RAS/G-MIST Meeting: Comparative Aeronomy in the Solar System

10 January 2003

Society of Antiquaries, Burlington House, Piccadilly, London

Meeting web site: **http://www.apl.ucl.ac.uk/ingo/Docs/RAS_schedule.htm**

Organizers: Ingo Mueller-Wodarg (i.mueller-wodarg@ucl.ac.uk),
Emma Bunce (emma.bunce@ion.le.ac.uk)

Programme

Morning Session

Chair: Ingo Mueller-Wodarg

10:00-10:30	**Coffee**
10:30-10:35	**Introduction**
10:35-11:05	**M. Mendillo** (BU), *Thermospheres and Ionospheres in the Solar System*
11:05-11:25	**G. Millward** (UCL), *Comparative modelling of planetary ionosphere-thermosphere systems*
11:25-11:45	**N. Achilleos** (IC), *Thermosphere-Ionosphere Coupling at Jupiter*
11:45-12:05	**T. Stallard**, G. Millward, S. Miller (UCL), *Jupiter's auroral/polar winds: observations and implications*
12:05-12:25	**J. Bailey** (AAO), *Observations of the Venus Night Airglow*
12:25-12:55	**M. Blanc** (OAMP), *Magnetospheres in the Solar System*

Lunch (a light lunch will be available for purchase)

Afternoon Session

Chair: Emma Bunce

14:00-14:20	**J. D. Nichols**, S.W.H. Cowley, and E.J. Bunce (Leicester) Magnetosphere-Ionosphere Coupling Currents in Jupiter's Middle Magnetosphere
14:20-14:40	**S. W. H. Cowley**, E J Bunce, and J D Nichols (Leicester), Magnetosphere-Ionosphere Coupling Currents in Jupiter's and Saturn's Magnetospheres
14:40-15:10	**S. E. Milan** (Leicester), *Convection and auroral signatures of solar wind-magnetosphere coupling at Earth - What might we expect at Saturn?*
15:10-15:30	**A. Coates** (MSSL/UCL) Ion pickup in the solar system
15:30-16:00	Tea at the Geological Society
16:00-18:00	RAS Monthly A&G (Ordinary) Meeting
18:00-19:00	Drinks Party (in RAS' Burlington House apartments)

Abstracts

Meeting Summary: The planets and satellites in our solar system interact with the solar wind and radiation in ways which are determined by their atmospheres, magnetospheres, geometry and distance from the Sun. Comparing the upper atmospheres and magnetospheres of planets and satellites helps us better understand the underlying physical laws which control these interactions, putting the different planetary configurations into perspective. The aim of this discussion meeting is to address the diversity of coupling, energetics and dynamics found in planetary and satellite environments, through theory, modelling, and observations.

Michael Mendillo (Center for Space Physics, Boston University, mendillo@bu.edu), *Thermospheres and Ionospheres in the Solar System*

The neutral atmospheres and ionospheres of the planets offer a rich set of conditions to test our understanding of upper atmospheric physics and solar-planetary coupling. The major constituents of the atmosphere (e.g., CO_2 versus N_2 versus H_2) determine the processes of solar photon absorption and planetary radiation, and thus the resulting neutral temperature profiles and upper atmosphere global winds. Atmospheric chemistry determines if plasmas produced by photo-ionization remain as ions related directly to their parent neutrals or to different ions via plasma-neutral transformations. Subsequent plasma chemistry determines if the ionosphere is one dominated by atomic or molecular ions, and thus to the resulting diurnal patterns of global ionospheric behaviour. The presence or absence of a planetary magnetic field governs the types of electrodynamical interactions between the solar wind and a planet's space environment.

George Millward (Atmospheric Physics Laboratory, University College London, george@apl.ucl.ac.uk), *Comparative modelling of planetary ionosphere-thermosphere systems*

On a fundamental level, a vertical slice through the atmosphere of a planet can be divided into three distinct regions. At the lowest level, the troposphere and stratosphere, an atmosphere consists of a dynamic mixture of neutral gases. In contrast, at the very outer extremity, an atmosphere consists entirely of charged particles. This plasma environment is known as the magnetosphere (for planets with a magnetic field), a region characterised by the interaction of the planets atmosphere with the high velocity stream of charged particles from the sun, known as the solar wind. Sandwiched in between is a transition region in which both the neutral gases of the lower atmosphere, and the charged particles of the outer atmosphere, co-exist. This region is the ionosphere-thermosphere. At the Atmospheric Physics Laboratory, University College London, sophisticated computational models of the global ionosphere-thermosphere system have been developed for the planets Earth, Mars, Jupiter, and Titan. In addition, recent developments have been concerned with the modelling of Saturn (in readiness for the arrival of the Cassini spacecraft in 2004) and also Jovian-like exoplanets. My talk will describe how three-dimensional, time dependent modelling of these systems provides invaluable insights into the underlying physical processes at work. It will focus on our comparative planetology approach in which the aim is to gain a better understanding by investigating the similarities and differences of the various systems.

Nick Achilleos (Space and Atmospheric Physics Group, Imperial College London, n.achilleos@ic.ac.uk), *Thermosphere-Ionosphere Coupling at Jupiter*

Observations of the motions of ions in Jupiter's auroral region have revealed that the dynamics of the ionosphere in this region are strongly coupled to the motions of the neutral thermospheric gas. Detailed global modelling using JIM (Jovian Ionospheric Model) has shown that this coupling is the result of: (i) The high ionospheric conductivity of Jupiter's auroral region; (ii) The strong electric field projected down onto the auroral ionosphere by the breakdown in corotation between the planet itself and the plasma in the distant magnetosphere. The results of this modelling study are presented in the wider context of the physical 'feedback' mechanisms, which link the dynamics and composition of the ionosphere, thermosphere and magnetosphere.

Tom Stallard, G. Millward, S. Miller (Atmospheric Physics Laboratory, University College London, tss@star.ucl.ac.uk), *Jupiter's auroral/polar winds: observations and implications*

Recent observations of the auroral / polar wind system on Jupiter show it to consist of several distinct regions. The main auroral oval is accompanied by a strong electrojet, with ion speeds reaching up to 2km/s. Poleward of the oval are two major regions - the Dark Polar Region (DPR) and the Bright Polar Region (BPR). The latter is seen to have rather flaccid winds. But the former has strong anti-sunward winds, as viewed in the planetary frame of reference. Transformed to the magnetic pole reference frame, this is shown to be a region of stagnation, linked to magnetotail field lines. Modelling of the electrojet shows that neutral winds are generated, with velocities reaching between 50% and 70% of the ions at the peak ionisation level. These winds may carry energy equatorward, helping to explain the high exospheric temperature of Jupiter.

Jeremy Bailey (Anglo-Australian Observatory, jab@aaoepp.aao.gov.au), *Observations of the Venus Night Airglow*

I will present the preliminary results of recent observations of the distribution and variability of the 1.27 micrometre O2 airglow emission from the night side of Venus. These and other recent results on the Venus airglow will be compared with the corresponding terrestrial emission. The implications for the photochemistry and dynamics in the Venus upper atmosphere will be discussed.

Michel Blanc (Observatoire Astronomique de Marseille-Provence, Michel.Blanc@oamp.fr), *Magnetospheres in the Solar System*

Steve Milan (Radio and Space Plasma Physics Group, University of Leicester, ets@ion.le.ac.uk), *Convection and auroral signatures of solar wind-magnetosphere coupling at Earth - What might we expect at Saturn?*

The circulation of plasma within planetary magnetospheres is controlled by the interplay between several competing processes. For instance, in the case of colder plasma, for which the effects of magnetic curvature and gradient drifts can be ignored, the two main sources of impetus for the motion are angular momentum donated from planetary rotation (corotation) and the coupling of momentum from the solar wind across the magnetopause via magnetic reconnection (the "Dungey cycle"). Observations and theoretical modelling show that magnetospheric convection driven by the latter dominates at Earth, whereas corotation is the dominant circulation at Jupiter. At Saturn, however, it is thought that the two processes compete on a more or less equal footing, and hence solar wind-magnetosphere coupling should play a much more important role in modulating the Kronian aurora than their Jovian counterpart. In this talk I will summarize the main features of the Earth's dayside aurora and convection which arise due to magnetic reconnection, to provide a guide for the possible identification of similar features during the Cassini mission at Saturn.

Stan Cowley, E. J. Bunce, and J. D. Nichols (Radio and Space Plasma Physics Group, University of Leicester, swhc1@ion.le.ac.uk), *Magnetosphere-Ionosphere Coupling Currents in Jupiter's and Saturn's Magnetospheres*

The dynamics of Jupiter's and Saturn's magnetospheres are both dominated by plasma pick-up and radial transport in corotation-dominated flow. In this poster we compute and compare the magnitude and spatial distribution of the currents that couple angular momentum from the planetary atmosphere and ionosphere to the magnetospheric plasma. We also comment on the consequent relationship of the current systems to the patterns of observed aurora.

Jon Nichols, S. W. H. Cowley, and E. J. Bunce (Radio and Space Plasma Physics Group, University of Leicester, jdn@ion.le.ac.uk), *Magnetosphere-Ionosphere Coupling Currents in Jupiter's Middle Magnetosphere*

The dynamics of Jupiter's plasma environment is dominated by the outflow of material originating from the moon Io, which orbits deep within the magnetospheric cavity. Breakdown of corotation associated with this radial transport results in the formation of a magnetosphere-ionosphere coupling current system which transfers angular momentum to the magnetospheric plasma and has been linked to the formation of the main jovian auroral oval. In this poster we compute solutions for this current system based on steady plasma outflow from the Io torus, and consider how they depend on the values of the effective jovian ionospheric Pedersen conductivity and iogenic plasma mass outflow rate. We go on to consider how the auroral precipitation associated with regions of upward field-aligned current flow modulates the effective Pedersen conductivity and thereby effect the solutions.

Andrew Coates (Mullard Space Science Laboratory/UCL, ajc@mssl.ucl.ac.uk), *Ion pickup in the solar system*

Ion pickup is an important process at work in several solar system contexts. It is central to the solar wind interaction with comets. In addition it plays an important role at Mars, Venus and probably Pluto. At Mars it has been responsible for atmospheric loss over the last 3.8 billion years. Ion pickup is also important at satellites such as Io and Titan and wherever a source of neutral particles occurs. The interstellar medium also provides a source of pickup ions. Here we review this process and its effects in the different contexts.