Scattering Mechanism of Erlanger crater using Chandryaan-2 L-band DFSAR data. Aanchal Sharma[1], Shashi Kumar[1], and Sriram Saran Bhiravarasu[2], [1]Indian Institute of Remote Sensing, ISRO, Dehradun, India (aanchalsharma7333@gmail.com, shashi@iirs.gov.in), [2]Space Application Centre, ISRO, Ahmedabad, India.

Introduction: The Moon has permanently shadowed regions (PSRs), which are located at the lunar poles. These dark regions have a very low temperature (<120 K) as the sun's rays never reach there. Volatiles from the solar wind and other sources reach the lunar surface and get trapped in PSRs. PSRs are believed to have volatiles like water-ice which can be used as a local source for future permanent human bases on the Moon[1]. Before any in-situ resource utilization (ISRU) missions, the distribution of volatiles should be fully understood. Radar remote sensing is proven to be effective to study such dark regions. Also, it provides high penetration capability to study the sub-layer of lunar regolith where water-ice deposits are believed to be concentrated. Several missions like Lunar reconnaissance orbiter (LRO) Mini-RF[2], Chandryaan-1 Mini-SAR[3], Chandryaan-2 DFSAR[4] were sent into orbit to study the distribution and properties of volatiles and lunar regolith. To understand the distribution of water-ice deposits, the scattering mechanism from the radar data can be helpful, though more information will be required for the confirmation. Nevertheless, it sure provides some initial evidence that can be further confirmed with other parameters. In this study, we have used the Chandrayaan-2 DFSAR L–band data to examine the scattering behavior of the Erlanger crater.

Erlanger Crater: Erlanger crater is located at 86.9° N, 28.6° E (North Pole). The crater lies in PSR whose PSR ID is NP_869610_3071360. It is a small crater with a diameter of 10.94 km. Shua Li et al. 2018 [1]studied the water-ice signature from the Chandryaan-1 M3 dataset and concluded that approximately 3.8% of cold traps exhibits ice exposures from which one of them was the Erlanger crater region. Mini-RF data revealed a high-CPR (Circular Polarization Ratio) for the Erlanger crater and Thompson et al. 2012[5] scattering model that categorized Erlanger as an Icy crater (CPR>1.5).

Methodology & Observations: For the processing Level-1A SLI product of DFSAR was used. Eigenvector-Eigenvalue-Based decomposition and Yamaguchi four-component decomposition were performed. These two decompositions handle the complex scattering scenarios very well[6]. A scattering matrix was used to simulate compact-pol data from which the stokes parameters were generated, to calculate CPR.

H-A-α decomposition. This is Eigenvector-Eigenvalue-Based Decomposition also known as Cloude-Pottier decomposition[6]. Entropy (H) is the degree of randomness and it lies between 0<H<1, where H approaches to 0 means that the scattering process is due to pure scatter and H approaches to 1 means that the scattering is due to the combination of pure targets (volume scattering) [6]. Alpha (*α)* is a mean alpha angle lies 0≤ α≤90°[6], where α approaches 0° implies surface scattering, α approaches to 45° implies volume scattering and α approaches to 90° implies double-bounce scattering. Anisotropy (A) is a parameter complementary to entropy and represents the non-similarity. H-A-*α* decomposition RGB is representing the scattering behavior of the crater where Red indicates the double-bounce, green indicates the volume and blue indicate the surface scattering. From figure (1), it is visible that some part of the crater is showing high entropy and alpha angle near 40-45°.

Yamaguchi four-component decomposition. This decomposition includes the three-component decomposition and a fourth component composed by either the left or the right helix scattering[6]. Yamaguchi four-component decomposition RGB is representing the scattering behavior of the crater where Red indicates the double-bounce, green indicates the volume and blue indicate the surface scattering. From figure (2), most of the region is exhibiting volume scattering.

Circular Polarization Ratio(CPR). It is the ratio of the same sense 'SC' and opposite sense 'OC' of circular polarization[2]. It can be also derived from the Stokes parameters, the relationship between CPR and stokes parameters are; CPR=$(S_1 - S_4)/(S_1 + S_4)$[2].The high value of the CPR is believed to be because of the water-ice deposits in the lunar regolith. Though it can be high due to surface roughness as well which is in the case of young craters [4]. From figure (2), high values of CPR can be observed.

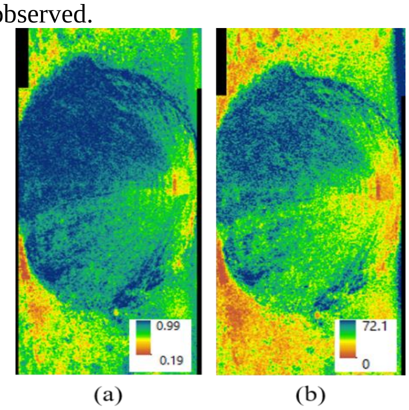
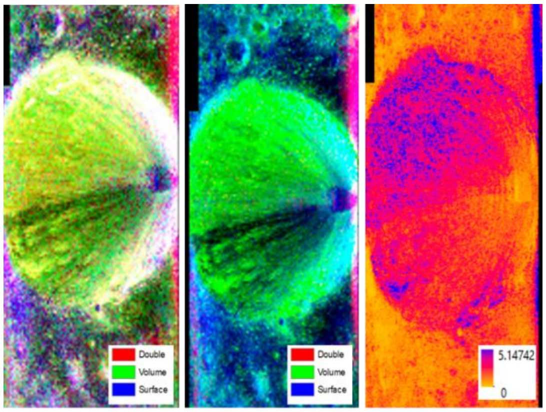


Figure 1: Decomposition parameters (a) Entropy (H), and (b) Alpha (α)



(a) (b) (c)

Figure 2: Polarimetric decompositions (a) HAα Decomposition, (b) Yamaguchi four-component Decomposition, and (c) Stokes parameters-based Circular Polarization Ratio (CPR)

Preliminary results: It has been observed that some regions in the Erlanger crater have high CPR values and are dominated by volume scattering. This could be due to water-ice deposits which contribute to volume scattering behavior[2]. This observation strengthens the observations made by previous studies associated with the water-ice deposits in the Erlanger crater[1][2] but solely these two parameters are not enough to make a concrete statement for water-ice deposits present in the lunar regolith. Thus, further investigation is needed to confirm the presence of water-ice deposits in the PSRs.

References:[1] S. Li et al.(2018), *Proc. Natl. Acad. Sci.,vol. 115, no. 36, pp. 8607-8912,* [2] P.D. Spudis et al.(2013), *J. Geophys. Res. Planets, vol. 118, no. 10, pp. 2016-2029*, [3] S. Shukla & S. Kumar(2018), *EUSAR-2018, p. 1-6*, [4] S.S. Bhiravarasu et al.(2021), *Planet. Sci. J.,vol. 2,no. 4, p. 134*, [5] T. W. Thompson et al.(2012), *Space Sci. Rev, vol. 150, pp. 1006-2009* [6] R. Yang et al.(2021),*polarim. Microw. Imaging,pp. 75-122.*