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Saturn's He and CH4 Abundances from Cassini VIMS Occultations & CIRS Limb Spectra

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Abstract

Cassini VIMS stellar occultations by Saturn, in concert with Cassini CIRS Saturn limb spectra have been used to infer the Helium abundance on Saturn, as well as methane abundance and temperature profiles from about 5 mbar to about 0.01 mbar. In addition we will report some constraints on methane transmissivities inferred from the occultations. The techniques we employ are discussed in detail in a companion abstract by Gierasch et al. [1].

1. Basic Approach

Our basic approach is to use the Cassini CIRS limb spectra to yield a temperature profile covering the pressure range from about 5 mbar to about 0.01mbar. Then, the Cassini VIMS stellar occultations can be inverted to yield an estimate of the scale height profile of the atmosphere in roughly this same vertical range, but with notably more accuracy toward the bottom of this range. Combining the CIRS measured temperatures with the VIMS measured scale heights allows us to infer the mean molecular mass of the atmosphere in this region. This is then principally a measure of the Helium mixing ratio in Saturn's atmosphere.

In addition to the refractive part of the VIMS stellar occultation, we also observe the occultation in wavelengths sensitive to methane (and other absorbers). We can thus extract the methane abundance over this same pressure range (~5mbar to ~0.01mbar) from the VIMS occultation spectral lightcurves.

2. Expected Results

We have demonstrated the ability to retrieve the scale height profile from Cassini VIMS occultation lightcurves with sufficient accuracy to represent a significant constraint on the Helium abundance at Saturn. We are in the process of developing the techniques to extract the methane abundance from the VIMS occultation spectral lightcurves as well.

With the Helium abundance in hand, we can use the VIMS scale height profiles to yield temperature profiles in this same 5mbar to 0.01mbar pressure range. We will compare our results to those of the radio science occultations from Cassini and the Voyagers. Ground-based observations of Saturn's stellar occultations probe much higher up in the atmosphere and have no overlap with our results.

We also expect that our VIMS occultation spectral lightcurve results may present a uniquely good way to infer the methane transmissivities in a cold outer planet atmosphere. The ray paths through the atmosphere will be well constrained, and the problem is one of an illumination behind an absorbing medium (that is also relatively well constrained). Additionally, the observational configuration allows for upper layers to be accounted for in the earlier stages of the occultation and thus their effects removed from the later stages, yielding better information on the lower layers in an onion peeling approach.

Acknowledgements

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References

[1] Gierasch, P.J., Banfield, D., Conrath, B.J., Nicholson, P.D., Hedman, M.M.: Saturn Cassini VIMS Stellar Occultations and CIRS Spectra: Collaborative Analysis Techniques. DPS 2011.