# Effects of Levitated Dust on Astronomical Observations from the Lunar Surface

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It is believed that a substantial population of levitated dust is present in the terminator region of the moon [1]. Stray light scattered by this dust layer may contaminate astronomical observations made from the lunar surface using infrared, visible, and ultraviolet light. The evidence for dust levitation stems from: Surveyor vidicon images of horizon glow [2]; anomalous brightness in photographs of the solar corona taken by Apollo astronauts while the spacecraft was just inside the moon's shadow [3]; and observations by Apollo astronauts of streamers just prior to lunar orbital sunrise or just after lunar orbital sunset [4]. It has been proposed that the differential charging of the lunar surface in the terminator region due to photoemission and the consequent strong local electric fields comprise the mechanism responsible for this levitation [5]. Although quantitative data on the levitated lunar dust distribution are meager, it is possible to estimate column densities and sizes. In this paper we summarize the estimates of particulate sizes and number densities of previous authors, and construct a nominal terminator dust distribution, as a function of particulate radius and altitude above the lunar surface. Using the model we estimate the brightness of scattered sunshine for three wavelength bands. For the results in the visible wavelengths, we compare the estimated brightness with the known brightness of selected astronomical objects and discuss the implications for lunar-based astronomy.

## Nominal Terminator Levitated Dust Model

The typical height to which an electrostatically levitated dust grain will be ejected depends on its radius through the charge on the grain at the time of its ejection from the lunar surface. Criswell [5], and Rennilson and Criswell [2], obtain estimates of 5-6 $\mu$m radii and levitated altitudes of 10-30 cm. McCoy's Model "0" [3] provides another size, 0.1 $\mu$m, and a scale height $\sim$3 km. Assuming the scale height to be a power law function of the grain radius provides the estimate $z_0 = 20a^{-8/3}$ where $z_0$ is the scale height in meters and $a$ is the particulate radius in $\mu$m. Based on the picture provided by McCoy's Model "0", we assume an exponential distribution of dust of radius $a$ with altitude $z$. We assume a column density, integrated over all particulate radii, of $2 \times 10^5$ cm$^{-2}$. The particulate density for a given size just above the lunar surface is assumed to satisfy a power law. Our model distribution over the terminator is then

$$\rho(a, z) = \frac{n_0}{a^p} \exp[-a^{8/3} z/20]$$

Normalizing the vertical column density, integrated over particulate radii 0.1 $\mu$m $\leq a \leq$ 6 $\mu$m, gives $n_0 = 8.08 \times 10^{-2}$ cm$^{-3}$ for $p = 1$, $n_0 = 5.88 \times 10^{-3}$ cm$^{-3}$-$\mu$m for $p = 2$, and $n_0 = 4.62 \times 10^{-4}$ cm$^{-3}$-$\mu$m$^2$ for $p = 3$. The results reported below are calculated for the case $p = 1$.

## Results and Conclusions

Assuming a refractive index appropriate to volcanic dust [6], the brightness of scattered sunlight can be calculated using Mie scattering theory. The solar spectrum used was taken from [7]. Plotted in Fig. 1 are results for scattering by the lunar dust layer in the near infrared (1–4 $\mu$m), the visible (350–650 nm), and the near ultraviolet (200-350 nm), as functions of solar scattering angle. These results were calculated using Monte Carlo integration; estimated uncertainties are typically a few percent. In Fig. 2 we have plotted the scattered brightness in the visible wavelengths in Rayleighs. In the same plot we have included the brightness of some known astronomical sources, along with the background brightness estimated by the Lunokhod-2 astrophotometer [8].

These results indicate that the lunar sky brightness near the terminator is several orders of magnitude times that of the terrestrial night sky. Lunar-based astronomical observations would be severely impaired one to two days per month at a minimum, due to the presence of the terminator dust layer. Although during the lunar night solar scattering is not present, on the lunar nearside scattered earthshine will enhance the sky brightness. The effects of earthshine and zodiacal light will be included in more detailed calculations.

A major uncertainty in calculating astronomical effects due to dust at locations away from the terminator is the absence of information on dust distributions there. Several strategies for detection of lunar dust altitude distributions using both passive and active lidar techniques have been evaluated and will be described.

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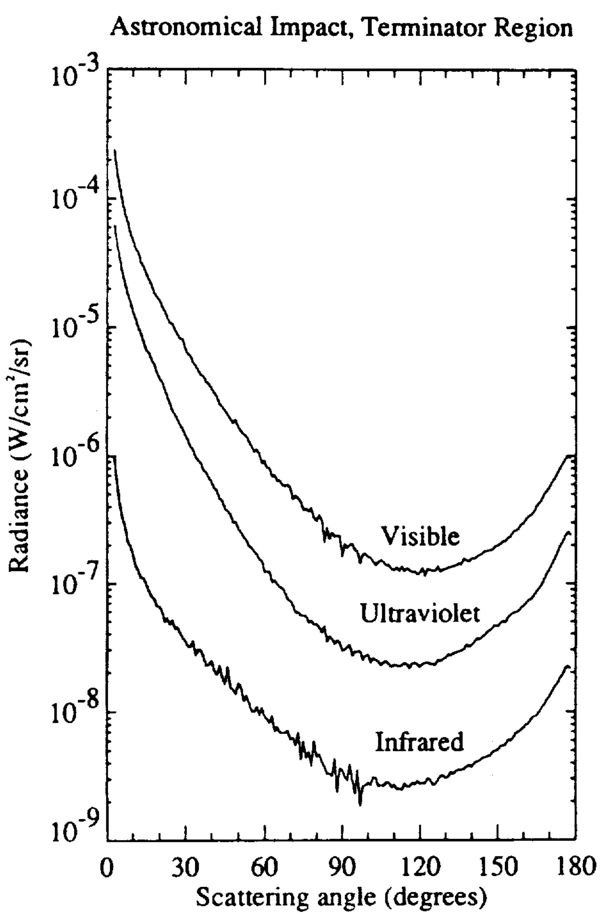


Figure 1

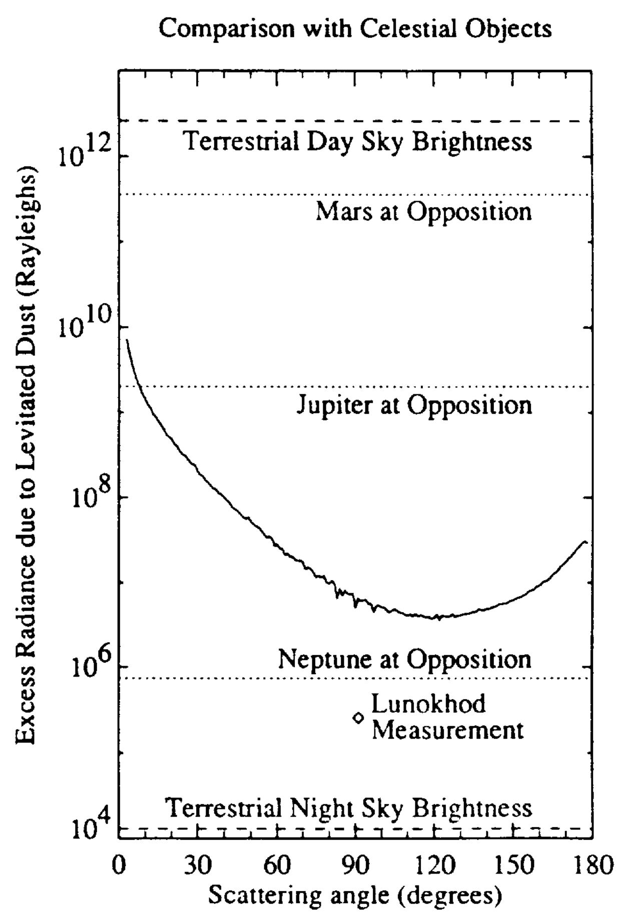


Figure 2