CHANG'E MICROWAVE BRIGHTNESS TEMPERATURE DATA AND LUNAR SURFACE CHARACTERISTICS. K. T. Tsang[1,3], Y. C. Zheng[2,3], and K. L. Chan[3], [1]United International College, Beijing Normal University-Hong Kong Baptist University, Zhuhai, China (k2tsang@gmail.com); [2]A20, Datun Rd. Chaoyang, Beijing, National Astronomical Observatories, CAS, China (zyc@nao.cas.cn); [3]Dept. Math., The Hong Kong Universty of Science and Technology, Hong Kong (maklchan@ust.hk).

Introduction: On board of each of the recent Chinese lunar orbiters, Chang'E-1 (CE-1) and Chang'E-2 (CE-2), launched on Oct 24, 2007 and Oct 1, 2010 respectively, there was a set of microwave radiometer (MRM) with four frequency channels, 3.0, 7.8, 19.35 and 37GHz. The goal of both MRM's is to measure brightness temperature (TB) of the moon from which one can derive the physical properties of the lunar surface. Using CE-1's TB data sets, the microwave map of the moon in the daytime and nighttime have been published [1] and many anomalous "cold spots" on lunar surface during lunar night were discovered [2], indicating the ability of the TB data to probe deep down into the lunar subsurface.

With the much improved spatial resolution and full diurnal coverage of CE-2's measurements, we are able to study detail local lunar surface and subsurface characteristics in combination with radiation transfer modeling result.

Correlation among brightness temperatures at Tycho crater area from CE-2 data: The central position of crater Tycho (43.31°S, 11.36°W) is taken as the center of a rectangle formed by longitudes 12°W & 10°W and latitudes 42°S & 44°S. This area has roughly a dimension of 61km in the N-S direction and 44km in the E-W direction, which fits inside the Tycho crater with a diameter of 86.2km as shown by the CE-1 visible image in Fig.1.

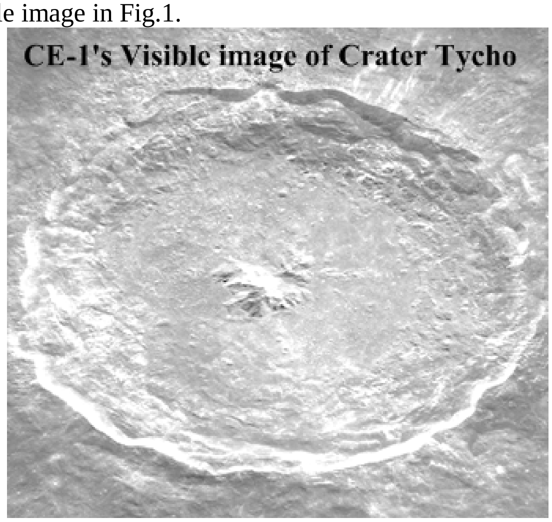

Fig.1 CE-1's Visible image of crater Tycho.

From the CE-2 MRM dataset, we selected all 495 records that were measured within this area. The TB associated with the 37 GHz, TB(37GHz), is the result of the contribution from temperature of the top surface layer and experiences the widest dirurnal variation, while TBs of lower frequencies are influenced by temperatures of deeper layers. Therefore, relationship between TBs of different frequencies reflects the vertical profile of the subsurface temperatures. In Fig.2 we have constructed the scattered plots of TB(37GHz) vs. the TB of the other 3 channels to study the correlation among them.

We observe in Fig.2a there is an extremely strong positive linear correlation between TB(37GHz) and TB(19GHz) with a correlation coefficient r=0.9927. Fig.2b shows that even the difference between them has a correlation coefficient r=0.98, still a very strong positive linear correlation. As the frequency decreases, the corresponding correlation deteriorates. At 7.8GHz, the correlation coefficient is still a healthy 0.9351. But at 3GHz, the linear correlation coefficient drops down to 0.7841, to the point of almost no correlation at all. Fig.2b is an observational evidence supporting the assumption used in most lunar thermal models [3,4] that the top layer of the lunar surface is consisted of a dust layer of low heat conductivity, as it shows that after sunset the top layer cools rapidly by radiation cooling to the point that the temperature of the top layer becomes lower than the layer beneath it.

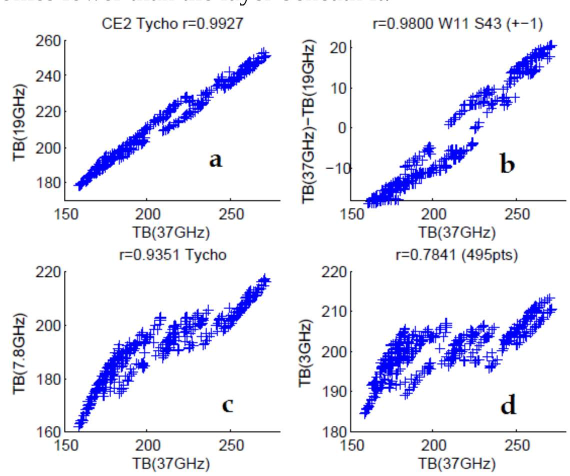

Fig.2 Correlation between the TB (in K) measured by the four frequency channels in CE-2 data from a rectangle centered at crater Tycho. (a) 19GHz vs. 37GHz, (b) difference between 37GHz & 19GHz vs. 37GHz, (c) 7.8GHz vs. 37GHz, (d) 3GHz vs. 37GHz.

Fig.2c can also be understood in a similar fashion. The more or less horizontal portion of the data between the linear trends can be interpreted as after sunset the temperature of the top layer cools rapidly while the temperature of deeper layers remains relatively stable until a while later the cooling effect is felt by the deeper layers. In Fig.2d, the narrow range in TB(3GHz) shows that temperature of the deepest layers hardly vary during the diurnal cycle. This temperature profile implied by the local CE-2 data is entirely consistent with the thermal model result of Vasavada et al. [3].

Radiative transfer model: The linear correlation between TB(37GHz) and TB(19GHz) as observed in Fig.2a can be explained by a simple radiative transfer model. Based on a model with three layered media, i.e. soil dust, regolith and underlying bedrock, the nadir TB emission (with frequency ν) from the layering media can be expressed as a sum of contributions from different layers [5]:

$TB(\nu)=A(\nu)T_1 + B(\nu)T_2 + C(\nu)T_3$,

where T_1, T_2, and T_3 are the temperatures of the topsoil dust, regolith and underlying bedrock. The parameters A, B, and C are functions of the dielectric constants of the three layers and ν.

Treating T_1 and T_2 as the variables of most dirurnal sensitivity, and T_3 constant with local time (as noted in [3, 6] the temperature is essentially constant in time below about 30cm), we can eliminate T_1 and T_2 from the equation above and obtain a linear relationship between the TBs of the two highest frequency channels. This linear relationship can set constraints on the parameters A, B, and C T_3.

In Fig.3 below, we have fitted linear relationship between TB(37GHz) and TB(19GHz) based on CE-1 data from 2 local areas (around Tycho crater and Sinus Iridum). Only daytime TB data are used in these fits, as the linear correlation is much stronger. In principle the constants obtained from the fitting will provide us with concrete information about physical parameters embedded in A, B, and C T_3, which we can exploit to unfold.

It is interesting to note that the linear fits shown in Fig.3 give different slopes and intercepts, which presumably are due to the difference in physical parameters in the two areas from which the data were gethered. We are still in the early stage of exploring how we can take advantage of this approach to gain insight of physical parameters of interest.

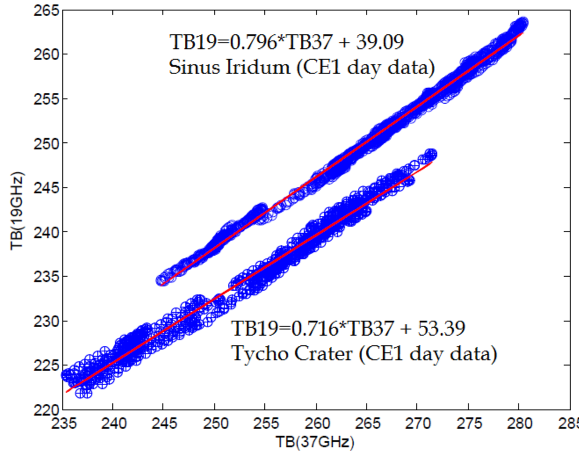

Fig.3: Least-square fitted linear relationship between TB(37GHz) and TB(19GHz) based on CE-1 data from 2 local areas (around Tycho crater and Sinus Iridum).

References:

[1] Zheng, Y. C., Tsang, K. T., Chan, K. L., et al. (2012) *Icarus*, *219*(1), 194–210. [2] Chan, K. L., Tsang, K. T., Kong, B., Zheng, Y. C. (2010) *Earth and Planetary Science Letters*, *295*(1-2), 287–291. [3] Vasavada, A. R., et al. (1999) *Icarus*, 141: 179–357. [4] Keihm, S. J., and Langseth, M. G. Jr. 1973. *Proc. Lunar Planet. Sci. Conf. 4th*, 2503–2513.[5] Fa, W. and Jin, Y. Q. (2010) *Icarus*, 190, 15–23.[6] Sum, S. F., Chan, K. L., Tsang, K. T., Zheng, Y. C. (2011) PS10–A011, *Asia Oceania Geosciences Society Annual Meeting*, Taipei.

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