Titan's atomic hydrogen exosphere

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Abstract

Based on measurements performed by the Hydrogen Deuterium Absorption Cell (HDAC) aboard the Cassini orbiter, Titan's atomic hydrogen exosphere is investigated. The data is used to infer the distribution of atomic hydrogen throughout Titan's exosphere, as well as the exospheric temperature, which are key parameters to understand the current and past evolution of Titan's atmosphere.

1. Introduction

Titan's neutral exosphere consists mainly of N_2, CH_4, H_2 and H. While the exobase densities of the former three constituents have been determined, the density of atomic hydrogen, however, could not be measured directly. In the past, the exobase density of atomic hydrogen has been inferred only once from measurements during the Voyager 1 flyby in 1980 [1]. Atomic hydrogen exobase densities inferred from current photochemical models that rely on recent data acquired by Cassini are up to a factor of two higher than the Voyager measurement.

The critical temperature above which atomic hydrogen on Titan features diffusion limited hydrodynamic outflow is reached above about 178 K. Since current measurements indicate exospheric temperatures in the range of 149 K up to 250 K, it is important to determine the exospheric temperature more precisely, in order to understand the evolution of Titan's atmosphere,

2. Models and tools

The measurements performed during the flyby are modeled by performing Monte Carlo radiative transfer calculations of solar Lyman-α radiation, which is resonantly scattered on atomic hydrogen in Titan's exosphere. Two different atomic hydrogen distribution models are applied to determine the best fitting density profile. One model is a static model that uses the Chamberlain formalism to calculate the distribution of atomic hydrogen throughout the exosphere, whereas the second model is a particle model, which can also be applied to non-Maxwellian velocity distributions.

3. Summary

The inferred exobase density using the Chamberlain profile is a factor of about 2.6 lower than the density obtained from Voyager 1 measurements and much lower than the values inferred from current photochemical models. However, when using the density profile provided by the particle model, the best fitting exobase density is in perfect agreement with the densities inferred by current photochemical models.

A best fitting exospheric temperature of $T_H = 175 \pm 25$ K was obtained when assuming an isothermal exosphere for the Monte Carlo radiative transfer calculations. The inferred temperature is thus close to the critical temperature for atomic hydrogen, above which it can escape hydrodynamically after it diffused through the heavier background gas.

References

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