

## Preface

This special issue of *Earth, Planets and Space* contains manuscripts dealing with scientific results presented at the 5th Alfvén conference on plasma interactions with non-magnetized planets/moons and their influence on planetary evolution, which was held at Hokkaido University during October 4–8, 2010. The guiding theme of the conference and the accompanying special issue is to compare non-magnetized planets and moons throughout the solar system in order to improve our understanding of the physical interactions that govern the interaction of an incoming plasma (mainly the solar wind, but in some cases a magnetospheric plasma) with solar system objects.

The Alfvén conference emphasized comparisons of phenomena from different, but similar, planets and moons, in order to increase our understanding of the general physics behind the object/plasma interactions and to facilitate planning for future missions, and that focus is continued in this special issue. The various moons and planets considered at the conference and in this special issue are organized for comparison purposes in terms of the strength of the magnetic field (induced or intrinsic) and the total neutral atmospheric mass, as described in the introduction by Barabash.

The conference was organized by process rather than the planet, and this reflects the contributions, which mixed simulation and observation, with 5 specific emphases.

### 1. How is the plasma interaction region above non-magnetized objects formed and maintained?

The interaction of plasma with an unmagnetized planet is a topic of interest from the standpoint of basic plasma physics. This involves time scales ranging from billions of years to milliseconds, dealing with phenomena ranging from the microphysics of ion and electron motions to long term planetary evolution. Observations of the farthest boundary where energization of the ions takes place—the bow shock—are described by Yamauchi *et al.* For non-magnetized moons and planets, the role of localized magnetic field is also important, as presented in lunar studies by Halekas *et al.* and Saito *et al.*

### 2. What is the coupling between the incident plasma and the ionosphere/upper atmosphere or the surface?

The electric current systems (planetary surface, ionosphere, and boundaries) around other planetary bodies can be quite different from their terrestrial analogues. This makes ionospheric morphology, dynamics and related escape potentially quite different from at the Earth. The paper by Fillingim *et al.* discuss the consequences of the Martian ionospheric electric current on the field-aligned current, while the paper by Andersson and Ergun discusses the consequences of ion heating and escape from Mars. Dubinin *et al.* report on the lack of azimuthal asymmetry of the Martian ionosphere seen in Mars-Express observations, while Dieval *et al.* investigate proton precipitation into the Martian upper atmosphere near the solar wind energy.

### 3. What are the main physical acceleration/energization processes leading to escape and mass-loss from non-magnetized planets and how do they affect the volatile inventory over time?

The evolution of planets and moons under an active star is a topic of highly interdisciplinary nature ranging from basic nuclear physics, plasma physics, to chemistry and origin of life. Planetary evolution is closely related to the problem of the atmospheric escape. Global observations of ion energization and escape at Mars are presented in a paper by Nilsson *et al.* Simulations can also be used to study the contributions of different physical processes to atmospheric escape. Kallio and Barabash discuss the implications of the presence of an intrinsic dipole with various magnetic moments on a Martian-like atmosphere, and Kallio and Jarvinen consider the effects of the finite gyro-radius effect on Mars, Venus and comets. The effect of localized remanent crustal magnetic fields on atmospheric escape is discussed by Brecht and Ledvina.

### 4. What is the role of the “Sun in time” in the evolution of non-magnetized planets/moons?

A crucial element of atmospheric escape is the energy input from the magnetized incoming plasma (solar wind and interplanetary magnetic field) and photons (solar UV). In order to understand atmospheric escape throughout the solar system’s history, we have to understand billions of years of evolution of the planetary atmosphere, including the solar inputs to planet/moon atmospheres back to 4.6 billion years ago, and the resulting effects on atmospheric escape. This element of the conference was discussed in papers by Lammer *et al.* and by Suzuki.

### 5. How do models implement the physics and variability of the system, and do models agree with data?

The global interactions with, and (in some cases) resultant escape from various planetary bodies are studied by numerical simulations. The paper by Ledvina *et al.* focuses on the global interaction and the escape problem at Titan by considering the effects of solar UV and a rather detailed ionospheric chemistry scheme implemented in a kinetic global simulation model. Meanwhile, papers by Umeda and by Holmström *et al.* focus on plasma processes in the wake/tail of unmagnetized bodies. The paper by McKenna-Lawlor *et al.* describes aspects of the interaction between the solar wind and Mars with minor high-energy components at MeV range, using a global simulation model to interpret the observation.

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