Autumn MIST Abstracts

Friday 27 November 2015

B. S. Lanchester – Auroral processes (invited talk)

The aurora is the most obvious and visible effect of the solar terrestrial connection, which we all now take for granted. This connection has been verified with multi-instrument measurements, starting at the Sun and following the chain of events in the solar wind and Earth's magnetosphere to the upper atmosphere. But with that passage of energy there is much that is not understood. How the particles that cause the aurora gain their energy remains the primary puzzle, but it is clear that more than one process is responsible for the variety of optical signatures that are observed. The multi-scale nature of the aurora is a fascinating clue, as are the temporal and spatial variations such as pulsations, flickering and splitting, which are an indication of waves in the magnetic field. Coincident satellite and optical data have always been a goal to help solve the questions about the source of the energy and structure of the aurora. Particle and field measured above the aurora are a crucial input for theoretical models. The auroral spectrum contains all the information about the energy of the precipitating particles, but the composition of the atmosphere must also be known. An added complication is the dynamic and spatially varying nature of the auroral emissions. The challenge that has been tackled over many years is to combine ground-based and satellite measurements with models to unravel the physics of the aurora. Some results from past and present experiments which have led to a better understanding of these processes will be shown.

M. O. Archer, M. D. Hartinger, B. M. Walsh, F. Plaschke, V. Angelopoulos – Occurrence and frequencies of standing Alfvén waves excited by fast mode resonances in the outer magnetosphere

Coupled fast mode resonances (cFMRs) in the outer magnetosphere, between the magnetopause and a turning point, are often invoked to explain observed discrete frequency field line resonances. Due to observational difficulties in the detection of these modes directly in space, the occurrence of this mechanism has often involved searching ground-data for the so-called "CMS" frequencies (1. 3, 1. 9, 2. 6-2. 7, 3. 2-3. 4 mHz). However, it is not clear how variable the frequencies of this eigenmode should be. We therefore quantify this variability, applying the theory to 5 years of observed magnetospheric density profiles and a realistic magnetic model.

We find that the dawn-dusk asymmetry in outer magnetospheric densities results in this mechanism being more likely around dawn, since the plasmaspheric plumes and extended plasmaspheres more often found at dusk can preclude their occurrence. The overall variability is estimated to be 28% at dawn and 55% at dusk, with the latter primarily due to the density whereas the magnetic field plays a comparably-sized contribution at dawn. Finally, at dawn we show that an observed bimodal density distribution results in bimodal cFMR frequencies, whereby it is the secondary peaks that are consistent with the "CMS" frequencies.

S. D. Browett, R. C. Fear – Timescales for IMF BY penetration into the Earth's magnetotail

Previous studies have shown there is a correlation between the By component of the interplanetary magnetic field (IMF) and the B_Y component observed in the magnetotail lobe and in the plasma sheet. This effect has been explained theoretically as either a consequence of the open model of the magnetosphere or through asymmetric field lines in the lobe, induced by a B_Y component of the IMF, putting pressure on the plasma sheet to induce a By component in the same sense as the IMF. Studies of the effect of IMF B_Y on several magnetospheric processes have indicated that the B_Y component in the tail should depend more strongly on the recent history of the IMF B_Y rather than on the simultaneous measurements of the IMF. Values for this timescale vary and, by using upper/lower quartiles of measurements of polar cap size and field line convection speed, estimates for this timescale can be calculated to be between 1-6 hours. We present a statistical study of how promptly the IMF B_Y component is transferred into the neutral sheet, measured by use of the penetration efficiency and Pearson's correlation coefficient. To carry out this study, Cluster magnetometer data was used, for the period 2001-2009, alongside solar wind data taken from the OMNI database. Neutral sheet crossings during this interval were identified, and crossings during periods of rapid variation in the solar wind or the magnetotail were excluded. Starting out with the correlation between instantaneous measurements of the lagged IMF and the magnetotail (recently reported by Cao et al. , 2014), we then vary the time delay applied to the solar wind data. We report preliminary results suggesting that the timescale takes either 1. 5 or 3 hours, depending on the sign of the IMF B_Z. We discuss how our observations fit with other studies and what they tell us about magnetospheric timescales.

A. G. Burrell, H. Lawal, T. K. Yeoman, S. E. Milan, M. Lester – Solar influence on high-frequency radar signal propagation

The polar ionosphere is a dynamic region that readily responds to changes in solar irradiance, solar wind, the magnetosphere, and the neutral atmosphere. The most recent solar minimum brought to light gaps in the current understanding of the relationship between ionospheric structure and solar irradiance. The Super Dual Auroral Radar Network (SuperDARN) observes the high-latitude ionosphere using coherent scatter High Frequency (HF) radars. SuperDARN has been operational over one and a half solar cycles, and so provides an invaluable dataset for studying long-term ionospheric variability at the northern and southern poles. This study explores the influence of solar forcing on HF ground-backscatter. Ground-backscatter, the backscatter that returns from a reflection point on the ground rather than from an ionospheric irregularity, provides a measure of the ionospheric density along the propagation path of the radar signal. By exploring the conditions that inhibit or enhance the propagation of ground-backscatter, we improve our understanding of the state of the bottomside ionosphere.

J. A. Carter, S. E. Milan, R. C. Fear, M. -T. Walach, Z. A. Harrison, L. J. Paxton, B. Hubert – Transpolar arcs: Seen in both hemispheres simultaneously

We present auroral observations for the 31st August 2005 that show two transpolar arcs in both northern and southern polar caps. Using both IMAGE and SSUSI data sets, these observations provide the first test of a model of transpolar arc formation using simultaneous observations taken in both the northern and southern hemispheres. In this model, a transpolar arc will form on closed field lines at mirror locations in magnetic local time about the midnight meridian in opposite hemispheres. The interplanetary magnetic field was primarily northward throughout, although with a dominant B_Y component. The observed movement of the arcs was as anticipated given the occurrence of low-latitude dayside reconnection under B_Y dominant conditions, as indicated by ionospheric convection patterns obtained from supplementary ground-based radar data. The data are consistent with the tested model; the arcs formed at mirror positions about the midnight meridian and are embedded in the ambient ionospheric flow.

S. C. Chapman, J. Dods, J. W. Gjerloev – Substorms as dynamical networks: Quantifying the time evolving pattern of spatio-temporal correlation seen in the SuperMAG database of ground based magnetometer stations

The overall morphology and dynamics of magnetospheric substorms is well established in terms of observed qualitative auroral features and signatures seen in ground based magnetometers. The detailed evolution of a given substorm is captured by typically ~100 ground based magnetometer observations and we seek to synthesise all these observations in a quantitative manner. We present the first analysis of the full available set of ground based magnetometer observations of substorms using dynamical networks. SuperMAG offers a database containing ground station magnetometer data at a cadence of 1min from 100s stations. We use this data to form dynamic networks. Windowed linear cross-correlation between pairs of magnetometer time series along with a threshold is used to determine which stations are correlated and hence connected in the network. Variations in ground conductivity and differences in the response functions of magnetometers at individual stations are overcome by normalizing to long term averages of the cross-correlation. These results are tested against surrogate data in which phases have been randomised. The network is then a collection of connected points (ground stations); the network properties can be captured quantitatively in time dependent dimensionless network parameters and we will discuss their behaviour for examples of 'typical' substorms and storms. The network parameter provide a detailed benchmark to compare data with models of substorm dynamics, and can provide new insights on the similarities and differences between substorms and how they correlate with external driving and the internal state of the magnetosphere.

C. H. K. Chen, L. Matteini, M. L. Stevens, C. S. Salem, A. A. Schekochihin, B. A. Maruca, M. W. Kunz, S. D. Bale – Multi-species measurements of instability thresholds

Recent investigations have examined how various temperature anisotropy and drift instabilities in different space environments constrain plasma parameters such as temperature anisotropy, beta, and differential flow. These investigations have tended to look at each species separately, and how the distribution of its parameters is separately constrained by the resonant kinetic instability arising from free energy in its own distribution. In reality, however, plasma stability depends on all species simultaneously. Here, we present an analysis which combines all major species (protons, alphas, electrons) together, and considers both anisotropies and drifts on an equal footing. A large data set from the 3DP and SWE instruments on the Wind spacecraft in the solar wind was used. We have found that the firehose instability, traditionally thought to be a proton instability, has a 33% contribution from non-proton species. Also, when all species are combined, the fluid firehose and mirror thresholds appear to constrain the distribution remarkably well, suggesting that non-resonant fluid versions of these instabilities may be active in the solar wind, in addition to resonant kinetic instabilities.

J. C. Coxon, C. M. Jackman, M. P. Freeman, C. Forsyth, I. J. Rae – Magnetic field strength fall-off in the magnetotail lobe

We use 13 years of magnetic field observations made by Cluster 1 in order to construct a new model for the decrease in magnetic field magnitude with increasing radial distance in the magnetotail lobes. We compare our new model to a previous empirical model, as well as comparing it to a model based on a simple dipole. We find that a simple dipole model accurately describes the gradient of the fall off that we observe.

Following on from this, we describe the observed magnetic field as a combination of the internal field of Earth with some perturbation field (introduced by the interconnection of terrestrial field lines with the IMF). We explore the contributions of either field to the magnetic field magnitude with radial distance and we describe the way the two fields combine to give the observed field, as well as the characteristics of the perturbation field.

T. W. David, D. M. Wright, S. E. Milan – Outflow of heavy ions from the Earth's upper atmosphere

Heavy ions in the upper atmosphere can outflow under the right conditions into the magnetosphere to moderate the magnetospheric dynamics in the sun-magnetosphere-ionosphere system. The ionosphere is a region of the upper atmosphere where upwelling of heavy ions, a process leading to loss of planetary atmospheres, takes place. It is believed that mechanisms responsible for these upwellings and outflows include electron precipitation, Joule heating and other forms of suprathermal energization. Over seven hundred events of upwelling ions were identified from observations by the EISCAT Svalbard Radar (ESR) during the international polar year (IPY) of

2007. Analysis of events shows that ion flux of the order ≥ 10^{14} m^{-2} s^{-1} associated with Kp ≥ 4 is distributed predominantly around local noon. In addition, ion flux of the order ≥ 10^{13} m^{-2} s^{-1} cut across the altitude range of 100 – 500 km with over 75% occurring at altitudes ≥ 300 km. Seasonal analysis of the ion flux indicates that local time variation is most commonly observed in the summer. Furthermore, the ESR detects electron precipitation (which, it is suggested, leads to the creation of an ambipolar electric field), and Joule heating as mechanisms responsible for increasing the ion scale height and ion upwelling as a result.

R. T. Desai, M. M. Cowee, S. P. Gary, H. Wei, A. J. Coates, D. O. Kataria – Hybrid simulations of positive and negative pickup ions and ion cyclotron waves at Europa

Europa orbits Jupiter within its own plasma and neutral torus at ~9. 38 R_J and has been identified as the secondary source of mass loading within the Jovian magnetosphere. Neutral material, picked up from the moon's atmosphere and periodically ejected through plume activity, become ionised and accelerated by the Jovian magnetodisk. These newly created ions form rings in velocity space unstable to the generation of electromagnetic Ion Cyclotron (IC) waves, the frequencies and amplitudes of which can be used to infer the ion species present, the ion densities, and the ionisation rates of the neutral material. Near Europa, Galileo observed IC wave activity at the gyrofrequency of a range of species including O_2, SO_2, K, Na and Cl. These transverse waves were observed as a mix of left and right-hand polarisations and led to the inference that both positively and negatively charged Cl ions were being picked up. In order to relate the observed wave amplitudes to ion production rates and local plasma conditions we conduct self-consistent hybrid simulations on the growth of IC waves in the Europan plasma environment. Using positively and negatively charged Cl pickup ion distributions we conduct a scaling study of the wave energy with ring densities and anisotropies, and provide estimates of a range of possible ion densities at Europa. We also draw comparisons to Cassini observations of IC waves generated in the Enceladus E-ring to understand differences in the pickup processes and wave properties within these plasma environments. This analysis represents the first step in constraining the production rates of minority ion species at Europa and understanding their role with respect to the moon's atmosphere, surface, and possibly salt-rich sub-surface ocean.

W. R. Dunn, G. Branduardi-Raymont, R. F. Elsner, M. F. Vogt, L. Lamy, P. G. Ford, A. J. Coates, G. R. Gladstone, C. M. Jackman, J. D. Nichols, I. J. Rae, A. Varsani, T. Kimura, K. C. Hansen, J. M. Jasinski – Solar wind driving of Jupiter's X-ray aurora

The relationship between the Solar Wind and Jupiter is not yet understood. To probe this relationship, we compare two Chandra X-ray observations of Jupiter's aurora: one coinciding with the predicted arrival of an Interplanetary Coronal Mass Ejection (ICME) and another observation two days later. We find that the ICME triggers emission from new regions and that several of these bright enhancements occur ~1 hour before a burst of non-Io Decametric radio emission, believed to be associated with solar wind forward shocks [Hess et al, 2012, 2014]. We also find variation in X-ray auroral periodic behaviour, spatial and spectral distributions.

We use magnetosphere-ionosphere mapping [Vogt et al, 2011] to identify the source of ions generating the X-rays and find that they originate from 10:30-18:00 magnetospheric local time (MLT) in regions close to the magnetopause. The model also maps some precipitation to open field lines. This suggests that X-rays may provide an excellent tool for analysing the processes occurring between the Jovian magnetopause and the solar wind.

To better understand the persistence of these features and/or their relationship to the ICME, we compare these 2011 observations with analysis of Chandra X-ray observations of Jupiter from 2007. At this time, New Horizons was approaching the planet and provides upstream solar wind measurements. We hope that this will provide a useful analogy for the Spring 2016 Juno approach. Jupiter is our local analogue for many of the recently discovered brown dwarfs and exoplanets. Understanding which auroral features have a solar wind driver and which are internally driven has deep implications for understanding the magnetospheres and future auroral signatures of exoplanets.

J. P. Eastwood, M. V. Goldman, X. -J. Zhang, D. L. Newman, H. Hietala, V. Krupar, V. Angelopoulos, G. Lapenta – On the role of Cherenkov emission in mediating electron hole and whistler wave interactions during magnetic reconnection

In magnetic reconnection, waves, together with the instabilities and processes responsible for growth and damping, are a crucial component of the controlling kinetic-scale physics. Whistler waves play an important role as they may modify the reconnection rate, contribute to anomalous resistivity and cause pitch-angle scattering of particles. Whilst it is well known that whistlers can arise as a result of kinetic instabilities, which grow exponentially from noise as a consequence of unstable electron distributions (e. g. , temperature anisotropy), recently it has been demonstrated theoretically and via computer simulations that whistler waves may also arise via Cherenkov emission from electron hole quasi-particles. Such wave emission can arise even when the temperature anisotropy leads to damping; in this case the system is analogous to a damped forced oscillator. We present novel experimental analysis from THEMIS, revealing evidence consistent with the generation of whistlers via Cherenkov emission during magnetotail reconnection. By examining the properties of the electron holes, the amplitude, phase speed and frequency of the associated whistlers, and the available subspin observations of the electron distribution function, we find that in the event examined here the data are best explained by the Cherenkov emission theory rather than by kinetic instabilities due to the electron temperature anisotropy. The interplay between Cherenkov emission and kinetic instabilities is discussed and it is suggested that Cherenkov emission of whistlers may in fact be a common phenomenon in space and laboratory plasmas.

T. Elsden, A. N. Wright – Modelling the dayside magnetosphere: MHD waves in observation and theory

Ultra low frequency (ULF) waves are a class of magnetic pulsation which are prevalent in the dayside magnetosphere. We model these waves using a 2D MHD simulation assuming an ideal, low-β, inhomogeneous plasma waveguide. We investigate driving the magnetopause boundary with a pressure perturbation, in order to simulate solar wind dynamic pressure fluctuations disturbing the magnetopause. The model is applied to two recent observations: one of a large scale Pc4 (7 – 22 mHz) pulsation observed by Cluster believed to couple to a field line resonance, the second a Pc5 (2 – 7 mHz) global mode observed by THEMIS. Our model is able to reproduce similar wave signatures to those in the data and despite its simplicity, can shed light on various features of propagating waveguide modes. For example, the location of the energy source relative to the spacecraft can be identified and we can determine clearly the driven portion of the wave packet.

C. Forsyth, I. J. Rae, J. C. Coxon, M. P. Freeman, C. M. Jackman, J. W. Gjerloev, A. N. Fazakerley – A new technique for determining Substorm Onsets and PHases from Indices of the Electrojet (SOPHIE)

We present a new quantitative technique that determines the times and durations of substorm expansion and recovery phases and possible growth phases based on percentiles of the rate of change of auroral electrojet indices. By being able to prescribe different percentile values, we can determine the onset and duration of substorm phases for smaller or larger variations of the auroral index or indeed any auroral zone ground-based magnetometer data. We apply this technique to the SuperMAG AL (SML) index and compare our expansion phase onset times with previous lists of substorm onsets [e. g. Frey and Mende, 2006]. We find that more than 50% of events in previous lists occur within 20 minutes of our identified onsets. We also present a comparison of superposed epoch analyses of SML based on our onsets identified by our technique and existing onset lists and find that the general characteristics of the substorm bay are comparable. By prescribing user defined thresholds, this automated, quantitative technique represents an improvement over any visual identification of substorm onsets, or indeed any fixed threshold method.

G. A. Graham, I. J. Rae, C. J. Owen, A. P. Walsh, C. S. Arridge, C. Forsyth, L. Gilbert, G. H. Jones, A. J. Coates – Radial evolution of strahl electron pitch angle width: Cassini observations

Observations of solar wind electron velocity distribution functions within the inner heliosphere have shown that solar wind electrons within the suprathermal energy range are made up of an approximately isotropic 'halo' component and a strongly field-aligned 'strahl' component. Strahl electrons have a much lower relative number density than the halo but, as they are strongly field aligned, they can provide valuable information about the interplanetary magnetic field topology and solar connectivity. Previous studies have demonstrated that the average pitch angle (PA) width of strahl electrons increases as the electrons travel radially outwards away from the Sun. This contradicts the theoretically predicted narrowing of the strahl beam due to adiabatic focusing of collisionless electrons, and implies that the strahl must be subjected to a PA scattering process or processes. Previous studies have estimated strahl scattering rates that are dependent on electron energy but independent of radial distance. However, a recent investigation using Cassini data found an indication of strahl electrons at 10 AU, suggesting that the scattering rate may decrease with radial distance. In order to fully understand the relative role of the strahl electron PA scattering mechanism or mechanisms, it is therefore necessary to study the radial evolution of strahl throughout the heliosphere. In this study we used Cassini election spectrometer data from its Earth Flyby in 1999 until its Saturnian orbit insertion in 2004, to determine strahl pitch angle width variation over a large heliospheric radial range of approximately 8 AU. We show a clear increase in strahl PA width with radial distance and indicate a possible energy dependence for strahl PA width at 1 and 5 AU. We conclude that, although there is evidence of suprathermal electron anisotropy, the strahl is most likely completely scattered by the time it reaches the orbit of Saturn and indistinguishable from halo electrons.

R. L. Gray, S. V. Badman, M. F. Vogt, J. D. Nichols, B. Bonfond – Auroral observations of radial transport in the Jovian magnetosphere

An outstanding question at Jupiter is how the plasma generated in the inner magnetosphere by Io's volcanism is transported through the system and lost downtail. The January 2014 Hubble Space Telescope campaign imaged the northern hemisphere of Jupiter's far ultraviolet aurorae over 16 days. We investigate auroral signatures of reconnection in the tail (polar spots) and of interchange in the inner/middle magnetosphere (low latitude emissions) to investigate radial transport of plasma through the magnetosphere. We present auroral observations from DOY011 of a super-rotating polar spot transitioning from the polar to main emission region in the presence of a broad and bright main emission feature and two large equatorward emission features. We analyze the magnetic mapping of the features to show large-scale plasma transport from the outer to middle magnetosphere. With reference to the long-term power trends over the observational campaign, we reconcile these observations of simultaneous polar spots and low latitude emissions by suggesting that the interchange in the inner magnetosphere and reconnection in the magnetotail are interdependent and further suggest that the enhanced mass outflow rate 'primes' the tail for reconnection.

B. E. S. Hall, M. Lester, B. Sanchez-Cano, J. D. Nichols, D. J. Andrews, H. J. Opgenoorth, M. Fraenz – Variation of Mars' induced magnetospheric boundaries over the last solar cycle

Since Mars lacks an intrinsic global magnetic field, the solar wind interacts directly with the Martian ionosphere and upper atmosphere. This interaction gives rise to an induced magnetosphere around the planet with distinct boundaries encapsulating, and separating plasma populations of differing origin. The European Space Agency Mars Express (MEX) mission has been in operation for a full solar cycle, affording us an extensive and unique dataset to study the response of the main Martian plasma boundaries to external and internal factors. From analysis of the electron flux measured by the Analyzer of Space Plasma and Energetic Atoms Electron Spectrometer (ASPERA-3 ELS) instrument on-board MEX, we present the initial results of identification of the bow shock and induced magnetospheric boundaries along with their variation in position over the last solar cycle. Compared to other bodies in the solar system that lack an intrinsic global magnetic field, the presence of crustal magnetic fields distributed across the Southern hemisphere of Mars further complicates and differentiates the Martian plasma system. The impact of the presence of these crustal magnetic fields on the location of boundaries is also studied.

C. Hewitt (on behalf of the CERN@school collaboration) – LUCID: First Results from a Prototype Cosmic Ray Detector on TechDemoSat-1

LUCID, the Langton Ultimate Cosmic ray Intensity Detector, is a new style of cosmic ray detector using technology developed at CERN for use with the Large Hadron Collider. Its purpose is to measure the radiation environment in Low Earth Orbit. The experiment was designed by students at the Simon Langton Grammar School for Boys in Canterbury, developed by Surrey Satellite Technology (SSTL), and launched on-board TechDemoSat-1 from the Baikonur Cosmodrome in July 2014.

The instrument consists of five Timepix pixel detectors, which can be used to give a visual readout of the trace left by a particle of ionising radiation across the plane of the chip, from which its energy and directionality can be determined. After a period of optimising the detector configuration, data has been captured over a large geographical area in order to build up a complete map of the flux of radiation at the altitude of TDS-1, ~635 km. This data should be of some value to the space weather community; in the words of Dr Jonathan Eastwood of Imperial College London, a supporter of the programme: "LUCID is not just an educational experiment. LUCID's research-quality data will be of direct interest and use to the wider science community, allowing students to engage in real research, studying the basic physics of how space weather works." The LUCID experiment will also be opened up to a wider group of student collaborators, allowing school students from across the country to contribute to the project.

We will present the results of the first basic analysis of the LUCID data including the current version of the radiation flux map, along with methods which will be used to extract more complex information, utilising the large-scale computational analysis capabilities of GridPP.

R. Hood, A. Aruliah, A. Aylward – Comparison of satellite, ground-based and model ionospheric electron temperatures during solar cycles 23 and 24

Ionospheric electron temperature data from several incoherent scatter radars and preliminary in situ measurements from the Langmuir probes of the three SWARM spacecraft are compared to the theory-based calculations used in the UCL Coupled Middle Atmosphere Thermosphere 2 general circulation model (CMAT2). The Global Ionosphere Plasmasphere model (GIP) is used within CMAT2 to provide the electron temperatures, and is in the process of being updated. Here we present the current findings of the study, probing the electron temperature response to solar activity during solar cycles 23 and 24, using these ground-based and satellite measurements to validate recent progress. We also discuss future work, including improvements to the model.

G. Hunt, S. Cowley, G. Provan, E. Bunce, M. Dougherty, A. Coates – Field-aligned currents in Saturn's southern magnetosphere: Comparison between midnight and pre noon currents

Saturn's magnetosphere has near planetary period oscillations (PPOs) throughout. Here we will focus upon two of these periodic phenomena, the rotating field-aligned current systems responsible for the PPOs observed in the magnetic field, and the intensification of the Saturn Kilometric Radiation (SKR) at ~08 local time. It has been proposed that in the dawn sector there is an enhancement to the PPO-independent upward field-aligned current and that once every ~10.7 hours when the PPO-related current system's upward field-aligned current passes through this local time sector there is an intensification of SKR emission. From our recent work on the midnight field-aligned currents in the southern hemisphere we have indeed separated the two field-aligned current systems. We now present the comparison between the southern hemisphere field-aligned currents at midnight and in the post-dawn sector, where the SKR power is approximately between a factor 2 to 3 greater compared to midnight. This is done by analyses of positions and strengths of the field-aligned current as derived from observations by the Cassini magnetometer in the midnight sector during 2008 and a smaller set in the pre-noon/post dawn sector during 2006-07. We are able to once again separate the field-aligned current systems and therefore investigate the local time effects observed in both. We find that the field-aligned currents signatures are modulated in the same manner as the midnight sector, and that there is no remarkable difference to either current system between the midnight and post dawn sectors in the southern hemisphere. Thus it appears that the intensification of SKR is not wholly due to the enhancement of the dawn PPO-independent field-aligned current. This raises the interesting question of whether there is another difference in Saturn's magnetosphere at dawn which can help explain the intensification of SKR.

M. K. James, E. J. Bunce, T. K. Yeoman, S. M. Imber – A statistical study of wave activity in the Hermian magnetosphere

A statistical study of wave activity within the Hermian magnetosphere is undertaken using data obtained from the MESSENGER mission between March 2011 and March 2014. Wave activity is categorised by its predominant polarisation - allowing for the comparison between compressional wave events and those more Alfvénic in nature. The position of the spacecraft at the time of each spectrum is mapped both to the magnetic equatorial plane, and the planetary surface at Mercury in order to determine the location of each wave event within the magnetosphere. We find that azimuthally oscillating events typically occur on the dayside of the planet, while compressional activity peaks in the night side. By mapping the wave activity to the surface of Mercury, we also find evidence for possible a polar cap boundary location.

R. Johnson, T. Stallard, H. Melin, S. Miller & J. Nichols – Measurements of the rotation rate of the Jovian mid-to-low latitude ionosphere

Previous studies often assume that Jupiter's mid-to-low latitude ionosphere is corotating, an assumption which is often a specific requirement of Jovian models. At these latitudes it is thought that the ions will rotate with the planet since this region maps to Jupiter's inner magnetosphere which near-rigidly corotates with the planet. However a model describing asymmetry in Hydrogen Lyman-α emission by Sommeria et al [1995] is in disagreement with this assumption. This study investigates the rotation rate of the Jovian mid-to-low latitude ionosphere by deriving the line-of-sight velocities of the ions from the Doppler shifted line at 3.953 and is the first study to do so. Data for this study were obtained with the long-slit echelle spectrometer, CSHELL, at the NASA Infrared Telescope Facility (IRTF), Hawaii. We have found that the line-of-sight velocities of the ions are consistent with the rigid corotation within the bounds of the experimental uncertainties. We thus confirm that the ionosphere does corotate at mid-to-low latitudes, and the departures observed [e.g. Stallard et al, 2001] are confined to the polar region and are therefore likely to be due to magnetosphere-ionosphere coupling at those latitudes, as is often asserted. As we do not observe any departures from corotation in the bulk flows of ions, this suggests that either the H

Lyman-α are decoupled at the equator, or that the H Lyman-α bulge is produced through different process than that modelled by Sommeria et al [1995].

N.M.E. Kalmoni, I.J. Rae, C.E.J. Watt, K.R. Murphy, C. Forsyth, R.G. Michell and C.J. Owen – The properties of auroral beads observed at substorm onset

An auroral substorm is marked by a sudden brightening and poleward expansion of the most equatorward auroral arc (onset arc). Using data from the THEMIS All Sky Imagers, small-scale azimuthal structures have been observed along the onset arc in the minutes leading up to auroral brightening and poleward expansion. These beads have been observed simultaneously in both hemispheres, suggesting they have a common magnetospheric driver. We have previously characterised the exponential growth and spatial scales of auroral beads, and found that the scales and growth rates are most consistent with a Shear Flow Ballooning Instability operating in the near-Earth magnetotail. In this talk we investigate whether auroral beads are a special case of onset arc, or whether all onset arcs exhibit similar azimuthal structuring and growth. Using higher spatial and temporal resolution all-sky imager measurements we investigate whether smaller spatial scales and higher growth rates can be observed along the onset arc. Finally we investigate whether multi-wavelength measurements can improve our understanding of what processes cause the substorm onset arc to go unstable.

J. Kinrade, S. V. Badman, G. Provan, J. D. Nichols – Evidence for rotational and inter-hemispheric modulation of Saturn's aurora from Hubble Space Telescope UV images

The discovery of rotating current systems in each of Saturn's hemispheres has led to questions about their potential modulation of the steady state auroral morphology. Hubble Space Telescope (HST) observations of the FUV aurora have so far shown the Northern oval position to oscillate with Northern planetary period phase, and have revealed dawn-side intensity enhancements associated with the rotating upward current sector as it passes through local dawn times. Infrared and magnetic field observations from Cassini have also indicated that these current systems may close in the opposite hemisphere. We present case study examples from the recent 2014 HST campaign, when at times we see both truncation and elongation of the dawn-side emission arc, and isolated patches moving in phase with the rotating current system dipole. Both hemispheres were partially visible during the 2009 equinox campaign, permitting the comparison of auroral intensities with respect to the planetary period oscillation currents in the opposing hemisphere. We investigate whether the occurrence of dawn sector patches is related to the planetary period oscillation phase in addition to instability driven processes. The upcoming Cassini Grande Finale mission will provide further opportunity to determine the inter-hemispheric current closure, with the HST making simultaneous auroral observations of the Northern hemisphere.

S. T. Lindsay, M. K. James, E. J. Bunce, S. M. Imber, A. Martindale, T. K. Yeoman – Magnetosphere-surface interaction at Mercury

The NASA MESSENGER spacecraft has recently completed its mission at Mercury and has provided a wealth of new information about the smallest planet in our solar system. The X-ray Spectrometer (XRS) instrument has detected unexpected X-ray fluorescence events on the nightside surface of the planet, presumably induced by the precipitation of magnetospheric electrons. Using a filter based on elemental fluorescence lines we construct a catalogue covering the full five years of the MESSENGER mission.

We find that the locations of these nightside events are aligned in two clear latitudinal "arcs" on the dawn side of the planet, centred about the magnetic equator at ~50°N and ~20°S respectively. This implies that there is a mechanism which produces the precipitation of electrons to the surface which is stable on timescales of at least several minutes. This timescale is long in comparison to characteristic times of Mercury magnetospheric dynamics. Conversely, the precipitation does not appear to be caused by a steady-state process as it is observed on ~30% of MESSENGER orbits, although we note that this may be limited by the energy range of the XRS instrument. Taking into account instrument limitations, we are able to place speculative limits on the energies of the precipitating electrons based on the excited fluorescence lines in the observed X-ray spectra.

We have magnetically mapped the surface features into the nightside magnetosphere and find that they map almost exclusively to the closed field region on the dawnside, according to the model of Korth et al [2015]. In addition the poleward boundaries of the surface events are found to be co-located with the modelled open-closed field line boundary. We discuss possible origins of this precipitating population and the implications for a large-scale magnetosphere-surface interaction.

M. Lockwood, M. Owens, L. Barnard, I. Usoskin, D. Willis, H. Nevanlinna, C. Scott, C. Watt – Sunsport number data series: Which should we believe?

Recently a new group sunspot number data series (called the “Backbone” series because of the way it was constructed) was presented at the IAU (International Astronomical Union). In addition SIDC, the Solar Influences Data Analysis Centre at Royal Observatory of Belgium, has issued a revised version of the International Sunspot Number (ISN) which is now the default series and the only one that they are updating. A special issue of Solar Physics is in preparation, reporting and discussing the outcome of a series of workshops of calibrating sunspot numbers and will include another new sunspot group data series from an international team led by Oulu University. Rather than bringing convergence, these new series differ from each other in a surprisingly radical way with the backbone series and new version of the ISN suggesting that the present grand maximum is the third since the Maunder minimum whereas in the Oulu series it is the first, as it was in all prior sunspot number and sunspot group number series. Most series use “daisy chaining” of calibrations and this leads to propagation and compounding of errors. A new method of calibration based on the frequency of observed spot-free days and which avoids this pitfall is used by the Oulu series. Tests have been made of the series in the 20th century using data on solar faculae and the ionospheric F region and on the 19th and 20th century data using auroral sightings and geomagnetic data. We conclude that revisions made by the backbone and new ISN series to data after 1980 are improvements to the original version of the ISN but that they both slightly overestimate sunspot numbers before 1945 and seriously overestimate them before 1850. We would not recommend the use of either and argue that the new Oulu series is the most robust.

L. Matteini, T. Horbury – Do in situ observations contain signatures of intermittent fast solar wind acceleration?

Recent observations [Matteini et al, 2014, 2015] have outlined the presence of intense (up to ~1000km/s) and short-living velocity peaks that ubiquitously characterize the typical profile of the fast solar wind (i.e the plasma coming from coronal holes). Such speed enhancements can be explained on the basis of the Alfvénic nature of the large scale solar wind fluctuations, where magnetic and velocity variations are strongly correlated, resulting in a spiky and intermittent fast wind profile. Remarkably, the observed speed modulation has a radial distance dependency and we expect it to be maximum closer to the Sun, a fact that can make the forthcoming in situ plasma measurements by Solar Orbiter and Solar Probe Plus particularly challenging.

More intriguingly, the existence of an intermittent and sheared plasma outflow in the inner Heliosphere, with speed variations of the order of some hundreds of km/s and lasting only for a few seconds, may also suggest the presence of a likewise intermittent solar wind acceleration. In this scenario, the short velocity peaks observed by the Helios spacecraft at 0.3AU could be the signature of pre-existing velocity shears in the Corona and acceleration region.

We discuss how future high-resolution observations will shed light on this scenario, and in preparation to that, how the available Helios dataset can already play a role in predicting and anticipating Solar Orbiter and Solar Probe Plus explorations.

L. Mejnertsen, J. Eastwood, J. Chittenden, A. Masters – Reconnection at Neptune's magnetopause: Results of a global simulation

Neptune is the furthest planet from the Sun in the Solar System, orbiting at a distance of ~30 au. Due to its remoteness from Earth, little is known about Neptune's space environment. Much of what is known was uncovered by Voyager 2 in 1989, the only spacecraft to fly by the planet. Many aspects of Neptune, ranging from its formation, to its composition and to the drivers in its magnetosphere (to name a few) are poorly understood. The fact that both Neptune's rotational and dipole axes are highly inclined relative to the solar wind flow mean that its magnetosphere is uniquely complex. Consequently, its interaction with the solar wind is thought to provide insight into a whole host of solar system sciences, as well as potential exoplanet research.

The role of reconnection at Neptune's magnetopause in driving magnetospheric dynamics is not well understood. It is likely to be heavily dependent on the interplanetary magnetic field orientation, as well as the season and the time of day of Neptune, due to the large tilt of both its magnetic and rotational axes. Here we presents results from a global simulation of Neptune's magnetosphere during the time of the Voyager 2 flyby. The simulation includes the extreme rotation of Neptune's dipole, allowing us to capture the diurnal reconfiguration of Neptune's magnetosphere. This talk will focus in particular on the nature of the outer magnetospheric boundaries (bow shock and magnetopause), and examine how the onset and duration of magnetopause reconnection is controlled by the planetary rotation. We will also discuss the implications for the circulation of plasma through the magnetosphere.

R. Mistry, J. P. Eastwood, T. D. Phan, H. Hietala – Development of bifurcated current sheets in solar wind reconnection exhausts

The Petschek reconnection model predicts that for antiparallel symmetric reconnection, reconnection current sheets should bifurcate. However, closer to the X-line it is expected that Hall physics effects should play a more significant role in controlling the reconnection dynamics. Whilst in-situ observations at the magnetopause and magnetotail have provided a detailed insight into reconnection physics, imprecise knowledge of the spacecraft location both within the reconnection exhaust and relative to the X-line limits the extent to which the spatial structure of reconnection exhausts can be probed. In the solar wind, however, the rapid transit of a spacecraft across the solar wind exhausts allow us to make detailed observations with precise knowledge of the spacecraft location within the jet, such that the magnetic structure of the reconnecting boundary can be directly deduced. If two spacecraft measure the reconnection jets either side of the X-line, this enables a much more precise reconstruction of the reconnection geometry, but this is a rare occurrence.

Here we present three solar wind reconnection events where different spacecraft (ACE, Cluster and Wind) sampled both of the oppositely directed reconnection exhausts from a common reconnection X-line, which allows us to estimate each spacecraft's distance from the X-line. We find that in all three cases spacecraft furthest from the reconnection site observed bifurcated current sheets, consistent with Petschek reconnection, whereas spacecraft closer to the reconnection site did not. This suggests that bifurcations of reconnection current sheets develop with increasing distance from the X-line, and that Petschek-type signatures are less developed close to the reconnection site. We discuss these results and consider implications for other reconnection environments.

D. Nunn – The numerical simulation of VLF chorus using a broadband Vlasov VHS simulation code

In the numerical simulation of collision free space and laboratory plasma the particle in cell (PIC) method has proved very popular and has created many excellent results. Although PIC is entirely correct it may be shown that it is actually very noisy and extravagant of computing resources. PIC follows particle or phase space trajectories forwards in time. Simple application of Liouville's theorem would give us distribution function F (and dF) at the particle phase space points at no computational cost. However PIC does not use this valuable information but merely deposits charge e and current –Ve onto a spatial grid.

Here we use the Vlasov Hybrid Simulation (VHS) method [Nunn, 1990, 1993; Omura et al, 2012] which follows particles forwards in time continuously, and at each time step interpolates F onto a phase space grid {r,v} allowing plasma current to be calculated. An identical algorithm has been developed in the fusion community [Kazeminezhad et al, 2003; Jenab et al, 2014]. A broadband 1D VHS code has been recently developed to simulate the phenomenon of VLF chorus generation due to nonlinear electron cyclotron resonance. The code is very simple and stable, and is robust against distribution function filamentation. Many of the features of chorus, namely sequences of rising elements, hook formation, sideband formation and development of chorus from a hiss band are reproduced.

Rising frequency VLF emissions and chorus have been successfully produced by PIC codes [Hikishima et al, 2009] but the code is far more expensive than VHS.

J. Parker, S. E. Pryse, N. Jackson-Booth – The main ionospheric trough in the European sector imaged by the EDAM model with GPS input

The main ionospheric trough is a large-scale depletion in ionospheric electron density. It forms at the interface between the high-latitude auroral region and the mid-latitude ionosphere and is observed at UK longitudes between late afternoon and dawn, moving equatorward during the course of the night. It exhibits substantial day-to-day variability in both its structure and latitude, and under periods of high geomagnetic activity the trough minimum reaches lower latitudes. The feature, and small scale electron density irregularities that can develop on its steep density gradients, may disrupt transionospheric radio systems.

The Electron Density Assimilative Model (EDAM) assimilates ionospheric observations into the background International Reference Ionosphere (IRI) to provide 3D representations of ionospheric electron density. For the current study, GPS observations from some 50 ground receivers for the month of October 2002 were assimilated into the model. The resulting ionospheric profiles reveal the trough in electron content and detail of its structure. Statistical results are presented of the latitude of the trough minimum, the total electron density at the minimum and other parameters that characterise the structure. The technique has potential for modelling the trough over large geographic regions on a routine basis, providing information on the equatorward edge of the auroral region, which influences its behaviour.

D. Pokhotelov, I. J. Rae, K. R. Murphy, I. R. Mann – Effects of ULF wave power on radiation belts at different phases of the geomagnetic storm

The dynamics of relativistic particle fluxes in the Earth's outer radiation belts is governed by a balance between multiple mechanisms of particle acceleration, loss and transport. It is necessary to understand various drivers involved in this balance in order to predict and model the behaviour of radiation belts. Electromagnetic ULF waves in Pc 4-5 range (150 - 600 s periods) are identified as one of the key factors in the radial transport and/or coherent acceleration of relativistic particles trapped in the outer radiation belts. Using in-situ observations by Van Allen Probes, THEMIS and GOES satellites, we analyze the behaviour of ULF waves throughout the geomagnetic storm of 8-9 October 2012 and compare with the dynamics of relativistic electron fluxes on-board the Van Allen Probes. We demonstrate that the ULF power in outer radiation belts changes its characteristics throughout the storm from being a mixture of compressive and shear magnetic components during the first (sheath-driven) phase of the storm to being dominated by the traverse (shear) component oscillations during the second (ejecta-driven) phase. We discuss the results in the context of previous studies of this geomagnetic storm (Reeves et al., Science, 2013; Thorne et al., Nature, 2013) to demonstrate how the behaviour of ULF waves can contribute to the evolution of relativistic fluxes throughout the storm.

K. M. Raymer, S. Imber, S. Milan – What controls the shape and location of the Earth's magnetopause?

The location of the Earth's magnetopause is governed by a combination of internal magnetospheric and external solar wind parameters. While the dependence of the magnetopause shape and size on the upstream solar wind dynamic pressure and direction of the interplanetary magnetic field (IMF) B_Z component have been the subject of many studies, few have characterised the influence of the internal magnetospheric parameters. We postulate that a combination of the open flux content and the ring current strength may order the magnetopause shape and size. We have developed an automated magnetopause crossing detection routine to determine the location of the magnetopause using a combination of plasma and magnetic field data. The technique has been applied to almost two solar cycles of data from the Geotail satellite producing a database of over 7000 magnetopause crossings. The locations of these crossings are then compared to the Shue et al. (1997) empirical magnetopause model in order to determine the causes of the differences between the observed magnetopause crossings and the Shue et al. model. Using both auroral oval radius data from the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) spacecraft as a proxy to calculate the open flux content in the magnetosphere and ring current indices from the D_{ST} and SYM-H databases we are able to characterise the influence of these parameters on the location and shape of the magnetopause.

J. J. Reed, C. M. Jackman, M. P. Freeman – The role of Io in the dynamics of Jupiter's magnetosphere: A sandpile modelling approach

Jupiter's magnetosphere is thought to be largely internally driven, by the combination of the loading of ~500 kg/s of plasma into the system by the volcanic moon Io, and the rapid rotation of the planet itself. Since we do not see a continuously expanding torus and magnetosphere, we would expect a long-term balance between the inflow of mass, primarily from Io, and the outflow of mass, via plasmoid release.

Simple calculations, which attempt to match the mass-loading rate from Io with the amount of mass lost via large-scale tail reconnection events, indicate a significant mass imbalance at Jupiter. This mass imbalance may be due to several reasons, including visibility issues linked to single spacecraft observations.

This is where modelling can be a powerful tool. A single spacecraft can only expect to observe a global 'systemwide' event, where energy is redistributed across the entire system, with any certainty. While 'internal' events, with a more local redistribution of energy, are likely to be missed. Using computational modeling we are able to 'observe' an entire system at any time. Cellular automata (CA) based on robust physical parameters and rules can allow us to manipulate the inputs and drivers of magnetotail physics, and to explore the response of the system over a range of temporal and spatial scales. Here we examine the variability of the mass-loading and the response of our CA sandpile model to an analogous driving. We explore whether Jupiter's magnetospheric dynamics can be explained purely in terms of Io mass-loading. In particular we examine the difference between the small local events ("internal" avalanches) and larger global events ("systemwide" avalanches), and what this can tell us about the fate of mass in Jupiter's magnetosphere.

B. Sánchez–Cano, M. Lester, B. E. S. Hall, S. E. Milan, M. L. Mays, O. Witasse, P. Kajdic, K. I. ReyesAyala, D. Andrews, H. Opgenoorth, S. Imber, D. Odstrcil – CME and CIR effects in the ionosphere of Mars at solar minimum

We report the observations of two different types of solar wind events that hit Mars in a short period of time during the solar minimum, when the Martian plasma system was at the weakest levels of the latest solar cycle. The first event was a small transient coronal mass ejection (CME) which was detected by STEREO B satellite on 6th March, 2008. Just after the trailing edge of the CME transient, the solar wind increases abruptly to almost 700 km/s and lasted for a few days. The

WSA-ENLIL model of the background solar wind captures this increase. At Mars, both events were observed by Mars Express with a different ionospheric response on 7th and 9th March 2008 respectively. For the first event, a clear compression of the magnetosheath- ionosphere system is found, with the location of the bow shock (BS) and magnetic pileup boundary (MPB) much lower than expected. The ionosphere is found to be more compressed and with a larger induced magnetic field. The second event, also caused a compression in the Martian plasma system, although lower than the first event. The high speed of the stream led to fast MPB boundary movements, which produced a different reaction in the thermal pressure of the ionosphere.

J. K. Sandhu, T. K. Yeoman, R. C. Fear, I. Dandouras – Variations of high-latitude geomagnetic pulsation frequencies: A comparison of IMAGE magnetometer observations and time-of-flight estimates

Field-aligned variations in the electron density and average ion mass were modelled based on Cluster data, from the WHISPER and CIS instruments, for the interval spanning 2000-2012. The combination of these models were used to infer an empirical model for the plasma mass density along closed geomagnetic field lines in the outer plasmasphere and plasmatrough ($5.9 <= L < 9.5$), including dependences with L shell and MLT (Magnetic Local Time).

In this study, the mass density model is utilised to investigate variations in the properties of magnetospheric ULF (Ultra Low Frequency) pulsations. Using the T96 magnetospheric magnetic field model with this empirical mass density model, a time-of-flight analysis is employed to estimate the frequencies of standing Alfven waves of closed geomagnetic field lines. The results describe variations in resonant frequencies with geomagnetic latitude and MLT.

In order to assess the validity of the estimates, a statistical survey of FLR frequencies is conducted using observations from the IMAGE ground magnetometer array. This required the development of an automated identification method for the resonant frequencies of high-latitude field lines, which involved using the cross-phase technique. The resulting statistical analysis of the resonant frequencies, considering variations with geomagnetic latitude and MLT, allow for a comparison with the time-of-flight estimates.

S.A. Taylor, A.J. Coates, G.H. Jones, A. Wellbrock – Photoelectrons at Enceladus

The Electron Spectrometer (ELS) of the Cassini Plasma Spectrometer (CAPS) measures electrons in the energy range 0.6-28,000 eV with an energy resolution of 16.7%. ELS has observed photoelectrons produced in the plume of Enceladus. These photoelectrons are found during Enceladus encounters in the energetic particle shadow where the spacecraft is shielded from penetrating radiation by the moon [Coates et al, 2013]. Observable is a population of photoelectrons at 20-30 eV, which are seen at other bodies in the solar system and are usually associated with ionisation by the strong solar He II (30.4 nm) line. We have identified secondary peaks detected by ELS which are also interpreted as a warmer population of photoelectrons created through the ionisation of neutrals in the E-Ring. We have noted differences in the relative intensities of these peaks dependant on the geometry of the encounter and whether the spacecraft passes through the plume. We have begun comparing the observations with models of photoelectron production spectra to try and explain how the plume materials may directly contribute to these photoelectron populations.

L. Trenchi, R. Fear, B. Mihaljcic, A. Fazakerley, K. Trattner – Multiple flux transfer events observed by Cluster

Time-varying reconnection at the Earth magnetopause generates magnetic structures called Flux Transfer Events (FTE). When a spacecraft passes through or near to these FTEs, the typical bipolar variation in the component of the magnetic field normal to the magnetopause is observed. Various generation mechanisms have been proposed: the original Russell and Elphic [1978] FTE model predicts a pair of elbow shaped flux tubes of reconnected field lines generated by intermitted and localized reconnection. Alternatively, Lee and Fu [1985] propose that FTEs are caused by reconnection along multiple extended X-lines while a third FTE model is based on bursty reconnection along a single X-line [Scholer et al, 1988; Southwood et al, 1988]. Here we studied a number of FTEs consecutively observed by Cluster spacecraft, during the dayside magnetopause crossing on 27 March 2007. We performed a detailed analysis of these FTEs applying the Grad Shafranov reconstruction and the multi-spacecraft timing to determine their orientation and motion. The Walén test allowed to identify the presence of several reconnection jets, and the transition parameter is used to determine their relative position with respect to these FTEs. These results have been discussed in the framework of the main FTE models cited above.

M.-T. Walach, S. E. Milan, T. K. Yeoman, B. A. Hubert, M.R. Hairston – Testing predictions of the ionospheric convection from the expanding/contracting polar cap paradigm

The expanding/contracting polar cap (ECPC) paradigm, or the time-dependent Dungey cycle, provides a theoretical framework for understanding solar wind-magnetosphere-ionosphere coupling. The ECPC describes the relationship between magnetopause reconnection and substorm growth phase, magnetotail reconnection and substorm expansion phase, associated changes in auroral morphology, and ionospheric convective motions. Despite the many successes of the model, there has yet to be a rigorous test of the predictions made regarding ionospheric convection, which remains a final hurdle for the validation of the ECPC. In this study we undertake a comparison of ionospheric convection, as measured in situ by ion driftmeters on board DMSP (Defense Meteorological Satellite Program) satellites and from the ground by SuperDARN (Super Dual Auroral Radar Network), with motions predicted by a theoretical model (Milan, 2013). The model is coupled to measurements of changes in the size of the polar cap made using global auroral imagery from the IMAGE FUV (Imager for Magnetopause to Aurora Global Exploration Far Ultraviolet) instrument, as well as the dayside reconnection rate, calculated using the OMNI dataset. The results show that we can largely predict the magnitudes of ionospheric convection flows using the context of our understanding of magnetic reconnection at the magnetopause and in the magnetotail.

D.K. Whiter, B. Gustavsson, B. Lanchester, O, Jokiaho, N. Ivchenko and H. Dahlgren – A new method for measuring the neutral temperature in the F-region ionosphere during low energy aurora

The O+ 2D-2P doublet emissions at 731.90 nm and 731.99 nm (together I732) and 732.97 nm and 733.02 nm (together I733) are visible in planetary nebulae, airglow, and aurora. These emissions result from a forbidden transition with a lifetime of about 5s. For astrophysical sources the brightness ratio R = I732/I733 varies between 1.24 and 1.31, depending on the density of the plasma. In aurora, the O+ 2D-2P emissions result from low energy electron precipitation and peak at an altitude of about 250 km. We have conducted a statistical study of the ratio R = I732/I733 observed in aurora over Svalbard during the 2003-2004 winter observing season, and have found the average value of R = 1.38+/-0.02. Theoretical modelling indicates that such a high value can only be produced if the total angular momentum quantum number J is conserved in the electron impact ionisation which occurs in aurora to produce O+ 2P from neutral O 3P. In this case the ratio R depends only on the temperature of the neutral O, and therefore measurements of R in low energy aurora can be used to infer the neutral temperature in the F-region.

I. C. Whittaker, S. Sembay, J. A. Carter, A. M. Read – Magnetosphere solar wind charge exchange: A comparison between the GUMICS-4 MHD model and XMM-Newton observations

The Solar Wind Earth Exchange Project (SWEEP) seeks to improve our understanding of the interaction of the solar wind with the Earth. X-ray emission resulting from charge exchange between oxygen in the solar wind and magnetospheric neutral hydrogen is modelled for a series of observations from XMM-Newton, an X-ray astronomical observatory. We use OMNI solar wind conditions, heavy ion composition data from ACE, the Hodges neutral hydrogen model and combine these with the GUMICS-4 MHD model to predict the global levels of X-ray emission from solar wind charge exchange (in the 0.5-0.7 keV band). The emission is then integrated along a line of sight and compared to the measured XMM-Newton sky background emissivity rates to determine the accuracy of these model predictions. Our results show that the magnitude of the integrated X-ray emissivity for both the modelled and observed flux is similar in a large number of cases, while the correlation of emission changes in detail between cases. We show that the accuracy of the oxygen density and relative charge state abundances is vital. The positional accuracy of the magnetopause is important as it forms the outer edge of the masking of the plasmasphere, including the cusps in our global emissivity rates. The derived position of the magnetopause and various masks are discussed with examples given, highlighting their relative accuracy. We also show the potential of X-ray emission for remote sensing of the magnetosphere, when used in combination with a wide field X-ray imaging system.

Z. Yao, A. N. Fazakerley, A. Varsani, I. J. Rae, C. J. Owen, D. Pokhotelov, C. Forsyth, R. L. Guo – Substructures within a dipolarization front revealed by high temporal resolution Cluster observations

The Dipolarization Front (DF), usually observed near the leading edge of a Bursty Bulk Flow (BBF), is thought to carry an intense current sufficient to modify the large-scale near-Earth magnetotail current system. However, the physical mechanism of the current generation associated with DFs is poorly understood. This is primarily due to the limitations of conventional plasma instruments which are unable to provide a sufficient number of unaliased 3D distribution functions on the timescale of the DF, which usually travels past a spacecraft in only a few seconds. It is thus almost impossible to unambiguously determine the detailed plasma structure of the DF at the usual temporal resolution of such instruments. Here we present detailed plasma measurements using the Cluster PEACE electron and CIS-CODIF ion data for an event during which it was possible to observe the full pitch angle distribution a cadence of 1/4 second. The observations clearly show details of plasma sub-structure within the DF, including the presence of field-aligned electron beams. In this event, the current density carried by the electron beam is much larger than the current obtained from the curlometer method. We also suggest that the field-aligned current around the DF obtained from the curlometer method may have been misinterpreted in previous studies. Our results imply that the nature of the DF current system needs to be revisited using high resolution particle measurements, such as those observations shortly to be available from the Magnetospheric Multiscale (MMS) mission.

P. Zelina, S. Dalla – Time variation of heavy ion abundances in SEP events

Solar Energetic Particles (SEPs) are ions and electrons accelerated at the Sun by solar flares and coronal mass ejections (CMEs). They propagate through the interplanetary medium and can precipitate on Earth in the polar regions, potentially affecting high-frequency communication and increasing radiation dosage for flights taking polar routes.

Heavy ion SEP data can be used to probe the propagation and acceleration of the particles. We analysed SEP observations from near-Earth spacecraft ACE and SOHO, and the twin STEREO spacecraft. We studied intensity time profiles and ratios of heavy ion SEPs to verify whether ion intensities behave differently compared to each other. The data show that the ratio of any two ion species changes in time. For example the Fe/O abundance can be 10 times higher than the average SEP abundance at the beginning of an SEP event, decaying to below average later in the event. We fit time profiles of abundance ratios and find that decrease time constants scale with the ratio of m/q's of the two SEP ions.

We analyse the results by taking into account several properties of the SEP events including as the relative location between the magnetic footpoint of the spacecraft and the associated solar eruptive events. We discuss possible rigidity dependent mechanisms that may explain the observed time dependence of ionic ratios.