Knowledge of the chemical species in vapors produced by hypervelocity impact on spacecraft impact detectors as well as planetary surfaces have applications ranging from determination of the composition of cosmic dust to the effects on atmospheres and climates of large impactors. Direct study of resulting atomic, molecular and ionic species is best accomplished via mass spectrometry. Pulsed laser desorption can be used to approximate small impacts on solid surfaces. We conducted pulsed laser desorption-ionization experiments using two different instruments: (1) a Caltech-built Time-of-Flight Mass Spectrometer (TOFMS) similar to that on board the Cassini spacecraft and (2) a commercial Matrix Assisted Laser Desorption Ionization TOFMS made by Applied Biosystems (Model, Voyager-DE Pro). Minerals included in this study were calcite, dolomite, gypsum, anhydrite, olivine, kamacite, brucite, serpentine, and pyrrhotite. We collected only positive ions. A nitrogen laser (337 nm wavelength, 4 μsec pulse width, and 300 mJ) with power density ranging from 1.0x10^7 to 1.3x10^9 W/cm^2 induced vaporization and ionization. The results can be summarized as: (1) from kamacite and pyrrhotite, only $^{54}Fe^+$, $^{56}Fe^+$, $^{57}Fe^+$ (both kamacite and pyrrhotite) and $^{58}Ni^+$, $^{60}Ni^+$ (kamacite only) as well as contamination ions such as $^{23}Na^+$ and $^{39}K^+$, $^{41}K^+$ were observed; (2) Ca-containing minerals (calcite, dolomite, gypsum and anhydrite) produced vapors containing $^{40}Ca^+$ ions, and, at higher laser power, both $^{40}Ca^+$ as well as CaO^+ ions; (3) Mg-containing minerals (dolomite, olivine, brucite and serpentine) produced vapors containing MgO^+ ion; (4) for all hydrous minerals, neither H^+ nor H_3O^+ were observed in the vapor; (5) in the vapors of silicate minerals (olivine and serpentine), SiO^+ was observed only from serpentine but not from olivine.

P22C MCC: Hall D Tuesday 1330h

Planetary Physics and Geophysics Posters *(joint with S, DI, MR)*

Presiding: **N J Rappaport,** Jet Propulsion Laboratory

P22C-0408 1330h POSTER

The Effect of Pressure on Complex Chemical Equilibria at Low Temperatures.

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Several papers have recently suggested that decomposition of gas hydrates could have played an important role in the geologic history of Mars and Europa. Gas hydrates form in porous sediments under low temperatures and high pressures. The FREZCHEM model was developed to predict chemical equilibria over the temperature range from -70 to +25 °C at 1 atm pressure using the Pitzer equations, which are valid to high ionic strengths. As currently structured, the FREZCHEM model lacks a pressure dependence and gas hydrate chemistry. The objectives of this paper were to (1) add a pressure dependence to the FREZCHEM model as a prelude to incorporating gas hydrate chemistry, and (2) use the model to examine the controversial subject of ice compressibility.

Incorporation of pressure as a driver into the model necessitated a consideration of volumetric properties such as partial molal volumes (volume/mole) or its inverse, density (weight/volume). For the gas hydrate model, key variables and constants that were quantified as functions of pressure and temperature were solubility products, gas solubilities, activity coefficients, the density of aqueous solutions, and the activity of water.

As an example of how pressure affects equilibria, even at a modest pressure of 100 bars, the solubility of gases was increased by about 17%; at 1000 bars, there was about a 400% increase in gas solubility. We used our model and experimental measurements of the freezing points of ice as a function of pressure to estimate the compressibility of ice (Kice). Our estimates of Kice were significantly lower than the Bridgman estimates, but in relatively good agreement with other more recent estimates.

P22C-0409 1330h POSTER

Predictable earthquakes?

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Summary: A world wide network has been continuously monitoring the secular change of the Earth's physical processes as recorded on the Earth like the geomagnetic field, the Earth's rotation, etc. The database, which has been collected by the observatories, gives us a chance to make a study of the temporal behaviour of the Earth's magnetic field and to understand the features of these and related phenomena. The long-term magnetic field data show a close qualitative relation both to the secular change of climate and to the variation in the sunspot cycle. On the other hand the fluctuations in the Earth's rotation also show a good correlation to the sunspot and climatic phenomena. This is a very important fact because the decade fluctuation in Earth's rotation depends on those streams in the outer core, which produce the long-term variation in the Earth's magnetic field. This result means that it may not be unrealistic to think of a rather strong interaction between the internal and external magnetic fields of the Earth, and the mechanical implications of this interaction. The outer reason(s) of both solar and the mentioned terrestrial physical processes is one of the possible theories, which is able to include and explain these observed facts. The calculated Earth's orbit, perpendicular to the ecliptic plane (so called Z-direction), and rather the 1st derivative in time of this orbital motion (Z-acceleration) is direct relation to the gravitational perturbations of the (primarily giant) planets. Therefore this time series gives us a chance to investigate the dynamical effects of the giant planets on the Earth. We ended up with quite accurate data sets both in the time series of the Earth's rotation (we used the so called dT-time series which is the measure of the cumulative discrepancy of Earth's rotation in time, and length of day [l.o.d.], which is the 1st derivative in time of dT, and the 1st derivative in time of l.o.d., which is related to the rotational acceleration) and global number of earthquake for this period from published literature which give us a great picture about the dynamical geophysical phenomena.

Methodology: The computing of linear correlation coefficients gives us a chance to quantitatively characterise the relation among the data series, if we suppose a linear dependence in the first step. The correlation coefficients among the Earth's rotational acceleration and Z-orbit acceleration (perpendicular to the ecliptic plane) and the global number of the earthquakes were compared. The results clearly demonstrate the common feature of both the Earth's rotation and Earth's Z-acceleration around the Sun and also between the Earth's rotational acceleration and the earthquake number. This fact might means a strong relation among these phenomena. The mentioned rather strong correlation (r = 0.75) and the 29 year period (Saturn's synodic period) was clearly shown in the counted cross correlation function, which gives the dynamical characteristic of correlation, of Earth's orbital- (Z-direction) and rotational acceleration. This basic period (29 year) was also obvious in the earthquake number data sets with clear common features in time.

Conclusion: The Core, which involves the secular variation of the Earth's magnetic field, is the only sufficiently mobile part of the Earth with a sufficient mass to modify the rotation which probably effects on the global time distribution of the earthquakes. Therefore it might means that the secular variation of the earthquakes is inseparable from the changes in Earth's magnetic field, i.e. the interior process of the Earth's core belongs to the dynamical state of the solar system. Therefore if the described idea is real the global distribution of the earthquakes in time is predictable.

P22C-0410 1330h POSTER

Thermal Convection in a Fluid Layer Heated From Below and From Within Implication for Planetary Evolution

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Solid-state thermal convection in terrestrial planets interiors is generated by both volumetric heating (radiogenic elements, secular cooling) and heating from below (cooling of the metallic core). However, the relative importance of plumes emanating from both boundary layers and their interaction is still poorly understood. The aim of the present study is to propose a precise scaling for heat transfer in this heating configuration. Our initial numerical experiments have examined an isoviscous fluid in a Cartesian geometry (both 2D and 3D), since this allows well resolved results to be obtained with modest-scale computation.

A relationship assuming that the top and bottom boundary layers are of equal thickness so that the ratio of temperature differences across them varies in a simple way with the fraction of heating from below produces a correct first order scaling. This leads to the prediction that the temperature of the well mixed interior does not vary with the fraction of heat supplied from below. However, in our numerical experiments, horizontally averaged temperature within the well mixed interior for a given amount of heat sources (basal plus internal) varies with the way heat is distributed between the bottom surface and the interior of the layer by an amount that can be significant on scales of interest for planetary evolution. In addition, systematic differences are observed between 2D and 3D numerical experiments ; other variations appear according on the basal heating mode (either flux or temperature can be prescribed). This reflects the dynamics of the interaction of plumes with thermal boundary layers and with each other. We thus propose a more complete scaling based on the influence of a plume on both the boundary layer where it forms and the opposite boundary layer where it produces a stagnation point. This leads to a scaling which predicts that the two boundary layers are of different thickness and allows a more accurate description of temperature in the well mixed interior.

P22C-0411 1330h POSTER

The Dependence of Atmospheric Circulation and Heat Transport on the Planetary Rotation Rate

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Simplified models of planetary climate require a parameterization for the equator-to-pole transport of heat and its dependence on factors, including the planetary rotation rate. Various such parameterizations exist, including ones based on the theory of baroclinic eddy mixing, and on principles of global entropy generation. However, such parameterizations are difficult to test given the limited available observational opportunities. In this study, we use a numerical model to examine heat flux dependencies, as part of a wider study of circulation regime sensitivity to rotation rates and other parameters.

This study makes use of a simplified version of the Geophysical Fluid Dynamics Laboratory (GFDL) "Skyhi" General Circulation Model (GCM). All terrestrial hydrological processes have been stripped from the model, which in the form used here, is adapted from the Martian version of Skyhi. The atmosphere has the gas properties of CO_2, except that it has been made uncondensible. No aerosols or surface ices are allowed. The model surface is flat, and of uniform albedo and thermal inertia. For the simulations presented in this study, the diurnal, seasonal, and eccentricity cycles have been disabled (i.e. the surface and atmosphere receives constant, daily- and seasonally-averaged incident solar radiation). Radiative heating is treated with a band model for CO_2 gas in the thermal and near-infrared bands.

The use of a complex model to examine simplified theory of heat transport requires some justification since it is not necessarily clear that these models (GCM's) provide an accurate emulation of the real atmosphere (of any given planet). In this study, we have intentionally removed those aspects of GCM's that are of greatest concern. Especially for terrestrial GCM's, the hydrologic cycle is a major source of uncertainty due to radiative feedbacks, and cloud coupling to small-scale, convective mixing. For other planets, aerosols are important as radiatively and dynamical active species. Yet an additional cause of error, especially when testing global entropy principles, is the condensation of the atmosphere (as in the case of Mars). We have eliminated all of these concerns in the pure, non-condensible gas atmosphere of our simplified model. Our results will be compared with those of simplified theoretical predictions, and differences discussed.

P22C-0412 1330h POSTER

Tidal Behavior of a Self-Gravitating, Viscoelastic Planet: Analytical Theory for a Multilayered Body

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This presentation will give the analytical solution of the equations governing the response of a gravitating stratified planet to an impulse stress. The complete solution is expressed as a sum of Bessel functions of positive and negative orders. Contrary to the usual method of numerical integration of the sets of six-order differential equations, our new method is merely implemented through the inversion of a (6N-3) square matrix, where N is the number of homogeneous layers constituting the body. We will compare the results provided by both methods for various types of planetary bodies such as icy satellite and Mercury, whose internal structure is under the focus of forthcoming space mission. Our method proves to be a straightforward and accurate way to compute Love numbers.

P22C-0413 1330h POSTER

Comparing Numerical Methods for Simulating Convection in Giant Planets

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As the first step toward developing a 3-D hydrodynamic code capable of modeling convection through the interior of giant planets and stellar bodies, two different 2-D hydrodynamic codes are compared for cases within the same turbulent thermal convection regime at high resolution. The first code uses spectral and finite differencing methods to solve the differential equations. The second, newer code employs the finite volume method to solve the same equations, but requires many more elements to achieve the same accuracy. The two codes are compared in a series of benchmark cases to verify that the finite volume method is returning results consistent with the spectral method.

P22C-0414 1330h POSTER

The origin of stellar, planetary, satellite and galactic rotation as tangential accretion of decaying orbital torus sections of relevant material transferring orbital momentum into rotational motion of the accreted body.

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The origin of planetary, satellite and stellar rotation is due to tangential accretion of orbiting torus sections of material which decay.In the case of the sun and other stars torus sections of mostly hydrogen gas are held together by magnetic and electric fields,and in the case of the planets, gaseous and rocky,torus sections are of relevant material such as gases as methane and ammonia and rocky materials such as silicatesheld together also by magnetic and electric fields. The torus section orbits decay due to slowing down and by gravitational attraction tangentially collide with a protoplanet or protostar such as the sun. The orbital motion of the torus section is transferred to the slowly rotating protoplanet in tangential accretion thereby speeding up the rotation of the protoplanet or star. This is a transfer of orbital motion into rotary motion through tangential collision. The evidence for this is the differential layering of the body of a planet or star.The origin of the torus sections is the Big Bang.

Galactic formation in part is due to already formed arms in slowly decaying orbital motion which tangentially collide with other already formed arms into spiral and barred spiral galaxies in which the rotation resulted from orbital motion being converted to rotary motion. Rotation of spiral galaxies slows down and the spirals change into ellipticals. All of this was seen in a coffee cup when some old creamer was put into it. Elliptical Galaxies do actually spin slower than Spirals.

Therefore, all heavenly bodies are rotating at their present speed due to tangential collision and accretion of already formed arms of material in which orbital motion is converted into rotary motion in which there may be some slowing down over time.

P22C-0415 1330h POSTER

Accumulation of Giant Planet Atmospheres Around Cores of a Few Earth Masses

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New numerical simulations of the formation and evolution of Jupiter with small mass cores are presented. Earlier studies of the core instability model demonstrated that it was possible for Jupiter to form with a solid core of 10 to 30 $M_\oplus$ within the lifetime of the protoplanetary disk of 10^7 years. However, recent interior models of Jupiter suggest a core mass of about 5 $M_\oplus$. Simulations of the growth of Jupiter were computed where the grain opacity and the initial planetesimal surface density, $\sigma_{init,Z}$, in the solar nebula were varied. Decreasing the grain opacity emulates the settling and coagulation of grains within the protoplanetary atmosphere. The implications of halting the solid accretion at selected core mass values during the protoplanet's growth, thus simulating the presence of a competing embryo, were also explored. The effects of adjusting these parameters to determine whether or not gas runaway can still occur for small mass cores on a reasonable time scale were examined.

Four series of simulations were computed. Each series consists of a run without a cutoff in the core accretion rate plus one or more runs with a cutoff at a particular core mass. The first series of runs is computed with a grain opacity that is 2% of the interstellar value and $\sigma_{init,Z}$ = 10 g/cm^2. Cutoff runs are computed for core masses of 10, 5, and 3 $M_\oplus$. The second series of Jupiter models is computed with the grain opacity at full interstellar value and $\sigma_{init,Z}$ = 10 g/cm^2. Cutoff runs were computed for core masses of 10 and 5 $M_\oplus$. The third series of runs is computed with the grain opacity at 2% of the interstellar value and $\sigma_{init,Z}$ = 6 g/cm^2. One cutoff run is computed with a core mass of 5 $M_\oplus$. The final series consists of one run which is computed with the grain opacity that is temperature dependent (i.e. 2% of the interstellar value for $T \leq 500$ K and full interstellar value for T > 500 K) and $\sigma_{init,Z}$ = 10 g/cm^2. No cutoff run is computed.

Our results demonstrate that decreasing the grain opacity results in reducing the evolution time by more than half of that for models computed with full interstellar grain opacity values. In fact, it is the reduction of the grain opacity in the upper portion of the envelope with T < 500 K that governs the lowering of the formation time. Decreasing the surface density of planetesimals lowers the final core mass of the protoplanet but increases the formation timescale. Finally, a core mass cutoff results in a reduction of the time needed for a protoplanet to evolve to the stage of runaway gas accretion provided the cutoff mass is not too small compared with the crossover mass.

P22C-0416 1330h POSTER

Percolation threshold of Fe-S melt in olivine matrix deduced from in situ electrical conductivity measurement

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The formation a metallic core in a terrestrial planet requires a mechanism for separating and mobilizing Fe-alloy. Measured dihedral angles of well over 60° for molten Fe-alloy in a solid, olivine-rich matrix have apparently precluded metal segregation by grain boundary percolation. However, excess melt over a percolation threshold can create permeability even though the dihedral angle is above the critical value of 60° and some liquid-metal can segregate from the silicate matrix. To determine the percolation threshold for iron alloy melt in crystalline silicate matrix, we performed in situ electrical conductivity measurements on mixtures of olivine and molten FeS compounds with variable volume ratios at high pressure and temperature. Electrical conductivity measurements throughout heating-cooling cycles were conducted at 3GPa using a cubic pressure cell in a DIA-type apparatus. The samples were held at 1473-1573K for over 20 hours to achieve textural equilibrium, which is above the eutectic melting point in the Fe-FeS binary system but below the melting point of Fo_{90} olivine. After heating at the maximum temperature in runs with metal proportions of 6 vol.% and above, the conductivity was high, nearly constant, and independent of temperature. At lower temperature conditions below the eutectic, preservation of the high conductivity values suggests that the Fe-FeS melt was well connected. In the runs with lower metal proportion (3 vol.%), conductivities were low and nearly constant up to 873K, but increased considerably as temperature was raised to the maximum temperature. Temperature-conductivity paths in these runs are essentially the same as that without Fe-FeS eutectic melt so we consider that melt was not connected. The percolation threshold of liquid Fe-S compound is approximately 5 vol.%. Dihedral angles determined from these runs were large (95°), consistent with that for pinch-off boundaries predicted by von Bargen and Waff (1986). This suggests that core formation due to the grain boundary percolation can occur when the temperature exceeds the Fe-S melting point. Planetesimals can heat to the FeS melting point within about 3 million years due to radioactive decay of Al^{26} and Fe^{60}, causing considerable amounts of Fe-alloy to segregate to form a core. This explains the early formation of cores in planetesimals as predicted from Hf-W chronometry, and also provides a mechanism for potential energy release in large proto-planets to form a magma ocean.

P22C-0417 1330h POSTER

Fe-diapirs Sinking in a Temperature Dependent Viscosity Mantle: A Model for Planetary Core Formation

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Core formation is generally thought to have occurred concurrently with or soon after planet formation and, therefore, determines the initial conditions for thermal evolution models to a significant extent. A possible scenario for the formation of a planetary core calls for the settling of iron-rich melt diapirs in a solid matrix. Assuming that a planet in the late stage of accretion has a magma ocean, there soon will form a layer of molten iron at the bottom of the magma ocean. Since the iron has a higher density than the underlying planetary mantle, it may sink in a Rayleigh-Taylor instability. Because the viscosity contrast is essentially infinite, the sinking melt diapir will take the shape of a sphere. We have modelled the Stokes falling of an iron sphere through a silicate mantle with temperature dependent viscosity using a 2-D finite element program (FEATFLOW) written by S. Turek. We solve the incompressible Navier–Stokes equation coupled with the energy and mass conservation equations. From these models the effect of the temperature dependence of the silicate rock viscosity on the sinking rate can be estimated. Depending on the rate of change of viscosity with temperature and the contrast in the rock viscosity immediately at the diapir (ν_0 and far from the diapir (ν_∞ the drag force exerted on the diapir can easily be reduced by several orders of magnitude. Equating the drag force with the body force will allow the terminal velocity of the sinking diapir to be calculated. For a viscosity contrast of ν_∞/ν_0 of 10^3 or more the terminal velocity can be increased by a factor of ten with respect to the isoviscous case with $\nu = \nu_\infty$. To further increase core formation rate it may help to include the stress dependence of the rock rheology.

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P22C-0418 1330h POSTER

Timescales of Planetary Accretion and Differentiation from ^{182}Hf-^{182}W Systematics

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The extinct ^{182}Hf-^{182}W isotope system is particularly suitable as a chronometer for the accretion and subsequent chemical differentiation of planetary bodies. Three recent studies (Kleine et al., 2002, Schoenberg et al., 2002, Yin et al., 2002) independently report a deficit of ca. 2 ϵ units in the ^{182}W/^{184}W ratio of chondrites relative to the terrestrial value and a ^{182}Hf/^{180}Hf ratio at the start of the solar system that is by a factor of ca. 3 lower than previously accepted (Lee and Halliday, 2000). Our preferred value for ϵ_W of chondrites is -1.9 ϵ units relative to the terrestrial value and the initial ^{182}Hf/^{180}Hf of the solar system is (1.09±0.09) x 10^{-4} (Kleine et al., 2002). Using these newly defined parameters core formation ages of ~3 Myrs for Vesta, ~13 Myrs for Mars, and ~33 Myrs for Earth can be calculated (here, Myrs refers to the time elapsed since the start of the solar system). These core formation ages correlate with the planet´s size suggesting a more protracted growth history for the larger planets. Accretion of Mars stopped earlier than that of Earth, which possibly is related to the role of Jupiter in planetary accretion. The less radiogenic ϵ_W values for the martian and terrestrial mantles compared to Vesta indicate later metal-silicate equilibration in Mars and Earth that most likely occurred in a magma ocean environment. Hf-W systematics suggest that core formation and mantle differentiation were two decoupled processes. Using the Hf-W whole-rock isochron for eucrites (Quitté et al., 2000) silicate differentiation and core formation on Vesta can be dated at ~4 Myrs and ~3 Myrs, respectively. Although the absolute ages for mantle differentiation and core formation on Vesta overlap within error, a relative time difference of ~1 Myr between these two processes is resolvable. This is because the errors on these two ages are correlated and therefore cancel when only the time difference between mantle differentiation and core formation is considered. A decoupling of core formation and mantle differentiation on Mars is indicated by elevated ^{182}W/^{184}W ratios (~2.2 ϵ units relative to chondrites) for samples that display chondritic ^{142}Nd/^{144}Nd ratios. Based on ^{142}Nd systematics a timescale of 27 Myrs timescale can be estimated for silicate differentiation (Harper et al., 1995), which is clearly resolvable from the time of core formation on Mars dated at ~13 Myrs. Combined ^{146}Sm-^{142}Nd data and ^{92}Nb-^{92}Zr systematics on terrestrial samples, and Hf isotope compositions of Earth´s oldest zircons suggest that there is no vestige of terrestrial silicate differentiation earlier than 20 to 70 Myrs after core formation. Although old silicate reservoirs on Earth might have been re-homogenized with primitive mantle reservoirs, these constraints tentatively suggest a decoupling of core formation and mantle differentiation on Earth.

References: Kleine et al. (2002), Nature 418, 952-955. Schoenberg et al. (2002), Geochim. Cosmochim. Acta 66, 3151-3160. Yin et al. (2002), Nature 418, 949-952. Lee and Halliday (2000), Chem. Geol. 169, 35-43. Quitté et al. (2000), Earth Planet. Sci. Let. 184, 83-94. Harper et al. (1995), Science 267, 213-217.

P22D MCC: 270 Tuesday 1330h

Advances in Planetary Geodesy, Mapping, and Imaging II *(joint with G)*

Presiding: **B Archinal,** U.S. Geological Survey; **R Kirk,** U.S. Geological Survey; **L Soderblom,** U.S. Geological Survey

P22D-01 1330h INVITED

Mert Davies: Pioneer in the Use of Spacecraft to Map Earth and Mars

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Mert Davies was one of the founding employees of the RAND Corporation in 1946, and continued that relationship until his death in 2001. He began his involvement in satellite imaging at Rand as one of about 100 researchers in Project Feedback in 1954, provided the basis for the initial US military space program. In 1957, in response to the Soviet launch of Sputnik, Mert and a small group of Rand cohorts proposed a family of recoverable reconnaissance satellites featuring spin stabilized cameras, for which he later received a patent. This work, now declassified, was for a short time considered as a basis for the Corona, America's first reconnaissance satellite Corona, although ultimately alternative technologies were employed. In addition he was looking beyond Earth quite early and in May, 1958 published an analysis of a lunar mapping satellite.

The 1957 work at Rand spurred considerations of space-based geodesy and mapping. These and other early contributions were recognized in 1999 by the National Reconnaissance Office which honored him as one of the founders of national reconnaissance.

He was so enthused by the opportunity developing in the mid 1960?s to explore photographically the planets that he changed careers and joined the Television Team of the Mariner probes being developed to flyby Mars in 1969 (Mariner's 6&7). His abilities and accomplishments there led directly to central roles later in the Mariner 9 Mars Orbiter mission (1971-72) as well as Mariner 10 to Mercury (1973-75) and Voyagers 1&2 (1979-89)

These early flights to Mars represented unprecedented technical challenges, especially to radio communications. As a consequence, analog television systems, like that carried on the Ranger impact probe in 1964-65 or film readout technology like that used on Lunar Orbiter in 1965-66 to send back high-resolution images from the Moon were not feasible from planetary distances. In order to exploit the remarkable communication potential of the DSN, JPL-based television teams invented the world?s first digital television cameras using primitive slow-scan vidicon sensors in order to overcome the 200-fold greater distance to Mars.

Spacecraft mapping and geodesy was initiated by the dual flybys Mariner 6 and 7 of 1969, each carrying a moderately high resolution optical system, but one plagued by the geometric limitations of a vidicon sensor necessarily using imprecise electro-optical imaging internally. He understood clearly that the number of resolution elements on the Mariner 6/7 cameras were too small for good photogrammetric solutions. Each picture contained only 70,000 resolution elements compared to a standard aerial photograph with about a third of a billion of comparable elements. Despite such limitations, Mert was able to exploit especially the far encounter imaging from Mariners 6/7 to create the first Mars surface control net based on topographic features, and to solve for the position of the rotational pole. Under his leadership, the Mariner 9 orbiter mission greatly expanded that coverage, providing the evolving basis of USGS Mars mapping practically until the present. Furthermore, Mert, in conjunction with Harold Masursky and Gerard de Vaucoleurs, established the topocentric reference point for the prime meridian on Mars as the small crater Airy-O, which thus occupies a role analogous to that of Greenwich, England for the Earth. He was to play that historic prime meridian role for nearly all the solid bodies in the Solar System over the ensuing decades as well as a continuing role on the IAU committee that named officially the surface features of Mercury, Venus, Mars, and the satellites of Jupiter, Saturn, Uranus.

P22D-02 1350h INVITED

Planetary Satellite Geodesy: Voyager to Galileo

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The Voyager mission provided the opportunity to explore not only the giant planets of the outer solar system, Jupiter, Saturn, Uranus and Neptune, but also their complex system of planetary satellites. A primary concern for the scientific exploration of these bodies was the development of map bases. Not only was this necessary for the correlation of other data and analyses of geological features, it also provide the key geophysical quantities of radius, shape and spin state required to constrain interior and dynamical models.

The Galileo mission to the Jupiter system provided the first high resolution mapping of the Galilean moons, building on the information provided by Voyage. Mert Davies played a central role in developing the camera systems and analysis tools vital to all these projects and tasks, contributing in a multitude of ways to discoveries ranging from the discovery of volcanism on Io and Europa's putative ocean to the chaotic spin state of Hyperion.

P22D-03 1410h INVITED

Cartographic Coordinates and Rotational Elements of Planets and Satellites

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Prior to 1976 there was neither a uniform system for planetary coordinates nor agreed values for rotational elements and coordinates. So in 1976 The International Astronomical Union (IAU) established a Working Group with Mert Davies as the chairman. Its first report in 1979 gave the guiding principles, conventions, and the rationale for their acceptance along with appendices with the initial values. Since then, with the additional sponsorship of the International Association of Geodesy(IAG), every three years the Working Group has produced a report giving the updated values based primarily on the results of space missions and some ground based observations. For twenty years Mert Davies was chairman of the Working Group and, through his participation on space mission teams, was a principal source of coordinate systems for planets and satellites, based on the imaging of the various bodies.

The triennial reports, published in Celestial Mechanics and Dynamical Astronomy, are the source of standard data for use by space missions, ground based observations, research, and publications. Now the report includes for the planets, satellites, and selected asteroids, the location and motions of their poles, the rotation of a prime meridian, and the size and shape parameters. Presently, the asteroids are selected based on those with radar or space mission observations, instead of just photometric observations. The reports continue to be updated and new material added, with the Working Group membership composed of the people active in the determination of data and the author of this paper having replaced Mert Davies as chairman in 1997.

P22D-04 1425h INVITED

Planetary Nomenclature

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Among his many other activities, Mert Davies was an active participant in the IAU Working Group for Planetary and Satellite Nomenclature (WGPSN), particularly on the Outer Solar System Task Group. I will review the history of these groups and their accomplishments, including the rules and categories that have been established for the nomenclature of different objects. The work is ongoing, with newly discovered satellites of Jupiter and Saturn, small craters on Mars, and anticipated surface features on Titan among the topics under consideration.

P22D-05 1440h

Mapping and Geodesy of Small Solar System Bodies

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Small satellites, asteroids, and cometary nuclei whose shapes are not gravitationally relaxed present distinct problems in development of maps and shape models. Objects less than about 100 km radius generally have shapes that are primarily determined by impact processes, thus simple analytic representations of their shapes is not possible. The frequently rough topography on these objects places practical limits on coverage by imaging. Development of shape models by imaging stereogrammetry and more recently with laser altimetry has provided important insights into the "geology" of these small bodies.

P22D-06 1455h

Mars, the Meridian, and Mert: The Quest for Martian Longitude

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From the mid 1960?s until his passing last year, Merton Davies of RAND was closely involved in establishing and maintaining the fundamental coordinate system for Mars. This included the establishment of the location of a modern 0-degree or Prime Meridian for Mars. In the early 1970's, images of the Martian surface became available via the Mariner 9 spacecraft. In 1973 G. de Vaucouleurs, Davies, and F. Sturms, Jr. proposed (JGR, 78, 4395) that a small easily identifiable crater in the area of Sinus Meridiani - the previously accepted origin - be used to define the Meridian. H. Masursky, de Vaucouleurs, and Davies selected an ~500 m diameter crater to serve this purpose. They proposed a name of Airy-0 for the crater in honor of Sir George Airy, who installed the transit instrument at the Greenwich Observatory, which for many years defined the Prime Meridian of the Earth. In a photogrammetric adjustment of Mariner 9 images Davies (Photo. Eng., 39, 1297; JGR, 78, 4355) held the longitude of Airy-0 fixed at 0-degrees, and thereby tied the entire Martian coordinate system to this crater. Davies and colleagues at RAND continued through 2001 in revising this coordinate system. All the while, these improved coordinate systems continued to be tied to Airy-0 and