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An insight into the sub-surface thermo-physical properties of Venus from observations of the Cytherean thermal radio emission at decimetre wavelength using the GMRT

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1 Extended Abstract

The passive low frequency, polarization observations on planetary surfaces are widely accepted for probing the surface and subsurface physical and dielectric characteristics. But these are least explored from Earth-based platforms due to the reduced planetary emission and increased system, background temperature and difficulty in conducting the observations at low frequencies. At these frequencies, due to deeper penetration of the radiation into the surface, the polarization state of the planetary emission comes out with far more information on the surface roughness conditions and sub-surface dielectric volume nature, besides the thermal information of the planetary body from the intensity of the emission. Moreover, there is a large uncertainty prevailing in the observed and the modelled brightness temperature (T_b) of Venus at higher wavelengths, especially at the decimeter (dcm) regime. The observations show a decreasing trend in the T_b at this regime and the current models are not able to explain this to a satisfactory level. The radiometric observations on Venus were limited to the lowest of 430 MHz ($\sim$70 cm) until the recent Giant Metrewave Radio Telescope (GMRT) observations (in 2004), further down the frequency spectrum, showed a further decrease in the radiometric T_b. The T_b values were reported as 526 K at 608 MHz, 409 K at 332.9 MHz with errors of $\sim$6% and <388 K at 239.9 MHz. During the observation, the limited time and the relative far off distance between Venus and the Earth had put a serious constraint in resolving the Cytherea and hence the data was only used to derive the disk-averaged T_b of the planet. In 2015, another set of observations were carried out at 233.67 MHz (128 cm), 607.67 MHz (49 cm) and 1297.67 MHz (23 cm) using the GMRT when Venus was close to its inferior conjunction. In this paper, we describe the results of the multi-frequency, multi-polarization radiometric observations of the planet carried out using the GMRT. The T_b values of the Venus were derived as <321, 548$\pm$38, and 622$\pm$43 K at the above respective frequencies. The T_b values derived at 606 MHz and 1280 MHz are consistent with previously reported values by several investigators but the 233.67 MHz result showed a further reduced value of T_b compared to the before reported value of <388 K. There are only limited polarization observations on Venus to study the surface characteristics and the other observations were limited to higher GHz frequencies studying the atmospheric properties. Previous observations of Venus at 4.99 GHz frequency ($\sim$6 cm wavelength) reported no significant polarized emission from the limb of the planet while observations at 1.49 GHz ($\sim$21 cm) reported an average degree of polarization of 0.14 towards the limb of the planetary disk corresponding to an effective dielectric constant of 2.5$\pm$0.5. This is much lower than those reported from radar-based observations. The low value of the dielectric constant was attributed to the surface roughness and attenuation by the atmosphere. From the current observation, using the degree of polarization maps of Venus generated from the GMRT data and the model generated using the Fresnel equations, the dielectric constant, ε, of the Venus surface was derived as $\sim$4.5 both at 607.67 MHz and 1297.67 MHz which are closer to the reported value of 4 to 4.5 from the radar-based observations by the predecessors. This is the first time polarization observation of Venus at 606 MHz frequency and provides uncontaminated information on the dielectric properties of Venus surface as, at this frequency, the surface roughness and the planetary atmosphere are expected to be least significant.