EPSC Abstracts
Vol. 12, EPSC2018-488, 2018
European Planetary Science Congress 2018

What is the plasma density in the Enceladus plume?

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Abstract

The *Cassini* spacecraft made 23 flybys of Enceladus, of which 11 passed through the plume above the moon's south pole. Plasma densities measured during those encounters are a key piece of information in understanding the density of gas and dust in the plume, interaction between Enceladus and the magnetosphere of Saturn and Enceladus' role as the main source of plasma in Saturn's magnetosphere.

Unfortunately, despite six types of independent measurements by the Cassini Plasma Spectrometer (CAPS) and the Radio and Plasma Wave Science (RPWS) instruments, there is no clear or consistent picture of what the plasma density within the plume actually is.

The CAPS electron spectrometer only observed a fraction of the ambient electrons when the spacecraft is charged negatively, as was the case during the Enceladus encounters. It did, however, detect negative ions on at least one encounter, but not on others. To avoid time aliasing, the CAPS instrument did not actuate during the Enceladus encounters, providing 2 and 4 second time resolution, as opposed to ~200 second resolution, but at the expense of only obtaining 2-D cuts through velocity space rather than 3-D coverage. This limits the assumption-independent results to ion flux rather than density.

The RPWS instrument provided three relevant measurements. Close to, but not within, the Enceladus plume, emission at the upper hybrid resonance were used to determine the electron density. However, within the plume itself, impacts from dust particles produced enough "shot noise" to preclude these measurements. Surprisingly, impacts on the RPWS antennas themselves did produce an oscillation in the instruments' wide band data, which has been interpreted as an oscillation at the local plasma frequency. When available, this produces an additional measurement of electron density. Finally, the RPWS instrument's Langmuir probe provided current-voltage curves, which can be fit to determine ion and electron densities. However, the measured current also depends on the density of charged dust, the density of negative ions, the secondary electron current from energetic particles, and a number of other parameters. As a result, the fits to these data are non-unique and the derived ion and electron densities have high correlated uncertainties.

While all these measurements are in partial agreement at some times, the overall agreement is poor. In many cases, the different techniques give results which disagree by an order of magnitude. In this presentation, I will present the various published results, describe the strengths and weaknesses of each technique, and attempt to reconcile these measurements.