STUDY OF THE BEHAVIOUR OF LUNAR EQUITORIAL FEATURES USING DATASETS OF CHANDRAYAAN-1 MINI-SAR. OPN Calla[1],Shubhra Mathur[1,2], Kishan Lal Gadri[1,3], International Center for Radio Science, Ranoji Ka Baag, Nayapura, Mandore, Jodhpur Rajasthan India. [1]opnc06@gmail.com; [2] shubhra.icrs@gmail.com; [3]kishangadri@gmail.com

Abstract: In the present paper, Chandrayaan-1 Mini-SAR data has been analysed over various Lunar features at Equatorial Region. Relative phase (δ), Degree of Polarization (m) and CPR values over various Lunar features are analysed using Mini-SAR data. m-Chi decomposition is also carried out to know single bounce and double bounce scatterings over lunar features at equatorial plane. Dielectric Constant (DC) of these lunar features at equatorial plane are estimated by implementing Campbell inversion model. A Correlation between CPR and LOLA roughness is also established in this paper.

Introduction: Microwave remote sensing encompasses both active and passive techniques [1]. Microwave sensors are used as tools for remote sensing and these are of two types - passive and active sensors. Passive sensor detects the self-emissions of the target while Active sensor measures the scattering coefficient of the target. These properties are useful for the study of planets and other heavenly bodies. The Mini-SAR onboard Chandrayaan-1 [2] is a hybrid polarimetric synthetic aperture radar. In this system a circularly polarized signal is transmitted and linear vertical and horizontal polarized signals are received by the radar for further processing. Among radar-based systems, which include Scatterometer, Altimeters; SAR is commonly used for imaging. SAR [3] uses relative motion between an antenna and its target region and provides distinctive long-term coherent-signal variations that are processed to obtain finer spatial resolution. SAR images have wide applications in remote sensing and are used for mapping terrestrial and planetary surfaces. The SAR-processor stores the radar returned signals, such as amplitude and phase, processes it over successive pulses obtained from elements of synthetic aperture. After a given number of cycles, the stored data is recombined to create a high resolution image of the terrain over which the SAR has collected data.

As Mini-SAR was primarily developed for lunar polar imaging, very few strips of images were acquired over non-polar regions. Some of the image strips acquired over equatorial region to study the scattering characteristics over lunar equatorial region where the distribution of Mini-SAR data strips available over lunar equatorial region in both far side and near side are shown. These image strips cover portions of some prominent features viz. Kopff, Bygrius crater, Oceanus Procellarum, Mare Imbrium, Macro Polo crater, Promontoriun Fresnel & Santos Dumont, Taylor & Descartes, Mare Fecunditatis in near side of Moon. In FAR side SAR strips cover portions Maunder, Rimae Focas, Jackson, King crater. The main aim to this paper is to see the scattering behaviour of various prominent features on lunar equatorial region. It covers very wide range of features which includes different types of craters, Mare, Oceanus, Promontoriun etc.

Methodology: Mini-SAR data is analysed in ENVI 5.0 and ISIS software and stored in a Planetary Data System (PDS) compliant standard where each pixel in an image strip consisted of 16 bytes data in four channels of 4 bytes each as $|LH|^2$, $|LV|^2$, Real (LH LV*) and Imaginary (LH LV*). Several useful quantitative measure follows from stokes vector [4]. Some of the quantitative measures are: degree of polarization (m, representative of polarized and diffuse scattering), circular polarization ratio (CPR, representative of scattering associated with planetary ice and dihedral reflection) and LH-LV relative phase (δ, an indicator of double bounce scattering). As CPR is associated with the roughness, so roughness is also calculated from the LOLA data at same spatial resolution. Along with these parameters, DC is also one of the important electrical parameter of the lunar surface and provides basic data necessary for further exploration. Inversion model was developed by [5] for estimating dielectric constant of rock-poor mantling dust based on the normalized ratios between the horizontal and vertical backscattering coefficient.

Results and Discussions

Estimation of Dielectric Constant & Polarimetric Studies of Lunar Equatorial Region

The behaviour of Relative phase (δ), Degree of Polarization (m), S0 and Dielectric Constant over various lunar equatorial region are illustrated in table 1.

Table 1: Polarimetric Parameters and DC Associated with Some Equatorial Features using Mini-SAR datasets. Here So indicates the total (LH+LV) intensity.

S.No.	Feature Name	DoP (avg.)	So (dB avg.)	Delta (avg.)	Dielectric Constant (avg.)
1.	Taylor	0.59	-14.43	-24.65°	2.88

	Crater				
2.	Descartes Crater	0.52	-14.20	-24.34°	2.54
3.	Jackson Crater	0.43	2.83	-43.26°	3.50
4.	Maunder Crater	0.39	-3.09	-37.08°	2.42
5.	Kopff Crater	0.51	-7.60	-80.98°	3.83
6.	Micro polo Crater	0.55	-13.97	-21.76°	2.22
7.	King Crater	0.38	-7.69	-31.45°	3.05
8.	Mare Imbrium	0.36	-20.96	-31.96°	2.58
9.	Rimae Focas	0.45	-15.22	-25.42°	2.87
10.	Byrius Crater	0.42	-12.21	-34.29°	3.31
11.	Mare Fencundi-tatis	0.41	-5.528	-34.78°	3.16
12.	Ocean Porcellum	0.60	-20.00	-38.28°	2.48
13.	Promon-toriun Fresnel	0.65	-16.98	-28.96°	2.61
14.	Santos Dumont	0.50	-12.21	-21.10°	2.96

Correlation between CPR and LOLA roughness

In figure 1 shows correlation between CPR and LOLA roughness observed over Lunar equatorial regions listed in table 1. In this analysis both the mare (Imbrium & Fencunditatis) is of similar topography. The Kopff crater is smooth as compared to other crater such as Taylor & Descartes Crater which is highly rough due to rough terraces and central peak. The roughness of Rimae Focas, Santos Dumont, Micro polo Crater and Maunder Crater lies in the same range. The relation between CPR and roughness is plotted in figure 1. The relationship as it is seen is linear with R2 0.934. Thus for not very rough surface this relationship holds and for the surfaces which are not highly rough we can use this relationship for understanding of CPR.

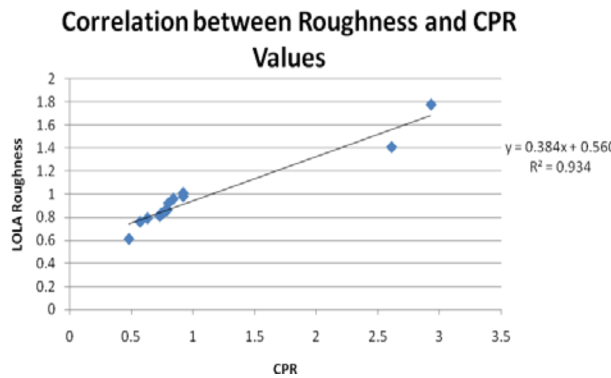

Figure 1: CPR v/s LOLA Roughness for Lunar Equatorial Region using datasets of Mini-SAR of Chandrayaan-1 and LOLA of LRO

Conclusion

The analysis has been carried out over lunar equatorial region using Mini-SAR datasets. Analysis includes computation of Stokes parameters and its derived parameters. We have studied available Mini-SAR data of equatorial region and viewed many features like Ocean Procellarum, Mare Imbrium, Rimae Focas etc. DC values have also been calculated using Campbell's model over lunar equatorial region. For Oceanus Procellarum & Rimae Focas maximum DC values observed are in range of 2 to 3 however for Bygrius crater more DC values greater than 3 are observed. The roughness from LOLA is also calculated over these features and the result show that Kopff crater is smooth as compared to other features while Taylor & Descartes Crater is most rough crater due to rough terraces and central peak. This analysis will be continued with the other polar craters with expectation of water ice in permanently shadowed areas of lunar pole

References

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