Earth's oceanic regions. Further analysis of flexure is warranted to determine if such a relationship holds for Venus.

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N93-14315

UNDERSTANDING THE VARIATION IN THE MILLIMETER-WAVE EMISSION OF VENUS.

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Recent observations of the millimeter-wave emission from Venus at 112 GHz (2.6 mm) have shown significant variations in the continuum flux emission [1] that may be attributed to the variability in the abundances of absorbing constituents in the Venus atmosphere. Such constituents include gaseous H_2SO_4, SO_2, and liquid sulfuric acid (cloud condensates). Recently, Fahd and Steffes [2,3] have shown that the effects of liquid H_2SO_4 and gaseous SO_2 cannot completely account for this measured variability in the millimeter-wave emission of Venus. Thus, it is necessary to study the effect of gaseous H_2SO_4 on the millimeter-wave emission of Venus. This requires knowledge of the millimeter-wavelength (MMW) opacity of gaseous H_2SO_4, which unfortunately has never been determined for Venus-like conditions.

We have measured the opacity of gaseous H_2SO_4 in a CO_2 atmosphere at 550, 570, and 590 K, at 1 and 2 atm total pressure, and at a frequency of 94.1 GHz. Our results, in addition to previous centimeter-wavelength results [4], are used to verify a modeling formalism for calculating the expected opacity of this gaseous mixture at other frequencies. This formalism is incorporated into a radiative transfer model to study the effect of gaseous H_2SO_4 on the MMW emission of Venus.

Experimental Configuration: The experimental setup used to measure the MMW opacity of gaseous H_2SO_4 atmosphere consists of a free-space transmission system as shown in Fig. 1. In this system, a glass cell contains the H_2SO_4/CO_2 gaseous mixture that is introduced prior to the measurement process. The glass cell is located inside a temperature-controlled chamber. A transmitting antenna is used to launch energy into the glass chamber. A receiving antenna is placed at the output of the glass cell in order to collect the outgoing signal. Using a precision variable attenuator, the resulting opacity of the gaseous mixture is measured.

Measurement Results: The measured absorptivity (dB/km) of H_2SO_4 at 94.1 GHz is shown in Fig. 2 where it is plotted as a function of temperature for 2 and 1 atm. The reported absorptivities in Fig. 2 are normalized to their respective mixing ratios. The measurements were performed at 550, 570, and 590 K in order to allow enough H_2SO_4 vapor pressure in the glass cell.

Although the measurements were performed at 94.1 GHz, care must be taken when projecting the absorption of H_2SO_4 at frequencies far from 94.1 GHz. As a result, we have developed an absorption model based on a Van Vleck-Weisskopf (VVW) formalism. In this formalism, we added the contributions from 2359 resonant lines of H_2SO_4 computed by Pickett et al. (private communication, 1991) that cover frequencies between 1.5 and 450 GHz.

In order to fully implement the VVW formalism, an appropriate broadening parameter must be determined. To solve this problem,

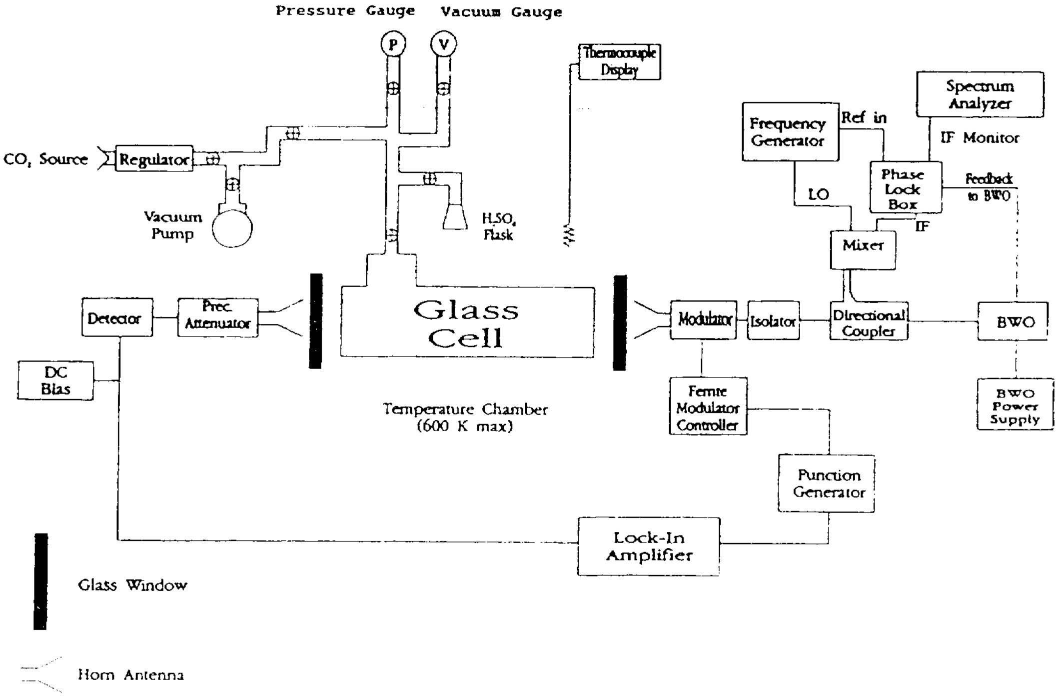

Fig. 1. Block diagram of the atmospheric simulator as configured for measurements of the millimeter-wave absorption at 94.1 GHz.

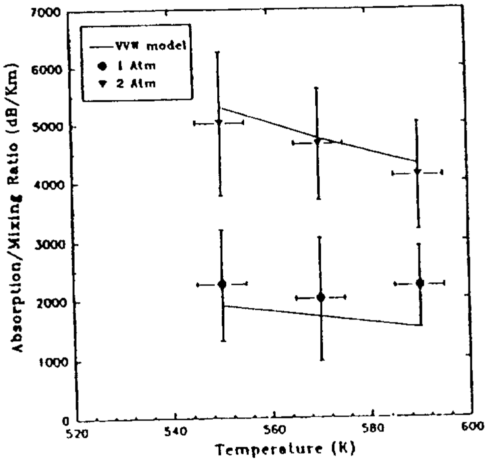

Fig. 2. Laboratory measurements of the normalized absorptivity (dB/km) of gaseous H_2SO_4 in a CO_2 atmosphere at 94.1 GHz. Solid curves are the theoretically calculated absorption from the VVW formalism.

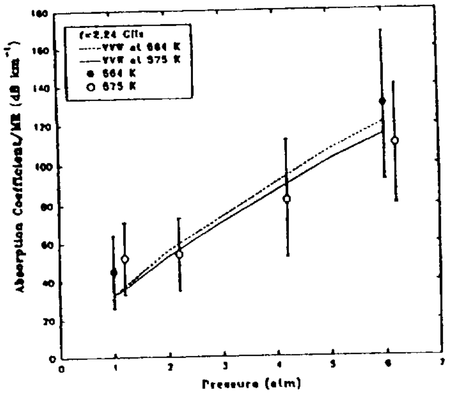

Fig. 3. Comparison between the measured absorption (normalized by mixing ratio) of H_2SO_4 [4] and the calculated absorption from the VVW formalism at 2.24 GHz.

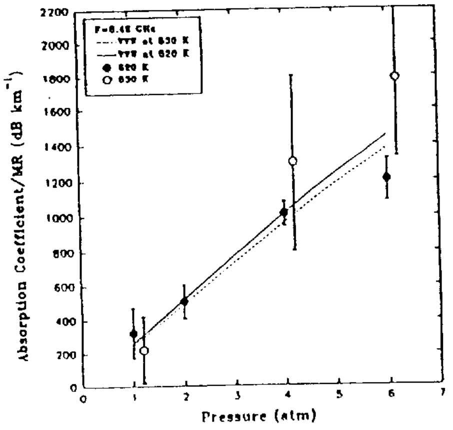

Fig. 4. Comparison between the measured absorption (normalized by mixing ratio) of H_2SO_4 [4] and the calculated absorption from the VVW formalism at 8.42 GHz.

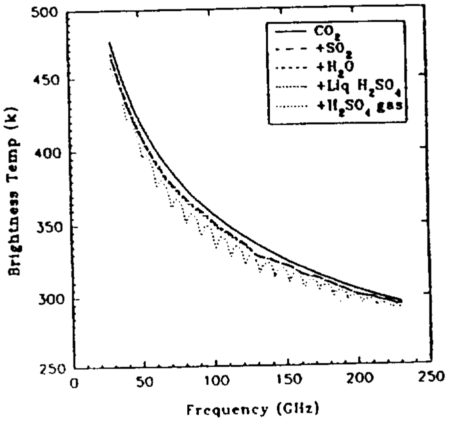

Fig. 5. Comparison of the effects of atmospheric constituents on the brightness temperature of Venus between 30 and 230 GHz.

we adjusted the broadening parameter so that the calculated opacity matches the measured absorptivity at 94.1 GHz and the microwave opacities at 2.24 and 8.42 GHz reported by Steffes [4]. Comparisons between the calculated and measured opacity of H_2SO_4/CO_2 are shown in Figs. 2, 3, and 4. A careful examination of these results indicates that the calculated opacities of H_2SO_4 using the VVW formalism with a broadening parameter of 1.55 MHz/Torr agree well with the measured microwave and millimeter-wave opacities of the gaseous mixture. This finding is quite important since it demonstrates for the first time that the VVW formalism can be used to accurately predict the opacity of H_2SO_4/CO_2 gaseous mixture over a wide frequency range.

Modeling of the Atmosphere of Venus: A radiative transfer model has been developed in order to investigate the effects of the atmospheric constituents of Venus on its MMW emission. Such constituents include gaseous SO_2, liquid sulfuric acid (cloud condensates), and gaseous H_2SO_4.

Sensitivity to Liquid H_2SO_4: Results from the radiative transfer model indicate that liquid H_2SO_4 does indeed affect the brightness temperature of Venus at millimeter wavelengths [3]. For instance, at 112 GHz a decrease in brightness temperature of 2 K is obtained for a uniform cloud layer between 48 and 50 km where droplets sizes of 25 μm and a bulk density of 50 mg/m^3 are assumed. However, this decrease in brightness temperature is much less than the reported variation in the emission of Venus, which indicates that variations in the abundance of liquid H_2SO_4 are not the major source of the observed brightness temperature variation.

Sensitivity of SO_2: The effects of gaseous SO_2 on the computed MMW emission of Venus are well described in Fahd and Steffes [2]. Using an abundance profile of 62 ppm below an altitude of 48 km, we have found that the brightness temperature is decreased by approximately 5 K. Although this decrease is significant, it cannot completely account for the measured variation in emission.

Sensitivity to Gaseous H_2SO_4: Using the developed model for the absorption of gaseous H_2SO_4 in a CO_2 atmosphere, we have found that this gaseous mixture seems to have the biggest effect on the calculated brightness temperature of Venus. Specifically, at 112 GHz, a drop of 14 K is observed assuming an H_2SO_4 (g) abundance of 25 ppm between 48 and 38 km. This decrease in brightness temperature is quite significant compared with the effects of gaseous SO_2 and liquid H_2SO_4. Thus, we can state that the variations observed by de Pater et al. [1] are most likely due to the variations in the abundance of gaseous H_2SO_4 and not to liquid H_2SO_4 or gaseous sulfuric dioxide as previously suggested.

A plot of the calculated millimeter-wave spectrum of Venus based on the presence of one or more constituents is shown in Fig. 5. The results reported in this figure show the effect that H_2SO_4 (g) has on the MMW spectrum of Venus. In addition, the results show that there are specific millimeter-wave frequencies that are especially sensitive to the abundance of H_2SO_4 vapor in the lower atmosphere of Venus.

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N93-14316

RADAR SCATTERING PROPERTIES OF PANCAKELIKE DOMES ON VENUS.

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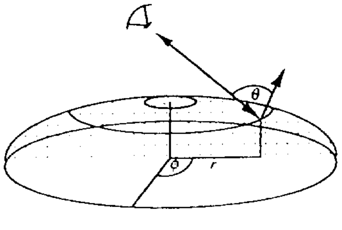
Magellan radar images have disclosed the presence of a large number of almost perfectly circular domes, presumably of volcanic origin, in many regions of Venus [1], several with diameters of 30 km or more. Their high degree of symmetry has permitted measurements of their shape, as determined by the Magellan altimeter [2], to be compared with models of dome production from the eruption of high-viscosity magmas [3].

In this work, we examine in detail the radar images of domes in Rusalka Planitia (2.8°S, 150.9°E) and Tinatin Planitia (12.2°N, 7.5°E), selected for their circular symmetry and apparent absence of modification due to large-scale slumping or tectonic rifting. Assuming that these domes are shaped according to the model of reference [3], we can orthorectify the available Magellan SAR image swaths (F-BIDRs: Full-Resolution Basic Image Data Records) to generate three-dimensional plots of the radar scattering cross-section σ_0 (r, θ, ϕ) as a function of distance from center of dome (r), scattering angle (θ), and azimuthal coordinate (ϕ).



The behavior of σ_0 with respect to changes in θ has been determined from Pioneer Venus radar data for many broad classes of Venus surface type [4], and parameterized as a combination of a quasispecular scattering component σ_{qs} and a diffuse component σ_d:

$$\sigma_0(\theta) = \sigma_{qs}(\theta) + \sigma_d(\theta) =$$

$$\frac{\alpha C\rho}{2}(\cos^4\theta + C\sin^2\theta)^{-3/2} + (1-\alpha)\rho K\theta^{v}$$

where α represents the fraction of the surface that contributes to quasispecular scattering, C is the Hagfors parameter [5], ρ is the Fresnel reflection coefficient, and K and v are functions of small-scale surface roughness. Average values of C, ρ, and α over an entire dome are extracted from altimeter measurements.

Variations of σ_0 with respect to radial distance r are interpreted as changes in the small-scale roughness of the dome, which would be expected from the radial dependence of the cooling rate of the lava, perhaps enhanced by subsequent weathering. The result of aeolian processes may also be seen in the dependence of σ_0 on azimuth angle ϕ, since fine-grained surface material that contributes to σ_d may be emplaced or rearranged by the prevailing surface winds.

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N93-14317

SEQUENTIAL DEFORMATION OF PLAINS ALONG TESSERA BOUNDARIES ON VENUS: EVIDENCE FROM ALPHA REGIO.

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Tesserae are regions of elevated terrain characterized by two or more sets of ridges and grooves that intersect orthogonally [1]. Tesserae comprise 15–20% of the surface of Venus, but the nature of their formation and evolution is not well understood; processes proposed to account for their characteristics are many and varied [2]. Two types of tessera boundaries have been described: Type I are generally embayed by plains; type II boundaries are characterized by being linear at the 100-km scale and often associated with steep scarps or tectonic features [2,3]. Margins such as the western edge of Alpha have been described by these authors as type II. Some of the tessera have boundaries that display deformation of both the edge of the tessera and the adjoining plains [2,3]. This study focuses on the western edge of Alpha Regio in an effort to characterize one occurrence of this type of boundary and assess the implications for the style in general. Using Magellan SAR imagery, lineament lengths, orientations, and spacings were measured for ten 50 × 60-km areas spanning 500 km of the western boundary. Structural characteristics and orientations were compared to stratigraphic units in order to assess the sequence and style of deformation.

Alpha Regio is a 1300 × 1500-km prominent radar-bright upland feature in the southern hemisphere of Venus that averages 1 km above the surrounding plains [4]. Ridges and troughs within Alpha average 33 km long 20 km apart in the north and 35 km long 17 km apart in the south; their prominent orientation is N20°E [4]. The ridges and troughs on the western edge of Alpha have an orientation of N15°E, but differ from the interior ridges as their average spacing is 4 km (Fig. 1). These lineaments are joined by a second set of lineaments and graben trending N55°W and extending into the plains. The deformation producing these northwest-trending lineaments has occurred over a period of time separated by several stages of plains emplacement. Two plains units have embayed the western edge of Alpha: a radar-dark plains unit (Pl_1) that embays the edge of the heavily deformed tesserae, and a radar-bright unit to the west that embays the radar-dark unit (Fig. 2). The plains unit closest to the tessera (Pl_1) has fewer lineaments than the tessera, but a greater number of lineaments (spaced at an average of 3 km apart) than the younger plains unit (Pl_2), which embays and covers unit Pl_1. The