Autumn MIST 2012 – 30th November, 2012

Oral Presentations (in talk order)

CINEMA/TRIO: MAGIC in space

Tim Horbury, Patrick Brown, Tim Oddy, Trevor Beek, Martin Archer, Jonathan Eastwood

MAGIC is a miniature, magnetoresistive magnetometer developed by Imperial College London for space science applications. Its first flight was on the CINEMA CubeSat, launched in September 2012 and currently operating in low Earth orbit. CINEMA also carries STEIN, a novel instrument to detect energetic neutral atoms from the radiation belts as well as precipitating ions and electrons.

The MAGIC magnetometer samples the magnetic field 8 times a second in science mode and has sufficient sensitivity to detect field-aligned currents, ULF waves and other magnetospheric transients. By flying in low Earth orbit, CINEMA allows wide latitude and local time coverage and provides a vital measurement location between the outer magnetosphere and the ground.

We present the first space data from MAGIC, demonstrating that it is operating nominally. We discuss the status of the instrument and the spacecraft; at the time of writing this abstract, due to spacecraft teething troubles, we have attitude mode data but we await the first science mode data.

MAGIC will fly on 3 more near-identical CubeSats within the next 12 months, offering the prospect of a constellation space weather mission in near-Earth space.

Temperature Anisotropy and Heating in the Presence of ULF Waves in the Foreshock.

Luke Selzer, Bogdan Hnat, Kareem Osman

Temperature anisotropy of the foreshock plasma in the presence of left- and right-hand polarised waves has been investigated for the first time. We find a distinct patterns when the temperature data is ordered according to the ratio of parallel and perpendicular temperatures and the parallel plasma β.
These patterns conform to previously reported results based on linear Vlasov simulations, which found that the reflected ion beam instability is the most likely origin of the left hand polarised waves, while the right hand polarised waves may arise due to the firehouse instability. These findings not only provide a bridge between the linear simulation studied and non-linear dynamics of the foreshock plasma, but are also relevant to a wider space plasma studies where similar techniques have been used to study the role of kinetic instabilities in plasma heating.

Magnetospheric Impact of Solar Wind Discontinuities: A source of Pc5-6 waves?

M. O. Archer[1], T. S. Horbury[1], J. P. Eastwood[1]
[1] Blackett Laboratory, Imperial College London

Observations suggest that solar wind discontinuities interacting with the shock can generate transient, large amplitude pulses in the magnetosheath dynamic pressure. While it is known that these pressure pulses can distort the magnetopause, their magnetospheric impact is not currently well understood. We present observations of such pulses in the magnetosheath and show that they generate field line resonances and compressional waves in the magnetosphere, the latter of which are observable down to the ground. Whilst the magnetosheath pressure pulses individually appear short and impulsive, the magnetopause acts somewhat like a low pass filter to these structures responding only to timescales of the order of a few minutes or longer. Therefore, solar wind discontinuities can be a source of Pc5-6 waves and hence could play a role in the mass, energy, and momentum transport within the Earth's magnetosphere.

The Spatio-temporal Characteristics of ULF Waves Driven by Substorm Injected Particles

M.K. James, T. K. Yeoman, P .N. Mager and D. Yu. Klimushkin.

A previous case study [Yeoman et al., 2010] observed a ULF wave with an eastward and equatorward phase propagation (an azimuthal wave number m, of ~13) generated during the expansion phase of a substorm. The eastward phase propagation of the wave suggested that eastward drifting energetic electrons injected during the substorm were responsible for driving that particular wave. In this study a population of 83 similar ULF wave events also associated with substorm-injected particles have been identified using multiple SuperDARN radars in Europe and North America between June 2000 and September 2005. The wave events identified in this study exhibit azimuthal wave numbers ranging in magnitude from 2 to 92, where the direction of propagation depends on the relative positions of the substorm onsets and the wave observations.
We suggest that azimuthally drifting energetic particles associated with the substorms are responsible for driving the waves, as suggested in Yeoman et al. [2010]. Both westward drifting ions and eastward drifting electrons are implicated with energies ranging from ~1 to 70 keV. A clear dependence of the particle energy on the azimuthal separation of the wave observations and the substorm onset is seen, with higher energy particles (leading to lower m-number waves) being involved at smaller azimuthal separations.

Forecasting the Earth's electron radiation belts with SPACECAST

R. B. Horne, S. A. Glauert, N. P. Meredith, D. Boscher, V. Maget, D. Heynderickx and D. Pitchford
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Satellites can be damaged by high energy charged particles in the Earth's radiation belts, and during solar energetic particle (SEP) events. Here we review the growing reliance on satellite services, new vulnerabilities to space weather and previous events that have led to loss of service. We describe a new European system to forecast the radiation belts up to 3 hours ahead which has three unique features: First, it uses physics based models which include wave-particle interactions. Second, it provides a forecast for the whole radiation belts including geostationary, medium and slot region orbits. Third, it is a truly international effort including Europe, the USA and Japan. During the March 8-9 2012 storm and SEP event the models were able to forecast the >800 keV electron flux to within a factor of 2 initially, and later to within a factor of 10 of the GOES data. Although ACE and GOES data became unreliable during the SEP event the system continued forecasting without interruption using ground based magnetometers. A forecast of the 24 hour electron fluence > 2 MeV is used to provide a risk index for satellite operators. We show that including wave-particle interactions for $L^* > 6.5$ improves the agreement with GOES data substantially and that a fast inward motion of the magnetopause to $L^* < 8$ is related to rapid loss of relativistic electrons at geostationary orbit. Thus we suggest that better wave-particle models and better coupling between the solar wind and models of the magnetopause and radiation belts should lead to better forecasting.

GOES Observations of Pitch Angle Evolution during an Electron Radiation Belt Dropout: A Two-Stage Process

D. P. Hartley, M. H. Denton, J. C. Green, T. G. Onsager, J. V. Rodriguez, H. J. Singer

Using in situ observations at geostationary orbit (GEO) from GOES 13, we examine the outer electron radiation belt during a high-speed stream (HSS) induced dropout. Pitch-angle-resolved Magnetospheric Electron Detector (MAGED) data allows us to study the temporal evolution of electrons and their directional anisotropy. During the HSS commencing on January 6th 2011, the flux over the entire energy distribution (30-600 keV) takes ~1.5 hours to dropout by around two orders of magnitude. At this time, the < 200 keV electrons begin to reappear at GEO; however the 350-600 keV electron flux becomes highly parallel oriented and continues to decrease. This indicates a two stage dropout process. A first stage explained by radial transport outwards from GEO, followed by a second stage, caused by other loss mechanisms; atmospheric loss being one explanation. Phase space density observations are consistent with this interpretation.

Superposed epoch analysis of ion composition data during HSS-driven storms in 1991

D. Forster, M. H. Denton, M. Grande, C. H. Perry

Ion data of H+, He+, He++ and O+, taken by the CRRES MICS instrument, are studied for five HSS-driven storms identified using solar wind and geomagnetic data during 1991. Superposed epoch analyses are conducted, and a pre-convection dropout in count rate and number density is observed to occur in all species. The minimum of the dropout is reached approximately at convection onset, with the recovery beginning immediately afterwards. Recovery begins with low energy ions that then spread to higher energies.

Exploring the Earth's inner magnetosphere

Kirthika Mohan Narasimhan, Andrew Fazakerley, Branislav Mihaljčić, Sandrine Grimald, Chris Owen, Iannis Dandouras

In previous studies, several authors have reported inner magnetosphere observations of proton distributions confined to narrow energy bands in the range of 1-25 keV. These structures have been known as "nose structures", with reference to their appearance in energy-time spectrograms and are known as "bands" if they occur for extended periods of time. These proton structures have been studied quite extensively with multiple mechanisms proposed for their formation, not all of which apply for electrons. We examine Double-Star TC1 PEACE data recorded in the inner magnetosphere (L<15) in the equatorial plane to see if these features are also observed in the electron energy spectra. These "bands" also appear in electron spectrograms, spanning an energy range of 0.2-30 keV, and are shown to occur predominantly towards the dayside and dusk sectors. We also see multi-bands in some instances. We investigate the properties of these multi-banded structures and carry out a statistical survey analysing them as a function of geomagnetic activity, looking at both the Kp and Auroral Indices over a few days and hours prior respectively, in an attempt to explain their presence.

An Investigation into Ring Current Energisation Through Wave-Particle Interactions and Their Importance within the Storm Time Terrestrial Magnetosphere

T. C. Booth, D. M. Wright and R. C. Fear

The terrestrial magnetosphere is a highly dynamic system which undergoes rapid changes over time periods of the order of hours. Enhancements within the solar wind due to coronal mass ejections (CMEs) and co-rotating interaction regions (CIRs) cause the contraction of the magnetosphere, acceleration of the magnetospheric plasma and an increase in particle precipitation to low altitudes. These time periods are referred to as geomagnetic storms and they drastically change the environment within the magnetosphere from quiet time periods. We report the initial results of a study which focuses on the importance of wave-particle interactions in accelerating magnetospheric plasma. . The temporal and spatial occurrence of the energised plasma during storm time periods in comparison to quiet time periods will also be presented. Using the Cluster instruments PEACE, CIS, RAPID, WHISPER, STAFF and FGM we have resolved the energisation and loss of magnetospheric ions and electrons in terms of MHD wave power in different frequency bands as well as the spacecraft location in the magnetosphere. A number of interesting features have been identified, most notably enhancements in plasma energy in the radiation belts.

Multi-spacecraft Detections of Plasma Sheet Fast Flows and their Relation to Dipolarisations & Substorm Phase

Roger Duthie (MSSL-UCL, London), Andrew Fazakerley (MSSL-UCL, London), Iannis S Dandouras (IRAP, Toulouse, France), Tielong Zhang (IWF, Graz, Austria), Elizabeth A Lucek (Imperial College, London), Mats Andre (IRF, Uppsala, Sweden)

A long standing debate within the field of magnetospheric physics regards the correct model used to describe the sequence of processes occurring during substorms. Whether substorm onset is an 'inside-out' process, initiated by inner magnetosphere current disruption, or an 'outside-in' process, initiated by reconnection in the near-midtail, is still hotly discussed. The focus of this study is to look for evidence of linkage between fast earthward flows generated by near-midtail reconnection (at the 'near-Earth neutral line' or NENL) and inner magnetospheric dipolarisation.

Using all four Cluster spacecraft, fast flows can be detected with minimisation of missing detections over single spacecraft observations; or even simply observations made with fewer than four Cluster spacecraft. The years 2004 & 2005 were investigated to allow link-up with observations made by the Double Star spacecraft. Changes in the tail magnetic field detected by Double Star may be attributed to dipolarisation fronts or global substorm related dipolarisations. Using Cluster and Double Star together a statistical picture of the dynamics within the tail relating to reconnection, fast flows, dipolarisation and the substorm phase can be attempted. To gauge the substorm phase, ground-based magnetic field observations were used.

Cassini Observations Of Saturn's Magnetospheric Cusps

Jamie M Jasinski, Chris S Arridge, Andrew J Coates

Magnetopause reconnection allows magnetosheath plasma to be directly injected into the magnetosphere along newly opened field lines. The cusp is a funnel shaped region in the high latitude dayside magnetosphere which is the entry layer for these particles. The Earth's magnetospheric cusps were first detected in the 1970s. Velocity filtering of ions were observed leading to energy-latitude and energy-pitch angle dispersions of ions which were interpreted as the result of dayside and lobe reconnection. Auroral and theoretical evidence for the cusp at Saturn has been presented and the (geometric) high-latitude cusp has been directly detected in Cassini in situ data. In this study we have been conducting a survey of cusp signatures and we present several case studies of cusp signatures. We consider the bi-directionality of electrons as was observed by *Saur et al.* (2006) on closed field lines, and see it disappear on open-field lines in the cusp, and show the composition of the plasma observed in the cusp.

Cassini CAPS-ELS observations of negative ions in Titan's ionosphere: Trends of density with altitude

Annie Wellbrock, Andrew Coates, Geraint Jones, Gethyn Lewis, David Young

Observations with the Electron Spectrometer sensor of the Cassini Plasma Spectrometer (CAPS-ELS) have revealed the existence of negative ions in Titan's ionosphere. Negative ions are observed during encounters whenever the instrument points in the ram direction at altitudes 950 - 1400 km. Complex hydrocarbon and nitrile chemical processes are believed to take place which probably play a role in haze formation. The heaviest ions observed so far have masses up to 13,800 amu/q. Using data from 34 Titan encounters we show for the first time negative ion density trends with altitude. We investigate trends of the total densities, and of individual mass groups. We determine peak densities and the associated altitudes at which they are observed, and the highest altitudes at which individual mass groups are found.

Turbulence in the fast solar wind measured using the k-filtering method and polarisation analysis

Owen Roberts, Xing Li

The k-filtering method has long been used for analysing magnetic field data from the Cluster mission in the magnetosheath and in the foreshock, but it is only recently that attempts have been made to apply this technique to the solar wind plasma. The method itself has many caveats and great care is needed when interpreting results. We found that velocity differences between protons and minor ions cause small change to the bulk velocity measured by the CIS instrument, which is used in the Doppler shifting from the spacecraft frame to the plasma frame. The change is small but can be significant to influence the interpretation of the character of plasma fluctuations present in the solar wind, especially those at high wavenumbers where direct wave/particle interaction may be readily possible. The difference in the velocities of the different species is investigated through the analysis of the ion velocity distribution function also from the CIS instrument on Cluster. Using this method in conjunction with the k-filtering method several fast wind time intervals from 2004 are analysed. The turbulence that is discovered by the method is found to be propagating at highly oblique angles with respect to the background magnetic field. The frequencies of the turbulence of several datasets are found to be much lower than the proton ion-cyclotron frequency. As an additional tool for discerning the properties of these waves the magnetic field components are transformed into the direction of wave propagation and their polarisations investigated.

Kinetic Signatures and Intermittent Turbulence in the Solar Wind Plasma

K.T. Osman, S.C. Chapman, B. Hnat, W.H. Matthaeus, F. Valentini, and S. Servidio

A connection between kinetic processes and intermittent turbulence is observed in the solar wind using measurements from the Wind spacecraft at 1 A.U. In particular, kinetic effects such as temperature anisotropy and plasma heating are concentrated near coherent structures, such as current sheets, which are non-uniformly distributed in space. Furthermore, these coherent structures are preferentially found in plasma unstable to temperature anisotropy driven instabilities.
The inhomogeneous heating in these regions, which is present in both the magnetic field parallel and perpendicular temperature components, results in protons at least 3-4 times hotter than under typical stable plasma conditions. These heated regions are also exclusively associated with the highest magnetic fluctuation amplitudes, and thus are the most nonlinear and turbulent. Hence, these results offer a new understanding of kinetic processes in a turbulent regime, where inhomogeneous plasma dynamics operate in the vicinity of non-Gaussian structures.

How do discontinuities affect our understanding of solar wind turbulence?

A.J. Turner , S.C. Chapman and G. Gogoberidze
Centre for Fusion, Space and Astrophysics; University of Warwick

In-situ solar wind observations of the magnetic field show a continuum in the power spectral density (PSD). The broad temporal extent of the PSD power-law between scales of seconds to an hour is reminiscent of turbulence in neutral fluids, with a value close to -5/3. *In-situ* solar wind observations thus offer an excellent opportunity to study MHD turbulence, which is ubiquitous in astrophysics. However, there are also discontinuities present in the solar wind in addition to the turbulence. Discontinuities are seen in the observed magnetic field time-series as abrupt changes in the magnetic field direction and/or magnitude. Thus, a topical question is what effect these discontinuities have on the quantitative analysis and signatures of turbulence.

There has been considerable interest in quantifying the power anisotropy of MHD turbulence. All such studies require the background field direction to be determined. Here, we will investigate how the presence of discontinuities impacts upon those methods which require the local background field to be determined at each scale. We propose a scale-dependent threshold to identify/remove discontinuities from the observed time-series. This approach of removing discontinuities is novel in that it does not impose a characteristic scale upon the time-series, which is crucial in quantitative studies of turbulence. We find that the removal of discontinuities from the observed time-series can significantly alter the statistical properties inferred from the data when analysed in the framework of turbulence. These statistical measures include the power anisotropy and associated PSD exponents. In particular we find no evidence for distinct power-law exponents when examining the power anisotropy.

As a consistency check we have also constructed a surrogate time-series from the observations that is composed solely of discontinuities. The surrogate demonstrates the effective "noise floor" present for all scales greater than a few ion-cyclotron scales produced by discontinuities in the observational time-series.

The 22-Year Hale Cycle in Cosmic Ray Flux - Evidence for Direct Heliospheric Modulation

Simon R Thomas, Mathew Owens, Mike Lockwood.

Predicting times of greater fluxes of galactic cosmic rays is important for reducing the hazards caused by these energetic particles on satellite communications, aviation and astronauts. During the 22-year Hale cycle, we see a difference in shape from a 'flat topped' to a 'spiked topped' peak in cosmic ray flux time series. It is thought that differing drift patterns for when the northern solar pole is predominantly positive ($qA>0$) to when the northern pole is negative ($qA<0$) cause this difference in cosmic ray modulation. Here, I demonstrate a link between cosmic ray modulation and properties of the large-scale heliospheric magnetic field during the declining phase of the solar cycle, when the difference between $qA>0$ and $qA<0$ cycles is most apparent. The results suggest that drift affects may not be the sole mechanism responsible for the Hale Cycle in cosmic ray flux at Earth. Further to this it is suggested that the Hale cycle in cosmic ray flux may be primarily limited to the grand solar maximum of the space-age.

Poster Presentations (in alphabetical order of first author)

QB50-CMAT2. Model predictions of the lower thermosphere in preparation for the launch of 50 cubesats in 2015

A.L.Aruliah, T.Spain, D.Johnson, A.D.Aylward, Dhiren Kataria
UCL

QB50 is an unprecedented multi-spacecraft mission to study the lower thermosphere, which is a region of space that is extremely difficult to measure due to its awkward altitude (too high for balloons and rockets, and too low for satellites) and low atmospheric density. QB50 consists of 50 cubesats, which are single or double cubes of length 10cm for each side. The mass, including instrumentation, is 2-3kg, which requires miniaturised instruments, which produces its own challenges. The cubesats are the primary payload for a rocket launched from a submarine at Murmansk in Northern Russia. The payload will be launched into a near Earth orbit at 320km altitude, with inclination 79°. The proposed launch date is April 2015. Owing to atmospheric drag, the orbit will decay over 3-4 months until the cubesats burn up on reaching an altitude of around 90km. Half the cubesats will carry instruments to make in-situ measurements of neutral constituents, while the other half will focus on the plasma. This is a technology demonstrator project involving over 50 universities and institutions around the world, but it is also a unique opportunity to improve upper atmospheric models such as the UCL Coupled Middle Atmosphere Thermosphere model (CMAT2). This poster will present some preliminary results in preparation for the QB50 launch and highlight what gaps in knowledge could be filled by a network of closely spaced instruments making in-situ measurements.

Modelling the thermospheric response to electric field variability from SuperDARN and Foster using the CMAT2 general circulation model.

David Barnes

The UCL Coupled Middle Atmosphere and Thermosphere (CMAT2) general circulation model is used to investigate thermospheric effects associated with electric field variability using both the Foster and SuperDARN (Super Dual Auroral Radar Network) electric field models. Foster's model is based on statistically averaged data from the Millstone Hill radar and so ignores the small-scale electric field structure that is important for simulating thermospheric energetics.
As a result the model fails to reproduce realistic joule heating and neutral wind speeds in the upper atmosphere. The SuperDARN electric fields possess far greater spatial and temporal resolution, providing a more realistic way of simulating the thermospheric energy input from the solar wind. This study presents a discussion of the Foster and SuperDARN electric field models and a comparison of the results from CMAT2 with observations.

The electron heating rate due to pump-induced upper-hybrid resonance at EISCAT

C. Bryers, M. J. Kosch, A. Senior, M. T. Rietveld

We present results from November 2011 campaign in Norway, using the EISCAT heater and UHF radar. We compare the height integrated electron heating rates from O- and X-mode pump waves to extract the components due to ohmic heating and upper-hybrid resonance. We show that the theoretical ohmic heating due to the electromagnetic pump wave electric field agrees with observations for X-mode pumping. For O-mode pumping, the observed electron heating rate exceeds the theoretical ohmic heating, the excess being attributed to upper-hybrid resonance.
A persistent UHF ion-line enhancement is observed, which descends in altitude for high-power O-mode pumping. We show that this is most likely due to ionization from pump-induced fluxes of supra-thermal electrons. For low-power O-mode pumping, no descent in altitude is observed.

A Magnetopause Survey Using the Cluster Spacecraft

N. A. Case & J. A. Wild

Since their launch in 2000, the four Cluster spacecraft have encountered the terrestrial magnetopause ten thousand times. The evolution of their highly-elliptical polar orbits has resulted in the spacecraft crossing the magnetopause over a wide range of latitudes and local times during a mission that has spanned an entire solar cycle. Applying an automated algorithm to Cluster magnetic field and plasma data, we have determined the location and orientation of the magnetopause during Cluster traversals between 2001 and 2010. Our findings are compared to empirical magnetopause models and recent surveys by other satellite missions.

High latitude observations of magnetotail plasma-sheet plasma in conjunction with a transpolar arc

R. C. Fear, S. E. Milan & R. Maggiolo

Transpolar arcs (TPAs) are auroral features which extend into the polar cap from the night side of the main auroral oval. Observations of the ionospheric flows preceding TPAs indicate that they are most likely caused by the closure of lobe flux in a twisted magnetotail; the closed flux is prevented from returning to the dayside as the twist causes the northern and southern hemisphere footprints of the closed field lines to straddle the midnight meridian. This mechanism predicts that closed flux should build up on the night side, and so plasma similar to typical plasma sheet distributions should be observed at high latitudes embedded within the lobe. We present in situ observations from 15th September 2005, when the Cluster spacecraft observed plasma-sheet plasma embedded within the lobes at much higher latitudes than the expected location of the plasma sheet. Each time the plasma sheet is encountered, the location of the spacecraft maps to a point on the TPA which is significantly poleward of the main auroral oval. These observations are consistent with TPAs being formed by the proposed reconnection/twisted magnetotail mechanism.

Recent developments in the BAS Radiation Belt Model used for SPACECAST forecasts

Sarah A Glauert, Richard B Horne and Nigel P Meredith

The population of relativistic electrons in the radiation belts is highly dynamic. Since these electrons can be hazardous to both spacecraft and humans the prediction of the electron flux throughout the radiation belts is an active area of research. The EU-FP7 project SPACECAST has been providing forecasts of the high energy electron flux using physics-based models since 1st March 2012 and is also undertaking research to improve the forecasts. This research has produced a better model for chorus diffusion, an improved starting condition for the model runs and an approach for modelling flux drop-outs. We present results illustrating the effect of these improvements on the forecasts.

Shock-Shock Collision: Cluster Observations

H. Hietala, P. M. E. Decreau, J. Mitchell, J. P. Eastwood, S. J. Schwartz, S. Enestam

Interplanetary (IP) shocks travelling in the solar wind can act both as sources of energetic particles as well as triggers of geomagnetic disturbances. Many studies address the physics of a single shock, as well as the interaction of such disturbances with the planetary magnetospheres. However, shock-shock interactions are also of great importance since an IP shock has to pass through the planetary bow shock before interacting with the magnetosphere.

We investigate a collision between an IP shock and the bow shock of the Earth on February 3, 2009, using an exceptional configuration of the four Cluster spacecraft. At the beginning of the interval, C3 was in the solar wind upstream of the bow shock, while the three other spacecraft were in the magnetosheath. C3 thus observed the IP shock before the collision with the bow shock. After the collision, the data from C1, C2, and C4 show that the IP shock had split into two separate discontinuities. In this study, we concentrate on the measurements of WHISPER, the electric field waves instrument, showing high frequency emission associated with the shock-shock interaction.

Solar Cycle Trends in Ground Activity Indices

P. Hush, S. C. Chapman, M. W. Dunlop

Geomagnetic indices provide a measure of geomagnetic activity over several solar cycles, allowing long term trends to be analysed. SuperMAG is a recent worldwide collaboration of organizations and national agencies that currently operate over three hundred ground based magnetometers. These can be used to create geomagnetic indices in the same manner as the `traditional' geomagnetic indices AE AU AL, but with an order of magnitude greater number of stations. We have performed a statistical analysis of trends in these indices over the solar cycle, with particular focus on comparing SME with AE etc. We find that activity is correlated, but are not in phase, with solar cycle activity as measured by sunspot number or other indicators. We further investigate the correspondence with the source of the ground indices such as the MLT and latitude locations of the SML and SMU ground stations. Comparisons are made between AE and SME to investigate the geographic pattern of activity. Work is in progress to investigate Dst trends and to compare results to solar wind key parameters.

New Online Access to Old Solar Data

Sarah James, Chris Brambley, Jonathan Warburton

The UK Solar System Data Centre (UKSSDC) has recently made accessible online two of its historical solar data sets.

These data sets contribute to the long-term record of solar activity, pre-dating the space age by many decades. It is hoped that by making them more accessible to researchers and by publicising that availability, they can contribute new data to current areas of research.

The UKSSDC holds in fragile, print form reports of Photo-Heliographic Results from the Royal Observatory Greenwich from 1874 to 1976. In a joint effort with the National Geographical Data Center (NGDC) in the US, these reports have now been digitised and made available on the UKSSDC website.

In the basement of the Rutherford Appleton Laboratory the UKSSDC also holds some of the solar images taken by the Royal Observatory Greenwich and its outstations between 1903 and 1942. There are about 20,000 printed images and 9000 images on glass plates. This physical collection has now been fully catalogued and the catalogue is available to search online at the UKSSDC website.

The UK Solar System Data Centre can be found online at http://www.ukssdc.ac.uk/.

Cassini Multi-instrument Assessment of the Open-closed Field-line Boundary of Saturn's Magnetosphere

Jinks, S.L. (1), E.J. Bunce (1), G. Provan (1), T.K. Yeoman (1), C.S. Arridge (2), M.K. Dougherty (3), N. Krupp (4), W.S.Kurth (5), D.G. Mitchell (6) J.E. Wahlund (7) and M. Morooka (7).

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In gas giant magnetospheres the balance between external solar wind driving and internal driving due to the planet's rotation is a critical issue which needs to be addressed. Since the arrival of the Cassini spacecraft at Saturn there has been much debate over whether the magnetic field lines of the planet are "open" to the solar wind. Following the high-latitude orbits of Cassini during 2006/7, 2008 and 2009 the open field region has been tentatively identified. However, precisely where and how the open-closed field line boundary is determined from the various in situ instrument data sets has not yet been systematically investigated. Studies have often simply assumed its position using one instrument data set in support of their more detailed studies of field-aligned currents, plasma boundaries or auroral morphology for example, without a more detailed investigation of the nature of the boundary itself. Here we present a Cassini multi-instrument assessment (using magnetic field analysis, CAPS-ELS electrons, MIMI-LEMMS electrons, Langmuir Probe electron density, and RPWS measurements of the auroral hiss) of the location between "open" and "closed" magnetic field lines for the high-latitude orbits in 2008. We will discuss the agreement between boundary location identification between the plasma/plasma wave data sets and we will assess the relationship of the boundary to the phase of the "planetary period oscillations" and previous field-aligned current studies.

Coupling between Earth's lower and upper atmospheres- steps towards whole atmosphere modeling

David Johnson

Using the data assimilation technique of Newtonian Relaxation, we show preliminary results of coupling UCL's CMAT2 Thermosphere Ionosphere GCM with the ECMWF ERA-Interim Reanalysis. The results show the importance of a proper representation of lower atmosphere circulation on the coupled Thermosphere Ionosphere system.

Geoeffectiveness of Interplanetary Coronal Mass Ejections as Drivers of Ground Level Magnetic Field Fluctuations

Robert Kidd, James A Wild

Global geomagnetic indices have proven to be invaluable tools for the investigation of the interplanetary drivers of geomagnetic disturbances. Mature global geomagnetic indices, such as Dst, yield multi-decadal time-series of geomagnetic activity levels. The geoeffectiveness of space weather drivers is commonly assessed using these global indices, yet they are not designed to capture the rapid and possibly localised geomagnetic disturbances thought to be responsible for unwanted effects on ground-based technologies (e.g. geomagnetically induced currents in power grids). Using data from the SuperMAG project (a collaboration of organisations and agencies operating over 300 ground-based magnetometers) we have explored indices that capture geomagnetic variations over spatially limited regions and derived from parameters not used in traditional indices (e.g. dB/dt). The geoeffectiveness of ICMEs is investigated, particularly in relation to the disturbances likely to result in geomagnetically induced currents.

The dominant role of the Hall-term at sub-ion Larmor scale solar wind turbulence as seen by high-resolution measurements from Cluster

Dr. Khurom H. Kiyani, Dr. Sandra C. Chapman, Dr. Bogdan Hnat

The anisotropic nature of solar wind magnetic turbulence fluctuations is investigated scale-by-scale using high cadence in-situ magnetic field measurements from the Cluster and ACE spacecraft missions. The data span five decades in scales from the inertial range to the electron Larmor radius. In contrast to the inertial range, there is a successive increase towards isotropy between parallel and transverse power at scales below the ion Larmor radius, with isotropy being achieved at the electron Larmor radius. In the context of wave-mediated theories of turbulence, we show that this enhancement in magnetic fluctuations parallel to the local mean background field is qualitatively consistent with the magnetic compressibility signature of kinetic Alfvén wave solutions of the linearized Vlasov equation. More generally, we discuss how these results may arise naturally due to the prominent role of the Hall term at sub-ion Larmor scales. Furthermore, computing higher-order statistics, we show that the full statistical signature of the fluctuations at scales below the ion Larmor radius is that of a single isotropic globally scale-invariant process distinct from the anisotropic statistics of the inertial range.
[Preprint http://arxiv.org/abs/1008.0525]

New evidence of an influence of the interplanetary magnetic field on middle-latitude surface atmospheric pressure

M. M. Lam, G. Chisham, and M. P. Freeman

Results have been published over several decades that indicate a meteorological response in the polar regions to the east-west component of the interplanetary magnetic field (IMF), By. There is evidence that this Sun-weather coupling is due to the influence of the global atmospheric circuit. It has been assumed that such an influence maximises at high latitudes and is negligible at low and mid latitudes because the IMF-induced convection electric field is concentrated in the polar ionosphere. However, the spatial variation of the IMF-weather coupling has not previously been investigated in detail, neither have the global consequences of such forcing on the atmosphere. Here we demonstrate a previously unrecognised influence of IMF By on mid-latitude surface pressure. The difference between the mean surface pressures for high and low values of IMF By possesses a statistically-significant mid-latitude wave structure, similar in location and form to the cyclones and anti-cyclones produced by the action of atmospheric Rossby waves on the jet stream. Thus our results indicate that a mechanism that is known to produce atmospheric responses to the IMF in the polar regions is also able to modulate pre-existing weather patterns at mid-latitudes. A relatively localised and small amplitude solar influence on the upper atmosphere could therefore have a possibly important influence, via the nonlinear evolution of storm tracks, on critical processes such as European climate and the breakup of Arctic sea ice.

First full quantitative characterization of intermittent multifractal turbulence in 3D particle-in-cell (PIC) simulations of magnetic reconnection.

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Recent fully self-consistent kinetic (PIC) simulations of reconnection in three dimensions reported in Daughton et al, Nature Phys. (2011) are highly suggestive of turbulent evolution of structures on multiple scales. These simulations are performed at sufficient spatio-temporal resolution to make analysis in terms of formal quantitative measures of turbulent fields possible.

The classical quantitative measures of turbulence are statistical, they test for similarity in structures by a statistical comparison of how the moments of fluctuations vary from one length scale to the next. Fully evolved inertial range fluid turbulence in a finite medium exhibits multifractal scale invariance in the statistics of its fluctuations, seen as power law power spectra and as nonlinear scaling of the higher order moments (structure functions) of fluctuations which have non-Gaussian statistics.

We present the results of such a formal quantitative tests for reconnection driven turbulence in these fully self-consistent kinetic (PIC) simulations. We find non-Gaussian pdfs of fluctuations and show that these follow multifractal scaling. Importantly, we can distinguish this scaling from that of the correlated noise generated by the PIC simulation. This is the first full quantitative characterization of fully kinetic simulations of turbulent reconnection in terms of turbulence phenomenology. It shows that kinetic range physics in turbulent reconnection shares the same phenomenology with classical intermittent fluid turbulence in finite sized systems.

Global model of lower band and upper band chorus from multiple satellite observations

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Gyroresonant wave particle interactions with whistler mode chorus play a fundamental role in the dynamics of the Earth's radiation belts and inner magnetosphere, affecting both the acceleration and loss of radiation belt electrons. Knowledge of the variability of chorus wave power as a function of both spatial location and geomagnetic activity, required for the computation of pitch angle and energy diffusion rates, is thus a critical input for global radiation belt models. Here we present a global model of lower band (0.1fce < f < 0.5fce) and upper band (0.5fce < f < fce) chorus, where fce is the local electron gyrofrequency, using data from five satellites, extending the coverage and improving the statistics of existing models. From the plasmapause out to L* = 10 the chorus emissions are found to be largely substorm dependent with the largest intensities being seen during active conditions. Equatorial lower band chorus is strongest during active conditions with peak intensities of the order 2000 pT^2 in the region 4 < L* < 9 between 2300 and 1200 MLT. Equatorial upper band chorus is both weaker and less extensive with peak intensities of the order a few hundred pT^2 during active conditions between 2300 and 1100 MLT from L* = 3 to L* = 7. Moving away from the equator mid-latitude chorus is strongest in the lower band during active conditions with peak intensities of the order 2000 pT^2 in the region 4 < L* < 9 but is restricted to the dayside between 0700 and 1400 MLT.

Planetary period oscillations at Saturn post-equinox.

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We examine the 'planetary period' magnetic field oscillations observed in the 'core' region of Saturn's magnetosphere on ~50 near-equatorial Cassini periapsis passes that took place between vernal equinox in August 2009 and September 2012. Previous studies have shown that these consist of the sum of two oscillations related to the northern and southern polar regions having differing amplitudes and periods, that had reached near-equal amplitudes and near converged periods ~10.68 h in the interval to ~1 year after equinox. The present analysis shows that an interval of strongly differing behavior then began ~1.5 years after equinox, in which abrupt changes in properties took place at ~6-8 month intervals, with three clear transitions occurring in February 2011, August 2011, and April 2012, respectively. These are characterized by large simultaneous changes in the amplitudes of the two systems, together with small changes in period about otherwise near-constant values of ~10.63 h for the northern system and ~10.69 h for the southern (thus not reversed post-equinox), and on occasion jumps in phase. The first transition produced a resumption of strong southern system dominance unexpected under northern spring conditions, while the second introduced comparably strong northern system dominance for the first time in these data. The third resulted in suppression of the oscillations followed by re-emergence of both systems on a time scale of ~75 days, with the northern system remaining dominant but not as strongly as before. We will discuss how these results relate to various theoretical models and to storms occurring at Saturn.

SCANDI's insight into the Thermospheric Density Structure

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Since Luhr et al [2005] reported CHAMP's observation of a doubling of the neutral density over many consecutive passes over the cusp region at 400km, there has been a lot of renewed interest in the cusp region. Before this the thermosphere has always been regarded as a smoothly varying medium with time scales of hours and length scales of several hundred to thousands of km. Due to modern society's reliance on the satellite communication industry it is important that we understand the mechanism explaining the cusp's density structure and its implications. On the CUSPN campaign in January 2012 simultaneous observations of cusp signatures were observed in both the ionosphere and thermosphere using UCL's SCANDI instrument.

Modelling features of the thermosphere for satellite drag

Timothy Spain, Herbert C. Carlson

Enhancements of neutral density have been observed in the geomagnetic cusp in satellite accelerometer measurements. These consist of a local double of density in a constrained region fixed in geomagnetic coordinates. By assuming that the heating is driven by soft precipitation through the cusp, the heating and density enhancement are modelled using the CMAT2 general circulation model. In addition to the enhancement of density, the heating produces a characteristic pattern of neutral wind and large scale gravity waves in the model, which may be observable in the satellite drag observations.

Electron Acceleration at Jupiter: Cyclotron-Resonant Interaction with Whistler-Mode Chorus Waves.

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It has been shown at the Earth that a major input to the creation of the radiation belts is cyclotron-resonant interactions with whistler-mode waves. Previous work has suggested that this mechanism is also viable at Jupiter. Here we present improved calculations of diffusion rates due to cyclotron-resonant interactions with chorus waves at Jupiter. Re-examination of the data used in previously published energy diffusion rates for Lshells from 6 to 18 show that the diffusion rates should be now be increased by up to a factor of 8 at Lshells greater than 10. In addition we investigate the effect of the latitudinal distribution of the chorus waves across the magnetic equator on the diffusion rates in both energy and pitch angle and in turn, how this is affected by the wave normal angle. A wider latitudinal distribution of chorus waves increases the energy diffusion rates by an order of magnitude or more but it also increases the pitch angle diffusion dramatically such that many more electrons are lost. The impact of oblique wave angles at higher latitudes will serve to reduce this effect. We then use these various wave scenarios to model the time evolution of electron flux at Jupiter at different Lshells with the British Antarctic Survey Radiation Belt model (BRB).

SuperDARN observations of high-m ULF waves with curved phase fronts, and their interpretation in terms of transverse resonator theory

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The Hankasalmi SuperDARN radar in Finland, whilst operating in a high spatial and temporal resolution mode, has measured the ionospheric signature of a naturally occurring ULF wave in scatter artificially-induced by the Tromso Heater. The wave had a period of 100 s and exhibited curved phase fronts across the heated volume (about 180 km along a single radar beam). Spatial information provided by the radar has enabled an m-number for the wave of about 38 to be determined. It is demonstrated here that the curved phase fronts are a generic feature of nonstationary poloidal waves in a transverse resonator, caused by the common action of the field line curvature, the plasma pressure, and the equilibrium current.
Some features of the observed event agree with the resonator in the vicinity of the ring current, where it is proposed that the wave is excited by a moving source in the form of a proton cloud drifting in the magnetosphere in the azimuthal direction.