ABSTRACT:

The Mars community is poised to come together to develop a fuller understanding of the Mars' space environment and its interaction with the solar wind. A number of significant advances have been made recently in the arenas of modeling and spacecraft measurement. For example, several modeling groups have achieved high enough resolution and completeness that the entire system, from the solar wind down to the atmosphere, can be included in a single model. Further, these models have advanced to the point where they could and should be compared with each other, and with in situ measurements. At the same time, the Mars Express spacecraft has increased the number of instruments currently making relevant measurements of the Martian plasma environment, and is for the first time enabling simultaneous measurements of different parts of the interaction region by different spacecraft. These advances have been made by a diverse group of investigators, both geographically and in terms of their expertise and experience.

In order to stimulate discussions between the various scientists interested in the Martian solar wind interaction, we propose to conduct a Chapman Conference on the solar wind interaction with Mars. The conference will cover the following topics:
1. How is the structure of the interaction region formed and maintained?
2. How do crustal magnetic fields affect the interaction locally and globally?
3. How does the interaction affect upper atmospheric structure and escape?
4. How do models implement the physics and variability of the system?
5. How does the Martian environment compare to other solar system bodies?

The meeting will occur over 4 days. Its format will include oral presentations and posters. Session chairs will present a synthesis of results, especially as they apply to the science questions in this proposal. Authors will be strongly encouraged to submit papers from the conference to a refereed proceedings volume such as a Geophysical Monograph or a special section of a journal. Participation in the conference will be open to anyone. We will invite key speakers from the major modeling groups, the spacecraft missions, and the laboratory community.

Proposal for AGU Chapman Conference

"The Solar Wind Interaction with Mars"

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"The Solar Wind Interaction with Mars"

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Science Focus and Objectives

The interaction of the solar wind with the Martian atmosphere has been studied and measured for more than four decades [e.g. Smith et al., 1965; Dolginov, 1978; Rosenbauer et al., 1989; Acuña et al., 1998; Lundin et al., 2004]. Despite this long history, many failed spacecraft and redirection of political priorities encumbered progress in the field until the last decade. Now, the data, funding, and motivation all exist to enable advancement in the understanding of this complex interaction. Because Mars lacks a significant global magnetic field and has an extensive exosphere, the solar wind interacts directly with the upper atmosphere. This is a factor in atmospheric loss at Mars and may have played a major role in the long-term evolution of the climate [e.g. Luhmann and Bauer, 1992; Brain and Jakosky, 1998; Jakosky and Phillips, 2001; Chassefière and Leblanc, 2004]. The Martian solar wind interaction shares characteristics with a variety of solar system bodies (such as Venus, comets, Titan, the Moon, and even Earth), and has been compared in different ways to each of them [e.g. Cloutier et al., 1999; Coates, 2004; Szegö et al., 2000]. Mars also provides an important laboratory for understanding a variety of space plasma processes (such as particle acceleration, magnetic reconnection, and the formation of instabilities) in a non-terrestrial plasma environment [e.g. Lundin et al., 2004; Krymskii et al., 2002; Grebowsky et al., 2004; Penz et al., 2005].

The community of scientists who study the Martian plasma environment is diverse, with widely different backgrounds, experience, and nationality. While special sessions at meetings and small workshops periodically serve to promote dialogue between subsets of these scientists, there has not been a community-wide meeting dedicated to discussion of the current state of knowledge of the Martian solar wind interaction for 15 years. This time span is especially long considering the improvement in our understanding that has emerged in the past decade. Even more importantly, advances in the past 2-3 years have not been limited to a single spacecraft or a handful of simulations unlike in the past. It is therefore increasingly important that the many different research groups be given an opportunity to come together in order to assimilate results. Then they can place their results into context with the larger science questions related to the solar wind interaction at Mars.

We propose to conduct a Chapman Conference in order to provide a focused forum for the scientists involved in the study of the solar wind interaction with Mars to gather, exchange ideas, cooperate in research, and disseminate results. **This conference will specifically address the following science questions:**

1. *How is the structure of the interaction region formed and maintained?*
2. *How do crustal magnetic fields affect the interaction locally and globally?*
3. *How does the interaction affect upper atmospheric structure and escape?*
4. *How do models implement the physics and variability of the system?*
5. *How does the Martian environment compare to other solar system bodies?*

These questions will be addressed over four days through oral sessions with invited and contributed talks and a poster session. Each session will conclude with a summary by the session chair of the important points and unanswered questions raised in the session. We will communicate the results of the conference to the community through publication of a proceedings volume and submission of a summary article to *Eos*

Objective: To draw the space plasma modeling, planetary aeronomy, and particles and fields instrumentation communities together to compile a better understanding of the solar wind interaction with Mars, its effects on the upper atmosphere, and its relationship to the solar wind interaction with other planetary bodies.

Session Topics

Each of the science questions listed above will serve as a session topic for the conference. Below, we provide a brief description of a few subtopics to be covered within each session, along with a partial list of "unanswered questions" compiled by the Conveners and Program Committee. In addition to the distinct session topics, we will emphasize a few themes throughout the entire meeting, including *variability* in the Martian solar wind interaction, long-term *evolution* of the system, and fundamental plasma *processes*.

Topic #1: Structure of the Martian plasma environment

In general terms we understand that the structure of the Martian plasma environment results from the interaction of the flowing solar wind with the upper atmosphere and localized crustal magnetic fields. This interaction creates a number of different plasma regions, identified by characteristic signatures in particles and/or fields measurements, separated by plasma boundaries. An important issue in the study of the Martian solar wind interaction stems from the fact that researchers naturally view the interaction through the tools (instrument/model) at their disposal. This approach often leads to different names for the same region or boundary, and more importantly can lead to incomplete or conflicting descriptions of the responsible physics. For example, most spacecraft instruments have identified a transition in the Martian environment somewhere between the bow shock and the ionosphere. The boundary represented by this transition has been given many names, including planetopause, ion composition boundary, protonopause, mantle boundary, proton dropout boundary, magnetic pileup boundary, the boundary, and induced magnetosphere boundary [e.g. Riedler et al., 1991; Breus et al., 1991; Sauer et al., 1995; Vignes et al., 2000; Lundin et al., 2004]. Despite the many measurements, it is currently not known whether all of the observed signatures are associated with the same boundary, or which physical processes are responsible for forming the boundary. One goal of this session is

Topic #1 Unanswered Questions

- How close to Mars does the solar wind penetrate?
- Which factors control the level of variability in each region of the interaction?
- What dictates the structure of the IMB/MPB? What type of discontinuity is it? What is its physical extent? What are the characteristics of the current layer that it represents?
- What is the magnetic field structure of Mars' distant tail? What is the structure of the neutral sheet? Which escape processes occur within the tail?
- What is the origin of the nonlinear upstream waves?
- Which factors govern the microscopic structure of the Martian bow shock?
- What causes the pressure anisotropies that generate mirror mode waves seen in the lower magnetosheath?
- What do multipoint observations by MGS and MEX reveal about the structure and variability of the interaction?

to bring together the different observational and model results, many of which are recent, in order to move from a phenomenological description of the different plasma regions to a physical understanding.

In addition to identifying the processes responsible for forming the different regions in the Martian plasma environment, it is important to understand how the system reconfigures in response to changes in external or atmospheric conditions. Variability comes on many spatial and temporal scales, and is observed in the bow shock, the magnetosheath, the magnetic pileup region, the magnetotail, and the ionosphere [e.g. Johnson and Hanson, 1992; Verigin et al., 1993; Tracadas et al., 2001; Crider et al., 2002; Vignes et al., 2002; Brain et al., 2003; 2005; Krymskii et al., 2004; Bertucci et al., 2005]. In order to understand this variability, one can study the structure as a function of different driving factors, such as EUV flux, solar wind pressure, crustal magnetic field orientation, etc. Alternatively, one can use concurrent data from multiple positions in the interaction region to learn the spatial scales and structure. These multipoint observations are possible now with Mars Global Surveyor (MGS) and Mars Express (MEX), both in operation at Mars. Further, there will be an opportunity to obtain 3-point observations when Rosetta flies by Mars in Feb. 2007. However, the best way to achieve a complete, physical understanding of the variability is to use models to determine the relative contributions of driving forces in the interaction. But the variability in the interaction introduces high levels of uncertainty when comparing models and data, which is necessary to validate the models. Thus it is crucial for modelers and data analysts to attack this issue from both sides. The proposed meeting will foster an exchange of information between the spacecraft teams and the modelers in order to determine the relative importance of (and response to) different drivers.

Topic #2 Unanswered Questions

- What are the strengths and limitations to the different approaches to modeling crustal sources?
- Which data have the least influence from external fields, thus being best for modeling the crustal fields?
- What are the plasma boundaries associated with crustal fields?
- How do crustal fields alter the occurrence and location of plasma boundaries?
- How do they affect large-scale current systems in the ionosphere?
- What fraction of Mars has open magnetic field lines and what is the temporal and spatial variability?
- How do crustal magnetic fields, Mars diurnal rotation, SW dynamic pressure, IMF, and seasonal variations combine to determine the structure and variability of the upper atmosphere and ionosphere of Mars?

Topic #2: Crustal fields and their effects

Remnant crustal magnetic fields add an intriguing component of spatial and temporal variability to the Martian plasma environment. Present over much of the planet [Acuña et al., 1998, 2001; Lillis et al., 2004], but strongest in the southern hemisphere [Acuña et al., 1999, 2001], the detection of crustal magnetic fields has influenced our understanding of the Martian interior and subsurface [e.g. Acuña et al., 1998; Schubert et al., 2000; Kletetschka et al., 2000, 2004, 2005; Stevenson et al., 2001; Connerney et al., 2001, 2004, 2005; Spohn et al., 2001; Nimmo and Tanaka 2005]. However, modeling the crustal fields relies on careful selection of orbital magnetometer data in order to minimize the contribution from external fields, such as those from the interaction with the solar wind. Thus, understanding the solar wind interaction is an essential element in using the crustal fields to interpret the geologic history of the Martian interior.

Likewise, the crustal fields (sometimes referred to as ‘anomalies’) are sufficiently strong that they influence the upper atmosphere and solar wind interaction, since the motion of charged particles is affected by magnetic fields. This influence has been observed locally, above the individual locations of each region of remnant magnetization. Certain plasma boundaries (PEB, MPB) are perturbed upward in regions of crustal magnetic field, presumably due to the added magnetic pressure contribution of the anomalies [Crider et al., 2002, 2004; Mitchell et al., 2001; Brain et al., 2005], and the structure of draped solar wind magnetic fields is changed [Crider et al., 2002, 2004a, 2004b; Brain et al., 2003]. The crustal fields also create complex current patterns in the dayside ionosphere [Vennerstrom et al., 2003]. The details of these effects are still under investigation. Ongoing research in these areas would benefit from the opportunity this conference will provide by convening representatives from the data and simulation groups.

Magnetic reconnection of crustal field lines to the passing solar wind magnetic field enables three different magnetic field topologies (closed, open, and unconnected) at Mars, and allows otherwise isolated particle populations to mix [Acuña et al., 1998; Mitchell et al., 2001; Krymskii et al., 2002; Brain et al., 2003]. UV auroral emission has been reported in crustal magnetic field ‘cusps’ [Bertaux et al., 2005]. Particle distributions reminiscent of auroral acceleration processes have been observed near crustal fields on the Martian night side [Brain et al., 2006; Lundin et al., 2006a, 2006b]. Interesting physics will be revealed by examining the similarities and differences between the plasma processes observed at Martian crustal fields (e.g. auroral and wave acceleration processes) and those observed at other solar system bodies, including the Sun.

In addition to these local consequences of crustal fields, there is some indication that the global solar wind interaction is influenced by their presence over distances of thousands of kilometers, both in terms of the locations of plasma boundaries and the structure of magnetic fields [Brain et al., 2005], and in terms of particle motion and plasma energization [Lundin et al., 2006a, 2006b]. The extent to which the crustal fields affect the global interaction is an open and emerging topic that will be addressed at the conference.

Coupled with the time variability in the solar wind and EUV flux, crustal fields make the Martian plasma environment incredibly dynamic and complex. Since the crustal fields are necessarily geographically fixed, Mars presents an ever-changing obstacle to the solar wind as it rotates. This last point is especially problematic in terms of global simulations, since the orientation of crustal fields with respect to the solar wind flow and magnetic field always varies (therefore many simulations can be required to model the interaction for a single set of external conditions). However, the longevity of MGS and its fixed orbit combine to alleviate this problem somewhat. There are many passes over the same ground track at the same local time and season, thus with the same orientation of the crustal fields to the solar wind. An exchange of information between the modelers and spacecraft teams would be beneficial now because there are enough data to compare the effects of various drivers using a single orientation for model runs.

Topic #3: Upper atmospheric structure and atmospheric loss

Except in some regions of strong crustal magnetic field, the Martian upper atmosphere acts as the primary obstacle to flowing solar wind plasma [e.g. see the review by Nagy et al., 2004]. The solar wind interaction, then, is the upper boundary condition for the Martian atmosphere. It deposits energy in the upper atmosphere via particle interactions, waves, and instabilities. This energy can heat and accelerate particles, and influence upper atmospheric structure, chemistry and dynamics. The upper atmosphere also serves as the particle reservoir for atmospheric escape. A variety of escape mechanisms remove both neutral and ionized planetary particles from the atmosphere by giving them escape velocity in a region where collisions are rare [see, for example, a recent review by Chassefière et al., 2004]. The solar wind influences both the particle reservoirs and many of the mechanisms themselves – especially mechanisms related to ion loss [Michel, 1971]. Loss processes for neutrals include Jeans escape for hydrogen and photochemical escape for heavier species. Loss processes for ions include pickup by the solar wind electric field, possible bulk removal processes via fluid-like instabilities, and possible ion outflow processes (e.g. processes analogous to Earth's polar wind). Both neutrals and ions near the exobase may be 'sputtered' away by energetic incident particles such as pickup ions or particles in solar storms (called SEPs).

Topic #3 Unanswered Questions

- Do the oxygen and hydrogen escape in the stoichiometric proportions of water?
- What fraction of the total atmospheric loss came from the solar wind interaction?
- How much of the ion outflow is lost from the planet and how much flows to the night side where it converges and flows downward?
- How are the model and measured ion density profiles affected by ion outflows?
- Is an F2 peak of O+ at high solar activity required to account for the alleged dominance of O+ in measured ion outflow, e.g. by PHOBOS-2? What do the recent models predict?
- What is the extent and variability of Mars' distant H corona?

A number of observations highlight the influence of the solar wind on atmospheric escape and the upper atmosphere. For example, Viking density profiles were significantly lower at high altitude than predicted by simple photochemical models, indicative of a loss process for upper atmospheric neutrals [Shinagawa and Cravens, 1989]. Phobos and Mars Express measurements showed that escaping pickup ions in the Martian magnetotail are controlled by the orientation of the Interplanetary Magnetic Field (IMF) [e.g. Kallio et al., 1995, Dubinin et al., 2006; Fedorov et al., 2006]. Auroral-like acceleration near crustal magnetic cusps (resulting in ion outflow) appears to be partly controlled by IMF direction, and is more intense during space weather events [Brain et al., 2006]. Mars Express has observed escaping planetary oxygen ions at low altitudes, demonstrating that the solar wind has direct access to the upper atmosphere [Lundin et al. 2004]. During space weather events, the high flux of solar energetic particles (SEPs) can heat the upper atmosphere for short time periods [Leblanc et al., 2002]. Additionally, Morgan et al. [2006] have shown that additional night side ionization results from the impact of solar energetic particles into the Martian atmosphere, preventing subsurface soundings of the MARSIS radar experiment on Mars Express.

The upper atmosphere and atmospheric escape processes are also affected by crustal fields. For example, ionization of the Martian dayside exosphere by charge exchange and electron impact can not occur in regions protected from the solar wind by strong anomalies [Mitchell et al., 2001]. Meanwhile, the solar wind has direct access to the upper atmosphere along open magnetic field lines in cusp regions [Mitchell et al., 2001; Brain et al., 2005]. This situation, in turn, drives differences in the ion and neutral densities in closed and open field regions. These differences have been directly measured in the form of electron density profiles [Ness et al., 2000; Krymskii et al., 2004; Breus et al., 2005; Withers et al., 2005], and in the form of vertical sheets of ionization near crustal field cusps [Gurnett et al., 2005; Nielsen et al. 2006]. This meeting will gather experts from both sides of the interface between the solar wind interaction and the upper atmosphere in order to define the role the solar wind plays in atmospheric processes, structure and evolution.

Topic #4: Modeling the interaction

The first simulation of the global Martian solar wind interaction was published by Spreiter et al. in 1970. Since this initial gasdynamic model, the last 35 years have seen continued advances in the complexity of the simulations, including their physical assumptions, implementation schemes, and resolution. In recent years, especially, improvements in computational resources have allowed significant new modeling results.

Simulations today may be classified according to the different physical assumptions they employ: gasdynamic, ideal MHD, Hall MHD, and hybrid. Within these classifications, models can be distinguished by whether they are 2-D or 3-D, the number of species they follow, their implementation, and the assumptions employed at the model boundaries. We count *at least* 10 different modeling groups that have been actively simulating the Martian interaction in the past several years: 3 single fluid MHD groups (Nagy et al., Maezawa et al., Schoendorf et al.); 5 hybrid groups (Brecht et al., Modolo et al., Kallio et al., Terada et al., Bößwetter et al.); a Hall MHD group (Harnett and Winglee); and a two fluid MHD group (Sauer et al.). In addition to these basic simulations, a number of "value-added" models employ some combination of a basic simulation and an added process such as electron transport [Liemohn et al., 2006], test particle trajectories [e.g. Luhmann et al., 1991; Luhmann et al., 1992], etc.

Topic #4 Unanswered Questions

- What is the present day global atmospheric escape rate?
- How do escape rates vary with EUV flux and solar wind conditions?
- How do solar wind conditions modulate the structure of the interaction region?
- Do models reproduce observations? Why or why not?
- How do the many hybrid simulations compare? MHD?
- For what purposes are each of the model types most appropriate (boundary locations, etc.)?
- How do crustal fields affect the magnetic field structure and particle flows?

These simulations have been used for a variety of purposes. They have been used to study atmospheric escape rates [e.g. Ma et al. 2002, 2004; Modolo et al. 2005;], the structure and topology of magnetic fields in the Martian system [Brecht, 1997; Harnett and Winglee, 2005], the structure of the ionosphere [Ma et al. 2002, 2004], the global shapes of plasma boundaries [Liu et al., 1999, 2001; Brecht et al., 1991, 1993; Bößwetter et al., 2004], and particle transport [Liemohn et al., 2006]. They can be used to simulate the interaction in conditions that may have existed in the past to trace the evolution of the system over history. Perhaps most importantly, simulations are powerful tools that can be used to study the effects of different drivers on the Martian system (i.e. variability) and place existing observations in context.

A number of challenges face the simulationists in the coming years (several of these are outlined in the adjacent textbox). Foremost among these is to identify the source of discrepancies between similar models. For example, four out of five of the hybrid modeling groups mentioned above employ 3D multi-species simulations. The different groups have different implementation schemes, and at least two have chemistry incorporated into their model. Yet the predicted atmospheric escape fluxes differ by an order of magnitude for similar conditions. Secondly, the simulations must be compared more rigorously to spacecraft observations in order to determine where the model assumptions are valid. These issues must be resolved before the simulations can reliably be applied to earlier epochs.

At the proposed conference, this session will provide the opportunity for modelers to compare their simulations to the data. Further they will be able to learn details about how their results compare to other modeling results and explore what aspects are critical to account for the differences in the simulations.

Topic #5 Unanswered Questions

- How does plasma behave in magnetic structures, like mini-magnetospheres, that have a scale size between the electron and proton gyroradius?
- How do ASPERA-3 and ASPERA-4 data (ion observations, electron observations, and ENA images) at Mars and Venus compare?
- Are "cometopause", "magnetic pileup boundary" and "ion composition boundary" different names for the same physics?
- What are the similarities in particle acceleration in auroral phenomena observed at Mars compared to Earth or other bodies?
- What are the commonalities in ULF waves at Mars, Venus, and comets?
- Is the photoelectron boundary the equivalent of Venus' ionopause?

Topic #5: Comparative planetology

Mars is a combination obstacle to the solar wind. Its conducting ionosphere, extensive exosphere, and crustal magnetic fields all have significant contributions to the solar wind interaction. Therefore, Mars shares characteristics with Venus (ionospheric obstacle), comets and satellites of outer planets (mass-loading), the Moon (mini-magnetospheres), and the Earth (particle acceleration and auroral processes). The combination of these also lends Mars some unique characteristics (asymmetries). Therefore, it is useful to compare and contrast features in the Mars solar wind interaction with the interactions between other bodies and space plasmas. Conversely, studying the solar wind interaction with Mars will further the understanding of other planets and universal processes.

In particular, many modelers apply their techniques/codes to objects throughout the solar system. Harnett and Winglee [2000; 2002; 2003;

2005] have progressively developed models to describe the effects of mini-magnetospheres in the solar wind. They began with simulations of the Moon and have continued to Mars. Nagy and coworkers [Liu et al., 1999; 2001; Ma et al.2002; 2004] have applied their MHD model to not only the solar wind interaction with Mars, but also Titan's interaction with Saturn's magnetosphere [Ma et al., 2004], Europa [Liu et al., 2000], comets [Kabin et al., 2000], and Venus [De Zeeuw et al., 1996; Bauske et al., 1998]. Brecht and coworkers have applied their hybrid model to Mars, Venus [Brecht and Ferrante, 1991], Titan [Brecht et al., 2000], and the Earth [Brecht and Thomas, 1987]. Cloutier and coworkers [Cloutier et al., 1979; Hoogeveen and Cloutier, 1996] have modeled the structure of magnetic fields in the ionospheres of Mars, Venus, and Triton. Cravens and coworkers have modeled the ionospheres of many objects, including Venus [Nagy et al., 1980; Cravens et al., 1980], comets [Korosmezey et al., 1987], Mars [Shinigawa and Cravens, 1989], and Titan [Keller et al., 1996; Cravens et al., 2000]. These are just a few examples of the breadth of objects and applications of models in comparative planetology.

Theorists have examined atmospheric escape processes at Venus, Earth, and Mars [e.g. Hunten and Donahue, 1976; Kaye, 1987; Kar, 1992; Luhmann and Bauer, 1992; Krasnopolsky et al., 1994; Shizgal and Arkos, 1996; Lammer and Bauer, 2003; Chassefiere and Leblanc, 2004]. Since the solar wind interaction influences a larger component of the overall loss at Mars than Earth or Venus, the comparison of atmospheric composition and loss rates at these other objects is important for evaluation of the overall effect of the solar wind interaction on the atmosphere.

Also, many scientists study data from similar instruments at different planets. Venus Express and Mars Express both carry the ASPERA package. Now, one can more easily interpret the differences observed at Venus and Mars as natural phenomena without accounting for significant instrumental differences. Radio science investigations have been conducted for many decades throughout the solar system. Radio science profiles of the ionosphere provide both a long history of observations to study solar cycle effects and a common format for studying the ionospheres of many objects. Comparison of different space environments using these instruments will enable the exploration of the parameter space in space plasma physics provided by the intrinsic differences of parameters throughout the solar system.

The Cassini spacecraft has an extensive plasma instrument complement and has studied the interaction between Saturn's magnetosphere and moons Titan and Enceladus. Based on an offset of the interaction region from what was expected at Enceladus, Dougherty et al. [2006] were able to infer the presence of a significant neutral jet near that moon's south pole. It is only through the comparison of similar interactions, predictions from well-tested models, and a physical understanding of the important processes that scientists can make such a profound discovery through magnetic fields data from one flyby. The study of Mars, in particular because of the hybrid nature of it as an obstacle, will be useful for the understanding of space plasma interactions elsewhere.

In regions where the crustal magnetic fields connect to IMF lines, auroral features are observed [Bertaux et al., 2005; Brain et al., 2006; Lundin et al., 2006]. Such features represent the first observation of aurora in non-global dynamo magnetic fields. As described above, it is worthwhile to compare these auroral signatures with those that are well-studied at Earth and other planets.

By dedicating a significant portion of the program to comparative studies between Mars and other bodies, we hope to attract a more diverse audience and expand the knowledge base in the community.

Conference Format, Schedule, and Potential Speakers

Format/Schedule: morning session talks, evening session varied (talks, posters, banquet), afternoons free. Table I is a potential meeting schedule that shows how the poster session and oral sessions combine into a complete program. We would have 8 half-day sessions. We expect that each of the first 4 science questions would be addressed in its own, dedicated, half-day oral session consisting of about 7-10 talks, about half of which would be invited. Topic 5 lends itself to be split among the first and last oral sessions because the comparisons serve as excellent introductory and concluding material. The six oral sessions would comprise the 4 morning slots and 2 evening slots. One evening would host the poster session. There would be a banquet on the other evening. This schedule leaves afternoons free for the participants to meet informally or to explore Myrtle Beach's many activities that are enjoyable even in the off-season, including golfing, fishing, swimming, shopping, and partaking in beach activities. The afternoons are left free as opposed to the standard evening-free schedule because many of these activities require daylight.

Table I. Meeting schedule

	Monday	**Tuesday**	**Wednesday**	**Thursday**
Morning 8:30-12:30	Registration/ Oral sess. topic 5	Oral sess. topic 2	Oral sess. topic 3	Oral sess. topic 4
Afternoon 12:30-4:00	Free	Free	Free	Oral sess. topic 5/ Wrap-up (1:30-5:30)
Evening 4:00-8:00	Oral sess. topic 1	Poster session	Banquet (6:30-9:30)	

Table II displays a hypothetical program for this conference, containing a sample list of invited speakers and topics. The list is divided into topics based on the 5 science questions in section 1. The Program Committee members, each of whom has agreed to serve on the committee, are listed below the science questions in bold. Then a subtopic related to each of the three unifying themes of the conference and a potential invited speaker. The example invited speakers for each subtopic were chosen from extensive lists of potential speakers provided by the Program Committee. These potential speakers have not yet been invited to the conference. This list is provided mainly to show that the potential speakers represent a broad cross-section of the community. Each oral session would have several contributed presentations, as well.

Table II. Topics, talks, and potential invited speakers

THEMES *Science topics* **(Program Committee)**	VARIABILITY	PROCESSES	EVOLUTION
How is the structure of the interaction region formed and maintained? **(Dubinin and Bertucci)**	Factors dictating the structure and variability of the IMB/MPB **C. Mazelle**	Multi-point observations of plasma processes in the Martian solar wind interaction **J.-G. Trotignon**	Outflow rates and escape processes in the Martian magnetotail **A. Fedorov**
How do crustal magnetic fields affect the interaction locally and globally? **(Acuña and Krymskii)**	Response of mini-magnetospheres to external drivers **D. Mitchell**	Plasma acceleration and reconnection near crustal fields **R. Lundin**	Do anomalies significantly influence loss processes and rates? **E. Harnett**
How does the interaction affect upper atmospheric structure and escape? **(Fox and Lammer)**	Ionospheric variability created by the solar wind and crustal fields **D. Gurnett**	The relative contributions of atmosphere escape mechanisms? **H. Lichtenegger**	Do O and H escape in the stoichiometric proportions of H2O? **Y. Yung**
How do models implement the physics and variability of the system? **(Nagy and Shinagawa)**	Which drivers have greatest influence on the global Martian interaction? **Y. Ma**	Kinetic vs. Fluid physics in global simulations? **E. Kallio**	Modeled loss rates over Martian history **N. Terada**
How does the Martian environment compare to other solar system bodies? **(Luhmann and Barabash)**	Factors governing ULF waves at Venus, Mars, and comets **C. Russell**	Auroral processes in the solar system **M. Galand**	Solar wind related loss processes at Venus, Mars and Titan **T. Cravens**
	The effects of solar activity on ionospheric scale height of terrestrial planets **M. Mendillo**	Are the MPB, IMB and the cometopause different names for the same physics? **U. Motschmann**	Neutral loss processes of the terrestrial planets **F. Bakalian**

Suggested Dates, Duration, and Location of Conference

Dates: Oct. 15-18, 2007. October on the Atlantic in South Carolina is in the off-season, so room rates are low. The off-season begins Oct. 1, so the proposed dates are not far into the off-season. Hurricanes tend to occur in August and September in the Carolinas, so although this is still Atlantic hurricane season, chances are remote. There is a small overlap between the constituency of American Astronomical Society's Division of Planetary Sciences (DPS) and this community. The DPS meeting is the week before in Orlando. International participants who are considering attending DPS, this meeting, and the Fall AGU would be able to attend both DPS and this meeting with one trip to the US and one visa. Yet it is still separated by almost 2 months from AGU (December 10-14). **These dates are not final** and can be adjusted to maximize attendance once a decision is made on this proposal.

Duration: 4 days (see Table I above)

Location: Myrtle Beach, SC. We propose an East Coast US city for the location. Myrtle Beach is a popular East Coast destination that is convenient to Convener Crider for planning purposes. MYR airport has connections to East Coast cities. Most Europeans can get there in 3 legs. Americans can get there in ≤2 legs. Of the US East Coast, the southeast is less expensive than other potential destinations. Myrtle Beach venues are quoting room rates of $59-$89.

Conference Cosponsors

NASA – We submitted a proposal to the NASA Mars Fundamental Research Program (MFRP) in May of 2006 requesting $31K in travel funds for 10-15 attendees, including foreign scientists and graduate students.

Expected Impact

We anticipate that the conference will directly benefit the community in the following ways:

1. Establish the current state of knowledge (measurement, simulation, theory) of the Martian solar wind interaction and upper atmosphere.
2. Establish the main unanswered questions facing the community over the next 10 years.
3. Help to place the Martian plasma interaction in the larger context of the Martian planetary system, from the evolution of the interior and crustal fields, to the state and evolution of the atmosphere, to Martian habitability.
4. Help to place the Martian plasma interaction and the processes that occur there in the larger context in the solar system given recent advances in our understanding.
5. Enable "cross-pollination" of ideas between scientists.
6. Provide a forum for vetting ideas for future Mars missions, including ones already proposed to the NASA Scout Program, the Mars Telecom Orbiter, and others.

These benefits will be achieved for those scientists attending the conference. They will be relayed to the community at large (including scientists from other disciplines) through publication of the proceedings of the conference and an *Eos* article. Graduate students and junior scientists, especially, should benefit from synthesis talks given by the session chairs (who are all recognized experts, and nearly all senior scientists), and from the resulting publications.

Anticipated Attendance

~75 A compilation of all of the potential *invited* speakers submitted by the Conveners and the Program Committee included 76 individuals. This list did not come close to exhausting the entire community. While we do not expect 100% attendance from the community, we think that the potential program is a good estimate of the expected attendance. Supporting this, there were 40-50 people in attendance at the recent Kiruna Mars Workshop, which was unadvertised. We expect that the prominent stature of the Program Committee members will attract participants. They include the PI of MGS MAG/ER, the PI of MEX ASPERA-3, some of the top modelers and theorists in the community, and researchers with involvement in Mars research since PHOBOS-2. These prominent members of the community will advertise the meeting to their team members and colleagues.

Related Previous Conferences

There have been focused conferences in the recent and distant past on the solar wind interaction with Mars. The last large, dedicated conference was a Chapman Conference in 1990 in Hungary, which included the atmospheres, ionospheres, and solar wind interactions of both Mars and Venus. Janet Luhmann, a member of the Program Committee for this conference, was one of the conveners of that conference. That conference resulted in a successful AGU monograph. However, many new data and better models exist today, warranting another such gathering.

Likewise, an ISSI workshop was held in Bern, Switzerland in Oct. 2001 to bring together PHOBOS-2 and MGS scientists. Although many MEX scientists were involved in PHOBOS-2 and were in attendance at this meeting, the success of MEX enables another visitation of the comparison of spacecraft data. This meeting was by invitation only because the facility did not allow too large of a group. Program Committee Member Mario Acuña was an editor of the proceedings from that meeting, which were published in a special issue of Space Science Reviews.

A conference dedicated to the solar wind interaction with Mars was held in Feb. 2006 in Kiruna, Sweden. Attendance to that conference was by invitation, and the size was limited by the organizers desire to keep it small. One of the Program Committee, Stas Barabash, convened that meeting.

An initiative exists that emphasizes comparing the processes in the upper atmosphere/ionosphere of objects in this and other solar systems. In 2001, the biennial Yosemite Meeting was entitled “Comparative Aeronomy in the Solar System,” from which has grown a Comparative Aeronomy in the Solar System news group, an AGU monograph, and a special “Union” session at the Spring 2006 AGU meeting. There is a lot that can be learned from comparing the processes occurring at various objects in the solar system. This meeting differs from that initiative in that it will focus on Mars and include processes occurring all the way from the upper atmosphere to the solar wind.

The 2005 Fall AGU meeting included a special session on the interaction of the solar wind with weakly and unmagnetized objects. Convener Crider and Committee Member Barabash organized this special session, which received about 50 abstracts. Concentrating on the solar wind interaction with Mars, such as in the proposed meeting, narrows a broad topic into something more tenable. We think that this will facilitate answering the science questions in this proposal.

These previous small meetings have not been open to the entire community. Big meetings like AGU, while open to everyone, often schedule concurrent sessions on these related topics making it impossible to assimilate information from pertinent fields. A dedicated solar wind interaction with Mars meeting would be timely, productive, and beneficial.

Anticipated Conference Reports and/or Publications

The Conveners, in collaboration with the Program Committee, will prepare a summary report on the conference for publication in EOS. In addition, the Conveners will solicit papers for a Conference Proceedings in the form of an AGU monograph or special issue of a journal. We anticipate that the proceedings will include papers from authors having invited conference talks, contributed conference talks, and posters. Additionally, we will require that the session chairs for each science topic (i.e. the Program Committee) contribute a brief synthesis paper outlining the current understanding and outstanding questions for each topic.

Biography of Conveners

Dr. Dana Crider received her B.A. in physics from the Johns Hopkins University and her M.S. and Ph.D. degrees in Space Physics and Astronomy from Rice University. She has been a Research Assistant Professor in the Physics Department at the Catholic University of America since 2001. Her research focuses on the solar wind interaction with planetary bodies, including Mars, Venus, the Moon and Mercury. She uses data analysis and modeling to understand those interactions, especially how the solar wind affects the evolution of volatiles. Dr. Crider has been interpreting data from the Mars Global Surveyor Magnetometer/Electron Reflectometer since the spacecraft arrived at Mars in 1997.

Selected relevant publications (see also reference section):

Crider, D. H., J. Espley, D. A. Brain, D. L. Mitchell, J. E. P. Connerney, M. H. Acuña. Mars Global Surveyor observations of the Halloween 2003 solar super-storm's encounter with Mars, J. Geophys. Res 110., A09S21, doi:10.1029/2004JA010881, 2005.

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Dr. David Brain is an assistant research physicist at the University of California Berkeley Space Sciences Laboratory. His research interests include the magnetic field and plasma environments of non and weakly magnetized planets such as Mars, Venus, and the Moon. His analysis efforts include: the interaction of the solar wind with these bodies; aurora, magnetic field topology, and reconnection at Mars and Venus; and the effects of solar storms at Venus, the Moon, Mars, and extrasolar planets. Dr. Brain is primarily involved with the analysis of spacecraft data (and supporting modeling) from the Mars Global Surveyor, Mars Express, Lunar Prospector, and Venus Express spacecraft. He was recently selected by ESA as a Supporting Investigator for Venus Express. Dr. Brain received a BA in Physics and Mathematics from Rice University in 1995, and an MS and PhD in Astrophysics and Planetary Sciences from the University of Colorado at Boulder in 1997 and 2002. He is a member of AGU and of DPS (the Division of Planetary Sciences of the American Astronomical Society).

Selected relevant publications (see also reference section):

Brain, D.A., F. Bagenal, M.H. Acuña, J.E.P. Connerney, D.H. Crider, C. Mazelle, D.L. Mitchell, and N.F. Ness, *Observations of low frequency electromagnetic plasma waves upstream from the Martian shock by MGS MAG*, JGR, 107(A6), 1076, doi: 10.1029/2000JA000416, 2002.
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