Reirradiation properties of the Lunar surface

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Abstract

The surface of the moon may be considered as rough at radio wavelengths and a large number of scattering areas simultaneously contributing to the signal. The lunar surface is therefore a very poor reflector of radio waves. In this paper we focus to analyze the reflection coefficient and its possible variations. The effective scattering area of a moon reflecting in this manner has been calculated, and the theoretical and observed signal to noise ratios are now in good agreement, indicating that the power reflection coefficient of the lunar surface is about 0.1, with some possible small variations. The effect of this type of variations on a moon relay communications system is briefly discussed.

Reflection coefficient

The reflection coefficient, is the diffuse reflectivity or reflecting power of a surface. It is defined as the ratio of reflected radiation from the surface to incident radiation upon it. Being a dimensionless fraction, it may also be expressed as a percentage.and depends on the frequency of the radiation.

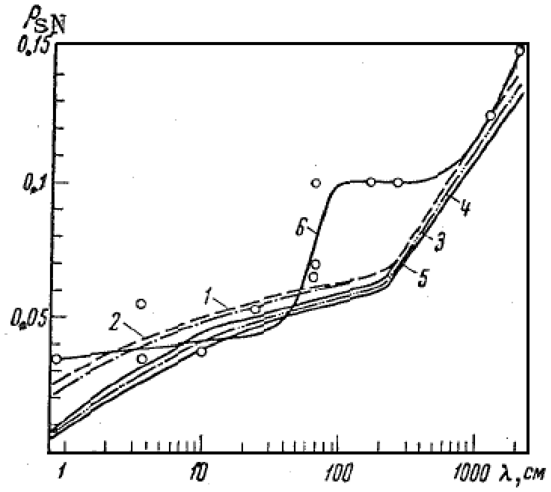

Fig.1 The graph display the normal incidence reflection coefficient. Circles show the findings of the different authors (see the table below).The incidence power reflection coefficient in terns of wavelength in this graphic shows that the reflection coefficient increases with wavelength. There is a smooth rise of from 3.2 to 4.5 percent between 0.8 and 30 cm, almost no change in the mean value of the reflection coefficient, which holds at 10 percent, between 1 and 5 - 7 meters, and an increase by a, factor of approximately 1.15 when the wavelength increases from 7 to 20 meters. There is an increase in the reflection coefficient by a factor of 2 between 30 cm and 1 meter, Bear in mind that the value in the decimeter and meter bands, calculated using the Evans and Pettengill method, will not be significantly larger than the psN values calculated including the reflections from large-scale irregularities. (Graph: RADAR STUDIES OF THE MOON (Nasa – Washington .DC. February 1973)

Wave-length, cm	ρ_{sN}	Author of Experiment	Author of Processing	Year of Measure-ment
0.86	0.035	Linn	Evans and Hagfors [108]	1961
3.2	< 0.1	Kobrin	Kobrin [31]	1957
3.6	0.035	Morrow	Girand [116]	
3.6	0.055	Evans and Pettengill	Evans and Hagfors [108]	1963
10	< 0.1	Kobrin	Kobrin [31]	1954
10	0.038	Hughes	Girand [116]	1961
68	0.065	Pettengill	Evans and Hagfors [108]	1960
68	0.057	Pettengill	Rea et al. [157]	1960
73	0.07	Fricker et al.	Fricker et al. [111]	1960
75	0.1	Leadbrand	Pettengill [154]	1959
150	0.1	Trexler	Trexler [70]	1958
250	0.1	Evans	Evans [80]	1957
300	0.1	Evans	Evans et al. [59]	1959
1130	0.125	Davis and Rohlfs	Davis and Rohlfs [103]	1964
1920	0.15	Davis and Rohlfs	Krupenio [40]	1964

Scattering area in the Lunar surface

Studies about radio wave scatter properties of the lunar surface at Jodrell Bank in 1956 revealed that most of the power in the reflected signal arose from scatterers lying near the center of the visible disk. The range extent of these returns was less than 1 ms. that is much less than the full radar depth of the moon (approximately 11 ms due to the curvature of the moon). Moreover, reflections observed from the moon by Trexler (1) employing a powerfull radar using 12 micro sec. pulses. The short range extent of the signal spectrum confirms that the reflections ae largely from the center of the visible disk. (As show in the figure 2.)

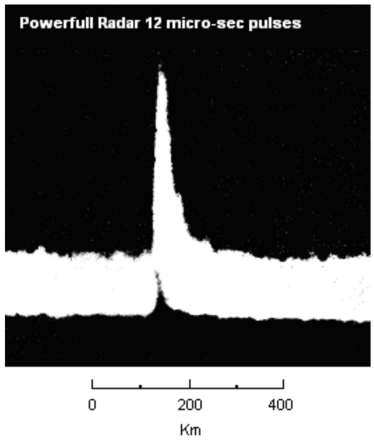

Fig.2 reflections observed from the moon employing a powerfull radar using 12 micro sec. pulses. The short range extent of the signal spectrum confirms that the reflections ae largely from the center of the visible disk. The Graph is taken from this document: "Radio communication via the Moon" by J.V Evans (COMSAT Laboratories-United States)

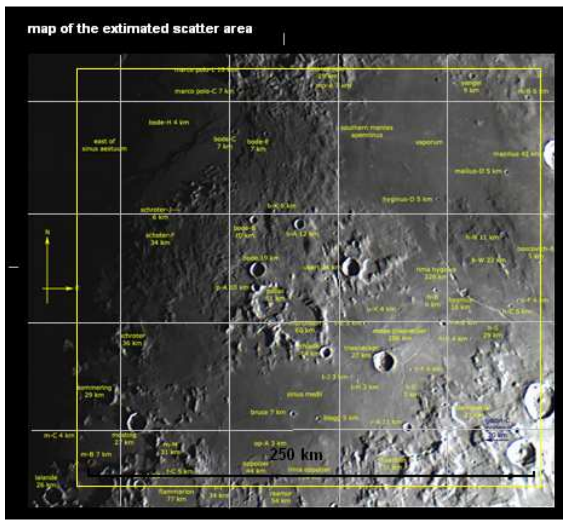

Fig.3 The map of the lunar surface on the center of the visible disk

Radar equation

Starting from the standard radar path link formula that is basis for EME path-loss calculations:

Loss-eme(dB) = 20Log(F) + 40LOG(d) - 17.49, F = MHz, d = km

I have obtained a graph that shows changes in path loss at the variation of the reflection coefficient. The variation in dB is not to exceed 3 dB in a range of 0,05 and 0,1 of the reflection coefficient.

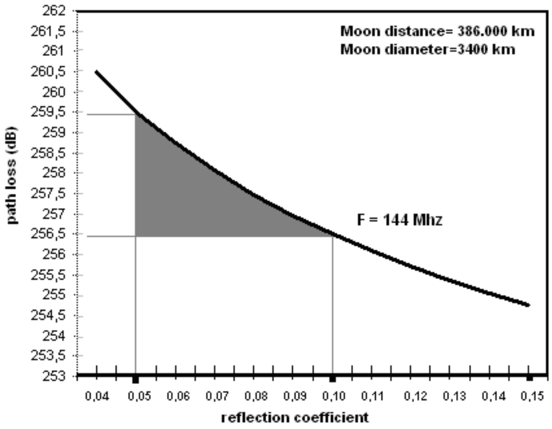

Fig.4 EME Path loss at the 144 Mhz versus reflection coefficient variations. The variation is about 3 dB in a range of 0,05 and 0,1 of the reflection coefficient. The calculation refers to a Moon distance of 386.000 Km (average distance from the earth).

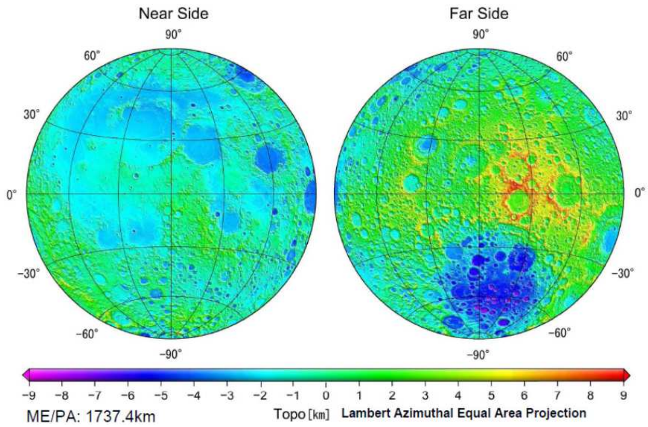

Fig.5 Lunar shaded topographic map (The Laser Altimeter (LALT) aboard KAGUYA captured data on the entire lunar surface height. The Lunar topographical map was produced by the Geographical Survey Institute (GSI) from the LALT product of the National Astronomical Observatory (NAOJ).

References

Notes on the Scattering Properties of the Lunar Surface at Radio Wavelengths by Volker Grassmann, DF5AI
Frequency-Dependent Characteristics of the EME Path Joe Taylor, K1JT
“Radio communication via the Moon” by J.V Evans (COMSAT Laboratories-United States)
RADAR STUDIES OF THE MOON (Nasa – Washington .DC. February 1973)
Lunar science by Kaguya

Notes:

(1) Trexler, J.H. 1958, “Lunar Radio echoes,” IRE,46, proc.286-292