with little time delay, inconsistent with purely radiative equilibrium condistions. Stratospheric temperature (or C_2H_6 abundance) peaked sharply poleward of 81°S latitude in a high-resolution Keck image in 1998. Meridional variations of stratospheric and tropospheric temperature are not strongly correlated with one another. Planetary-scale zonal waves as large as 1 Kelvin amplitude are seen in the stratospheric temperature field, with some evidence for even larger-amplitude waves in the troposphere. Similar to vortices in Titan and Jupiter, we might expect Cassini to detect a polar vortex (*e.g.* a region of depressed temperatures with a sinusoidal boundary), if driven by the seasonal loss of insolation poleward of its arctic circle. This work was supported by funds from NASA to the Jet Propulsion Laboratory, California Institute of Technology and the Goddard Space Flight Center. Brett Beach-Kimball was supported by the Undergraduate Student Researcher Program (USRP); Brian Jackson was supported by JPL as a Caltech Summer Undergraduate Research Fellow.

P51C-0466 0830h POSTER

Representing Planetary Atmospheric Structures and Observables with Radio Occultation Transform Pairs

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Current methods for relating radio occultation observables (the bending angles) to the refractivity profile of a planetary atmosphere require significant numerical integration. Although accurate and valid, this approach does not clearly illustrate how changes in refractivity, based on physical parameters such as temperature, pressure, or number density, relate to changes in the observed bending angles, and vice versa. However, the radio occultation Abel transform does have one known transform pair directly relating refractivity to bending angle, as derived by Eshleman (1973). The radio occultation transform pair has the potential to allow direct understanding of how changes in atmospheric refractivity and the observed bending angles map to each other. The complete analytical form of the radio occultation transform pair is complicated, in part because the radio occultation Abel transform includes ray bending effects. However, it can be written out in terms of a series expansion. Assuming certain common atmospheric conditions, such as a thin atmosphere, allows significant simplification by keeping only a few terms of the series and does not affect the validity of the representation (Eshleman, 1996). These simplifications allow representation of atmospheric refractivity structures in terms of power law expressions with controllable constants that map directly to the observed bending angles. We evaluate the superposition of several power law refractivity terms to represent atmospheric structures for both thin and thick atmospheres, the errors introduced in the refractivity profiles at different levels of simplification, and make initial observations of how physical differences in a planetary atmosphere, expressed in terms of refractivity, map to changes in the observed bending angle. The radio occultation transform pair approach allows us to better understand how differences in the refractivity structure of a planetary atmosphere relate to changes in radio occultation observables, without numerical integration.

P51D MCC: Level 1 Friday 0830h

The Young Solar System I Posters *(joint with NG)*

Presiding: **Y Nakagawa,** Kobe University

P51D-0467 0830h POSTER

General Circulation of the Transiting Exoplanet, HD209458b

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Showman and Guillot 2002 (A&A, 385, 166S) presented preliminary numerical simulations of the meteorology of HD209458b's atmosphere in the radiative region using the EPIC model of Dowling et al. 1998 (Icarus 132, 221). Their simulations reveal that the intense radiation of the star sustains a steady temperature difference between the day and night sides of the planet. In steady state, the models predict strong eastward equatorial jets. The magnitude of the day-night temperature difference depends on the radiative transfer of the upper atmosphere, the physics of the deep atmosphere at the interface with the planet's fully convective interior, and the effects of winds. We will present improved, higher resolution three-dimensional models of the general circulation of HD209458b. Day-night temperature variations and winds are potentially observable both in the infrared light curve of the planet, if it can be measured, and in the planetary albedo, which is likely to be variable across the planet's surface due to variations in upper atmospheric chemistry and cloud formation.

P51D-0468 0830h POSTER

A Planetesimal Accretion Zone in a Circumbinary Disk.

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Until recently, it had been believed that only single solar-type stars might harbor planetary systems. On the other hand, circumbinary disks have been detected by mm/sub-mm wavelength observation. Planets may be formed also in such disks. We investigate the conditions for planetesimal accretion in a circumbinary disk. The binary system gives stronger gravitational perturbation against planetesimals orbiting nearer to the binary. Therefore, the relative velocities between planetesimals will be larger, and when they exceed the escape velocity, it is impossible for the planetesimals to accumulate into a planet. We perform long-term numerical integrations of binary and planetesimal orbital motions, and find the upper limit of planetesimal semimajor axes where the velocity dispersion of the planetesimals exceeds the escape velocity. That is, when the binary semimajor axis is set to 1 AU, the eccentricity to 0.1 and the total mass to 1 $M_{\odot}$, the planetesimals are prevented from accreting when they orbit in a zone within 13 AU from the barycenter of the binary system. In regions outer than 13 AU, planetesimals can accrete. We also derive an analytic expression of the eccentricity of a planetesimal excited by the gravitational perturbation of the binary.

P51D-0469 0830h POSTER

No Evidence for Trapped Noble Gases in CAIs

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Refractory inclusions (CAIs) in meteorites probably are the first solids in the solar system. Although formed at high temperatures, CAIs are reported to contain trapped noble gases [1,2,3] which would provide information on CAI formation and solar system evolution. We reassessed this question by measuring Ne and Ar in CAIs of primitive chondrites (Allende, Axtell, Efremovka) by IR-laser extraction suitable for measuring low gas concentrations [4]. We chose meteorites with different preatmospheric radii, exposure ages, and degrees of alteration to take into account those effects on CAI noble gas compositions.
$^{20}Ne/^{22}Ne$ is below 0.9 indicating the absence of common trapped Ne. We suggest that elevated $^{20}Ne/^{22}Ne$ of [1,2,5] resulted from contamination of their CAI samples with matrix rich in trapped Ne. $^{21}Ne/^{22}Ne$ is 0.72 to 0.86; more altered CAIs show the lower ratios. The Ne might be a mixture of chondritic cosmogenic Ne and nearly pure ^{22}Ne, e.g., from presolar SiC [3]. However, calculated cosmogenic Ne for CAI minerals perfectly mimics the observed trend; in particular Na-rich alteration phases shift the $^{21}Ne/^{22}Ne$ to lower values.
$^{36}Ar/^{38}Ar$ is 0.7 to 4.8, thereby more altered CAIs have higher ratios. The Ar might be a mixture of chondritic cosmogenic Ar (mainly produced from Ca) and trapped Ar [3] or solar wind Ar [2], the latter supporting CAI formation in an X-wind scenario [6]. However, due to high Cl concentrations in CAIs also nearly monoisotopic ^{36}Ar produced cosmogenically by neutron capture and beta- decay on Cl must be taken into account. Modelling Ar ratios and concentrations using only cosmogenic Ar from Ca and Cl nicely match the measured data. Thereby more Cl-rich altered CAIs show higher $^{36}Ar/^{38}Ar$.
Although the data do not principally contradict the presence of trapped Ne or Ar in CAIs they can be straightforwardly explained by cosmogenic productions mainly from Na, Ca, and Cl.
[1] Smith et al. (1977) GCA, 41, 627-647; [2] Shukolyukov et al. (2001) Geochem. Int., 39(1), 110-125; [3] Russel et al. (1998) MAPS, 33, A132; [4] Vogel (2003) PhD-Thesis, ETH Zuerich, Switzerland; [5] Goebel et al. (1982) GCA, 46, 1777-1792; [6] Shu et al. (1997) Science, 277, 1475-1479.

P51D-0470 0830h POSTER

Consideration of formation process for the nuclei on precursor

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The very isotropic microwave background and the Hubble expansion indicate that the universe has evolved from an earlier state of high temperature and density that can be reasonably well described by Friedman-Lemaitre-Robertson-Walker cosmological models. The nuclear evolution of non-degenerate matter expanding from very high temperature was studied in detail for various values of the expansion rate and of the proton-neutron abundance difference and baryon density[1,2,3]. In this calculation, many nuclear reactions were included, and its results suggested important reaction process for the evolution of nuclear abundances. 3He and 4He are very important elements in these nuclear reactions as the primordial nucleosynthesis. Microscopic study for few body system is one main topic in nuclear theoretical physics. In this field, very accurate calculations are available by using the Faddeev equations[4]. Recently, many data for pd, p-3He and d-3He have been obtained including polarized observables. Model calculations for systems including 3He and 4He (for example, d + 3He → p + 4He) are carried out using the Faddeev equations based on the meson exchange models[4]. This model reproduces well the empirical phase shifts which are determined by so-called phase-shift analyses using all of available scattering data measured at various laboratories around the world[5,6,7]. Constructions of models for the nuclear reactions including 3He and 4He will give important information for calculations of the primordial nucleosynthesis after big-ban. The calculations are carried out until the sum of the abundances at each mass number ceases to change. Various different set of initial conditions for the baryon mass density, the expansion rate and the neutron-proton ratio are used. Dusts kept in precursor asteroid nebular form precursor asteroid, then, formations of planet start [8]. Possible values of parameters in the initial conditions for theoretical calculations will be searched considering an information from precursor asteroid References:
[1] R. V. Wagoner, W. A. Fowler and F. Hoyle (1967), Astrophys. J. 148, 3. [2] R. V. Wagoner. (1969), Astrophys. J. 162, 247. [3] R. V. Wagoner (1973), Astrophys. J. 179, 343. [4] For example, S. Gojyuki and S. Oryu (2003), Mod. Phys. Lett. A18, 302. [5] Y. Yoshino, V. Limkaisang, J. Nagata, H. Yoshino and M. Matsuda (2000), Prog. Theor. Phys. 103, 107. [6] H. Yoshino, J. Nagata, V. Limkaisang, Y. Yoshino, M. Matsuda (2001), Nucl. Phys. A684, 615c. [7] H. Yoshino, H. Kazuo, M. Matsuda, J. Nagata, (2003), Mod. Phys. Lett. A18, 444. [8] Hayashi, C. et. al., 1985, Protostars and Planets, Univ. of Arizona Press, pp. 1100.

P51E MCC: 2002-2004 Friday 0915h

The Asteroid Impact Hazard: Moving Beyond Spaceguard *(joint with PA)*

Presiding: **A W Harris,** Space Science Institute, University of Colorado; **D Morrison,** NASA Astrobiology Institute

P51E-01 0920h INVITED

An Updated Assessment of the Hazard Due to Earth Impacts

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We report on a recent comprehensive and quantitative reassessment of the hazard posed by Near-Earth Objects (NEOs). This hazard originates from three distinct impact-related phenomena. We estimate, in the mean, 60(+45/-25) fatalities per year from direct blast effects, 180(+200/-120) people displaced per year from impact tsunami inundation, and 1000(+2050/-700) fatalities per year from global climatic disruption. Of these hazards, the global threat is largely associated with impacts by kilometer-plus diameter objects. These larger objects are far fewer and much easier to discover than the sub-km objects that are primarily responsible for the blast and tsunami risks. We find as a result that current survey efforts are making substantial progress in reducing the global hazard, in terms of fatalities per year, and should retire over 90% of it before 2008, but that little progress can be expected in removing the hazard from sub-km impactors. By 2008 the remaining global hazard will be on par with the remaining sub-km hazard and a more capable survey will be required to preserve momentum in NEO hazard retirement.

P51E-02 0935h 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 NASA under 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."

P51E-03 0950h INVITED

Beyond Spaceguard: Steps Toward Protecting Planet Earth, and Stepping Stones on the Path to Exploration

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Asteroids and comets are not well understood, but their hazard is mitigable if we take time to learn their structural mechanical properties, and in turn how to divert them (if we have secured adequate lead time) or to disrupt them if not. NASA has already taken a primary role in the scientific exploration of near-Earth objects, or NEOs. Because there is no central entity assigned the task of NEO hazard mitigation, it was recently recommended by a major scientific workshop (see http://www.noao.edu/meetings/mitigation) that NASA, guided and aided by close international cooperation, assume a leadership role in quantifying the population and physical diversity of near-Earth objects that may collide with our planet. While it has acquired political and societal impetus, NEO science is fundamental solar system exploration. Beyond posing a threat, these building blocks of planets record the solar system's origin and evolution, offer potential resources for solar system exploration, and have been a critical component of terrestrial biology. It is therefore natural that mitigation technology be rooted in fundamental planetary exploration, and in the coming decades the paths may be identical. Techniques for this exploration will be presented, and the fruits of knowing how to manipulate a dangerous asteroid will be described.

P51F MCC: 2000 Friday 1020h

The Young Solar System II *(joint with NG)*

Presiding: **L W Esposito,** Laboratory for Atmospheric and Space Physics, University of Colorado**; R Canup,** Southwest Research Institute

P51F-01 1020h

Time and Length Scales for Planetary and Satellite Gas Disk Clearing

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Observationally, the maximum ages of T Tauri stars that show evidence for disks is $\sim 10^6 - 10^7$ years (Strom et al. 1989). On the other hand, a time of $10^6 - 10^7$ years is needed for giant planet formation through core accretion depending on gas opacity (Pollack et al. 1996; Hubickyj, private communication). One approach to satisfy these constraints involves matching the planetary formation timescale to the unrelated timescale of disk clearing due to turbulent viscosity. In this model, the above agreement of timescales is a coincidence. In contrast, Goodman and Rafikov (2001) considered the possibility that the acoustic waves launched by small (a few Earth mass) planets introduce an effective viscosity that clears the disk in the required timescale. However, such objects are likely to drift in an be lost due to Type I migration (Ward 1997) before the gas disk (where most of the angular momentum of the system is stored) evolves. Mosqueira and Estrada (2003b) (in the context of satellites, but the same argument would apply to planets; see Mosqueira and Estrada, this conference) advanced a related mechanism involving those objects large enough to stall and open a gap in the disk (Rafikov 2002). Here we investigate the possibility that the tidal torque of planets and giant planet satellites clears the gas disk in which they formed in timescales of $\sim 10^6$ years and $\sim 10^5$ years respectively. Also, such a gas clearing mechanism may only be effective to a distance possibly connected with the region where solids are stranded following gas dissipation ($\sim$ 40 AU at the edge of the Kuiper belt for the solar system, and the region where regular satellites are found for satellite systems), i.e., outside this region gas would linger and rocky bodies formed there would be removed by gas drag or tidal torques. This work was supported by the National Research Council and a NASA PGG grant.

P51F-02 1035h

Planet Embryos in Vortex Wombs

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One of the enduring puzzles in the formation of planetary systems is how millimeter-sized dust grains agglomerate to become kilometer-sized, self gravitating planetesimals, the "building blocks" of planets. One theory is that the dust grains settle into the mid-plane of the protoplanetary disk (thin, cool disk of gas and dust in orbit around a newly forming protostar) until they reach a critical density that triggers a gravitational instability to clumping. However, turbulence within the disk is likely to stir up the dust grains and prevent them from reaching this critical density. A competing theory is that dust grains grow by pairwise collisions, forming fractal structures. It is unclear, however, how robust such structures would be to successive collisions. A new and exciting theory is that vortices in a protoplanetary disk may capture dust grains at their centers, "seeding" the formation of planetesimals. We are investigating the dynamics of 3D vortices in protoplanetary disks with a parallel spectral code on the Blue Horizon supercomputer. Some of the lingering questions we address are: What is the structure of 3D vortices in a protoplanetary disk? Are they columns that extend vertically through the disk, through many scale heights of pressure and density? Or are they more "pancake-like" and confined to the mid-plane? Are the vortices stable to small perturbations, such as vertical shear? Are 3D vortices robust and long-lived coherent structures? Do small vortices merge to form larger vortices the way vortices on Jupiter do?

P51F-03 1050h

Is Hydrodynamic Escape from Small Orbit Extrasolar Planets Fast or Slow? New Solution of Hydrodynamic Equations and Its Applications

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Hydrodynamic escape has important applications in the formation and evolution of planetary atmospheres. Solutions to the time-independent hydrodynamic equations are difficult to find due to the existence of a singularity point. New method to solve time-dependent hydrodynamic equations is developed and validated. When applied to extrasolar planets under intense radiation from parent stars (HD209458b), we tried to answer the following 2 questions: 1) are these planets undergoing hdyrodynamic escape; 2) how fast are they losing their mass. Simulation results are compared with observations.

P51F-04 1105h

TIDAL DISRUPTION OF PRIMORDIAL PLANETARY BODIES

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