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Volume of Abstracts

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Oral Presentations

Session 1: Surface Science and Exploration

The Evolution of Venus: Themes Derived from the Observed Geologic Record for Tectonism, Magmatism, and Atmosphere/Climate.

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Introduction: The primary focus of Venus-SC 2023 is on "modelling, observations, data analysis, conceptual design and scientific experiments for exploration of Venus, in order to provide a platform for interaction and exchange of knowledge." We take a Venus System Science approach, examining the relationships between the surface geomorphology and geologic record, the geodynamic evolution, atmosphere, the current climate, and the long-term thermal evolution of Venus.

We use the currently preserved global geologic record [1-4] as a baseline to identify the broad outlines of:

1) Geodynamic and Tectonic History: At the beginning of the visible geologic history (Fortunian Period) intensive and extensive tectonic deformation produced the globally occurring tesserae, regions of highly deformed, variably-oriented often superposed folds and faults, and thickened crust, embayed by younger volcanic units and now forming ~8% of the surface. Deformation waned into the Guineverian Period, with extensional linear groove belts deforming tessera-embaying volcanic plains, and the onset of some individual coronae. Following this Global Tectonic Regime, tectonics were manifested in global networks of contractional wrinkle ridges deforming the near-global regional volcanic plains. The latest Atlian Period was characterized by a global network of major interconnected rift zones and associated volcanic activity, concentrated at rift junctions (the Network Rifting-Volcanism Regime).

2) Magmatic History: Plutonism and volcanism varied significantly in volumes, rates, styles, sources and sequences throughout the preserved geologic record. Evidence for volcanism is sparse in the tessera-dominated Fortunian, although tessera rocks may be deformed basalts and the ribbon terrain blind dikes. Tessera-embaying volcanism is dominated by volcanic plains, early global distribution of abundant small shield volcanoes, and a population of Steep-Sided Domes. These are embayed by globally distributed, flood basalt-like, regional plains (the Global Volcanic Regime), at the end of which ~85% of Venus had been resurfaced. A change in style marks the Guineverian-Atlian Period transition, with the Atlian dominated by rift-associated volcanism and plutonism, and volcanism concentrated at coronae and isolated, globally distributed volcanic centers (large shields, coronae and radial dike swarms) signaling a change in style from Guineverian flood volcanism to globally distributed rift and plume-dominated magmatism.

3) Atmospheric and Climate History: We use the preserved geologic record to probe the volumetric abundance of volcanism and its volatile input to the atmosphere in the most recent Atlian and during the Global Volcanic Regime and observations of the preservation and alteration of geologic features and units to assess evidence for potential eolian, mass wasting, and hydrologic modification processes.

Using this Venus System Science approach, we address the following questions:

1. What are the broad outlines revealed in the currently preserved geological record?: Rates and styles of tectonism and magmatism have clearly changed radically during this period, from intense, concentrated deformation and flood volcanism, to rift-dominated and globally distributed plume volcanism. At issue is whether this trend was gradual or potentially geologically catastrophic.

2. What is the geologically recent rate of volcanic gas input into the atmosphere and did the currently observed atmosphere and climate form during this time? If not, when is it likely to have formed?: We find that the recent rate of volatile input to the atmosphere is insufficient to explain currently observed variations in atmospheric gas species. We also find that the volume of volcanism emplaced during the Global Volcanic Regime is insufficient to account for the current Venus atmosphere, and that the current atmosphere is more likely a 'fossil' atmosphere, dating from Pre-Fortunian geologic history.

3. What are the sources of surface erosion and sedimentation on Venus and how have they changed with time?: We find no evidence in the preserved geologic record for significant eolian or aqueous erosion and lateral transport processes. Tessera terrains are rough/blocky due to 'tectonic erosion' and local mass-wasting processes, but we found little evidence for any significant erosion of tessera and/or transport of erosional products into surrounding regions. The primary process of rock breakdown and transport of material on Venus is impact cratering and related plume sedimentation, and subsequent eolian modification of the emplace ejecta.

4. If Venus was once characterized by a clement Earth-like atmosphere and climate, with ocean-scale bodies of water, is any evidence of this preserved in the current geological record?: We found no convincing evidence for any significant erosion or alteration that might be related to an active hydrological cycle.

5. Is Venus geologically and geodynamically active today, and if so, at what level?: As might be predicted from the outlines of geodynamic and magmatic history given above, Venus is surely active today and in the recent geologic past, with evidence for active volcanism in recent rift zones and related areas.

Summary: Our Venus System Science synthesis [5], based on the observed, preserved geological record suggests that:

1) Venus is Earth-like in the sense that the current global record is dominated by deposits from activity that occurred in the last 20% of planetary history, but differs in that there is no clear evidence of plate tectonic activity on Venus during this period.

2) Venus underwent a major change in geodynamic/magmatic styles and rates during this latest history, whose origins are not yet clear. The earlier Earth geological record should be reassessed through this lens to see if there are any analogous periods in the first 80% of Earth history.

3) The current fundamental difference in Venus-Earth atmosphere and climate is likely to have taken place in the Pre-Fortunian, the first 80% of Venus history.

4) The upcoming international armada of Venus missions has the capability to resolve many of these outstanding issues.

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Active Volcanism on Venus

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One of the key focus of the upcoming Venus missions is to explore the potentially active volcanic zones on Venus. This is important from a perspective of understanding the temporal evolution of volcanic and tectonic processes on Venus. During the past decade, a number of studies have identified locations (e.g. Ganis Chasma and Atla Regio) with evidence of geologically recent volcanism [1-2]. Additional evidence of morphological changes in volcanic vent and lava flow has been recently reported to document active volcanism [3]. In this work, we have analyzed the Magellan radar, topography and emissivity datasets of the Atla Regio to understand the relationship between the morphology, topography and radar emissivity properties of the volcanic units identified in the region. We find that the region hosts lava flows that superpose the fractures and grabens in the region. These flow units have smooth texture, low radar backscatter and exhibit high emissivity. Alternatively, the flow units with moderate emissivity possess rough texture, moderate radar backscatter, and partially superpose the fractures and grabens systems in the region. With respect to the impact craters in the vicinity of lava flow units with moderate emissivity, they tend to superpose the crater dark halo, thereby suggesting lava to be younger than 0.5T (i.e. Upper Atlian or even Aurelian). Under this scenario, the high emissivity lava flow units are relatively younger. Our observations provide key insights into the ongoing tectonism and volcanism in the Atla Regio. In the future, higher resolution datasets are going to be crucial in identifying the sources and stratigraphy of younger generation of lava flow units in Atla Regio on Venus.

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Surface and Subsurface Science: From Isro's Venus Mission Perspective

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Introduction: Past missions to Venus revealed to some extent the complex interactions of the planet's interior, surface, and atmosphere [1–10]. In particular, surface observations were so far limited to single- and dual-polarization radar images obtained at coarse resolutions, which limits our understanding about the near-surface processes observed on Venus [e.g. 8–11]. ISRO's first planned mission to Venus will focus on understanding the geological evolution of the planet using an S-band polarimetric synthetic aperture radar (VSAR) with a capability to image the Venus surface at high spatial resolutions [12]. Moreover, in order to obtain fundamental information on subsurface geology, a low-frequency radar sounder that can obtain vertical resolutions of 5-15m along with surface penetration capability (up to 1 km depth) is also proposed for ISRO's Venus mission. Based on the results obtained from Magellan mission and Earth-based radar mapping, we note below some of the significant and compelling science questions that would be focused upon by the proposed VSAR and radar sounder instruments:

Is Venus active?: With the recent discovery of the surface changes on a Venusian volcano [13], a major goal of the proposed polarimetric SAR instrument is to detect active volcanic processes and provide a detailed global characterization of volcanic landforms in order to understand the current geologic activity on Venus. An essential aspect of this characterization will be the integration of polarimetric SAR data with other complementary observations of the surface obtained at other wavelengths.

Geologic history: Significant advancements in understanding geologic processes on Venus can be achieved by making radar imaging at a scale of several to tens of meters that will allow (when combined with high-resolution topographic information) a detailed assessment of three-dimensional stratigraphic relations to better discern relative ages of units. In addition, high-resolution polarimetric SAR data would enable identification and refinement of geologic contact boundaries, and in turn the series of geologic events, detailed structure of various geologic units, as well as characterizing potential landing sites for future missions.

Surface-Atmosphere interactions: Polarimetric SAR data will enable a better understanding of the phenomena behind the unusually radar-bright material (coupled with low emissivities) observed at many of Venus's high elevations from Magellan radar studies. This radar-brightness is independent of geomorphology but dependent on altitude and latitude, implying that it might be controlled by atmospheric interactions, the nature of which is currently unknown.

Resurfacing history: Synergetic observations from polarimetric SAR and radar sounder instruments could address some of the issues related to the timescales, rate and mechanisms of resurfacing on Venus at a global level.

The proposed microwave instruments onboard ISRO's Venus mission support both overlapping and distinct science objectives compared to the near-future planned missions by other space agencies such as VERITAS, EnVision, DAVINCI+, and Venera-D

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Venusian Ionosphere: Current Understanding and Outstanding Questions

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The space environments of the solar terrestrial planets vary significantly due to differences in their distances from the Sun, as well as their unique atmospheric compositions and the presence or absence of intrinsic magnetic fields [1,2]. Earth and Mercury possess near-dipolar intrinsic magnetic fields, whereas Mars possesses crustal magnetic fields that noticeably influence the plasma environment surrounding these planets [3]. In contrast, Venus lacks any intrinsic magnetic fields, implying that its ionosphere primarily depends on electrostatic forces. Spacecraft missions such as the Pioneer Venus Orbiter and Venus Express have played a pivotal role in providing invaluable insights into the structure and variability of the Venusian ionosphere, as well as its intricate interactions with the Sun [4,5]. This presentation will offer an overview of the current understanding of the Venusian ionosphere, drawing from spacecraft observations and model simulations. Additionally, it will delineate the unresolved questions and intriguing challenges that continue to captivate scientists in this field. Moreover, the potential scope of future spacecraft missions to Venus will be explored, and key areas of focus for these missions will be discussed.

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Exploring the Venus ionosphere using radio techniques and physics based ionospheric models

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Venus, being the closest planet to Earth, has been a subject of numerous planetary missions aimed at studying its atmospheric and ionospheric composition and density. The Venus ionosphere is formed by the photoionization of the neutral atmosphere by solar EUV and X-ray radiations and, as a secondary effect, by photo-electron impact ionization at lower altitudes. In addition to the V2 layer, Venus is known to have the presence of a secondary layer of enhanced ionization at the lower height (~125 km) as well [1,2]. Though Venus has been thoroughly explored in the past various missions, there are still outstanding questions even related to the formation of the different layers. In the present study some of these outstanding scientific issues are addressed using both Radio occultation measurements and physics based ionospheric model.

On of such outstanding issue is the formation of the V1 layer. Measurements from earlier missions like Mariner 5/10, Venera 9/10, and PVO, had shown pieces of evidence, albeit limited, for the existence of a layer of enhanced ionization at about 125 km. A more detailed study addressing the characteristic features of V1 layer such as peak altitude, peak density, and morphological changes with respect to SZA and solar activity better were done by Venus Express radio occultation (VeRa) observations [2]. Though, VeRa reported different types of V1 layer, no theoretical understanding has been developed so far which could explain the occurrence of different types. Another interesting feature is the enhanced ionization below 120 km. This is known as V0 layer. Though there are different mechanisms possible for the formation of an ionization at the lower altitude, the exact reason is not yet sort out. The study of the formation and characteristics of different layers enable us to understand the physics of that region and its variability. Though there are observations reporting an additional layer above 160 km (V3 layer), its origin is still not understood. In addition to these, the variabiltities observed in the ionosphere such as day and night, ionopause and the upper atmosphere etc are not understood completely.

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Latest results from Akatsuki radio occultation

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Radio occultation observations of the Venusian atmosphere in JAXA's Akatsuki mission have provided information on the vertical structure of the atmosphere over broad latitude, longitude and local time regions [1,2]. The measured quantities are the atmospheric pressure, temperature, sulfuric acid vapor mixing ratio and electron density. Recent studies conducted using Akatsuki radio occultation data include: meridional thermal cross section [3], characteristics of gravity waves revealed by radio holographic analysis [4], radio scintillation analysis for short vertical scale waves, fine vertical structures of the ionosphere, and solar corona [5]. Selected results from Akatsuki radio occultation experiments will be introduced in the presentation with an emphasis on gravity waves.

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Session 3: Lightning and Habitability

Whistler mode waves from lightning on Venus

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The lightning has been detected in the clouds of Earth, Jupiter, Saturn and Uranus. We expect that lightning should also occur on Venus and Mars. Recently, Akatsuki detected a flash of lightning on Venus, which was 10 times more energetic than lightning on Earth. But there was only one flash. The lightning normally occurs in clusters. It is possible that it was not a lightning but flash was caused by a large meteor shower in the Martian atmosphere. This seems an unlikely explanation because meteors and lightning discharges are completely different. The lightning is a flash of light produced between clouds or between clouds and Earth. The meteor is a atmospheric phenomenon.

In the present paper we will talk on Venus lightning which is generated by whistler mode waves in the ionosphere of Venus. Venus Express has observed regularly lightning generated by whistler mode waves. We have considered that whistler mode waves are generated below 350 km, The ionosphere of Venus is produced between 0 km and 350 km. At 350 km altitude the lightning generated whistler mode waves are created about 5%. The median Poynting flux of the signals was 1.0 x 10-9 w/m2 and the peak value occurred at low altitude implying a lightning source from below the ionosphere.

Figure: The MAG experiment on-board Venus Express detected wave signals that show evidence of

lightning in the atmosphere. (Courtesy: ESA)

In search of habitability in Venus through its atmosphere - A hypothetical and experimental analysis

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Surface conditions of planet Venus are listed as an extremely high temperature, high surface pressure, no intrinsic magnetic field, super rotating wind and its atmosphere is acidic in nature. So, to know about the origin of the habitable planets like our Earth, then Venus is easy accessible planet to study. This study covers portions such as beginning of solar system, planet evolution, habitability, and functioning. Presently, based on available data, surface of the Venus is not in habitual zone. It has no plate tectonics, it made up of single plate and no appreciable place for ocean. But its atmosphere contains water mixed sulphuric acid aerosol cloud with ambient temperature and pressure give a hope for life at 45-50 km above the surface of the Venus.

In this discussion, possibilities that favours for habitability in Venus through its atmospheric condition are to be discussed. Experimental opportunities on the optical and chemical structural properties of atmospheric cloud are to be mainly addressed.

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Ground Based Optical Observations of Lightning on Venus

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Lightning on Venus has been an unanswered question since long. Many space missions in the past like Venera landers [1], Pioneer Venus Orbiter (PVO) [2] and recently Lightning and Airglow Camera onboard Akatsuki [3], have signalled its presence. Majority of the measurement is done using radio waves or using optical camera. Hansen et. al. [4] carried out an observation using an Earth based telescope at 777.4 nm, which corresponds to excitation of neutral oxygen and a lightning flash was expected to release radiation with such an excitation [5]. The measurement was carried out on night side of Venus and they observed six flashes from different locations during the observation period. This is the only reported study where lightning on Venus is observed from Earth.

Lightning is an important process for a planetary atmosphere as it can lead to physical conditions that wouldn't exist otherwise. To understand the process better, we aim to carry out an observation campaign to detect lightning on Venus using a similar setup. We plan to utilize the PRL's Mount Abu telescope facility for this purpose. Here, we discuss about past measurements and our measurement plan for lightning detection.

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Session 4: Atmosphere

Venus Climate from Radio Occultation Atmospheric Profiles Obtained since 1967

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Introduction: The atmospheric thermal structure of Venus, first deduced by radio occultations from Mariner 5 fly-by on 19 October 1967 [1-3] has now been investigated by Mariner 10 fly-by [4], Venera 9, Venera 10 orbiters [5], Pioneer Venus orbiter [6], Venera 15,and Venera 16 orbiters [7], Magellan [8], Venus Express [9, 10] and Akatsuki orbiters, [11]. Collectively, nearly one thousand occultation profiles have been obtained (Table 1) with vertical resolution of 1 km or better. These measurements collectively provide a good sampling of the thermal structure between 40-80 km over all local times and latitudes (Figure 1).

The radio occultation retrievals of temperature of planetary atmospheres relies on the calculation of the bending angle of the radio beam which is determined from the shift in frequency of the radio signal during the occultation. The thermal structure determined from radio occultations thus does not suffer from the challenges that face other remote sensing techniques for determining the temperature structure and in general provide a higher vertical resolution with the caveat that the retrieved profile is not a true vertical profile but along a long swath that cuts through the atmosphere during the occultation event. All the profiles were retrieved assuming a constant CO_2 +N_2, however the measurements indicate a small variation below 60 km [12]. The latitude-local time coverage from the three long duration orbiters is far from desired but the collective data offer an improvement on the Venus International Reference Atmosphere (VIRA, [13]) and a proposed update [14, 15].

Date	Mission	# Profiles	Frequency
19-Oct-67	Mariner 5	2	423.3 MHz
5-Feb-74	Mariner 10	1	2.3/8.4 GHz
Oct-76	Venera 9/10	20	936/3747 MHz
1978-1992	Pioneer Venus	392	2.3/8.4 GHz
1983	Venera 15/16	27	936 MHz
1992	Magellan	20	2.3 GHz
2006-2014	Venus Express	384+25	2.3/8.4 GHz
2016-present	Akatsuki Orbiter	112+	8.4 GHz

Table 1. Venus Radio Occultations

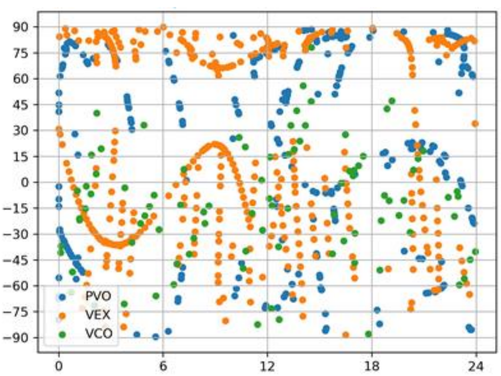

Figure 1. Latitude - Local Solar time coverage of radio occultations from PVO, VEX and VCO mission Pioneer Venus Orbiter, (PVO), Venus Express (VEX) and Akatsuki/Venus Climate Orbiter (VCO)

Acknowledgments: Retrieval of Venus Express temperature profiles from the frequency shift data archived at ESA Planetary Science Archive was funded by the NASA Venus-GRAM project (80NSSC21K0927). Akatsuki profiles were retrieved from the JAXA archive.

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Venusian Clouds using AKATSUKI UV imager

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Venus is surrounded by a more massive atmosphere than Earth, with a surface pressure about 90 times higher and a composition predominantly of carbon dioxide. It has a higher albedo than Earth due to the presence of clouds. Unlike Earth's clouds which are formed due to the condensation of water vapour, Venus clouds are H_2SO_4 clouds formed by photochemical reactions of SO_2 and H_2O near the cloud top altitude. It has been observed that the spectrum of solar radiation reflected by Venus has a broad absorption feature between 0.2 and 0.5 μm and 0.2 and 0.32 μm is well explained by the presence of SO_2 at the cloud tops. The spectrum above 0.32 μm implies the presence of an unknown absorber that has not been identified so far. The objective of the recent study is to use the data from Akatsuki UV imager to examine the cloud morphologies and structure. The UVI takes ultraviolet (UV) images of the solar radiation reflected by the Venusian clouds with narrow bandpass filters centered at the 283 nm and 365 nm wavelengths. The radiance of a 365 nm image is about ten times larger than that of a 283 nm image. The 365-nm image shows more contrast and a bright area in the equatorial region near the center of the image. These differences in UVI images suggest that the spatial distributions of SO_2 and unknown UV absorbers are governed by, at least partly, different chemical and/or dynamical processes. Three-level cloud structures are clearly discernable in the images. The channel ratio method (Nair et al., 2003) (CH#2 vs CH#1) was applied to examine the occurrence frequency of clouds. It is found a perfect sloped line in the image of CH#2 vs CH#1 with a wider spread. The observed images are in comparison with INSAT 3DR.

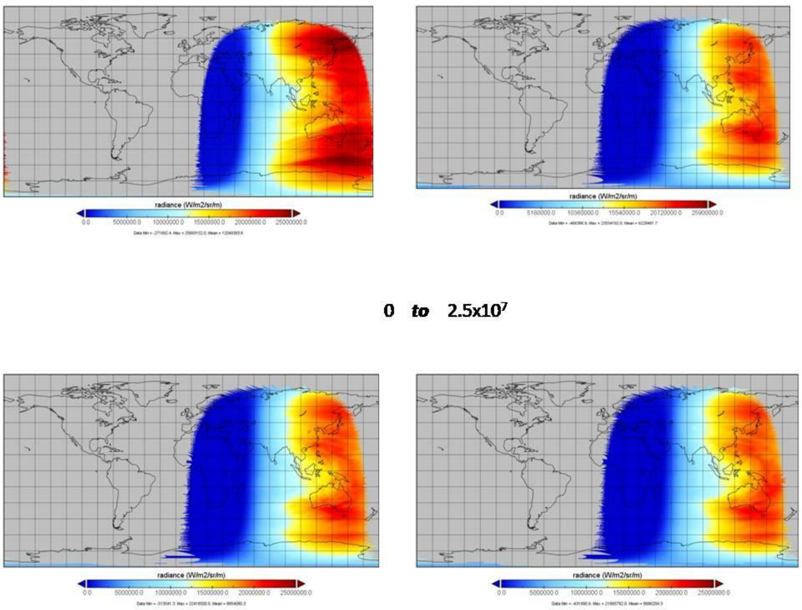

Figure: Diurnal variation of UV reflectance on earth map overlay.
(UVI Imager, Akatsuki mission)

A study on Venusian atmospheric characteristics with a special focus on wind variability and thermal tides

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The study of the Venusian atmosphere has been an area of interest over the past few decades, especially, the super-rotating upper atmosphere, even though the planetary axial rotation is very slow. To comprehend different properties of the Venusian atmosphere and its relation with the super-rotation, an attempt is made to understand the wind dynamics in the low latitudes and the structure and variability of thermal tides. The typical variation of wind speed is analyzed over low-latitude regions of Venus, using the 283 nm wavelength images from the Ultraviolet imager (UVI) instrument on-board Akatsuki, over the observational tenure from 22nd June 2016 to 18th February 2017. The zonal winds observed were slightly higher in many cases when compared to the ones from 365 nm images, although the zonal wind direction was found comparable with the traditional measurements. However, the meridional wind speed was observed to be roughly similar to the ones found through traditional images. The zonal wind speed was also seen to be decreasing as one moves away from the equator. Near the equator, SO_2 concentration was observed to be very high. The meridional wind flow showed evidence of Headley cell circulation. And the average zonal wind speed was also seen to show a pronounced minimum around noon. Explicit topographical influence on the wind speed was not found. To study the global structure of the thermal tides in the uppermost cloud layer, observations from the Longwave Infrared Camera (LIR) were used over a period of 5.8 Venusian years. The analysis was performed in both hemispheres from the equator to the mid-latitude region and for the entire local time period. The study indicated the dynamical wave modes mainly consisted of thermal tides and the diurnal tide is mostly comprised of Rossby and gravity wave modes, whereas the semidiurnal tide primarily consisted of a gravity wave mode. The apparent vertical structures were broadly consistent with the above wave modes, although some differences were observed when the waves were monochromatic [1, 2]. As a result, the heating profile that stimulates the tidal waves can be limited to match this disagreement, advancing our understanding of Venus's atmosphere significantly.

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Occurrence of electrostatic solitary waves in the Venusian atmosphere permeated by the solar wind

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In the absence of intrinsic magnetic field, the solar wind impinging on Venus with a thick atmosphere result in an "induced magnetosphere" that is analogous to Earth's magnetosphere with regard to plasma regions but varies in the spatial extent [1]. The solar wind-Venus interaction facilitates the loss of plasma particles from the Venusian atmosphere, subsequently leading to the generation of numerous plasma waves [2]. Despite plethora of spacecraft missions to Venus, the multitude of information on the waves occurring in the Venus is provided by the Orbiter Electric Field Detector (OEFD) on board the PVO [3]. The observation of waves by current missions like parker solar probe, solar orbiter etc. has revived the interest in the study of the waves occurring in the Venus [4, 5].

Broadband electrostatic noise (BEN) and electrostatic turbulence is a prevalent phenomenon in the space plasma environment and are explained in terms of electrostatic solitary waves (ESWs) [6]. The occurrence of the ESWs in the Venusian atmosphere pervaded by the solar wind are studied using a homogeneous, collision less, and magnetized multicomponent plasma comprising of Venusian H^+ and O^+ ions, Maxwellian Venusian electrons and streaming solar wind protons, and suprathermal electrons following κ - distribution. The model predicts the existence of positive potential slow O^+ and H^+ ion-acoustic solitons. The characteristics and evolution of the solitons existing in two sectors, viz., dawn-dusk and noon-midnight sector of the Venus ionosphere at an altitude of (200–2000) km, are studied. The theoretical model supports the existence of solitons with amplitude ~ (0.067–56) mV, width ~ (1.7–53.21) m, velocity ~ (1.48–8.33) km s-1, bipolar electric field amplitude ~ (0.03–27.67) mV m^{-1} with time duration ~ (0.34–22) ms. The Fourier transform of these bipolar electric field pulse results in a BEN, with frequency varying in the range of ~9.78 Hz – 8.77 kHz. These results can be utilized to explain the observed electrostatic waves in the frequency range of 100 Hz–5.4 kHz in the Venus ionosphere by the PVO [7, 8]. The model can also be relevant in explaining the recent observation of ESWs in the Venus magnetosheath by the Solar Orbiter during its first gravity assist manoeuvre of Venus [4].

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VIRAL – the instrument for Venus atmosphere studies onboard the Venus Orbiter Mission of the Indian Space Research Organization

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In 2019, the Indian Space Research Organisation (ISRO) opened an Announcement of Opportunity for space-based experiments onboard planned ISRO's Venus Orbiter Mission. The proposal of VIRAL instrument was chosen by the ISRO mission program committee. VIRAL (Venus InfraRed Atmospheric gases Linker) is a remote sensing infrared (IR) spectrometer to study the composition and structure of the atmosphere at the top and above the cloud layer of Venus in the altitude range 65 to 180 km, with the solar occultation technique. VIRAL will cover the IR range from 2.3 to 4.3 μm with spectral resolution above 22000 and achieve high vertical resolution (with a footprint of <1 km at the limb, depending on the mission orbital configuration) to retrieve the layering of the Venusian upper atmosphere and its composition like as CO_2 and its main isotopes (with related retrievals of the atmospheric temperature), H2O and HDO (related to the evolution of water on Venus), CO, SO_2, HCl, HF, H_2SO_4 droplets and aerosols. Its enhanced sensitivity will allow establishing refined upper limits or new detections for a number of trace gasses, such as OCS, H_2S, H_2CO, C_2H_2, phosphine. VIRAL will thus improve results obtained by the previous experiment using the same principle (Solar Occultation in the InfraRed, SOIR) onboard the Venus Express orbiter (Nevejans et al., 2006).

The VIRAL is a compact, light-weight echelle instrument capable of achieving very high performances for measuring with unprecedented sensitivity. The VIRAL employs a combination of an echelle spectrometer and an acousto-optic tunable filter (AOTF) that is for the selection of diffraction orders. This concept relies on a series of new-generation instruments that have orbited and operated around Venus and Mars for the last more than decade years, in particular the ACS instrument onboard ExoMars TGO mission (Korablev et al., 2018).

The echelle-AOTF combination allows the sequential acquiring of several diffraction orders during one measurement, which can be located anywhere within the accessible spectral range thanks to the AOTF flexibility. This makes VIRAL both an extremely capable and a versatile instrument efficiently packed in a <7 kg housing, requiring less than 20W (peak power) and implementing onboard intelligence to limit telemetry to <100 Mbits/orbit. The mechanical requirements are restrained to an envelope of $12×40×25\ cm^3$.

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Session 6: Interplanetary Dust Science

Dust Populations in the Inner Solar System Observed Continually with Solar Orbiter

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Solar Orbiter provides unique in-situ data from between 0.3 AU and 1 AU, which is a region of interest to the dust community. While not being equipped with a dedicated dust detector, its electrical antenna suite of Radio and Plasma Waves (RPW) were designed with dust impact detection capability as a lower-level objective.

We present the results of our ongoing evaluation of dust measurements of RPW. First, we employ machine learning techniques to identify dust impacts within the electrical measurement data. Second, we utilize Bayesian techniques in order to fit the stochastic model of dust detection to the detected events with day-to-day resolution. Third, we constrain the presence of different dust populations, namely β-meteoroids, Keplerian dust, interstellar dust, and nano-dust. This is no easy task, since the individual impacts can rarely be assigned to a specific population – this has to be done on statistical basis.

We report the presence of β-meteoroids in great number, and Keplerian dust in possibly important number, while presence of nano-dust, and interstellar dust remains a possibility for now. Since the orbit of solar Orbiter is constantly changing, so does its sensitivity to different dust populations. Therefore, outlook for Solar Orbiter dust measurements is discussed as well.

The population and dynamics of interplanetary dust in the orbital region of Venus.

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Metallic ion layer in Venusian atmosphere

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Ablation [1] of interplanetary dust in Venusian atmosphere is a continuous process, resulting in formation of a metallic ion layer [2] at certain altitude. The flux of Interplanetary Dust Particles (IDPs) acts as an input to the ablation model for estimation of production rates [3]. Since, the non-gravitational forces like P-R drag are prevalent toward Venus during evolution of IDPs, it is suggestive to use available observations for the flux instead of a direct scaling. The proposed IDP flux model and a velocity distribution model from Galileo dust observations [4] will be presented. Further, production rates of atom and ions of Fe, Mg and Si will be discussed [4]. The results can be useful to better understand IDP at Venus, its effect on the atmosphere and also to prepare for data analyses of upcoming space missions for Venus.

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Short Oral Presentations

Study of Venus Subsurface Using Shallow Radar

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Venus is a closet planet to the Earth, but in terms of exploration, it is minimum. The dense atmosphere and high surface temperature make it difficult to conduct an intense investigation of the surface and its geological features. Three new missions, ESA's EnVision and NASA's VERITAS and DAVINCI, are planned to investigate the surface and its atmosphere through Venus orbit. India is also planning to send an orbital Venus mission to study the surface geology and chemical composition of its dense atmosphere. Radar is an integral part of all these missions. Radar instruments can penetrate the dense atmosphere and give high-resolution images of the surface. Radar instruments in the Magellan mission have shown their capability in terms of acquiring data of surface morphology and its DEM. Magellan's radar data shows that the surface of Venus is mostly covered by volcanic materials. Volcanic surface features, such as vast lava plains, fields of small lava domes, and large shield volcanoes, are common morphological features on the Venusian surface.

But still, we do not know the subsurface stratigraphy of Venus. Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) and SHAllow RADar (SHARAD) on Mars have demonstrated the most suitable geophysical technique to investigate planetary subsurface stratigraphy. MARSIS has detected the structure of a buried basin, and SHARAD detected the subsurface ice deposit in midlatitude, subsurface lava flow in the Tharsis and Elysium region, sediment deposit in Madusa Fossa region, infilled crater with ice and sediment, and layered structure of the subsurface ice deposit in the Polar Regions. These discoveries provided geophysical evidence of the present inventory of subsurface ice and past martian climate conditions and geological activities. In this context, a shallow radar can be a useful instrument to deploy in the Venus orbit to understand the subsurface stratigraphy. This will help us to understand the pattern of lava flow, dielectric values, and stratigraphy of the subsurface. It will also help to understand the extent of lava flow in the Venusian subsurface. Infilled craters are also dominant in the surface morphology of Venus. Subsurface radar can help us to understand the infilling process of the crater, and its composition will provide information about the source of infilling.

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Deciphering Venusian Polygonal Patterns: Exploring Potential Clues to Climate Change Dynamics

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Venus has a geologically young surface. Morphological and spatial patterns and surface conditions are challenging due to high temperature, pressure, and relative atmosphere. Planetary heat loss caused deformation. Wrinkle ridges are found on Venus and also on other terrestrial planets. Wrinkle ridges provide information about orientations of shallow crustal stresses. In Venus, wrinkle ridges are associated with polygonal features indicating more recent resurfacing or regional stress.

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Study of variations in the height of Venusian Ionopause

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The ionosphere of Venus is located ~120 kms altitude from the surface. On dayside of the planet, ionosphere is heavily bombarded by the solar wind, causing high level of ionization. The uppermost boundary of ionosphere is known as the ionopause, which is regarded as a location where the external pressure (solar wind dynamic pressure) balances the thermal pressure of ionosphere [1]. Solar wind activity changes significantly throughout the 11-years solar cycle [2] [3]. As ionization in the Venusian ionosphere is dependent on solar wind, the changes in solar wind activity should correspond to changes in the ionosphere as well.

It is expected that the altitude at which pressure balance occurs, should vary with respect to the solar cycle. In this study, we shall present possible variations in the location of ionopause from the available data sets, provided by the Orbiter Electron Temperature Probe (OETP) [4] and Spacecraft Position (POS) [5] on PVO. These observations will help us for better understanding of interaction between the Venusian ionosphere and solar wind.

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Whistler wave by generalized distribution function for relativistic plasma in the Venusian ionosphere

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In this paper, the field aligned whistler made wave have been studied for relativistic plasma by generalised distribution function which are reducible to Bi-Maxwellian for j=0, loss-cone for j=1 and also j=∞ for δ function in the ionosphere of Venus. We have also analysed the effect of plasma parameters on the growth of wave by using method of characteristic solutions. The effect of temperature anisotropy, number density of particles and relativistic factor has been discussed on the growth rate and real frequency from data provided by satellites observations. This result is of great significance for analysing the very low frequency radiation observed in ionosphere of Venus a wide frequency range.

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Spacecraft charging estimation using PVO data set

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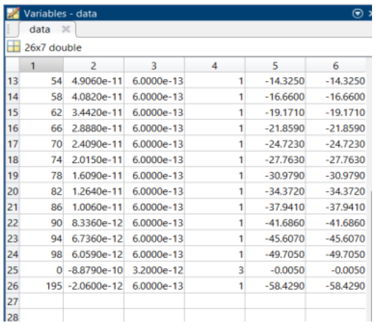
Surface charging in geosynchronous orbit is one of the best-known space plasma interactions on Earth. The potential created on a spacecraft by the accumulation of charges on its surface while passing through a plasma environment in Earth's atmosphere or space is known as spacecraft potential. This action is also known as "spacecraft charging," and it can have catastrophic effects for a spacecraft since it might affect delicate electronics, power sources, and other on-board equipment. The paper provides an in-depth investigation into how spacecraft charge can be calculated, a critical scenario in space missions[1]. In the course of our research, we are diligently examining the pivotal factors that contribute to the precise estimation of charges. This comprehensive investigation takes into account the complex environmental parameters of the planet through the utilization of the Pioneer Venus Orbiter (PVO) satellite [2]. Our focal point lies in understanding the intricate mechanics of spacecraft charging and discharges from a remote standpoint. This entails the detection of high-energy electrons (or ions) making contact with the spacecraft's surface, and the subsequent observation of radiated emissions generated by the movement of electrons through the material, as well as emissions from the arcs themselves. A thorough analysis of these aspects forms the crux of our discourse[3]. Furthermore, we are in the process of exploring potential avenues to ascertain the


Variables - data
data
26x7 double

	1	2	3	4	5	6
13	54	4.9060e-11	6.0000e-13	1	-14.3250	-14.3250
14	58	4.0820e-11	6.0000e-13	1	-16.6600	-16.6600
15	62	3.4420e-11	6.0000e-13	1	-19.1710	-19.1710
16	66	2.8880e-11	6.0000e-13	1	-21.8590	-21.8590
17	70	2.4090e-11	6.0000e-13	1	-24.7230	-24.7230
18	74	2.0150e-11	6.0000e-13	1	-27.7630	-27.7630
19	78	1.6090e-11	6.0000e-13	1	-30.9790	-30.9790
20	82	1.2640e-11	6.0000e-13	1	-34.3720	-34.3720
21	86	1.0060e-11	6.0000e-13	1	-37.9410	-37.9410
22	90	8.3360e-12	6.0000e-13	1	-41.6860	-41.6860
23	94	6.7360e-12	6.0000e-13	1	-45.6070	-45.6070
24	98	6.0590e-12	6.0000e-13	1	-49.7050	-49.7050
25	0	-8.8790e-10	3.2000e-12	3	-0.0050	-0.0050
26	195	-2.0600e-12	6.0000e-13	1	-58.4290	-58.4290
27						
28						

Fig1: Formatted dataset of PVO

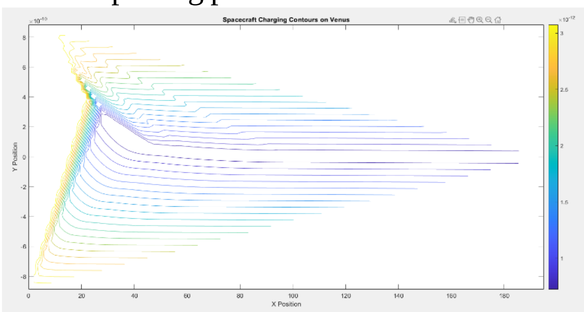


Fig 2: Contours of Charge over the spacecraft

feasibility of remote sensing methods for this purpose. We're also investigating ways to improve mission planning, particularly for Venus exploration, and coping with Signal-to-Noise Ratio (SNR) issues. We're dismantling lightning instruments, gathering data from magnetometers, and experimenting with different approaches to reduce the influence of charging effects. For example, we're considering combining Dipole Antenna Arm configurations. Our research aims to improve our understanding of how spacecraft charge on Venus by combining data from NASA's PDS PVO with novel equations and modelling software. We hope that this work will be valuable to those in academia and engineering who are grappling with the complexities of spacecraft charging.

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Retrieving sulphuric acid profiles of Venus Atmosphere from Radio Occultation data of Akatsuki spacecraft

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This research aims to examine the distribution of sulfuric acid H2SO4 in the Venusian atmosphere by employing radio occultation (RO) measurements. As a well-established method for atmospheric and ionospheric profiling, RO analyzes changes in frequency, phase, and power received at ground stations. In this study, we have utilized one-way downlink single-frequency (X-band: 3.6 cm wavelength) radio signals transmitted from the Ultrastable Oscillator, a radio science payload onboard the Akatsuki spacecraft, and received at the UDSC-64M receiver during occultation year 2020. Our primary objective is to develop a signal processing technique for data analysis and the subsequent retrieval of altitude and latitudinal distribution of H2SO4 in Venus's atmosphere.

The outcomes of this research will enhance our understanding of neutral atmospheric profiles and shed light on the formation of dense Venusian clouds. We have derived global 3D temperature and pressure profiles using RO as well, and our preliminary results reveal that equatorial and mid-latitude regions exhibit an H2SO4 concentration of 4.15 ppm, with peak concentrations reaching 12 ppm, while higher latitudes average 4.60 ppm with peaks between 13-15 ppm. We also identified the presence of H2SO4 gas at higher altitudes in the 60°-70° region, indicating the existence of thicker clouds. This study is a precursor to our study working towards generating a 3D profile of the H2SO4 present in the atmosphere of the planet. The data gathered by the Akatsuki probe offers valuable insights into Venus's atmospheric conditions, and our investigation contributes to the ongoing efforts to unravel the mysteries of this intriguing planet.

Statistical Analysis of lightning frequency spectrum obtained using LIVE Instrument

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Lightning is a large electrical discharge of very short duration of the order of few tens of microseconds that occurs in a planetary atmosphere. Though the lightning on Earth is well studied, it is not yet fully understood in the case of Venus. In case of Earth, water clouds are responsible for the lightning to occur; while in case of Venus, Sulphuric acid is an important constituent of the atmospheric cloud, at heights from ~47 to 65 km [1]. On Earth, lightning flash is mostly detected as cloud-to-ground discharge and ~20 % of the events are cloud-to-cloud discharge type [2]. However, the cloud-to-cloud lightning is more likely to be observed on Venus [3]. To understand the lightning on Venus in detail, a Lightning Instrument for VEnus (LIVE) is proposed for future Venus mission [4]. The captured signal by the instrument is processed further to obtain more information of the detected lightning event. We have captured several lightning events using LIVE, at PRL during the Monsoon season. Further, we analyze the data using Fast Fourier Transform (FFT) technique to get the frequency spectrum of the captured lightning event. In this work, we present the different design configurations of the LIVE instrument and the analysis of frequency spectrum of several lightning events obtained.

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ELF-VLF Remote Sensing – A Powerful Tool to Detect Lightning

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The Extremely Low Frequency (ELF) and Very Low Frequency (VLF) waves span the frequency range of few Hz to 30 kHz of the electromagnetic spectrum. A typical lightning stroke on Earth emits an electromagnetic pulse over a wide spectrum from a few Hz to several MHz, but the most intense energy released lies in the ELF and VLF range[1] with peak around 5-10 kHz[2, 3]. This very fact gives the opportunity to detect lightning discharges or Transient Luminous Events (TLEs) taking place in Planet's atmosphere. It may be noted that lightning has been repeatedly observed at Jupiter and Saturn and is not in dispute, and firm non-detections are established at Titan. At Venus, however, there are many superficially conflicting positive and negative reports[4]. As the Venusian atmosphere has diverse environment, it is likely that TLEs may be present along with the lightning bolts. The presentation will focus on how the VLF networks on Earth are successfully used to detect lightning on Earth and how the technique can be extended to detect and understand Venusian lightning. The presentation will also discuss possibility of TLEs in Venus' atmosphere.

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Design and Development of Processing Electronics for Lightning Instrument for VEnus (LIVE)

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Lightning is a natural phenomenon of large electric discharge that occurs in planetary atmosphere for a very short time duration. It is an important process to understand as it evolves the atmospheric chemistry of the planet [1]. In case of Earth, the process of lightning is well understood but in case of Venus, it is not well understood yet. In PRL, we are developing an instrument "Lightning Instrument for VEnus (LIVE)", proposed for future Venus mission, to detect lightning in Venusian atmosphere. [2]

In LIVE, the lightning events are captured using antenna [3] and is further processed using processing electronics. The front-end electronics has two configurations, where the first configuration is PVO OEFD like architecture [4] having six channels for six different frequencies and the second configuration has a wide band filter (Hz-kHz). All channels are sampled simultaneously using an Analog-to-Digital Convertor at required sampling rate and the digital data are stored in a memory for processing using FPGA. In this work, the processing algorithm with results will be discussed.

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Whispers of Venus: Speculative Explorations into its Mysterious Atmosphere and Possible Inhabitants

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We live in a world that is getting warmer and warmer each day[1]. The possible ontology of Earth offers insight into the hottest planet in our universe - Venus. Human activities, akin to how we warm our home, might influence Earth's twins and lead to similar melting[2]. This paper explores the inevitable responsibility of Venus' inhabitants for its inhospitable atmosphere. Venus, Earth's "sister planet," fascinates scientists and space enthusiasts due to its extreme climate. Enveloped in a carbon dioxide-rich atmosphere[3][4], Venus boasts Lead-melting surface temperatures[5], making it unsuitable for life. Despite this, our exploration of celestial bodies sparks imaginative speculation about otherworldly conditions and inhabitants.

This paper employs Mathematica's computational prowess to simulate the evolution of hypothetical Venusian species, whether native or via Panspermia[6]. We delve into species emitting greenhouse gases, potentially contributing to Venus' runaway greenhouse effect. Extensively studied on Venus[7][8], this phenomenon involves an uncontrollable atmospheric heat trap. While geological and atmospheric processes are often studied as triggers [9][10], this paper ventures into speculative biology, proposing unique flora and fauna that might have shaped Venus' fate.

The possibility that Methane Trees, Hydrogen Bacteria, Ice Worms, etc., could evolve on Venus under its primary conditions. Methane-producing organisms may have influenced Venus' contemporary atmosphere. Methane arises via anaerobic bacterial decomposition, as seen on Earth[11]. Large-scale evolution of such organisms on Venus could exacerbate environmental deterioration with methane and other gases. Organic matter decomposition might also drive Venus' atmosphere to its current situation.

Mathematica aids our exploration by creating a simulation model. We probe the impact of gas-emitting species on Venus' climate over time. Simulating evolutionary scenarios, we envision these organisms releasing gases into the Venusian atmosphere. We simulate trait evolution regarding greenhouse gas concentration and atmospheric change over time.

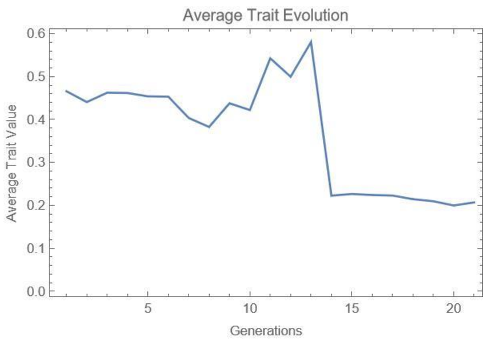

Figure 2: "Simulation of the evolution of traits with generations"

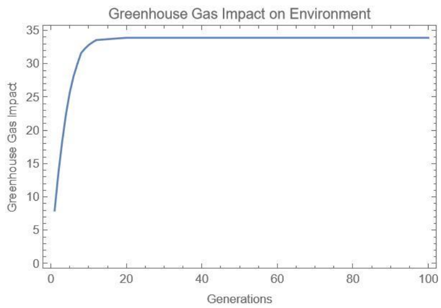

Figure 3:"Simmulation of the effects that such traits will have on the Greenhouse effect"

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Biotic Habitability, Adaptability, Associations, Resilience and Geodynamics in Venusian Analogues (BHAARGAVA)

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Biotic habitability and adaptability on Venus remain highly speculative with its formidable environment. For known forms of life, these capabilities span over a very narrow window almost 'not possible' on present Venus, except in the upper atmosphere clouds [1, 2]. Venusian meteorite analogues reaching Earth are rare propositions due to the planet's large escape velocity [3]. Finding similar environments too might be limited to hot mantle and volcanoes. Intriguingly, the two twin planets, Earth and Venus, were both vibrant in Life ~ca. 700 Ma bp, when they faced two different global catastrophic events. While Earth froze down to 'Snowball', Venus experienced 'Global Resurfacing Event' igniting a pandora of its volcanoes to heat it up to present day ~700K surface temperature and unusually high pressured, greenhouse atmosphere. Earth restored itself back to its living potentials, but the reversal of Venusian life was impossible, for reasons still an enigma.

On Earth, it is being increasingly appreciated that the Snowball Event was not a single-global freezing event, but parenthesised a series of inter-snowball warming phases [4, 5] like the Sturtian Glaciation (740-700 Ma), Marinoan Glaciation (665-635 Ma), Gaskier's Glaciation (ca. 580 Ma) [5]. This time marked the diversification of multicellular living beings or Eukaryotes in domains of Plantae, Animalia and Fungi. The later part of this age also marked the widespread appearance of the Ediacaran Period (635-541 Ma), from Marinoan glaciation to the base of Cambrian. It was also the second Great Oxidation event on Earth. Though green-algae (Chlorophyta) had already appeared, prior to Snowball, this event marked the on-set of the 'algal world'. Fossil records around the globe showed complex redox status of oxygen, sulphur, carbonates and phosphorus. The Fe-S-Mo-P-O related redox situation during the whole Snowball Earth Event still appears debatable and nascent, as does the origins of the Ediacaran fossils. Largely debated as being cyst-of dinoflagellates, to early unique eukaryotic lineages that got extinct at Cambrian base, to giant phosphorus-storing sulphur bacteria, even the exact age sequence of the Ediacarans varies globally, making geochronology more complex [5]. Being extremely challenging to procure efficient Venus analogous *per se* on Earth, the Snowball Event might be revisited from the Venusian perspective to begin with. Given same time of solar influx measures and similar rock composition, factors like magnetic anomalies, rotation, tilt, angular momentum, volcanic eruptivity and mineral emissivity of the two twins might have been the differentiating factors that changed the thermodynamic faces of Earth and Venus, diversifying life in the former and completely destroying the later. Thus, exploration of the Snowball Chronologies and Ediacaran Biota, vis-à-vis geophysical and geochemical constraints, both marine and terrestrial are hereby proposed as potential first-generation Venusian Analogous.

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Venus Thermal Observations: Retrospects and Prospects from VTC

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Venus' atmospheric temperature is 730 K at ground level, decreasing to 230 K at cloud-top altitudes of 65 km [1]. Venus Thermal Camera (VTC) proposed by Space Applications Center (SAC) operates in the 8-12 µm spectral range and has high-temperature sensitivity. Venus Thermal Camera (VTC) has a NEdT of 0.1K at 230K. VTC will provide approximately 0.5 km resolution from the periapsis and 60 km from the apoapsis (considering the typical elliptical orbit of 500 km x 60,000 km). It aims to capture planetary-scale thermal features at the apoapsis and fine features at the periapsis. The detector is based on a cooled MCT rather than a Bolometer, so it can capture finer thermal features with exceptional NEdT performance. VTC, with its high thermal resolution (better NEdT), will allow us to study cloud top temperature variations globally in the Venusian atmosphere with more precision, contributing to long-term data records of the atmospheric evolution of the Venusian atmosphere, which in turn will help us to understand its dynamics (super-rotation). Furthermore, VTC will assist in studies involving cloud-based processes, particularly diurnal variations.

The Akatsuki spacecraft is currently orbiting Venus. Observations of Venus' cloud-top temperature have been conducted by Akatsuki using a Longwave Infrared Camera, LIR [2], since the start of nominal observations in April 2016. Figure 1 shows the brightness temperature anomaly, i.e., the difference between observed and mean brightness temperature for near hourly datasets for 15 Oct 2020.

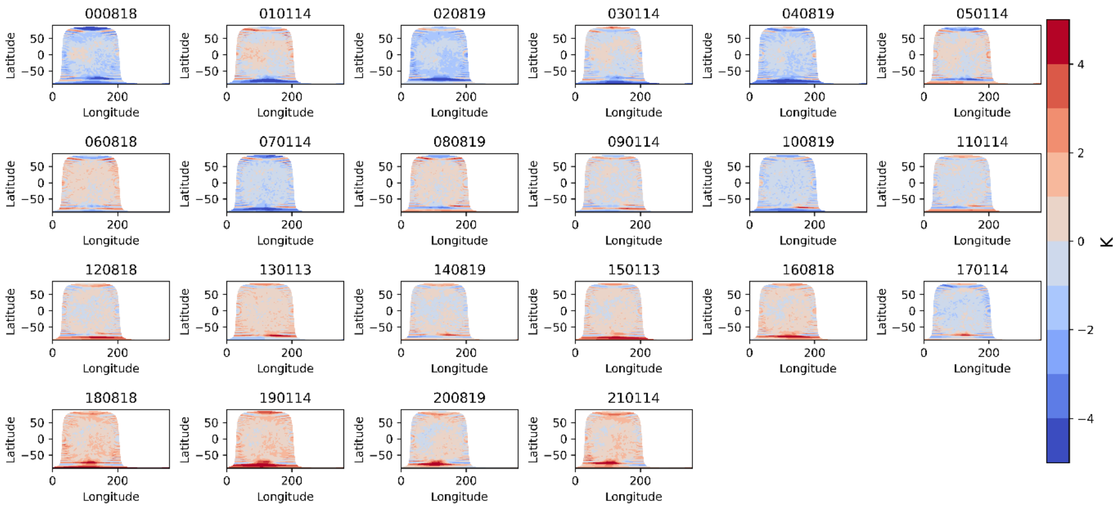

Figure 1: Brightness Temperature anomaly**,** l3c data from Akatsuki LIR.

As part of the Venus orbiter mission, VTC will provide valuable observations to improve the structure of stationary waves discovered by Akatsuki/LIR and to maintain the Super-rotation of the atmosphere through the thermal tides of the atmosphere. In the polar region, we will search for small scale stationary structures, which are not resolved by Akatsuki LIR.

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A GCM-based theoretical inspection of the Cyclostrophic Balance in the Atmosphere of Venus

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Venus is known to exhibit a permanent superrotation in the middle atmosphere, but direct observations of its zonal wind fields remain highly limited. Alternately, several studies have retrieved Venusian winds from temperature/pressure profiles assuming a state of cyclostrophic balance, i.e., the dynamical balance between the poleward pressure gradient and equatorward centrifugal force components [1-5]. While the slow rotation of Venus and resultant lack of Coriolis force do hint towards a cyclostrophic atmosphere, the validity of this assumption has never been examined thus far.

In this work, zonally averaged pressure profiles from the Institut Pierre-Simon Laplace (IPSL) Venus Global Climate Model (VGCM) [6, 7], accessed using the Venus Climate Database (VCD 2.0) [8, 9], are used to derive the zonal winds of Venus assuming cyclostrophic balance. A first-of-its-kind theoretical inspection of the cyclostrophic balance in Venus is carried out by comparing the derived cyclostrophic winds back with the modeled zonal wind fields from the VGCM. In addition, computation of the pressure gradient and centrifugal force components using the VGCM data enabled a further direct evaluation of the cyclostrophic balance.

The analysis confirms that the Venusian atmosphere is predominantly cyclostrophic in nature, and the derivation of zonal winds under this assumption is valid within an error of ± 22 m/s. Distinct latitudinal and altitudinal deviations from cyclostrophic balance are observed however, including a purely cyclostrophic band with meridionally decreasing altitude, and specific regions of over/under-estimation. This is the first ever attempt to corroborate the cyclostrophic assumption in Venus, presenting a novel use of the VGCM to theoretically examine the dynamical state of the planetary atmosphere. The study also acts as retrospective validation of all previous works that have relied on the cyclostrophic assumption to derive winds in the Venusian atmosphere.

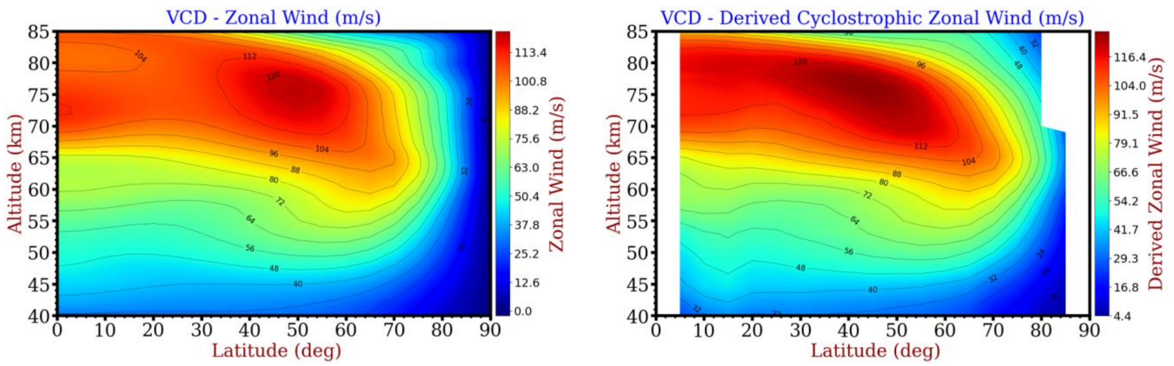

Figure 1: (Left panel) Zonally averaged zonal wind fields of Venus modeled by the IPSL VGCM and accessed through VCD 2.0. (Right panel) Zonal winds derived under the assumption of cyclostrophic balance, using zonally averaged pressure profiles from the VGCM.

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Dynamics of Dust in the Orbit of Venus

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Measurements of the Venera 9 and 10 spacecraft [1] served as first evidence for a co-orbital dust ring around Venus. These measurements were tested later by the Helios mission [2] and were confirmed with observations from STEREO [3]. We study the dynamics of co-orbital dust in the inner Solar system that is the role of Solar Radiation pressure, the Poynting Robertson effect and the Solar Wind [4] on the location of micron-sized dust grains situated in the mean motion resonance with Venus by variation in heliocentric distance in the inner Solar System. We have analyzed the forces by taking Interplanetary Dust mass range from 10^2 kg to 10^{-21}kg [5]. We have considered mainly protons and alpha particles as Solar wind species [6]. Since Gravitational force always dominates and therefore, we have considered only the effects of Non-Gravitational forces on dust for the better understanding of dynamics near Venus with variation in Solar Cycle.

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On the method to calculate the Venus's circumsolar dust ring's momentum & mass

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Interplanetary Dust Particles which sometimes referred to as (IDPs) are found everywhere in our solar system and the sources of these IDPs are like comet or Asteroid belt and in their journey, they get affected by different forces and many times they captured by the planets [1]. The Venus's circumsolar dust ring which is in the orbit of Venus [2] would provide observational data, which should lead to understanding of the factors which are affecting the rings, such as like solar wind, drag forces, and gravitational perturbation by an exterior planet [3].

So, in one aspect of it we developed a way to get some idea about how the particles are captured by planets and the formation of dust rings around the planets and also in their orbit which is referred to as circumsolar dust ring and one example of the circumsolar dust ring is in the orbit of Venus so, taking ring as combination of patches each patch is going under the some mathematical conversions to get the spherical symmetry and then by using the self-gravitational energy of that system to examine the mass of that system and maybe in this way we can show the total approximate mass of the ring system and to do so, we need multiple observations of the ring and multiple parameters to test and validate our hypothesis and method.

Another aspect of characterizing the momentum distribution, cluster velocity, radial width [4] and locations of density enhancements [5] of ring was done using Image Analysis techniques, Fourier Transform and Principal component analysis (PCA) [6]. Derivations reveal connections between image space and momentum space through Fourier transformations, thereby allowing to make rough estimations of velocity and particle momenta of the ring. Switching between Fourier space and principal component space allows for parallel estimations of particle distribution. Attempts have been made at studying large datasets of images to verify the predicted results for momentum distribution using step density and convolution functions.

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Polarisation: Probing the dust particles of Solar system bodies

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Comets are the primordial remnants of our Solar system containing pristine materials that were present in the proto-Solar nebula. Generally termed 'dirty snowballs' as they are built up of both dust and ice. These objects are inactive and non-detectable during larger part of their orbit as ambient temperature is not high enough to sublimate the volatiles. As the comet moves closer to the Sun, the volatile materials present in it sublimate, also pushing out the dust present in it. The light observed from a comet is composed of two components, the fluorescence emission from the gas and the Sun light scattered by the dust particles present in it. As the light scattered by the dust particles are polarised, polarisation measurement in cometary bodies has been a preliminary technique to probe the dust particles. It is observed that the degree of polarisation varies with the Sun-Target-Observer (STO) angle, also known as the phase angle. Also, the characteristic phase-polarisation curve of distinct comet varies. Such difference between distinct comets would be due to the variation in the physical and chemical composition of the dust present in these bodies. Hence, polarisation-phase curve of each comet, clubbed with dust modelling techniques, can be used to get a general understanding of the properties of the dust present in them. Similar technique can also be employed with asteroids and Moon to extract the physio-composition properties of dust present in these bodies.

The polarimetric observation of comets and other Solar system bodies are performed using the in-house developed EMCCD based optical imaging polarimeter [1] mounted on the 1.2 m Mt. Abu telescope. In this talk, brief details regarding the working of the instrument and the science goals that can be achieved through such instruments for comets [2] and Solar system bodies like Moon [3] would be discussed.

References:

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