, 6, and 7 (S-1, S-5, etc.) spacecraft for up to two hours after sunset [1, 2, 3]. This lunar horizon glow, or LHG, was clearly separated from the solar corona, and varied in brightness (detectable photons per cm^2 per second per unit solid angle) by over two orders of magnitude from S-6 to S-7 [3]. The S-7 LHG was the brightest LHG observed, at a maximum of about $10^{-6}B_o$ for the first half-hour after sunset, where B_o is the average brightness of the Sun. This is comparable to the average brightness of the full Moon, which is about $2*10^{-6}B_o$. Criswell [2] argued that this LHG, with a scale height of 10 to 20 cm, was caused by a cloud of lunar dust grains continuously being ejected above the lunar surface. He further argued that this ejection was due to electrostatic repulsion between charged lunar dust grains and a like-charged local lunar surface, as the LHG brightness was about 10^5 times too high to be due to meteoroid impact ejecta. He speculated that the charging was primarily due to solar UV photons ejecting electrons from sunlit portions of the Moon near the sunset terminator to nearby dark areas of the Moon (perhaps along local magnetic field lines).

Apollo 16 and 17 LHG Observations: Each of the three Apollo 17 astronauts observed and sketched a naked eye LHG as their orbiting Command Module, at an altitude of 110 km, approached orbital sunrise [4]. One of the sketches, by Command Module Pilot Ron Evans, is shown in Fig. 1. One notes the LHG surrounding both sides of the zodiacal light bulge exterior to the lunar limb in this sketch. Zook and McCoy [4] estimated that the LHG brightness sketched by the astronauts was about $2*10^{-12}B_o$ with a scale height of 10 to 20 km. This brightness estimate was considered uncertain to a factor of 2 or 3, although a larger error in the estimate could not be ruled out. However, the Soviet Lunokhod II lunar rover [5] measured the vertical brightness of the LHG when the Sun was about 1° below the western horizon, and obtained a brightness of $4*10^{-12}B_o$; the lunar shadow extended about 260 meters above the Lunokhod spacecraft at the time of measurement. The Lunokhod observation is somewhat higher than, but qualitatively confirms, the brightness estimates of Zook and McCoy [4]. An

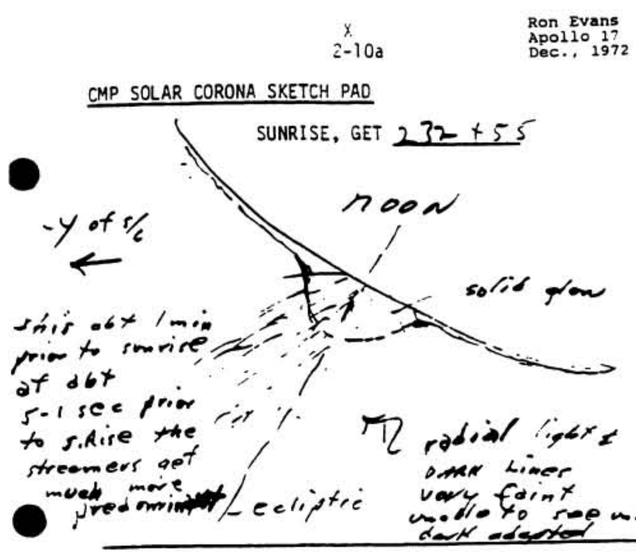

Figure 1

THE LUNAR DUST EXOSPHERE: Zook et al.

LHG was also photographed by the Lunar Surface UV camera (sensitive to light between 1050 and 1600 angstroms) that was placed on the Moon during the Apollo 16 mission [6]. The authors attributed the observed LHG to a lunar dust cloud above the surface. Because these photographs were taken during lunar daytime, some mechanism other than the Criswell mechanism [2] would have to operate. Perhaps charge separation of the impinging solar wind electrons and protons by the local lunar magnetic fields causes differential charging of the surface. This mechanism could act in addition to the Criswell mechanism.

Apollo 17 LEAM: The Apollo 17 Lunar Ejecta and Meteorite (LEAM) experiment [7] recorded an especially high flux of dust particle impacts during sunrise/sunset terminator crossings. This is seen in Fig. 2 where the number of particles seen during three hour intervals, and summed over 22 lunations, is plotted versus time in hours past lunar sunrise. This remarkable time variation of the impact rate makes no sense under impacts by interplanetary meteoroids. The Criswell mechanism [2], however, does make understandable an increased impact rate as being due to increased electrostatic ejection of dust near lunar terminator crossings.

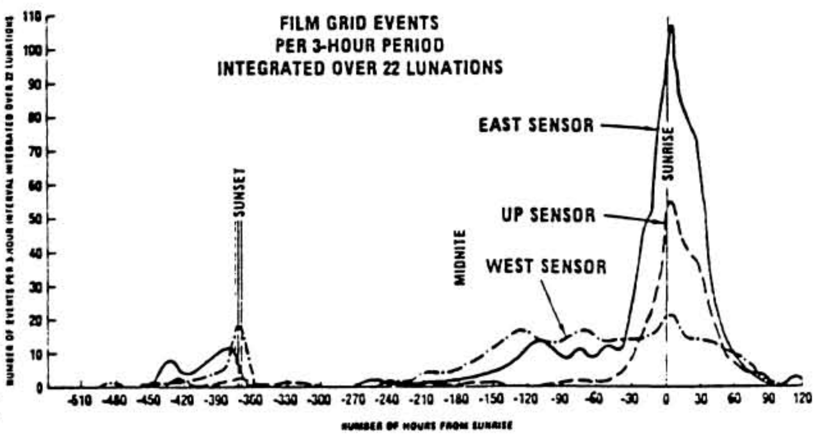

Figure 2

Clementine LHG: Finally, a very dim LHG, at about $10^{-13}B_o$ brightness and with a scale height of 10 to 20 km, has been observed with the star-tracker camera on the Clementine spacecraft [8]. This finding is still somewhat uncertain, as final corrections for camera characteristics, subtraction of the background zodiacal light, and subtraction of a probable LHG of Na vapor (with a scale height of about 100 km) have not yet been made. Why should the Clementine LHG be so much dimmer than the LHG observed by the Apollo astronauts? We offer two possibilities: (1) Zook and McCoy badly over-estimated the LHG brightness suggested by the astronaut sketches. (2) The Clementine observations were taken during a time of low solar activity (Mar. and April 1994) compared to when the astronaut sketches were made (Dec. 1972), and this is the cause of the low Clementine LHG brightness. We believe possibility (2) is much more likely to be correct than possibility (1) for the following reasons: First, the brightness estimated for the astronaut observations is backed up by the brightness determined from the Lunokhod II observation. Second, if LHG is primarily due to solar far UV charging of the lunar surface, then it is understandable that LHG is low at times of low solar activity and high at times of high solar activity.

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