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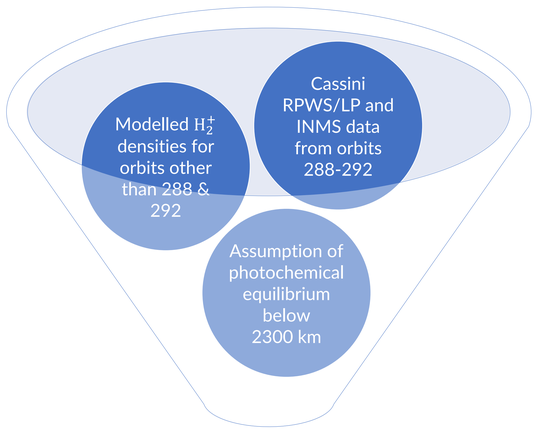
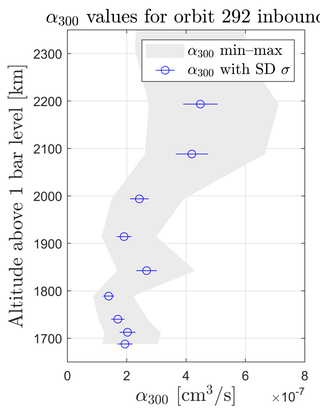
# *On the effective recombination coefficient in Saturn's ionosphere*

PRESENTER:
Joshua Dreyer
✉ joshua.dreyer@irfu.se

**BACKGROUND:**
The composition of Saturn's lower ionosphere is not well understood, with dust and heavy ions likely playing a major role in the chemical balance. At the lowest altitudes, a strong electron depletion is observed, which is seemingly due to dust particles taking on the role of negative charge carriers and yet to be included into many of the current models.
The presented method can provide a way to constrain the nature of the positive ions.




Upper limits for the effective recombination coefficient $\alpha_{300}$ at a reference electron temperature of 300 K




- Upper limits of ~ 2.5E-7 cm$^{-3}$ s$^{-1}$ below 2000 km
- Not compatible with previously suggested water group ions or complex hydrocarbons
- Modelled results for other deep orbits produce similar values

# **Saturn's** lower ionospheric **positive ions** are likely dominated by species with **low recombination rate coefficients.**

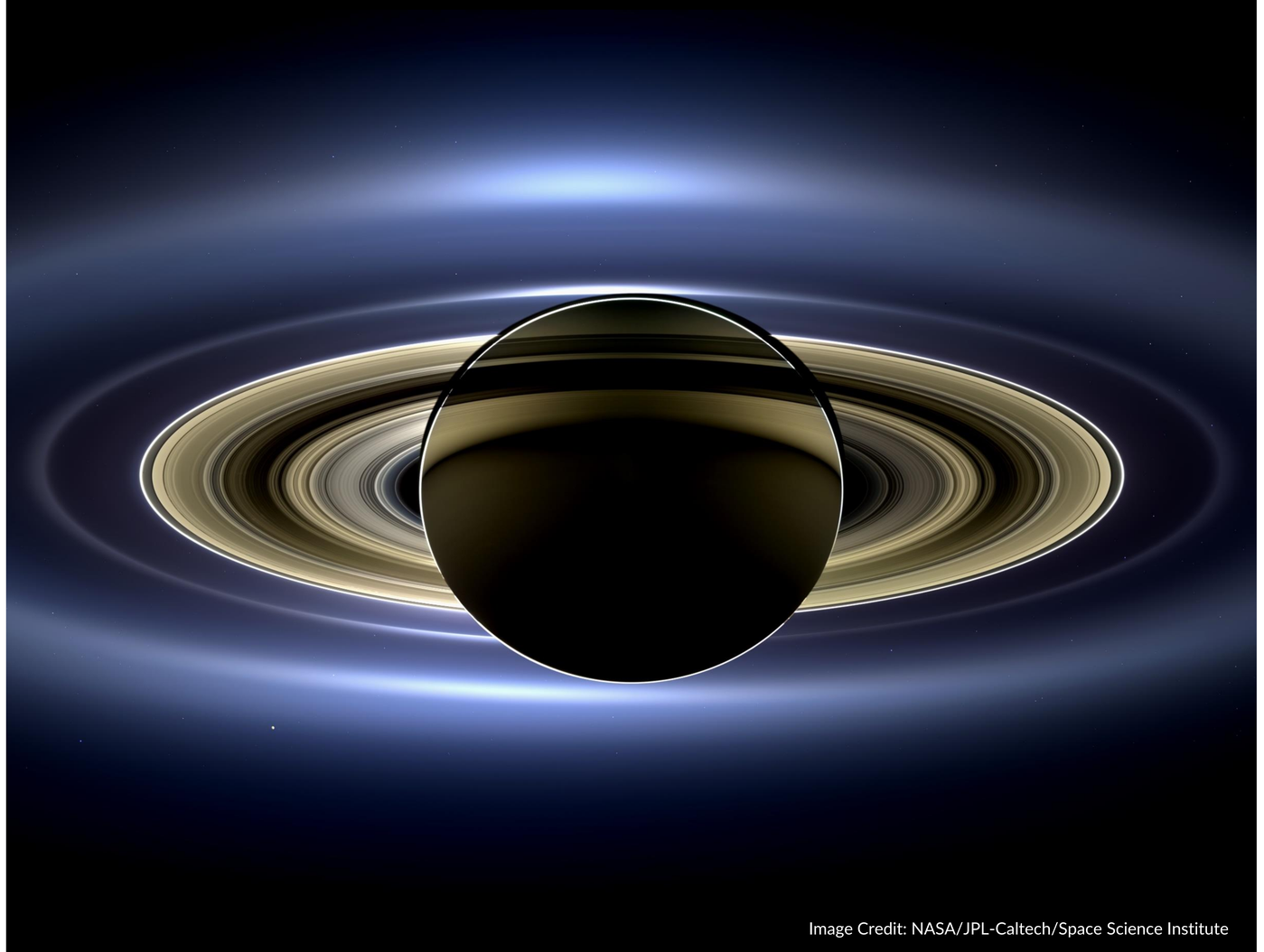


Image Credit: NASA/JPL-Caltech/Space Science Institute

## Details

$P_e = P_{e,gas} + P_{e,dust}$

$L_e = n_e(k_{DR} n_i + X_{dust})$

$P_{e,gas} = n_e(k_{DR} n_i + X_{dust}) - P_{e,dust}$

$n_e X_{dust} - P_{e,dust} > 0$ from observations, e.g. Morooka et al. (2019)

$X_{dust}$ is a collective term for various dust properties

$k_{DR} = \alpha_{300} \left(\frac{T_e}{300}\right)^{-0.7}$ known relation from laboratory measurements

In photochemical equilibrium:

$P_{e,gas} = k_1[H_2][H_2^+]$

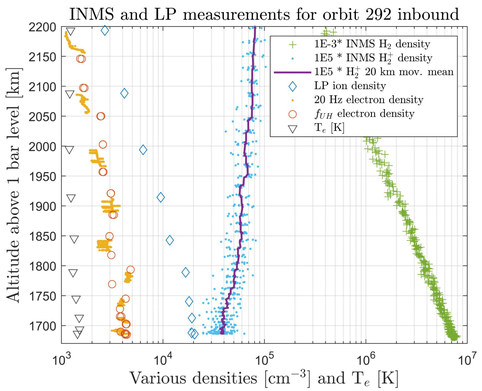
$P_{e,gas} > k_{DR} n_e n_i$

main production equals main loss channel

$2\times10^{-9}$ cm$^{-3}$ s$^{-1}$ INMS EUV model

$$\alpha_{300} < \frac{k_1[H_2][H_2^+]}{n_e n_i} \left(\frac{T_e}{300\ \mathrm{K}}\right)^{0.7}$$ Eq. [1]

RPWS/LP




Derived upper limits from orbits 288–292 below 2000 km:
$\alpha_{300} \sim 2.5 \times 10^{-7}$ cm$^3$s$^{-1}$

Potential positive ions with low recombination coefficients:

$N_2H^+$: $\alpha_{300} = 2.7 \times 10^{-7}$ cm$^3$s$^{-1}$

$HCO^+$: $\alpha_{300} = 2.0 \times 10^{-7}$ cm$^3$s$^{-1}$

$HCNH^+$: $\alpha_{300} = 2.8 \times 10^{-7}$ cm$^3$s$^{-1}$

**Joshua Dreyer**, Erik Vigren, Michiko Morooka, Jan-Erik Wahlund, Stephan Buchert, J. Hunter Waite (SwRI)

IRF
UPPSALA UNIVERSITET