Laboratory Measurements of W-band Continuum Opacity of Ammonia Using a Fully Confocal Fabry-Perot Resonator

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Knowledge of the molecular composition of the Jovian planets is fundamental to understanding the processes which formed these planets and the solar system as a whole. Although many gases and various cloud layers influence the millimeter wave spectra of the outer planets, ammonia is the main microwave absorber. Accurate determination of opacity of ammonia (NH_3) under simulated Jovian atmospheric conditions can be used to better interpret the emission spectrum of those planets and to deduce spatial variations in its abundances in their atmospheres. Millimeter wavelengths have been extensively used for disk-averaged emission measurements of the outer planets (Griffin and Orton, Icarus, 105, 537-547, 1993; Muhlemen and Berge, Icarus, 92, 263-272, 1991), interferometric mapping of Saturn (van der Tak et al., Icarus, 142, 125-147, 1999) and imaging of Uranus (Hofstadter et al., B.A.A.S., 39, 2007)

Earlier measurements taken at the 3.2 mm wavelength (Joiner and Steffes, JGR, 96, 17463-17470, 1991; Mohammed and Steffes, JGR, 109, 2004) gave little insight into the frequency dependence of ammonia opacity and were limited by the sensitivity of their equipment. Hence, a new high quality-factor (Q) fully confocal Fabry-Perot resonator was designed to facilitate measurements of the W-band (75 -110 GHz) continuum opacity spectrum of ammonia under simulated Jovian atmospheric conditions. To generate signals in this frequency range, a times-six active multiplier chain was used, and a harmonic mixer locked to the 18th harmonic was used with a spectrum analyzer for detecting the signals. The radius of curvature of the mirrors is around 30 cm and the distance of separation was kept at 15.2 cm (diffraction losses are minimal and Q is high at near-confocal configuration (Culshaw, MTT, 8, 331-339, 1962)). The Qs of the resulting resonances ranged from 80,000 to 140,000.

The functional capacity of the new resonator and the sensitivities that can be achieved by it will be presented. Results for the opacity and refractivity measurements of NH_3 in a hydrogen/helium (H_2/He) atmosphere will also be presented. Measurements have been made for a gas mixture with various NH_3 concentrations in the 2.5-4 mm wavelength range at temperatures of 208K-293K and at pressures of 0.5-3 bars.