ION COMPOSITION IN SATURN'S PLASMA ENVIRONMENT: EARLY RESULTS FROM THE CASSINI PLASMA SPECTROMETER. D. B. Reisenfeld[1], R A Baragiola[2], F J Crary[3], A J Coates[4], R Goldstein[3], T W Hill[5], R E Johnson[2], D J McComas[3], E C Sittler[6], M D Shappirio[6], J T Steinberg[7], H T Smith[2], K Szego[8], M F Thomsen[7], R L Tokar[7], and D T Young[3], [1]Department of Physics & Astronomy, University of Montana (#1080, 32 Campus Dr., Missoula, MT 59812; dan.reisenfeld@umontana.edu), [2]Engineering Physics, University of Virginia (Thorton Hall, Charlottesville, VA 22904), [3]Division of Space Science and Engineering, Southwest Research Institute (6220 Culebra Rd., P.O. Drawer 28510, San Antonio, TX 78228), [4]Mullard Space Science Laboratory, University College London (Holmbury St. Mary, Dorking, Surrey RH56NT, England), [5]Physics & Astronomy Dept., Rice University (MS 108, Houston, TX 77251), [6]Goddard Space Flight Center (Code 692, Greenbelt, MD 20771), [7]Space and Atmospheric Sciences, Los Alamos National Laboratory (MS D466, Los Alamos, NM 87545), [8]KFKI Reearch Institute for Particle and Nuclear Physics (P. O. Box 49, H-1525 Budapest, Hungary)

Introduction: Prior to Cassini's arrival at Saturn, most of what was known about the composition of the plasma in Saturn's environment was derived from limited measurements by Pioneer 11 and Voyager 1 and 2 in 1979-1981[1-3]. The measurements reported here were made by the Cassini Plasma Spectrometer (CAPS) [4] during the first two Cassini orbits, including the closest approach to Saturn and the rings during the tour, and a close flyby of Titan. The CAPS instrument resolves ion energy/charge from 1 V to 50 kV and ion mass/charge from 1 to ~100 amu/e, and it measures electron energy from 1 eV to 28 keV. Initial composition measurements of Saturn's magnetosphere show that protons dominate outside ~8 R_S, while inside this radius the plasma is dominated by a mix of water-derived ions and N^+. Over the A and B rings a plasma layer is observed composed of O_2^+ and O^+. The close passage near Titan shows a rich network of both positive and negative molecular ions. We report preliminary analysis of these and other composition findings.

Water-Derived Ions: Within ~14 R_S, the CAPS instrument detected H^+, O^+, and water group ions (denoted as W^+ and defined as a combination of OH^+, H_2O^+ and H_3O^+), and within ~8 Rs, O^+ and W^+ dominate the ion composition. The latter region is identified as the inner plasmasphere and its sources include the E ring (~3 to 8 R_S), a rich source of water vapor [5]. In this region the relative speed between neutral gas and ions is low and ion-molecule reactions become important [6]. The presence of H_3O^+ is consistent with this picture, as it is created through collisions between H_2O^+ and neutral H_2O.

Nitrogen Ions: Also within 8 R_S we detect N^+ at fractional concentrations ~3%; this is the first identification of atomic nitrogen ions in Saturn's magnetosphere. Suprisingly, N^+ has so far been observed only in the inner magnetosphere, not further out; specifically, not in the vicinity of Titan's orbit. Possible nitrogen sources are: neutral nitrogen from Titan that is transported inward and locally ionized [7], or nitrogen derived from a small abundance of ammonia within the surfaces of inner icy satellites and subsequently sputtered off [8]. Neither explanation is entirely supported by the data and further modeling is required to resolve the origin question.

Ring "Ionosphere": When Cassini passed over the A and B rings during orbital insertion, CAPS detected a plasma layer dominated by O_2^+ and O^+ at densities ranging from ~0.1 cm^{-3} to ~1 cm^{-3} and temperatures ~ 1 eV. The presence of O_2^+ suggests the existence of an O_2 layer over the rings, similar to the atmospheres of Europa and Ganymede [9]. These observations are consistent with a model where O_2 is liberated from ring ice by ultraviolet photons and redistributed throughout the magnetosphere. O_2^+ and O^+ are produced via direct photoionization and photodissociation, respectively, of O_2 [10, 11].

Titan's Ionosphere: Plasma data from the first flyby through Titan's ionosphere show the presence of a complex network of cold molecular ions. Individual species identification is still pending, but more than 10 positive ion mass peaks and 3 negative ion mass peaks have been resolved, ranging in mass up to ~110 amu. An ongoing detailed composition analysis should provide strong tests of Titan atmospheric/ionospheric models.

References:

[1] Frank, L. A., et al. (1980) *Geophys Res. 85*, 5695. [2] Bridge H. S. et al. (1981) *Science, 212*, 217. [3] Sittler, E. C., (1983) *J. Geophys Res., 88*, 8847. [4] Young, D. T., et al. (2005) *Space Sci. Rev*. in press. [5] Jurac, S., et al. (2002) *Geophys Res. Lett., 29*, L2172. [6] Johnson, R. E., et al. (1989) *Icarus, 77*, 311. [7] Smith, H. T., et al. (2004) *Geophys. Res. Lett., 31*, L16,804. [8] Kargel, J. S. & Pozio, S. (1996) *Icarus, 119*, 385. [9] Johnson, R. E. et al. (2003) *Astrobiology, 3*, 823. [10] Shi, M. et al. (1995) *J. Geophys. Res., 100*, 26,387. [11]Johnson, R. E. & Quickenden, T. I. (1997) *J. Geophys. Res., 102*, 10,985.