EVIDENCE FOR A LUNAR DUST ATMOSPHERE FROM APOLLO ORBITAL OBSERVATIONS

J. E. McCoy - NASA Johnson Space Center, Houston, Texas 77058
D. R. Criswell - Lunar Science Institute, Houston, Texas 77058

It appears that the Apollo-17 crew has observed from lunar orbit the optical effects of a lunar dust atmosphere or local scattering layer which extended above their orbital altitude (1). Figure 1 is a photograph of sketches by Capt. E. A. Cernan (Commander, Apollo-17) depicting his visual observations of sunrise as seen from lunar orbit. The crucial observations indicating the occurrence of local light scattering are shown in the sketches made at T-2 minutes, T-1 minute, and T-5 seconds. These show the appearance of "streamers", of linear extent perhaps twice that of the diffuse "corona" which has been visible for more than 4 minutes (T-6 minutes and T-3 minutes). These streamers were not visible when the smaller region of diffuse "corona" glow first came into view, but have now intensified with respect to that glow to become definitely visible. From T-2 minutes until sunrise, the streamers were observed to intensify at a progressively increasing rate such that their enhancement in the final five seconds exceeds that during the previous two minutes. Both the 2 minute and 5 second time scales are totally incompatible with any possible phenomena occurring in the solar corona which is located 50-150 million miles from the observation point. The greater than 30-40° angular extent of the streamers requires a linear extent of more than 50 million miles if they are located in the corona. Even at the speed of light, a disturbance would require four minutes to propagate along such a feature. The streamers must be produced by some process operating in the vicinity of the moon.

The only physically reasonable location for the observed streamers is between the edge of the lunar shadow and the vicinity of the lunar terminator. Concentrations of atmospheric gases observed by both lunar surface and orbital experiments are entirely too small (2,3) to give visible scattering of light. Dust present in a lunar "atmosphere" at number densities many times the interplanetary density responsible for the zodiacal light can explain the observed scattering of the sun's rays from this region. The possibility of optically significant concentrations of dust at 100 km altitude is not inconsistent with presently available observations of dust at lower altitudes. Surveyor observations of a sunset horizon-glow (4, 5) have been interpreted in terms of light scattering by low altitude (10-30 cm above surface) clouds of dust which are generated by the momentary ejection of lunar fines at flux levels approximately 10^7 times more than estimated for secondary meteoritic ejecta (6, 7). Photometers on board Lunokhod-II have observed ultraviolet and visible light scattering by particles present 1 km or so above the surface (8). Thus, it's not entirely unreasonable or unexpected to interpret the Apollo-17 crew observations of streamers as light scattering by even higher altitude dust.

Figure 2 depicts a physical situation which is consistent with the visual observations. During the final 5 seconds of rapid change in streamer inten-

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sity, the Apollo spacecraft is approaching the lunar shadow boundary surface at an angle of approximately 20°. The boundary surface between lighted and unlighted space, therefore, passes less than 1 km above the observer at this time, and is closing rapidly. Since this surface will be irregular due to surface irregularities at the lunar terminator, a rayed effect qualitatively similar to that often observed from the ground during terrestrial sunsets would be expected to become increasingly evident upon close approach. The streamers would be superimposed upon an overall diffuse glow from scattering by more distant dust particles in the fully illuminated region above the terminator. Present data are insufficient to determine whether the observed scattering occurs near the shadow interface, over the terminator, or both. However, any such source must necessarily extend to altitudes greater than that of the Apollo orbit because of the 30° to 40° extent of the streamers above the local horizon of the command module. Resolution of specific particle sizes and distributions will require extensive photometry of the available sets of photography with sufficient resolution and dynamic range to determine absolute brightnesses and separate the light scattered by the localized lunar dust from the solor corona/zodiacal light contributions.

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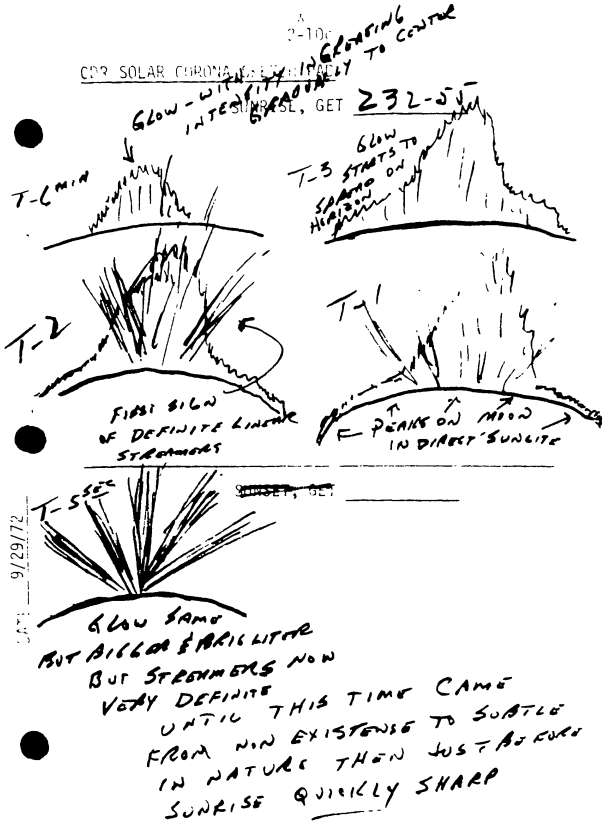

Figure 1

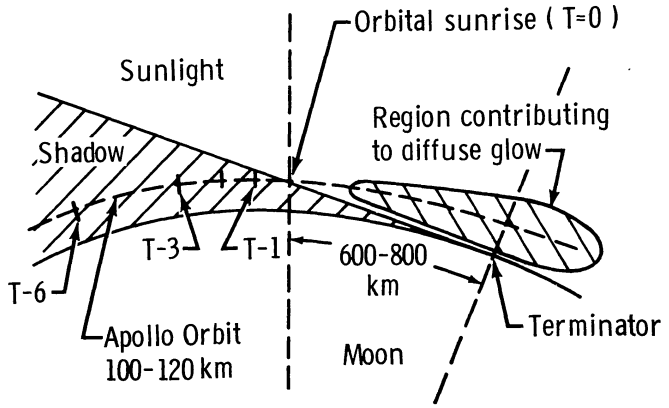

Figure 2