Modeling the H_2 production in the Cassini Ion and Neutral Mass Spectrometer at Enceladus: Effect of Ice Grains Impacts in Low Velocity Flybys and Implication for the Identification of Native H_2 in the Plumes.

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Introduction: The data from the Cassini-Ion and Neutral Mass Spectrometer (INMS) at Enceladus' plumes shows presence of H_2 in important quantities (15% for low speed flybys). H_2 can be considered as a "smoking gun" for the suspected hydrothermal activity in Enceladus' ocean ([1][2]) as it is ultravolatile and would need to be the result of an ongoing production. However, while results for low velocity (7.5 km/s) are consistent with regard to the abundance of H_2, high velocity flyby show a higher quantity, up to 40%. This is attributed to the presence of ice grains in the plumes [3]: their impacts on the walls of the titanium antechamber of INMS expose/project fresh titanium that will react with water to form hydrogen. The large number of small ice grains arriving during a single integration period of INMS creates a background signal in addition of large grains causing punctual spikes. This process poses the question of how much of the detected hydrogen is native and how much is an artifact.

Models: A surface chemistry model of the INMS has been developed in order to determine how much H_2 is produced from the expected ice grains distribution for each flyby (given by Cassini CAPS data [4]). This model considers adsorption and chemisorption effects to follow the evolution of surface and gas phase species in the antechamber. [5]

CTH Simulations of impacts on an titanium surface [6] have shown that above 16 km/s (as is the case for flyby E5) the impact produces titanium vapor, while at the velocities of the slow flybys, the titanium stays in the form of solid fragments. Multiple CTH simulations of low velocity impact have provided the total amount of fragments created by impacts of ice grains of all sizes.

In order to translate antechamber population into simulated counts given by the INMS, a revised sensitivity model [7], including entry/escape of plumes species through other pathways in the instrument, has been combined to the antechamber model.

Results: As shown in Figure 1, taking only ice grains into account (no H_2 coming from the plumes) the quantity of H_2 produced just by the grains is obviously excessive, pointing to an excess of titanium. The excess can however be explained by the uncertainty on the ice grains population.

Even with an excessive ice grains population, it takes time to accumulate enough titanium to produce a noticeable H_2 signal. The shape of the H_2 background signal is therefore expected to differ from the shape of the H_2 signal from the plumes (if there is one). The two major spikes in the graph are attributed to ~2 microns ice grains.

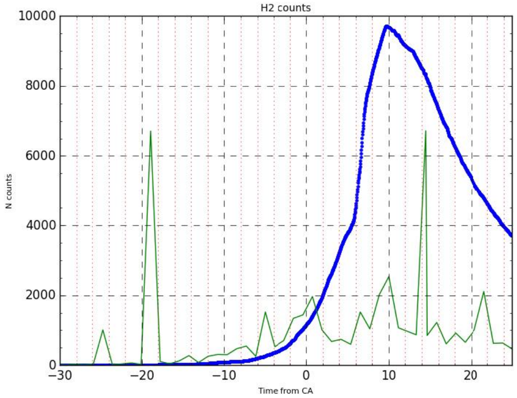

Figure 1: Comparison of H_2 counts per integration period from the simulation (blue) and from E18 slow flyby data (green). Time is given is seconds relative to closest approach.

Way forward: We will first adjust the ice grains total to the residual H_2 signal after plume crossing (since it only depends on total titanium from impacts) and from there adjust the quantity of H_2 in the plumes to match the total of counts from plumes crossing. Application to other slow flybys E14 and E17 will be needed to consolidate the final value of H_2 quantity.

References:

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