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Towards further understanding of the negative ion and nanograin dataset acquired by Cassini at the moons Titan and Enceladus

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Abstract

The detections of negative ions up to ~13,800 amu/q in Titan's ionosphere by the Cassini Plasma Spectrometer (CAPS) Electron Spectrometer (ELS) was remarkable in that the observations were made by an instrument designed and calibrated for measuring electrons [1, 2, 3]. These species have been detected whenever the CAPS-ELS is oriented in or close to the spacecraft 'ram' velocity vector at altitudes below 1450 km, where they revealed a complex and chemically dynamic atmosphere rich in organic molecules. In addition to this, at Enceladus, negative water clusters [4] and fluxes of nanometer-sized water-ice grains were detected at the top of the instrument's E/q range [5] within the Enceladus plumes. These were similarly detected in the spacecraft ram direction whenever Cassini traversed the moon's 'plume ionosphere' at high southern latitudes. In this study we present further examination into these negative ion and nanograin data-sets through an increased understanding of the instrument response to these unexpected species.

The intrinsic energy resolution, ΔE/E=17%, of the instrument [6, 7, 8], as well as spacecraft potential effects, limit the positive identification of specific species, as the instrument was designed for electrons. This corresponds to Δm/m for mass spectra when observed.

In earlier analyses at Titan, the negative ion observations were presented in broad 'mass groups' based on the observed spectra [1], [3]. We explore the idea that as the CAPS-ELS scans through the spacecraft ram direction, oversampling of Titan's atmosphere occurs due to the relatively high rate at which the scans in energy are performed compared to the rate at which the sensor is actuated, potentially adding an extra dimension to the data-set. Convolving ELS calibration data with the Titan data, we examine trends in the spectra which may be interpreted as being due to the presence of specific masses. We discuss these in relation to corresponding negative ion species identified as likely to be present in Titan's upper atmosphere [1, 9].

The ELS Microchannel Plate (MCP) efficiency to negative ions and nanograins has previously been estimated as a uniform 5% over the ELS energy range, using a study conducted by Fraser [1, 10, 11]. In this analysis we present updated MCP efficiency curves relevant to the Titan and Enceladus negative ion and nanograin detections.

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