INSTRUMENTATION FOR THE PETROLOGICAL EXPLORATION OF THE MOON AND MERCURY, R. C. Henry, W. G. Fastie, and R. L. Lucke, Department of Physics, The Johns Hopkins University, and B. W. Hapke, Department of Earth and Planetary Sciences, University of Pittsburgh.

A far-ultraviolet spectrometer (1) carried on Apollo 17 has revealed spectral and locale variations of the lunar albedo, in the spectral range 1200 to 1700 Å, that appear to correlate strongly with the mineralogical composition of the lunar surface. An extension of these observations to the exploration of the planet Mercury, and planetary moons having negligible atmospheres, appears desirable. An important first step would be to place in polar lunar orbit a small scanning telescope, to extend the Apollo 17 measurements from the 3% of the lunar surface already observed to total coverage, and to improve the spatial resolution from 30 km to 3 km. The result will be a better understanding of planetary crustal processes and composition, and of the interaction of mineral surfaces with the solar wind.

The albedo of planetary surface materials in the far ultraviolet is expected to be determined only by the refractive index of the material, since virtually all minerals are opaque in the far ultraviolet. This is confirmed by the spectral properties of the lunar surface as measured in the far ultraviolet by Lucke, Henry, and Fastie (2): the lunar albedo shows an increase from 1700 to 1200 Å, which is expected since the index of refraction of most minerals increases over this range. The situation is different in the visible, where the body color of the material, as modified by absorption bands created by solar x-rays and protons, contributes largely to the observed color. Additional support for these ideas comes from the fact that the substantial variations in the far ultraviolet lunar albedo from place to place on the moon, that were discovered by Lucke, Henry, and Fastie (3), show only a partial (inverse) correlation with the optical albedo. Factors independent of the index of refraction are assumed to be affecting the optical albedo, making it unsuitable for petrological exploration. Also, Lucke (4) finds correlation of the ultraviolet albedo with the Al/Si ratio measured by the x-ray fluorescence experiments on Apollos 15 and 16.

The instrumentation needed to provide complete coverage of the moon in the far ultraviolet is simple, lightweight (2 kg), inexpensive, reliable, and has low power and telemetry requirements. Three photomultiplier tubes, each with a different bandpass in the far ultraviolet, are in the focal plane of an off-axis parabolic telescope, which views the moon

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as reflected by a 45° plane mirror. The entire instrument is placed transverse to the spacecraft motion, so that when a small motor-driven cam causes the 45° mirror to oscillate, a portion of the lunar surface is scanned. The combination of this scanning with the spacecraft motion will permit a complete mapping of the moon in a 27 day period. From the knowledge of the lunar surface brightness obtained on Apollo 17, it is clear that a 5 cm diameter, f/2 collecting mirror is quite adequate to the task. The instrumentation is sketched in figure 1.

The large scale variations in lunar brightness as a function of solar angle and viewing angle that occur in the far ultraviolet part of the spectrum (e.g., see figure 23-7 of Fastie, et al. (6)) have been interpreted by Lucke (4) in terms of the theory of the lunar albedo developed by Hapke (5). Lucke finds a somewhat different scattering law in the far ultraviolet than Hapke finds in the visible, which is expected due to the fundamental difference in reflection mechanisms discussed above. However, the Apollo 17 data are virtually all for a single viewing angle, and it would be valuable to explore the effect of varying the viewing angle.

Also, just as for visible light, a particularly favorable circumstance occurs when the experiment views directly in the anti-solar direction. All angle effects are eliminated, and scanning across the lunar surface results in a direct measurement of intrinsic albedo variations.

The planet Mercury has been observed in the far ultraviolet by Broadfoot, Kumar, Belton, and McElroy (7), who find that the albedo of mercury depends on wavelength in the same way as that of the moon. They have not yet analysed their data fully. A complete survey of Mercury in a manner similar to that of the moon would be extremely valuable.

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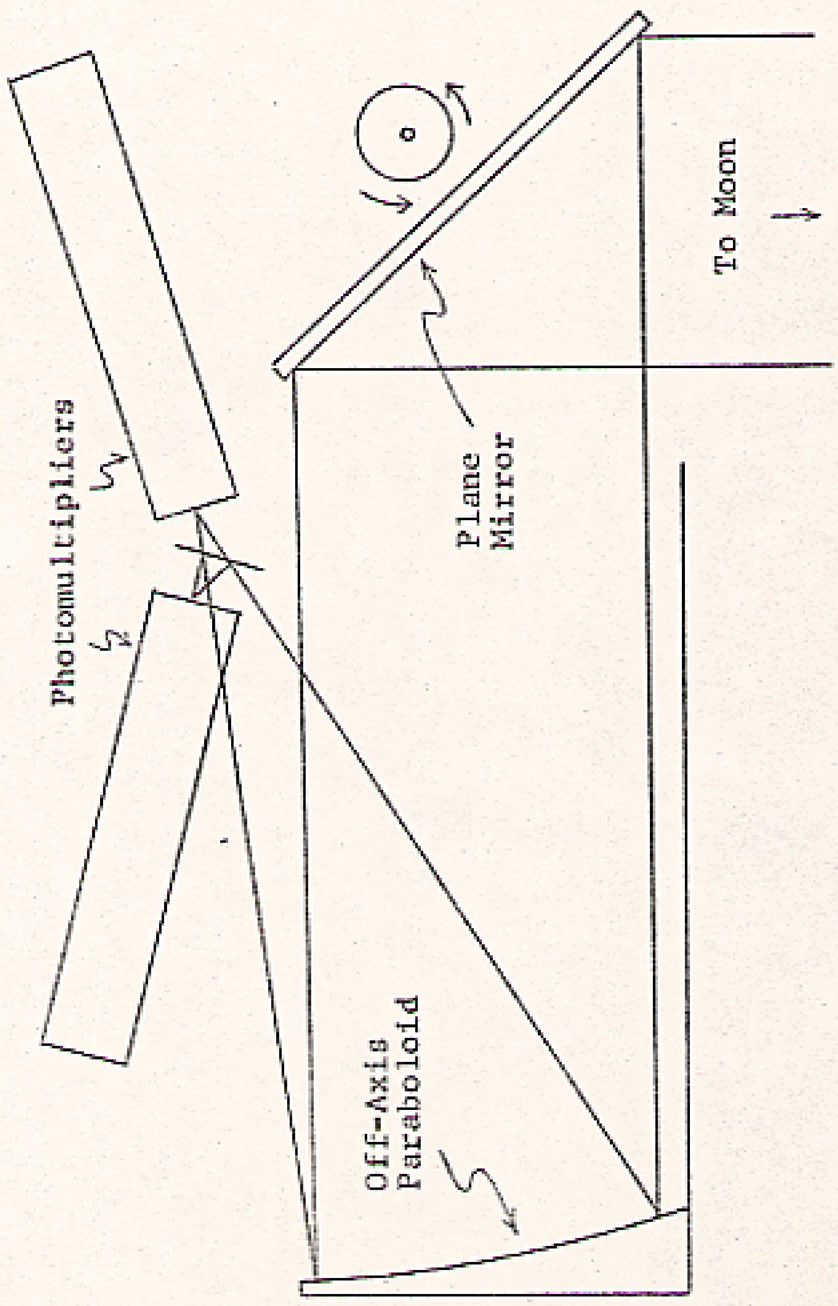

Figure 1. Sketch of proposed instrumentation for the petrological exploration of the moon.