Investigating the Interactions between Saturn’s Upper Atmosphere and Rings from Cassini INMS Measurements. J. Serigano\(^1\), S.M. Hörs\(^2\), C. He\(^3\), T. Gautier\(^2\), R.V. Yelle\(^2\), T. Koskinen\(^3\), \(^1\)Johns Hopkins University, Baltimore, MD, USA, \(^2\)CNRS, Sorbonne Université, Guyancourt, France, \(^3\)University of Arizona, Tucson, AZ, USA.

Cassini’s Grand Finale: In September 2017, the Cassini-Huygens mission to the Saturn system came to an end as the spacecraft intentionally entered the planet’s atmosphere. Prior to entry, the spacecraft executed a series of 22 highly inclined orbits, the Grand Finale orbits (26 April 2017 to 15 September 2017), through the previously unexplored region between Saturn and its extensive ring system, yielding the first ever direct sampling of the planet’s upper atmosphere.

During these proximal orbits, the spacecraft obtained measurements near the equatorial ring plane at various heights above the planet’s 1-bar pressure level. The final five of these orbits directly sampled Saturn’s upper thermosphere. The spacecraft’s last encounter, known as the final plunge, represents the deepest sampling of Saturn’s atmosphere and provided measurements down to approximately 1370 km above the 1-bar pressure level before losing contact with Earth.

INMS Observations: The Ion and Neutral Mass Spectrometer (INMS) aboard Cassini returned a surprisingly complex mass spectrum from the planet’s upper atmosphere. These first ever direct measurements enable the investigation of the chemical composition of the upper atmosphere, the thermal structure and energetics of the upper atmosphere, and the transfer of material from the rings to the atmosphere. The measurements were taken with the Closed Source Neutral (CSN) mode of INMS, which measures neutral species by ionizing the sampled molecules in order to detect the signature of the fragmented species. INMS has a mass range of 1 to 99 amu with a resolution of 1 amu.

Modeling: INMS measurements are complicated by the fact that multiple species contribute to the signal of individual mass channels, creating a complex combination of mass peaks associated with a mix of the fragmentation patterns of the species detected by the instrument. An accurate determination of the molecules present in the atmosphere must begin by first decomposing the spectrum in order to determine the relative contribution of each species to their respective mass channels. Due to a lack of proper calibration data for certain molecules, we decompose the mass spectrum using a mass spectral deconvolution algorithm that uses a Monte-Carlo approach to handle the uncertainty in fragmentation peak intensities of the molecules.

Results: INMS measurements of Saturn’s upper atmosphere revealed a much more chemically complex region than previously believed (see Figure 1) with evidence of many molecules having an external origin into the atmosphere, most likely from Saturn’s rings [1, 2, 3]. Recent work has also suggested that the mass influx of this neutral ring material entering the atmosphere is unsustainably large, approximately 10\(^3\) kg/s. An influx of such magnitude would deplete the entire ring system in less than 10\(^6\) years, leading to the speculation that the observed influx is time-dependent [2, 3]. We report here ongoing work to understand this mass spectrum and constrain the relative abundances of species present within the spectrum. Density profiles of major and minor constituents suggest that multiple species (along with CH\(_4\)) exhibit behavior indicative of an external source, and that Saturn’s upper atmospheric composition is heavily influenced by infalling ring material.

![Inbound mass spectrum from Cassini Orbit 288](image)

Figure 1: This mass spectrum of Saturn’s upper atmosphere contains complex organic molecules that were not predicted prior to Cassini’s proximal orbits.

References:

