Planetary Sciences

P11A CC: 519 B Monday 0830h

Small Bodies of the Solar System

(joint with V)

Presiding: **A R Hildebrand,** University of Calgary; **R Binzel,** Massachusetts Institute of Technology

P11A-01 0830h INVITED

Compositional Properties of Near-Earth Objects

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The near-Earth object (NEO) population contains the immediate precursors to meteorites studied in our laboratories. All meteorites, by definition of their intersection with Earth, were NEOs prior to their arrival. Because NEOs have dynamical lifetimes that are short (due to collisions with the sun, planets, or ejection) compared with the age of the solar system, all currently observed asteroid-like NEOs must have been supplied from reservoirs of small bodies such as from the main-asteroid belt or from extinct short period comets. Thus NEOs are the nexus of our study of asteroid-comet-meteorite relationships. What's more, by virtue of their proximity NEOs are the smallest observable planetary bodies, thereby providing a challenge to our understanding of planetary processes in low gravity regimes. Their proximity allows detailed study by radar and also makes them among the most easily accessible solar system destinations for sample return missions, human exploration, and space resource utilization. The small, but non-zero chance of a hazardous impact over human lifetimes brings a further pragmatic reason for NEO studies as well. In this talk we will overview our current understanding of NEO compositions and their links to meteorites. A particular focus will be on new insights to likely processes of space weathering that appear to be highly dependent on the surface age or the ability of a surface to retain a regolith. The diversity of NEO compositions appears to match that of the main asteroid belt. Some signatures of specific main-belt asteroid source regions are recognizable within the NEO population. In addition, compositional and source region signatures of NEOs suggest that the cometary contribution to the NEO population may be somewhat larger than previously thought.

P11A-02 0850h INVITED

Radar Investigations of Asteroids

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Radar investigations have provided otherwise unavailable information about the physical and dynamical properties of about 230 asteroids. Measurements of the distribution of echo power in time delay (range) and Doppler frequency (line-of-sight velocity) provide two-dimensional images with spatial resolution as fine as a decameter. Sequences of delay-Doppler images can be used to produce geologically detailed three-dimensional models, to define the rotation state precisely, to constrain the internal density distribution, and to estimate the trajectory of the object's center of mass. Radar wavelengths (4 to 13 cm) and the observer's control of transmitted and received polarizations make the observations sensitive to near-surface bulk density and macroscopic structure. Since delay-Doppler measurements are orthogonal to optical angle measurements and typically have much finer fractional precision, they are powerful for refining orbits and prediction ephemerides. Such astrometric measurements can add decades or centuries to the interval over which an asteroid's close Earth approaches can accurately be predicted and can significantly refine collision probability estimates based on optical astrometry alone. In the highly unlikely case that a small body is on course for an Earth collision in this century, radar reconnaissance would almost immediately distinguish between an impact trajectory and a near miss and would dramatically reduce the difficulty and cost of any effort to prevent the collision. The sizes and rotation periods of radar-detected asteroids span more than four orders of magnitude. The observations have revealed both stony and metallic objects, elongated and nonconvex shapes as well as nearly featureless spheroids, small-scale morphology ranging from smoother than the lunar regolith to rougher than the rockiest terrain on Mars, craters and diverse linear structures, non-principal-axis spin states, contact binaries, and binary systems.

URL: http://echo.jpl.nasa.gov/

P11A-03 0910h INVITED

A Study to Determine the Feasibility of Extending the Search for NEOs to Smaller Limiting Diameters: Report of a NASA Science Definition Team

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In 1998, NASA formally commenced efforts toward the goal of finding and determining the orbits of at least 90% of all near-Earth asteroids with diameters 1 Km or larger by 2008. The 1 km diameter metric was chosen after considerable study indicated that an impact of an asteroid greater than 1 km would likely cause a worldwide catastrophe and could potentially result in worldwide damage up to and including extinction of the human race. The NASA commitment has resulted in the funding of several focused asteroid search efforts that are making considerable progress toward the 90% by 2008 goal. To date, more than 50% of the expected population of these large asteroids capable of passing near the Earth has been discovered and the discoveries continue at a high rate. While the current goal covers the larger objects, which could cause global devastation, it is silent on the much more numerous smaller objects (between 50 meters and 1 km diameter) that could cause local or regional damage should they impact. Given the significantly larger population of Near Earth Asteroids (NEAs) with decreasing diameter, it is much more likely that civilization will experience the impact of an asteroid smaller than 1 km than a larger event. In addition, the public and the science community are beginning to see more information on objects with smaller diameters. Because the current asteroid survey programs are designed to find the "large" threatening objects, they now search a large enough portion of the sky each month that many smaller objects are found as well. These detections are expected, and should be viewed as an indication of the increasing capabilities of the search programs; however, in some cases the discoveries have been interpreted by the press and public as surprising and threatening. Since the existing search programs are making good progress toward meeting the current goal, given the emerging discussion of smaller objects it is natural to ask what, if any, action should be taken to catalogue or warn against potential impacts of objects smaller than 1 km in diameter. From August 2002 to June 2003, NASA commissioned a Science Definition Team to develop an understanding of the threat posed by smaller objects and to assess methods of detecting them and providing warnings of any potential impacts. The Team provided recommendations to NASA and outlined an executable approach to addressing any recommendations made. Specifically, the team was chartered to address the following questions: 1. What are the smallest objects for which the search should be optimized? 2. Should comets be included in any way in the survey? 3. What is technically possible? 4. How would the expanded search be done? 5. What would it cost? 6. How long would the search take? 7. Is there a transition size above which one catalogs all the objects, and below which the design is simply to provide warning? The Team has conducted an in-depth analysis of the asteroid impact hazard and methods for characterizing the risk by discovering and cataloguing the potentially hazardous asteroid population. A cost/benefit approach was used to analyze the effectiveness of a broad range of search methods and technology and to provide answers to the seven specific questions stated above. This work was sponsored by the National Aeronautics and Space Administration under Air Force Contract F19628-00-C-2002. "Opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the United States Government."

P11A-04 0930h

Resonant and Co-orbital Asteroids Associated with Earth

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There are presently 18 asteroids known with semi-major axis between 0.99 and 1.01 AU and thus potentially affected by resonant interaction with the Earth. Of these, 2002 AA29 and 2003 YN107 move on low-eccentricity orbits very similar to that of the Earth, with moderate inclinations of 4 and 11 degrees. These objects both have horseshoe orbits with respect to Earth and are capable of being captured as quasisatellites (which 2003 YN107 currently is). Two other objects are known to have horseshoe orbits deviating further from Earth's orbit. 54509 (2000 PH5) and short-arc object 2001 GO2 have eccentricities of about 0.2 and low inclinations. The remaining objects have eccentricity higher than 0.2 and may have high inclinations. At least one such object, 3753 Cruithne, nevertheless has a complex horseshoe-like orbit with respect to Earth. We summarize this group of objects through statistics of their orbital parameters and characterization of the nature of their interaction with Earth. We find that some of this group are suitable targets for space missions, with the known objects on very Earth-like orbits not energetically the most favorable largely due to their inclinations. Other factors than energy may be important. Relatively long periods spent near Earth when at one end of a horseshoe orbit favor mission operations, whereas the small size of objects known to date would present a targetting challenge. The objects investigated to date have shown relatively short periods of stability in their current orbits and are thus not likely primordial. They likely are recent arrivals from the asteroid belt, as is suspected to be the case for most other near-Earth asteroids.

P11A-05 0945h

Compressional and Shear Wave Velocities in Meteorites

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Elastic properties of asteroids govern much of their response to impact events, and are germane to impact mitigation and exploitation strategies. However, elastic wave velocities have been one of the least explored physical quantities of meteorites. Velocities measured to date (roughly 30 determinations) show a wide range for both compression and shear wave velocities and a strong dependence upon porosity. We have measured compressional and shear wave velocities in 72 meteorites. Meteorites were measured in the form of slabs as commonly found in collections. Pieces with two roughly parallel flat sides are required to accommodate the velocity transducers' shape. Each measurement was made three times at different positions to improve statistics and to test for sample variation. Bulk densities were measured with a modified Archimedean method using 1 mm-diameter glass beads. Porosities were measured for 9 specimens in a commercial He pycnometer. Porosities for other meteorites measured were taken from literature sources. Bulk and grain densities and porosities were generally found to be consistent with previous work, although rare large discrepancies were found. Seismic velocities were also found to be generally similar to previously obtained values. Various relationships have been quantified; velocity vs. fall date, class, petrologic type, porosity, bulk density, and darkness. Derived relationships were generally restricted to only the data obtained for ordinary chondrites, as they constituted the largest sampled population (and presumably represent the bulk of the undifferentiated asteroids). Falls from the last 50 years exhibit a smaller range of velocities indicating that older samples have experienced variable subtle weathering effects (probably crack propagation vs. filling pores by secondary minerals) from exposure to the Earth's atmosphere. This indicates that meteorite physical property studies as proxies for asteroidal properties must be restricted to the freshest possible material, and that recently fallen meteorites must be curated in inert atmospheres. Velocities inversely correlate to porosities as found in previous work, but were also found to correlate (inversely) to petrologic type in contrast to previous work. Possible darkening due to weathering complicates interpreting the observed correlation between velocity and the darkness of a meteorite (presumed to be related to shock history).

P11A-06 1030h

Measuring the Meteoroid Bombardment History of the Inner Solar System With Lunar Glass Spherules

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We are using lunar glass spherules to measure changes in the meteoroid bombardment of the inner solar system through the last four billion years. Spherules, which range in size up to a few hundred microns in diameter, are formed in meteoroid impacts and volcanic fire-fountaining events on the surface of the Moon. The ages of formation of the impact spherules, which we determine using the $^{40}Ar/^{39}Ar$ isochron technique, record the timing of the impacts that produced them. The distribution of 155 ages of spherules taken from Apollo 14 soil sample 14163 (which we reported in 2000 in Science 287, 1785) showed a gradually decreasing abundance of spherules formed from 3.0 to 0.4 Ga as the solar system matured, and then a surprising fourfold jump in spherule production in the last 400 Myr. We now seek to learn whether the recent increase in spherule production is due to increased meteoroid bombardment since that time, an increase in the efficiency of spherule creation in impacts, or a change in preservation conditions at the Apollo 14 landing site. To determine whether the abundance of young spherules truly implies a Solar System-scale phenomenon, we are repeating the experiment with samples from a different location on the Moon. We have selected 178 spherules from Apollo 12 soil 12023 which, like 14163, was taken from the ejecta of a recent bedrock-penetrating impact, and therefore should offer a representative selection of spherules from various depths in the regolith. These spherules are each larger than 180 microns in diameter, and, because precision of our age measurements is limited by the scarcity of K, the larger size of these spherules relative to those in our previous study should compensate for the somewhat lower K content of Apollo 12 soils. Chemical compositions, which we measured using energy dispersive x-ray spectrometry, imply that nearly all the Apollo 12 spherules were produced in impacts rather than in volcanic eruptions. Impact origin is indicated by Fe-Ni surface grains, chemical heterogeneity, and low Mg/Al ratios. Radioisotopic age measurements on the spherules are now under way. If the Apollo 12 measurements confirm our earlier observation that the meteoroid bombardment has been four times higher over the last 400 Myr than previously, we shall need to consider where a new population of impactors could have come from, how long such epochs of high meteoroid flux last, and how significant such periods might be for the evolution of life on Earth.

URL: http://jlevine.lbl.gov

P11A-07 1045h

Chromium-Isotope and iridium-Abundance Measurements for Late Eocene Impact-Derived Spherule Deposits

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The late Eocene (approx. 35 Ma) was a time of multiple large body impacts superimposed within an interval of dust accretion. At least two spherule layers are preserved in deep sea sediments: North American microtektites and the slightly older cpx spherules. The two largest impact structures in the Cenozoic, the 45 km Chesapeake Bay structure and the 100 km Popigai structure, are indicated as the respective spherule sources. Enhanced 3He concentrations extending across a 3 m.y. duration in upper Eocene sediments from the Massignano quarry in Italy indicate accretion of <50 micron dust over this time interval. To characterize one of the impactors we have analyzed splits from the 125-250 micron cpx spherules from ODP 709C, and two fractions from the Massignano layer. Splits of each sample were analyzed for minor and trace elements by instrumental activation analysis (INAA) including Ir, Cr, Fe, Ni, and Co. Additional splits were analyzed for their Cr-isotopic composition, using thermal ionization mass spectrometry. Significant concentrations of Ir were found in all samples, with the highest levels in the Massignano coarse sample and the lowest in the 709C sample. In all cases, element/Ir ratios are much higher than in chondritic meteorites; this may reflect elemental fractionation due to preferential concentration of Cr in spinel growing in the impact fireball. The Cr-isotopic compositions of the 709C and Massignano coarse samples are both non-terrestrial with a positive epsilon 53, indicating a 53Cr/52Cr ratio higher than in terrestrial materials. Microprobe surveys showed that the Massignano samples had significant fine grained oxide grains (mixed with the spherules in the coarse sample) that were not Ni- or Cr-rich, including Ti-rich spinels (likely terrestrial contaminants). In contrast, the ODP 709C sample is a pure extract of generally well-preserved cpx spherules composed of clinopyroxene in a glass matrix. Both the Massignano coarse and the 709C cpx samples have sufficiently high epsilon 53 values that it is clear that a large proportion of their Cr is from meteoritic sources. The positive epsilon 53 values and normal terrestrial 54Cr/52Cr ratios for these samples exclude carbonaceous chondrites as a source for the meteoritic component - all measured C-chondrites [1] have excess 54Cr. Our results are generally consistent with an ordinary chondrite source for the Cr. An ordinary chondrite source for the largest of the Late Eocene impacts permits an H chondrite projectile. We note that the 35 Ma spike in cosmic ray exposure ages for the H chondrites [2] could be an indication of a major disrupting collision in the asteroid belt. Simulations indicate that an asteroid shower initiated by disruption of a large asteroid near a Main Belt resonance can have durations as short as 5 m.y. [3], but repeated collisions of disrupted fragments would be necessary to keep dust levels sufficiently high for 3 m.y. to explain the 3He peak at Massignano. If the Late Eocene impact flux peak in multi-kilometer to dust-sized projectiles is due to an H chondrite asteroid disruption event, several implications for Solar System history follow. [1] Shukolyukov et al. (2003) LPSC XXXIV, abs. 1279; [2] Marti, K. and Graf, T. (1992) Ann. Rev. Earth & Planet. Sci. 20, 221; [3] Zappala et al. (1998) Icarus 134, 176.

P11A-08 1100h

The Trajectory, Orbit, and Acoustical analysis of the Park Forest Fireball

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The Park Forest meteorite fall of March 27th, 2003 was the first large bolide to occur over a major urban area in modern history. As such, characterizing various aspects of the event has been the subject of particular interest. This has been made possible due to the wide array of different instrument detections. Instrumental recordings of the Park Forest fireball include eyewitness video, optical and infrared light observations by orbiting satellites and acoustic recordings by audible sound, infrasonic and seismic instruments. Optical and infrared satellite observations fused with data from ground based video have allowed an accurate determination of the fireball's trajectory and velocity. The trajectory along with modelled atmospheric conditions has in turn allowed the source regions for audible acoustic and seismic recordings of the fireball's sound waves to be identified. These sources are consistent with the sound waves originating from several major fragmentation points along the fireball's path. Infrasonic recordings appear to be typical of stratospherically ducted waves. The best estimates of the original size of Park Forest is 1.5m with an observed entry velocity of 20 km/s implying an energy of 0.5 kTon TNT equivalent. Finally by employing the same model atmosphere, dark flight paths of the soon-to-be meteorites were modelled using the major fragmentation altitudes as possible ejection points. Results show that fragments ranging in size from 5 kg to 2 g agree very well with recovery observations, falling within and around the known meteorite strewn field and being released at altitudes from 38 - 22 km. This suggests that fragments may have ejected at wide a range of altitudes and that the bolide travelled through the atmosphere as a conglomeration of fragments and not as a single large stone. The observed fragmentation occurred under ram pressures of 2-7 MPa, with early minor disruption under at less than 1 MPa. This provides an estimate for the limiting tensile strength for meter-class near-Earth asteroids - implications of this observation will be discussed in the talk.

P11A-09 1115h

Modeling Large Radar Observations of Meteors

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Despite decades of research, many questions on the global flux of meteoroids at Earth remain unanswered. We see large radar observations of meteors taken at the Arecibo, Jicamarca, ALTAIR, EISCAT and other facilities as a valuable tool for answering these questions. To improve our understanding of meteor radar observations, we model both the origin of head echo reflections and non-specular trails. To study the non-specular trails, we conducted plasma simulations demonstrating that meteor trails are unstable to growth of Farley-Buneman gradient-drift (FBGD) waves. These waves rapidly become turbulent and generate large B-field aligned irregularities (FAI) which result in radar reflections called non-specular meteor trails. To understand the head echoes (reflections from the leading edge of the meteor plasma), we model the ablation and ionization processes that create meteors. Combining these models allows us to follow meteor evolution from ablation and ionization to diffusion into the ionosphere. We will present results from this model showing that we can reproduce many aspects of these large radar observations, allowing us to better interpret meteoroid properties such as number, mass, velocity, and provide some composition information.

P11A-10 1130h

The Detection of Moonlets Near Amalthea

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On November 5, 2002, the Galileo spacecraft crossed the orbit of Amalthea. Two instruments, the Energetic Particles Detector (EPD) and the Star Scanner, recorded evidence of approximately 12 moonlets along and near Amalthea's orbit. The EPD detected the moonlets as absorption features in the flux of energetic electrons. The Star Scanner made optical observations of the moonlets by detecting them as flashes of light. We provide size estimates of the moonlets. For several of these bodies, which were observed simultaneously by both instruments, we can provide the instantaneous location, although not necessarily the orbits. We also attempt to constrain the albedo of some of the moonlets.

P11A-11 1145h

Modeling the effect of solar wind discontinuities on the plasma tail of a comet

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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