they will behave during the course of energetic surface operations (from penetrometry to human visitation to diversion). We describe a concept for a robust multiple-rendezvous science mission to three representative near-Earth objects including a dormant or extinct comet nucleus. Key features include solar electric propulsion, autonomous navigation, stereogrammetric imaging, plus dual-wavelength radio tomography from orbit and small cratering science experiments for material and dynamical studies. The cratering experiments (conducted by instrumented blast payloads) will serve as precursors to future landed seismic investigations, and will enable the construction of realistic simulation environments for lowering the risk of future landed NEO missions. Mission science goals include: (1) definitive test of the rubble pile hypothesis for asteroids, (2) definitive test of the mantling hypothesis for comets, and whether primitive materials inhabit their interior, and (3) definitive study of the depth and mobility of regolith. This mission can be delivered for under the NASA Discovery cost cap. Significant payload margins allow for the addition of auxiliary landed instruments (penetrometer/seismometer) at each NEO visited, in which case the existing cratering experiments would serve as seismic signals. This combination of multiple wavelength radar tomography and seismic analysis would be an especially powerful probe of NEO interiors.

P21B MCC: Hall D Tuesday 0830h

Planetary Sheaths Posters *(joint with SM)*

Presiding: **C Paranicas,** Applied Physics Laboratory**; S Livi,** Applied Physics Laboratory

P21B-0365 0830h POSTER

The Medium and High Energy Neutral Atoms (MH-ENA) detector for the BepiColombo Mission to Mercury

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The charge-exchange interaction of energetic plasma of solar wind or magnetospheric origin with the exospheric gas around Mercury has the potential of generating strong energetic neutral atom (ENA) emission. The temporal evolution on short time scales of the solar wind-magnetosphere interaction as well as the magnetospheric plasma dynamics could be studied through the analysis of the flux of such energetic neutrals. The MH-ENA detector is part of the Neutral Particle Analyzer (NPA) to be proposed for the BepiColombo mission to Mercury. MH-ENA is a nadir-pointing 2-D sensor with an instantaneous FOV of 88 deg x 60deg. Its design is optimized for the detection of energetic neutrals, from 1 keV to >30 keV. The detector consists of a pinhole-focusing ENA camera. First, the environmental ions are suppressed by a biased HV collimated pin-hole telescope. The collimated energetic neutrals traverse a thin carbon foil (< 1 g/cm2), causing an up-streaming SE emission, that are collected by a dedicated MCP to generate the START signal. After a short (1cm) flight, particles then hit a 2D detection system, which generates the STOP signal for Time-of-flight measurement, as well as the positional information for determining the velocity direction.

P21B-0366 0830h POSTER

Hermean Ion Environment

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Mercury is a planet with a relatively weak intrinsic magnetic field without an atmosphere and an ionosphere. The weak intrinsic field produces a small magnetosphere compared with the size of the terrestrial magnetosphere in which plasma can interact directly with the planetary surface. The small spatial scale, the associated short time scales for plasma processes, and the direct plasma-surface interaction produces a plasma environment that is anticipated to have unique features among the plasma environments near other planetary bodies in the Solar System.

Our knowledge of the ions near Mercury is limited due to the fact that we lack of in-situ ion measurements near the planet. The properties of the ions near Mercury are thus based on computer models, and with analogy models with the terrestrial magnetosphere. These studies suggest, for example, that the planetary ions might play an important role as a current carrier affecting thus to the global Mercury-solar wind interaction. Planetary ions can also be picked-up by the solar wind thus providing a not-thermal loss mechanism for the planetary exosphere neutrals. Some of the ions may also be precipitate the surface and affect to the emission rate of planetary neutrals and ions from the surface. Properties of the ions near Mercury gives thus a variety of information about how the solar wind particles and energy is transported through the magnetopause, the exosphere densities, acceleration of ions, the plasma-surface processes, the loss of planetary neutrals, and the role of planetary ions to the near planet.

So far the more sophisticated models to study the properties of the solar wind protons near Mercury are based on self-consistent three-dimensional MHD models. The properties of the Hermean ions have instead been studied by non-self consistent test particle simulations. We have developed a global model to analyze near Hermean ions self-consistently. The model, a quesineutral hybrid model, includes several planetary ion species, such as Na+, K+, and O+ ions, which have been taken into account self-consistently. The planetary ions are formed from both from the exospheric neutrals by photoionization, and from the surface by ion sputtering processes. In the presentation we show how the various ion species are distributed spatially around the planet at different upstream conditions and how the ions are accelerated, by putting a special emphasis to study the question about the role of the planetary ions to the overall Mercury-solar wind interaction

P21B-0367 0830h POSTER

Electron Density Profiles Near the Midnight Venus Ionosphere

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Electron densities in the Venus nightside upper ionosphere that were derived from measurements made with the Orbiting Electron Temperature Probe (OETP) of the Pioneer Venus Orbiter (PVO) have been examined in connection with effects associated with the plasma channels that have been assumed extend downstream from the magnetic polar regions [Perez-de-Tejada, J. Gephys. Res. 106, 211, 2001]. The ionospheric density profiles obtained near the midnight plane have a signature that is different from what it is seen throughout most of the nightside hemisphere. The data in various orbits show that in the vicinity of the midnight plane there is a near constant density plateau that extends across most of the upper ionosphere from the nightside ionopause crossing (up to 2000 km) to very low (200 km) altitudes located near periapsis in the PVO trajectory. The density plateau is limited by a low altitude sharp rise with a slope that is larger than the altitude variation in the density profiles seen away from the midnight plane. It is suggested that the peculiar shape of the electron density profiles near the midnight plane is produced by the displacement of the upper ionosphere adjacent to the plasma channels that is eroded by the solar wind; and that the sharp lower edge of the density plateau results from crossing near the bottom of the plasma channels. It has also been suggested that the plasma channels provide a useful account of the ionospheric holes observed in the OETP data as regions where the ionospheric plasma density in the nightside hemisphere falls to very low values. A set of these latter features was selected to show that when they occur near the midnight plane the magnetic field measured in the solar wind is mostly oriented near the ecliptic plane. Different from this orientation it is found that in the electron density profiles with a near constant density plateau the magnetic field in the solar wind has a significant latitudinal angle with respect to the ecliptic plane. It is argued that the observation of density profiles with ionospheric holes near the midnight plane or with a density plateau in that region results from the different latitudinal orientation of the magnetic field in the solar wind. That orientation defines the position of the magnetic polar regions in the Venus ionosphere and hence that of the plasma channels that extend behind them.

P21B-0368 0830h POSTER

Structure of the Magnetic Field Fluxes Connected with Crustal Magnetization at Mars and the Effect of Crustal Magnetic Fields on the Near Terminator Ionosphere: Mars Global Surveyor Observations

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The magnetic fluxes associated with the Martian crustal remnant magnetization have been studied in order to investigate the global structure of the magnetic field in and above the level of Martian ionosphere. The intensely and nonuniformly magnetized crustal sources generate an effective large-scale magnetic field. Re-connection with the interplanetary magnetic field can possibly take place in many localized regions. This will permit solar wind (SW) and more energetic particles to precipitate into and heat the neutral atmosphere. This may occur not only in cusp-like structures above nearly vertical field anomalies but also in halos extending several hundreds of kilometers from these sources. In the Northern hemisphere, the crustal fields are rather weak and usually do not prevent direct interaction between the SW and the Martian ionosphere/atmosphere. Exceptions occur in the isolated mini-magnetospheres formed by the crustal anomalies. Much stronger crustal fields are located in certain regions in the Southern hemisphere and lead to the formation of large-scale mini-magnetospheres. Numerous cusp-like regions may exist above the many crustal anomalies in the Southern hemisphere. Electron density profiles of the ionosphere of Mars derived from radio occultation data obtained by the Radio Science Mars Global Surveyor (MGS) experiment have been compared with the crustal magnetic fields measured by the MGS Magnetometer/Electron reflectometer (MAG/ER) experiment. A study of the electron density profiles obtained when the mini-magnetosphere regions are near the terminator has been conducted using the magnetic field measurements at altitudes 170-180 km and 40034 km. The altitude and magnitude of the electron density peak, the effective scale-height of the electron density and the normalized standard deviation for two altitude ranges, 145-165 km and 165-185 km, have been derived for each of the 326 selected profiles. In each hemisphere, the longitudinal variations of these derived parameters have been studied. A significant difference between the large-scale mini-magnetospheres and regions outside of them has been found. The variations of the magnitude of the electron density peak indicate that the electrons are usually "hotter" inside a large-scale mini-magnetosphere than outside. Comparison with the MGS in-situ Accelerometer data also indicates that the neutral atmosphere is persistently cooler inside the large-scale mini-magnetospheres. It appears that the strong crustal magnetic fields prevent additional heating of the neutral atmosphere by direct interaction of the SW as well as confine the hotter electrons created by photo ionization.

P21B-0369 0830h POSTER

Magnetic Field Oscillations in the Martian Magnetosheath and Magnetic Pileup Region

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Turbulent magnetic oscillations have been detected by the Mars Global Surveyor spacecraft in the region between the Martian bow shock and the magnetic pileup boundary (MPB). Initial analyses of these very low frequency (<10 Hz) waves are presented. We find that these waves show several principal frequencies of oscillation. This indicates that multiple wave modes are present including ion cyclotron waves of various populations. The waves tend to be principally left-hand circularly polarized throughout the magnetosheath (MS) but linearly polarized near the MPB. The direction of the linear polarization relative to the planetary surface evolves throughout the magnetic pileup region. We also find that throughout the MS the amplitude of the waves in the direction parallel to the mean magnetic field tends to be larger than the amplitude of the waves perpendicular to the mean field. However, near the MPB the amplitudes become nearly equal. These parameters indicate that several physical mechanisms may be involved in the production of these waves and further analysis will be required to fully identify each mechanism.

P21B-0370 0830h POSTER

Magnetic Field Variation Effects on Electron Distributions at Mars: Comparisons of Theory and Data

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The Electron Reflectometer (ER) onboard the Mars Global Surveyor (MGS) satellite is intended to remotely probe the magnetic field of the planet. By measuring the velocity space distribution of fast electrons (10 eV < E < 20 keV), the spatial and temporal variability of the magnetic field topology far from the satellite can be deduced. In this presentation, results from a multi-stream kinetic calculation of fast electrons in the Mars ionosphere are compared against MGS/ER data. The influence of a non-uniform magnetic field in the electron transport simulation results is discussed, showing that pitch angle anisoptropies in the data can be explained by this effect. Data from the first few months of the mapping phase are examined to compare the similarities and differences between nearly-identical flights over the crustal field regions. This analysis yields information about the variability of the loop structures in the ionosphere, and comparison against modeling results quantifies the magnitude of the topology changes.

P21B-0371 0830h POSTER

Charged Particle Precipitation into Jupiters Subauroral Atmosphere

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Energetic charged particle precipitation into Jupiters subauroral atmosphere is modeled with respect to longitude and latitude. Trapped magnetospheric particles bounce-orbit magnetic field lines mapped by Connerney et al. 1998. Pitch angle scattering is simulated by a probability function originally designed for the terrestrial magnetosphere (Thorne et al. 1996). Satellite and ring influences on the precipitation pattern, such as the absorption and emission of charged particles, are neglected, aside from their contributions to the magnetic field model. Diurnal effects, such as variations in the atmospheric scale height, are not included.

The calculations indicate that inner magnetospheric (1.5RJ - 4.0RJ) precipitation is greatest in the Southern Hemisphere, but the interhemispheric differences decline with increasing L, along with the longitudinal variation. The effects of particle mass, charge and energy on the precipitation pattern were negligible for the species (electrons, protons, and singly charged oxygen and sulfur ions), energies (0.3 to 10 MeV) and diffusion rates (0.001 to 0.1 of the strong diffusion rate) considered at 1.5RJ and 2RJ, although species variations were apparent at L=4. Observations of H3+ and x-ray emissions were strongly correlated to our precipitation calculations at 1.5RJ, especially in the Northern Hemisphere, where magnetic field asymmetries are most intense. The correlation between observations and modeled precipitation fluxes diminishes at higher latitudes, particularly for H3+, suggesting that ion transport from auroral latitudes contributes to the observed emissions.

P21B-0372 0830h POSTER

Jupiter's Aurora: Correlations with Solar Wind? Results of the Millennium Campaign

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During the Millennium campaign over Dec 2000 - Jan 2001, UV images of Jupiter's aurora were obtained with the HST STIS instrument while Cassini flew past Jupiter and Galileo moved out into the magnetosphere. There has now been sufficient time for the various experimenters to examine their data, and a consensus has developed about the strength of the solar wind at Jupiter during the periods of HST observations. There have been theoretical predictions about the effect of pressure increases in the solar wind on Jupiter's main auroral oval, predicting both an increase and a decrease in the auroral brightness. The satellite footprint emissions are not expected to be sensitive to the solar wind conditions, and there have been no theoretical predictions for the response of the auroral emissions poleward of the main oval. This paper will present the measurements that have been taken, and discuss any correlations between auroral activity and solar wind conditions at Jupiter.

URL: http://aoss.engin.umich.edu/Aoss/AOSS_Web_Site/aurora/aurora.html

P21B-0373 0830h POSTER

Stress balance in Jupiter's neutral sheet

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From the time of the plasma measurements made by Voyager, there has been uncertainty about how charged particles and magnetic fields achieve force balance in the Jovian neutral sheet. Using Voyager data from the Jupiter encounters, we previously reported pressure anisotropies in the Jovian neutral sheet which added to the total particle stresses. At 3 radial distances between 15-40 Jovian radii, we found that parallel ion pressure was slightly but importantly larger than perpendicular pressure. The pressure anisotropy, along with forces associated with corotation and pressure gradients, brought the total particle forces nearly into agreement with the magnetic forces. That analysis was done using the Low Energy Charged Particle (LECP) instruments on the Voyager spacecraft. LECP detects charged particles from tens of keV to tens of MeV in energy and these have been found to significantly contribute to, if not dominate, the total plasma pressure in Jupiter's magnetosphere. The absence of ion pressure anisotropies in the Galileo Energetic Particles Detector (EPD) data from two events in which high time resolution measurements were made at comparable locations has led us to re-visit this issue in more detail. We also extend the force balance to include the region 9-15 Jovian radii using Galileo data. Developments since the original work will be discussed and magnetic energy storage will be considered.

P21B-0374 0830h POSTER

New Galileo and VLA Observations of Jupiter's Radiation Belts near the vicinty of Amalthea.

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In November, 2002, the Galileo spacecraft is scheduled to flyby Amalthea, one of Jupiter's inner most moons (2.4 RJ). We present VLA observations of Jupiter's synchrotron emission obtained simultaneously with Galileo's flyby of Amalthea. If available, in-situ measurements from Galileo's Energetic Particle Detector and Plasma Wave Subsystem will be compared with the synchrotron emission maps at 6 and 20 cm wavelengths. The total measurement set will provide constraints on the high energy electron distribution functions near Amalthea and the types of waves affecting the particle population in the vicinity of Amalthea. These observations represent the first opportunity for direct comparison of Jupiter's radiation belts by both in-situ and remote observations near Amalthea.

P21B-0375 0830h POSTER

Particle Tracing Studies of the Mass Loading of the Io Torus

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Mass loading of the Io torus by sulfur dioxide and sulfur monoxide ions leads to the generation of ion cyclotron waves at the gyrofrequency of the ions, powered by the free energy in the "ring beam" produced in the pickup process. The region in which these waves are observed is spatially limited, resulting in rapid changes in amplitude, as observed by the Galileo spacecraft during its passes by Io. The location of the boundaries potentially can tell us about the source regions for the ions. We perform forward calculations of ion trajectories varying source location and plasma flow characteristics to determine what controls these boundaries and where each species originates. Sodium monoxide associated waves appear over a greater region around Io than sodium dioxide waves, and even though the sodium dioxide emissions may dominate when they appear, the source region of sulfur monoxide ions appears to have greater longitudinal extent than that of sulfur dioxide.

P21B-0376 0830h POSTER

The Source of Protons at Io

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The ionosphere of Io is known to be dominated by the molecule ion of sulfur dioxide and the surface and atmosphere are nearly devoid of hydrogen bearing molecules. It is noteworthy, therefore, that electromagnetic waves have been observed near the second and fourth harmonics of the proton gyrofrequency, which is indicative of the presence of a population of pickup protons. We investigate the possible sources of indigenous hydrogen atoms and protons in the exosphere of Io and conclude that charge exchange between incident torus oxygen ions and a population of bound iogenic hydrogen atoms is the only mechanism that can suffice to provide the needed pickup proton source strength and number density. We evaluate various possible sources for such a population.

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P21B-0377 0830h POSTER

Groundbased Observations of Io [O I]6300 Å Emission During the Galileo I24, I25, and Cassini Encounters

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For the past 12 years, we have conducted a synoptic study of [O I] 6300 Å emission from Io using the high-resolution (R 120,000) stellar spectrograph at the National Solar Observatory McMath-Pierce telescope. We showed in a recent paper (Oliversen et al. 2001, JGR, 106, 26183) that this emission allows us to use Io as a localized probe of the three-dimensional plasma torus structure. We report on selected recent spectroscopic observations of Io [O I] 6300 Å emission obtained during the Galileo I24 (1999-Oct-11) and I25 (1999-Nov-26) encounters with Io and the Cassini Jupiter encounter (closest approach 2000-Dec-30). The exposure time for each spectrum was 15 minutes, with a 5.2" x 5.2" aperture centered on Io. We obtained over 100 spectra for the I24 encounter during 1999 October 9-13, over 100 spectra for the I25 encounter during 1999 November 24-30, and for the Cassini Jupiter flyby almost 600 spectra from 2000 December to 2001 January 21. We use our database of observations to track long- and short-term variations in torus structure. We compare our results to Galileo, Cassini, HST, and other groundbased contemporaneous observations to gain insight into torus variability and structure.

P21B-0378 0830h POSTER

On Inverting the Magnetic Field of Jupiter and Saturn

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While Galileo completed over 30 orbits of Jupiter to date, many of these orbits are not useful by themselves for determining higher order multipoles because of data gaps that limit longitudinal coverage. In the past we have used condition number quality analysis to evaluate the relative accuracy of solutions based on coverage. In this work, we perform parameter error quality analysis and combine orbital segments from complementary orbits to obtain improved inversions, even when the original data have significant gaps. This allows us to obtain reliable solutions up to octupole moments and increase our ability to determine the secular variation of the Jovian magnetic field. This analysis also has implication for the analysis of the higher order terms of the Saturn magnetic field to be observed by Cassini. The initial Saturn orbit injection pass is at very low altitude with coverage over a limited longitude range, but later high altitude passes with high inclination can complement those observations to provide a reliable measurement up to the 5th order moment. We illustrate the identifications of these critical Cassini Passes.

P21B-0379 0830h POSTER

Energetic Nitrogen Ions within the Inner Magnetosphere of Saturn

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Titans interaction with Saturns magnetosphere will result in the energetic ejection of atomic nitrogen atoms into Saturns magnetosphere due to dissociation of N_2 by electrons, ions, and UV photons (Strobel and Shemansky, 1982). The ejection of N atoms into Saturn's magnetosphere will form a nitrogen torus around Saturn with mean density of 6 atoms/cm^3 with source strength of 6×10^{26} atoms/sec (Barbosa, 1987). These nitrogen atoms can then be ionized by photoionization, electron impact and charge exchange reactions producing an N^+ torus of 1-2 keV suprathermal ions centered on Titans orbital position. It has been reported that the Voyager plasma instrument has detected the presence of a suprathermal ion component within Saturns outer magnetosphere (Lazarus and McNutt, 1983; Richardson, 1986). The Voyager LECP data also reported the presence of inward diffusing energetic ions from the outer magnetosphere of Saturn which could have an N^+ contribution. If so, when one conserves the first adiabatic invariant the N^+ ions will have energies in excess of 100 keV at Diones L shell and greater than 400 keV at Enceladus L shell. With energetic N^+ ions bombarding the icy satellite surfaces chemical reactions can occur at the end of the ions track and produce nitrogen oxides or other nitrogen containing molecules (Delitsky and Lane 2002). These can accumulate over the lifetime of the Saturn system. We will present results of an analysis of the Voyager PLS and LECP data sets to explore this possibility and make a prediction for the Cassini Mission for the possible detection of suprathermal N^+ ions within Saturns inner magnetosphere and ionized nitrogen molecules sputtered from satellite surfaces.

P21B-0380 0830h POSTER

Magnetic Field Draping Enhancement at Weakly Magnetized Bodies

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The lack of an intrinsic magnetic field at Venus, Mars and comets makes their interaction with the solar wind to exhibit many similarities. Among these, the formation of a magnetic barrier in front of a highly conducting obstacle and an induced magnetic tail are the most characteristic peculiarities. At Mars and comets, a sharp plasma boundary that represents the outer edge of the magnetic barrier, the Magnetic Pileup Boundary (MPB), has been identified by very clear observational signatures, including a gradient in the magnetic field magnitude (frequently observed as a sharp jump) accompanied by a decrease in the magnetic field fluctuations, and a simultaneous drastic decrease in the solar wind electron and proton densities, as the exospheric-induced ions become more important. Recently, an analysis of the 3-D magnetic field topology in the surroundings of the Martian MPB using Mars Global Surveyor magnetometer data has revealed a sudden enhancement of the field line draping exactly at the boundary itself. This feature appears to be a ubiquitous characteristic of this boundary, even when there is no obvious signature on the magnetic field magnitude. We apply the same technique to magnetometer data acquired near comets and Venus to show that this enhancement of draping is a commonplace for all weakly magnetized atmospheric bodies. As a corollary, we propose for the first time a mean to find the location of the counterpart of the MPB at Venus. Despite numerous studies on the physics of the Venusian magnetic barrier, such boundary has never been reported since there is usually no clear signature on the magnetic field magnitude.

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Ion Composition of Comet 19P/Borrelly as Measured by the PEPE Ion Mass Spectrometer on DS1

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Cometary compositions are of great interest because they hold important clues to the formation of the outer solar system, and to the sources of volatiles in the solar system, including the terrestrial planets. In order to understand the primordial compositions of cometary nuclei, it is important to also understand their evolution, as many of the comets most accessible to spacecraft are highly evolved. It is also important to understand the ion and neutral chemistry that occurs in the coma surrounding the nucleus if the coma ion composition is to be used to determine the original composition of the nucleus. Deep Space One (DS1) was only the second spacecraft, after Giotto, to use an ion mass-resolving instrument to explore cometary coma compositions in-situ, which it did during the flyby of Comet Borrelly on September 22, 2001. Borrelly is significantly more evolved than Halley. In addition, the encounter occurred at a significantly greater distance from the sun (1.36 AU vs 0.9 AU for Giotto at Halley).

The Plasma Experiment for Planetary Exploration (PEPE) on board DS1 was capable of resolving electron and ion energy, angle of incidence, and ion mass composition. The PEPE ion data from the seven minutes surrounding closest approach (2171 km) have been extensively analyzed. The instrument response was modeled using SIMION and TRIM codes for all of the major species through 20 AMU plus CO (at its operating voltage PEPE was very insensitive to heavier molecules). Chi-squared minimization analysis is being carried out to determine the best fit and the uncertainties. Preliminary results for the predominant heavy ions are OH^+ at (72 ± 9)% of the total water-group ion density, H_2O^+ at (25 ± 7)%, CH_3^+ at (5 ± 3)%, and O^+ at (4 ± 5)%. Uncertainties are quoted at the 90% confidence level. Comparison with reported Halley compositions from Giotto shows that Borrelly clearly has a lower H_3O^+ abundance (< 9%), consistent with a more evolved comet. The presence of relatively high amounts of CH_3^+, proposed in the context of Halley to be produced by protonation of CH_2^+, is somewhat surprising in this context. Because the H_3O^+/H_2O^+ ratio is an indicator of the degree of protonation in the coma, a low H_3O^+/H_2O^+ ratio would predict a low CH_3^+/CH_2^+ ratio as well. However, this is not the case at Borrelly. The CH_3^+/H_3O^+ ratio will need further study in future comet models and observations.