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Heavy positive and negative ions in Titan ionosphere

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Titan has long been known to harbor the richest atmospheric chemistry in the solar system that culminates in the generation of thick haze layers. Until recently, it was believed that the bulk of the chemistry occurred in the stratosphere, where Far Ultra-Violet (FUV) solar radiation dissociates the major neutral species (nitrogen and methane). Minor hydrocarbon and nitriles would then subsequently be produced through neutral chemistry that would eventually lead to the formation of micrometer size organic aerosols. However, some discrepancies persist. For example, it has been difficult for photochemical models to reproduce the haze production altitude required by microphysical models.

Recent measurements by the Cassini spacecraft are drastically changing our understanding of haze formation. The Ion and Neutral Mass Spectrometer (INMS) and the CAssini Plasma Spectrometer (CAPS) performed the first composition measurements of Titan's upper atmosphere. They revealed an extraordinary complex ionospheric composition. INMS detected roughly 50 positive ions with m/z $<$ 100 and a density higher than 0.1 cm^{-3}. CAPS provided evidence for 3 low mass negative ions, heavy (100$\sim$350 amu) positively charged and negatively charged (20$\sim$8000 amu) ions. The Ultra-VIolet Spectrometer (UVIS) and the Visible and Infrared Mapping Spectrometer (VIMS) showed that the haze extends to 1000 km altitude, and possibly higher.

These observations all indicate that Titan ionospheric chemistry is incredibly complex and that aerosol growth starts in the upper atmosphere rather than at lower altitude. While the formation of positive ions can be understood as a direct consequence of the presence of heavy neutrals, the detection of negative ions still remains to be explained. Nor is it at present clear what are the processes leading to macromolecules formation. We review our current knowledge on Titan ionospheric chemistry. We base

our discussion on laboratory data, as well as models of Titan's lower ionosphere, of Polycyclic Aromatic Hydrocarbons (PAHs) properties in the interstellar medium, and of dusty acetylene plasmas.