P12A MC: Hall D Monday 1330h

Galileo's Polar Io Flybys: Magnetospheric and Geologic Observations II *(joint with SA, SM)*

Presiding: **P Geissler,** Univ. of Arizona

P12A-0491 1330h POSTER

Heat Transport by Melt Segregation in Io

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Silicate volcanism is well established at Io, adding to the curiosity of Jupiter's innermost large satellite. It is clear that a balance between tidal heating and convective heat transport in Io results in a stable equilibrium with internal temperatures are somewhat above the solidus, because dissipation is still increasing as the solidus is crossed. As the rocks of Io's mantle begin to melt, an interconnected network of melt forms, allowing the less dense melt to percolate upwards. In steady state, this melt is replaced by a slower flow of solid downward. The net result of this segregation is the transport of latent heat with the melt, which eventually is deposited at the surface. Quantitative solution of the equations of melt transport coupled to tidal heating rates derived from a layered, Maxwell-viscoelastic model of Io reveal that the heat transported by melt segregation overwhelms (and shuts down) convective heat transport in Io's mantle when melt fractions exceed a few percent. This leads to a new heat balance in Io, which predicts maximum melt fractions less than 20%, and interior temperatures near the solidus. Since the solidus temperature increases with pressure, the deep mantle is probably convecting. Combining parameterized convection models with melt segregation heat transport and a parameterization of heat-pipe transport in the lithosphere allows the calculation of Io's internal temperatures consistent with the surface heat flow.

P12A-0492 1330h POSTER

Is Io's Mantle Really Molten ?

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The tidal deformation responsible for the intense volcanic activity at the Io's surface, dissipates a prodigious amount of heat in Io's interior. The averaged surface heat flux is $2.5 W/m^2$. In order to extract heat by magma through isolated vents, we have introduced an open boundary condition at the top surface, in both spherical and cartesian models of convection with pure internal heating. We find that the averaged temperature Rayleigh number relationship follows a power law function with an exponent of -0.5 instead of -0.25 with an impermeable boundary condition. This suggests that Io's mantle is mainly solid for a Rayleigh number between 10^6 and 10^8, and that melting occurs only at the base of the mantle and inside plumes. Hot plumes are the only consequence of a permeable boundary and are not observed in the classical case of impermeable boundary and pure internal heating. Even if, plumes are more easily reliable to the hot spots observed at Io'surface, their number in the model is in agreement with the observation only when the convective layer thickness does not exceed $200 km$, suggesting a two layer mode of convection or a convection restricted to the crust. In order to investigate the possible convection modes established in the crust, we have developed a two layers model of convection, in a cartesian framework, where a $150 km$ thick crust overlies the mantle. the top boundary is permeable and a free slip boundary condition is imposed at the crust-mantle boundary. The internal heating is concentrated in the mantle. We find for a Rayleigh number in the crust of 10^7, that the crust is globally solid and only molten in a greater number of plumes, and the mantle beneath is partially molten.

P12A-0493 1330h POSTER

Electron Acceleration by Plasma Waves in the Io Flux Tube

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Ios interaction with the jovian magnetosphere generates auroral and radio emissions. The underlying electron acceleration process is not well understood and only few observations exist to constrain the theoretical models. The Galileo spacecraft made a number of low altitudes passes near Io and the plasma wave/particle instruments have collected new information. The source of energy for the electron acceleration is in all likelihood supplied from the Alfvn wings that stretch out from both poles of Io into the two Jovian hemispheres. Here we will present observations that help understand how the electromagnetic energy in the Alfvn wings is transformed into particle acceleration.

In particular, intense electromagnetic waves at frequencies up to several times the local proton gyrofrequency have been observed while Galileo was passing over the south and north poles of Io (flybys I25 and I31, respectively). Hot and warm parallel electron beams have been observed during the I0 and I27 flybys, respectively. For some technical reason no particles instrument was on during I25. At the time that this abstract is written data are not yet available from the I32 south polar pass but observations similar to those obtained during the I25 and I31 flybys are expected. We suggest the following three-steps acceleration process: (1) Due to the strongly inhomogeneous conductivity of Io's ionosphere, the currents flowing along the Alfvn wings are distributed inside the whole Alfvn tube and not only on its surface. (2) As the plasma density of the Io torus decreases with increasing latitude, the currents of the Alfvn wings become strongly unstable for "high-frequency/small scale" electromagnetic waves. (3) The current driven "high-frequency/small-scale" waves generated in the direction of Jupiter which are not reflected at the boundary of the Io torus, are able to accelerate efficiently magnetospheric electrons by Landau resonance, up to the required energies and flux. The observation of electron beams during the flyby I31 (and I32) would provide a critical test for this interpretation.

P12A-0494 1330h POSTER

Io-Related Auroral Arcs: Modelling Parallel Electric Fields

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The observations of auroral arcs downstream of Io's magnetic footprint suggest electrons must be accelerated, probably by field-aligned electric fields. A large-scale model of magnetic field-aligned electric fields in the upward current region of the Io-related Jovian aurora will be presented. This model is based on a 1-D spatial, 2-D velocity static Vlasov simulation under the constraint of quasi-neutrality. Localized electric potential drops are formed at $2-3\ R_J$. The width of the electric potential drop is much narrower than the spacial grid size resulting a sharp discontinuity. When the secondary electron density is high enough, an auroral cavity is obtained where the ionospheric protons and Io electrons are dominated. Owing to the parallel electric field, an unstable horseshoe electron distribution is formed inside the auroral cavity, which may easily trigger the shell electron-cyclotron maser instability. The results suggest parallel electric fields to be fundamental particle acceleration mechanism and the source mechanism of Io-controlled decametric radio emissions. Moreover, H^+ ions in the Io plasma torus may be an important factor to require larger parallel electric fields and accelerate electrons to higher energies.

P12B MC: Hall D Monday 1330h

Galilean Satellites *(joint with SM)*

Presiding: **C Hibbitts,** University of Hawaii

P12B-0495 1330h POSTER

The Non-ice Material on Callisto

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Spectra of the non-ice material on Callisto have been derived from telescopic spectra [*Calvin and King*, 1997] and from a few early NIMS observations of the leading hemisphere [*McCord et al.*, 1998]. We use all available NIMS data sets to improve upon these works. Currently, by using 6 global-scale observations, we have derived average spectra in the 0.7 to 5 micron range for ice-poor regions over large longitude ranges. The non-ice components of the spectra were then derived by subtracting water-ice albedo models from those averages. The ice and non-ice materials on the surface of Callisto are assumed to be discretely mixed due to thermal segregation [*Spencer*, 1987] and Galileo SSI images provide compelling evidence of this [*Klemaszewski*, 1998; *Moore et al.*, 1999; *Greeley et al.*, 2000a,b]. Unmixing of the average spectrum of the ice-poor regions in each global observation shows that only a few percent of 50-micron or larger water-ice is present, as has previously shown to be the case for at least a few early NIMS observations [*Hansen et al.*, 1998]. All resulting non-ice spectra are very similar and possess no discernable dependence on longitude. The reflectance spectrum increases from the visible to about 2.5 microns, possesses a strong 3-micron OH-stretch vibration absorption, and increases again to 5 microns, which is consistent with the previous telescopic and NIMS analyses. The spectra of the non-ice material also contains the absorption features due to CO_2, SO_2, CN, and SH that were identified by [*McCord et al.*, 1998]. There is a very slight reddening in the .7 to 2.5-micron region with increasing phase angle (from about 5^o to about 96^o).

By using all available high-spatial resolution observations of Callisto by NIMS from widely different regions we will report on the spectral nature of the non-ice material for ~ 10 to 50 km^2 areas. By investigating the spectral nature of the non-ice material in localized areas we have investigated 1) spectral dependencies of the non-ice material that are associated with geologic features, 2) local variations in relative concentrations of the trace materials such as CO_2 and SO_2, and 3) a possible phase angle dependency at a smaller spatial scale then previously analyzed. Finally, we have made qualitative bulk compositional suggestions by comparing the non-ice spectra with spectra of analogue materials such as carbonaceous chondritic material (e.g. *Johnson and Fanale*, [1973]; *Calvin and Clark*, [1991]) and oxyhydroxides.

P12B-0496 1330h POSTER

Tidal Dissipation and Stability of the Laplace Resonance in the Galilean Satellites

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We present revisions to previous calculations of tidal dissipation in the Galilean satellites. Numerical simulations show that the evolution of the orbital elements in the two-dimensional model is very different from the evolution obtained with a three-dimensional model that also includes the Sun and Saturn, in addition to Jupiter and the four satellites. A new expression for the tidal dissipation valid to second order in eccentricity and for arbitrary inclination is therefore derived. Numerical simulations with values of ν ($\nu = 2n_2 - n_1 = 2n_3 - n_2 = -0.74^o$/day), increasing from the current value to ν=0.5, are carried out in order to check the stability of the Laplace resonance.