Millimeter Wavelength Opacity of H_2SO_4 Vapor at Venus: Initial Results A. B. Akins[1] and P. G. Steffes[1], [1]Georgia Institute of Technology, School of Electrical and Computer Engineering, 777 Atlantic Drive NW, Atlanta, GA 30332-0250

Introduction: Radio astronomical measurements of Venus in the millimeter-wavelength region have the potential to provide information on the state of the sub-cloud region of the atmosphere and the governing processes. Several observations of this type have already been made, and with the capabilities of the Atacama Large Millimeter Array (ALMA), more observations are yet to come. Proper analysis of these radio astronomical images requires laboratory data on the millimeter wavelength pressure-broadened opacity of the dominant microwave absorbers present at Venus. While accurate models exist for CO_2/N_2 and SO_2, H_2SO_4 vapor opacity has yet to be measured in this wavelength range. This is a compelling problem, as previous images from the Hat Creek Interferometer in this region suggest a brightness temperature variation of ~30 K between the day and night sides of the planet [1]. Are variations in the abundance of H_2SO_4 vapor responsible for this? Accurate models of the millimeter wavelength opacity of H_2SO_4 vapor must be developed before this question can be answered.

Measurement System: A semiconfocal microwave open resonator system has been constructed using corrosion-resistant materials and used for measurement of the millimeter-wavelength absorption of H_2SO_4 vapor. This resonator is effectively a microwave analog of a Fabry Perot interferometer in the optical range. The semiconfocal resonator system is housed within a pressure vessel and a temperature chamber. H_2SO_4 vapor is introduced into the pressure vessel at temperatures between 500 and 550 K, and the variation of the resonator quality factor from baseline conditions gives the gas absorption. Carbon dioxide is also added to the system up to a pressure of 3 bar to characterize pressure broadening. The nominal quality factor of the system is 50,000.

Uncertainties in Measurement: Sources of possible error in the absorption measurement have been systematically characterized. These errors include errors due to instrumental inaccuracy and electrical noise, errors due to resonance asymmetry, errors due to variations in signal transmission, errors due to the shifts in the peak frequency of resonances measured at vacuum, errors due to the effect of temperature on waveguide conductivity, and errors due to the accuracy of temperature and pressure measurement systems. After combining all of these errors, the nominal sensitivity of the resonator system is +/- 25 dB/km. An additional source of uncertainty is amount of H_2SO_4 that has vaporized and entered the pressure vessel. Precise measurements of the volume and piping of the pressure vessel system have been made, and the pressure within the pressure vessel is measured before and after each absorption measurement. Additionally, the volume of 98% H_2SO_4 liquid solution is measured before and after the measurement sequence, taking into account the initial evaporation of water to achieve azeotropic concentration. Even with this verification, uncertainty is still difficult to estimate, as only a small amount of the liquid solution will vaporize. This is particularly true at lower temperatures.

Initial Results: Initial measurements in the W Band (2.7-4 mm) at 500K and 530K suggest that the centimeter-wavelength expression of Kolodner and Steffes [2] deviates substantially from measured absorption when extrapolated to millimeter wavelengths. The measured absorption resembles more closely the results of pressure-broadened lineshape theory.

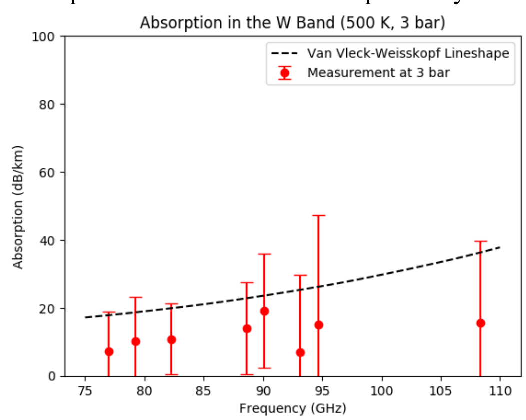

***Figure 1**: W Band Opacity of H_2SO_4 vapor mixed with three bars of CO_2 compared with absorption predicted by a Van Vleck-Weisskopf model*

This implies that the substantial brightness temperature variations observed would require substantially elevated concentrations of H_2SO_4 vapor, if H_2SO_4 vapor is indeed the source of this variation. Further measurements will attempt to confirm this finding, and a suitable lineshape model will be developed utilizing the JPL microwave and millimeter wavelength line catalog [3].

References: [1] de Pater, I. et al. (1991) *Icarus, 90,* 282-298. [2] Kolodner, M. A., Steffes, P. G. (1998) *Icarus, 132,* 151-169. [3] Pickett, H. M. et al. (1998) *J. Quant. Spectrosc. Radiat. Transfer*, *60*, 883-890