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Possible reasons for cometary tail disconnection events are studied in sets of time-dependent global MHD (BATS-R-US) simulations. The effects of several solar wind discontinuities on the plasma tail of a comet are discussed. In particular, idealized simple discontinuities like a tangential iscontinuity and a density jump are investigated. Moreover, effects on the plasma tail created by some more complicated but balanced disturbances, and some more realistic solar wind disturbances are presented as well. The advanced flux solver and adaptive-mesh grid system utilized in this analysis allow us to track variations simultaneously on scales from two million kilometers sunward to a few kilometers above the cometary nucleus and back out into the distant tail. During the simulation, in addition to the morphology of the thin plasma tail, a well-resolved magnetic cavity can be seen responding to the solar wind disturbances.

P21A CC: 519 B Tuesday 0830h

Planetary Science General Contributions I *(joint with A, GP, T, V, NG)*

Presiding: **M Grande,** Rutherford Appleton Laboratory**; W B Moore,** University of California, Los Angeles

P21A-01 0830h

Magnetism of the Galilean Satellites Io, Europa and Ganymede

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The Galileo magnetic field observations at the Galilean Satellites present a number of open questions. Among those is the following: Why should Ganymede have a self-sustained magnetic field while both Io and Europa have not? For Io, the absence of a dynamo in the core may be explained by the enormous amount of tidal heating in the satellite's mantle that keeps the interior warm and the core from freezing. A dynamo driven by chemical convection upon inner core freeze out is then impossible. A dynamo driven by thermal convection is equally unlikely as Wienbruch and Spohn (1995) have already shown. For Europa and Ganymede, tidal heating, at present, is much less important or, respectively, of no importance at all. Because Europa is about 1000km smaller in radius than Ganymede, the former should be cooling faster than the latter and, if anything, Europa should grow an inner core and produce a magnetic field, but not Ganymede. We will argue that the explanation may lie with Ganymede's core having much less Sulphur than Europa's. Sulphur in the core acts to depress the melting point and may have frustrated inner core growth in Europa for the age of the Jovian system. We use the chemical model of Kuskov and Kronrod (2001) in which the three inner Galilean satellites are close to L and LL chondrites in composition and model the interior structure while satisfying the known masses and moment of inertia factors calculated from Galileo data. When stripped of their ice shells, Ganymede has a smaller moment of inertia factor and larger density than Europa. Thus with the same silicate mantle composition, Europa's core must be less dense than Ganymede's. We take the bulk concentration of Sulphur in the iron-silicate deep interiors of the satellites to be about 2 weight-% (Lodders and Fegley, 1998) and assume that the Sulphur is entirely in the core. We then find that Ganymede should have 15 to 20 weight-% Sulphur in its core while the Europan core typically has Sulphur concentrations of 20 weight-% or more. The latter concentration is approximately equal to the eutectic composition in the Fe-FeS system at Europa and Ganymede core pressures (Fei et al., 1997). For about 15 weight-% Sulphur, core freezing is feasible. At the eutectic composition, the melting temperature is about 1100 K (Fei et al. 1997) and core freezing is unlikely. For larger Sulphur concentrations the usual chemical dynamo will not work. The potential for dynamo action on the FeS rich part of the eutectic is largely unexplored, however. Fei et al. 1997, Science 275, 1621-1623; Lodders and Fegley 1998, The Planetary Scientists Companion, Oxford Univ. Press; Kuskov and Kronrod 2001, Icarus 151, 204-227. Wienbruch and Spohn 1995, Planet. Space Sci. 43, 1045-1057.

P21A-02 0845h

Thermal Equilibrium in Tidally Heated Bodies and Europa's Special Place

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The strong temperature dependence of the viscosity of planetary materials leads to an interesting coupling between heat generation and heat transport in tidally heated bodies. As a result of this coupling, multiple thermal equilibria exist, some stable and some unstable. For rocky bodies such as Io, heat transport by melt segregation can balance tidal heat production at temperatures somewhat above the solidus, corresponding to at about 20% fractional melt abundance. A higher temperature equilibrium between convection in a mostly molten suspension is also stable, but is inconsistent with Io's large heat flow. In icy shells such as exist on Ganymede and Europa, melt segregation does not contribute to heat transport, instead the negatively buoyant melt segregates downward, reducing the thickness of the solid ice shell. Europa is in a special position, where the orbital period (3.6 days) is very nearly the Maxwell time of ice at the solidus. If the orbital period is longer than the Maxwell time at the solidus, then a stable thermal equilibrium exists between tidal heating and convection with an internal temperature very near the solidus. In this case, high-viscosity downwellings have Maxwell times nearer the orbital period and therefore experience more heating than low-viscosity upwellings, melting is suppressed (due to the lower heating rates in warm ice), and the equilibrium is stable for shells of arbitrary thickness. If the orbital period is shorter than the Maxwell time at the solidus, then the nature of the thermal equilibrium is quite different. The equilibrium is unstable with respect to temperature perturbations, but melt segregation or re-freezing at the base of the shell can act to stabilize it through the dependence of tidal heat production on the ice thickness. Both quasi-equilibrium and time-dependent calculations are used to investigate the nature of this equilibrium. The possibility exists that Europa went through a transition as the orbital period increased (due to dissipation in Io) from a state in which the equilibrium is unstable to thermal perturbations to one in which the equilibrium is stable. Also, tidal heating in the ice may be on the decline if the orbital period is now longer than the Maxwell time at the solidus.

P21A-03 0900h

Europa's Hydrogen Atmosphere

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Europa's Hydrogen Atmosphere The presence of a tenuous atmosphere on Europa consisting of a column of (2 - 15) x 10^{14} cm^{-2} of O_2 has been inferred from the measurements of OI 1304 emissions (Hall et al. Nature 373, 1999 and Astrophys. J. 499, 1998). Model calculations (Shematovich and Johnson, Adv. Space Res 27, 2001; Marconi DPS meeting, 2003; and Shematovich et al., preprint, 2004) have since elucidated the structure of the oxygen atmosphere and shown that such columns are obtainable for the expected sputtering rates at Europa. Hydrogen, however, is also produced in substantial amounts by sputtering of Europa's largely H_2O surface by energetic heavy ions and to a lesser extent by sublimation of H_2O. We have calculated Europa's H and H_2 atmosphere using a 2 D hybrid fluid/kinetic model (Marconi, Icarus 166, 2003) and the resulting Europa H torus with the AER Neutral Cloud Model (Smyth and Combi, Astrophys. J. 328, 188). We find that while oxygen dominates near the surface,hydrogen is the principal species at higher altitudes. We also find the hydrogen is the most abundant of the escaping species, and hence, an important source for the Europa neutral gas torus. Results for the structure of Europa's hydrogen atmosphere and escape will be presented. The Europa hydrogen torus and some implications for energetic neutral particles measured by Cassini (Mauk et al., Nature 421, 2003)will also be discussed.

P21A-04 0915h

First Results from the D-CIXS X-ray Spectrometer on the ESA SMART-1 Lunar Mission.

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The DCIXS (Demonstrator Compact Imaging X-ray Spectrometer) on the recently launched ESA technology demonstration mission SMART-1 consists of a high throughput spectrometer, which will perform spatially localised X-ray fluorescence spectroscopy, and a solar monitor to provide the calibration of the illumination necessary to produce a global map of absolute lunar elemental abundance. The objective is to provide high quality spectroscopic mapping of the Moon, while at the same time demonstrating a radically novel approach to instrument building. D-CIXS will provide the first global coverage of the lunar surface in X-rays, providing measurements of Fe, Mg, Al and Si under normal solar conditions and several others during solar flare events. The combination of DCIXS data with information obtained from other instruments on SMART-1 and from previous missions, will allow a more detailed look at some of the fundamental questions that remain regarding the origin and evolution of the Moon and will help us to map Lunar resources more effectively. DCIXS will also carry out cruise science. We will present first results.

P21A-05 0930h

Internal Structure and Thermal Evolution of Massive Extra-Solar Planets

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In the past decade Astronomers have found approximately 120 planets orbiting Sun-like stars. Currently, the detection capabilities restrict the findings to very massive objects. It is presumed some extra-solar planets could be Earth-like in composition. The internal conditions and structures of these planets would have similarities with the Earth's, but due to their much larger mass and different conditions (i.e. Extremely hot surface temperature) their properties are expected to differ considerably. With the use of EOS for terrestrial planets and physical laws we are obtaining radial structure profiles (density, pressure, mass, temperature) for massive Earth-like planets. Parameter space in properties is being explored to study the implications, such as the presence of a liquid core and thermal history of these planets.

P21A-06 0945h

Cosmology of the Solar System

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The early solar system accreted from ice crystals, which encapsulated the refractory elements. Ice was needed to bind the smallest particles, so accretion only occurred in the outer solar system. Solar wind gusts expelled dust in the inner solar system to where it became accreted into the giant planets. Thus, the original solar system comprised four giant planets, accreted from ice and dust. Their initial accretion was rapid, forming rocky iron cores from the refractory elements. But due to their great orbital radii, the entire process required more than 50 million years, so the bulk of the process was cold. Studies of young Sun-like stars show that hydrogen gas is expelled from the nebula before the accretion had hardly begun. As a result these are all solid bodies and not gas giants. The recognition that Jupiter is solid was masked by a high energy impact which occurred 6,000 years BP. The hot gases still streaming from the impact crater heat the atmosphere, forming the GRS, while the planet remains frozen. The temperature excesses, thought to be primordial, are an important factor in the gas giant assumption. Scientists have come close to recognizing the true nature of these bodies in recent years, due to the study of clathrates beneath the our oceans. These strong, low density structures of water molecules form naturally at low temperature and high pressure, exactly the conditions in the large bodies of the outer solar system. Their properties are responsible for the low average density of the giant planets. Clathrates encapsulate foreign molecules, such as methane. One expert has proposed that clathrates

are the most abundant form of matter in the outer solar system - the Galilean moons, Pluto, Charon and the KBOs. However, until now, no one has suggested that the giant planets themselves are so composed, moreover that these bodies alone comprised the original solar system. The terrestrial planets result from later, high energy impacts on the giant planets. Fortunately, the birth of a new terrestrial planet, Venus, occurred within proto-history and the entire process is documented in ancient writings. It formed as a result of the impact on Jupiter cited above, expelling a plasma cloud several times the mass of Venus and thousands of times the volume of Jupiter. Most escaped Jupiter and entered an eccentric planetary orbit, while contracting to a star-like proto-Venus, with a temperature above 10,000K. Its perihelion, close to the ancient interior orbit of Mars, and its aphelion, at the orbit of Jupiter, gave it a period of some five years. But its great orbital energy was rapidly reduced, due to repeated interactions with Mars and the Sun at perihelion. The tidal force of the Sun and its magnetic field combined to heat the ionized, fluid body, slowing its orbital velocity. Each pass reheated it, further reducing its aphelion and increasing the frequency of interactions. Its repeated heating caused the out-gassing of most lighter elements to space by Jeans escape. Thus the loss of orbital energy resulted in the increasing of its average density from 1.3 gm/cm3, the density of Jupiter, to over 5.5 g/cm3, the density of Venus. This is how all terrestrial planets were formed. This catastrophic birth ensures the concentration of iron in the core, the rising of hot radioactive elements Th, Ur, K, and the less dense materials to the surface. Although the volatiles, H2, C, N, O2, which comprised the vast majority of the rebounded cloud, were initially lost, they remained in the inner solar system, to be captured later by the proto-planet as it cooled or by extant planets, thereby rapidly providing the elements necessary for life.

P22A CC: 519 B Tuesday 1030h

Planetary Science General Contributions II *(joint with A, GP, T, V, NG)*

Presiding: **M Grande,** Rutherford Appleton Laboratory**; W B Moore,** University of California, Los Angeles

P22A-01 1030h

Atmospheric Science by the Mars Exploration Rovers.

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While the Mars Exploration Rovers were primarily designed to address geologic questions on Mars, they have also proved to be capable and innovative atmospheric science platforms. We have used the rovers for both characterization and monitoring studies of the martian lower atmosphere in both the Gusev and Meridiani sites. The bulk of our observations fall in the following categories: (1) Thermal infrared spectra of the Martian sky taken by the Miniature Thermal Emission Spectrometer (Mini-TES). The actual sequences consist of both standard 200-second integrations and long "stares" of up to (almost) an hour. These data are highly diagnostic of vertical thermal structure (from 10 meters to 3-5 kilometers), aerosol optical depth along with particle size, and under the right thermal conditions, the water column. (2) Direct solar imaging using the Panchromatic Camera (Pancam) with the 440/880 nm + neutral density (ND5) filters, providing accurate measurements of visible optical depths. (3) Near-sun and "sky-arc" sequences using Pancam's full suite of geological filters, intended to capture the forward-diffraction peak and the phase function characteristics of the aerosol particles. (4) Carbon dioxide (15 micrometer band) profiling of the Mini-TES surface observations, providing an average near-surface (1 m) air temperature. The above activities have been used to characterize short-term, diurnal and secular trends, and to also examine spatial variability. In addition, serendipity has provided the unique opportunities of watching the decay of a moderate dust storm from two widely-separated sites as well as of multiple simultaneous orbiter-rover observing "campaigns." The latter group includes thus far the Mars Express over-flights of Spirit on sols 13A and 29A and the nearly-nadir Mars Global Surveyor over-flight of Opportunity on sol 22B and Spirit on sol 45A. Finally, we have taken sunset movies to further diagnose the aerosol scattering properties and their vertical distribution. During our presentation, we will summarize the breadth of the atmospheric results, highlighting the novel contributions that the MER suite of instruments has provided to advance our understanding of the martian atmosphere.

P22A-02 1045h

Initial Results on the Mineralogy and Geochemistry of the Mar Exploration Rover Gusev Landing Site

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The Spirit rover has investigated the geochemistry and mineralogy of the Gusev crater site using in situ Alpha Proton X-Ray, Mossbauer, visible, and infrared spectroscopy. The Gusev site is covered with angular to sub-rounded rocks that are typically less than 1 m in maximum dimension. More than 90 percent of these rocks are dark-toned, with the remainder being lighter-toned rocks that may predominantly be dark rocks with a thin (10's of microns) coating of easily removed fines. APXS analysis has been obtained of a rock (Adirondack) following the removal by grinding of the surface dust and the upper few mm of the rock surface. These data give a modal mineralogy corresponding to olivine basalt. High quality Mini-TES data have not been obtained of a completely dust-free rock surface. The Mini-TES data of Adirondack do show long wavelength (15-25 microns) absorptions due to olivine of composition Fo60. All of the rocks observed are very compositionally homogeneous in the Mini-TES spectra. These findings are consistent with the detection of olivine-bearing basalt at this site from orbital TES infrared spectroscopy. Mossbauer spectra of Adirondack show the presence of forsteritic olivine and magnetite, with possible pyroxene. The soils at Gusev are a mixture of reddish fine-grained to sandy materials, granular-sized particles that occur in ripple forms, and minor pebbles. Mini-TES spectra of the soil show an excellent match to the TES spectra of high-albedo, fine-grained material found in regional bright regions that is interpreted to be windblown dust. This agreement suggests at least the uppermost layer of the soil at Gusev has been accumulated from airfall dust. By analogy with prior analysis of TES data these materials contain several percent carbonate, minor bound water, and a framework silicate interpreted to be either feldspar or zeolite. APXS spectra show similar oxide abundances to those determined for the Pathfinder site, except for higher MgO, and lower total iron. The preliminary potassium abundances are lower than predicted from orbital GRS data. The material that fills small hollows is finer-grained than the surrounding soils based on temperatures from Mini-TES, and may be predominantly airfall dust. To date there is no evidence from the mineralogy and geochemistry of the materials at Gusev to support the hypothesis that the surface materials being sampled were deposited in a lacustrine or evaporite environment. The data are consistent with materials formed by volcanic processes similar to those found throughout much of the equatorial and mid-latitudes, and locally redistributed by impact and aeolian processes.

P22A-03 1100h

Isolating Diffraction Signatures in New Horizons Multi-tone Radio Occultation Data and Resolving Their Related Structures at Pluto

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A planetary radio occultation experiment typically consists of a single tone transmitted toward a receiver as the line of sight is obscured by, or emerges from, the planet limb. Phase shifts in the tone are recorded and are attributed, in part, to the presence of a refracting atmosphere. Under the assumption of a spherically symmetric atmosphere with no "small-scale" structure, the Abel inversion may be applied to the phase data in order to recover an atmospheric refractivity profile. Unfortunately, being rooted in geometrical optics, the Abel inversion does not account for wave optics effects such as diffraction, which can arise from sub-Fresnel-scale structure (e.g., temperature inversions, waves, planet limb). When applied in the presence of such features, the Abel inversion produces atmospheric profiles blurred by diffractive ringing. To resolve sub-Fresnel-scale structure, more advanced inversion techniques, such as back propagation, have been developed that allow for profiles with resolutions better than the size of the first Fresnel zone - an order of magnitude better in some cases. By using multiple tones that are closely spaced in frequency, the New Horizons Radio Occultation Experiment (REX) will attempt to generate several atmospheric profiles of Pluto from a single fly-by, which includes both ingress and egress occultations. Since Pluto has a very tenuous atmosphere, it is expected that limb diffraction from each tone will dominate over any phase signature from atmospheric structure. Consequently, successful construction of atmospheric profiles for Pluto requires an inversion method that accounts for limb diffraction from not one but multiple carriers. This research presents the results of ongoing investigation into the interaction of multiple tones in radio occultation (most notably for New Horizons REX) and the effect of additional carriers upon wave optics inversion methods, i.e., back propagation. Also, various techniques for isolating each carrier, including their corresponding frequency signatures from planetary structure (diffractive and otherwise), are explored.

P22A-04 1115h

Shock Features of the Vargeão Dome Structure, Santa Catarina, Brazil

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The circular Vargeão structure, approximately 12 km in diameter, lies in western Santa Catarina state, Brazil. The structure is characterized by a central domed uplift of shocked and brecciated late Paleozoic/Mesozoic quartzose sediments, surrounded by brecciated basaltic flows of the early Cretaceous Serra Geral Formation within the Paran á Basin. Structural aspects of possible impact origin include radial and annular fracture patterns with apparent vertical slickenlines. Distinct mesoscale shock features (ie. especially an ejecta blanket and impact melt) are absent, presumably due to erosion, but their absence has promoted the consideration of alternative geologic origins. Qualitative and quantitative documentation of petrofabric shock features are presented that are consistent only with a meteorite impact origin. Four distinct orientations of planar deformation features in quartz and shock features in plagioclase along with secondary zeolitization will be described. Detailed studies of unit cell dimensions emphasizing shocked quartz are underway. The Vargeão impact structure is one of few known terrestrial impacts in basalt target rocks; comparisons with the other terrestrial impacts in basaltic target rocks will be presented.

P22A-05 1130h

Saturn's Atmosphere and rings: A Recent Assessment Using Infrared Imaging

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For the past several years, a program devoted to understanding the Saturn system prior to the arrival of the Cassini spacecraft has used thermal infrared imaging to define the variability of temperature, cloud properties, and minor constituents in the atmosphere, together with thermal properties of the ring system. This research, sponsored by NASA programs at the Infared Telescope Facility and the W. M. Keck Observatory on Mauna Kea, Hawaii, has used images at wavelengths between 5.2 and 24.3 μm. Thermal features have been noted which change with time, particularly in Saturn's south polar region. Upper stratospheric temperatures are distinctly higher at latitudes poleward of 83°S; this is also true of the lower stratosphere/upper troposphere where the region within 1° of the pole is paricularly warm. A series of alternating warm and cool axisymmetric bands characterizes the morphology of the tropospheric temperature field at "midlatitudes" from approximately 45° to 83°S. Zonal wave features are present in Saturn's upper troposphere, achieving particular prominence in a moderately warm band between approximately 35° and 45° S and in the warmest band

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