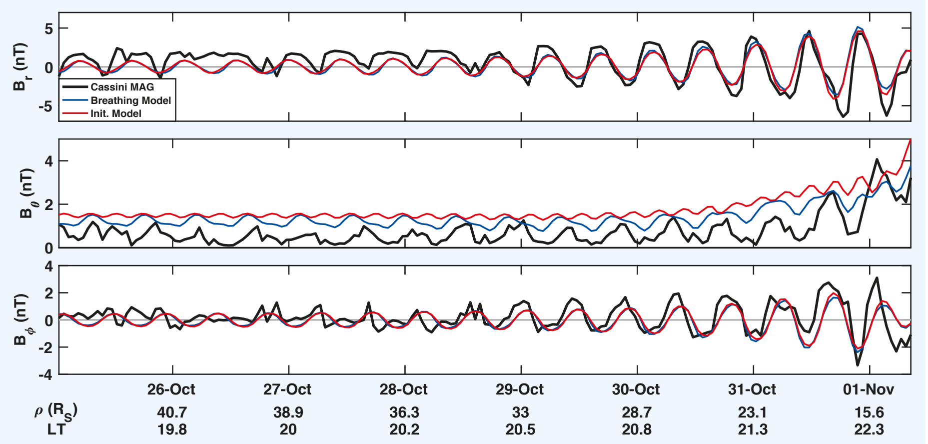
Autumn MIST 2017

Jasmine Sandhu, **Georgina Graham**, **Sarah Bentley** and **John Coxon** report on the annual Magnetosphere, Ionosphere, and Solar–Terrestrial (MIST) meeting, highlighting science results from the Cassini and Juno missions.



1 Modelled field components (blue, red) compared with Cassini magnetometer data (black). (A Sorba)

The 48th annual MIST meeting was held on Friday 24 November 2017 at the Royal Astronomical Society in Burlington House, where more than 90 delegates discussed a wide variety of subjects. The meeting highlighted results from both the Cassini and Juno missions, commemorating a notable year in space science: 2017 marked the dramatic end of the Cassini spacecraft in September, after 13 years in orbit around Saturn, while the arrival of the Juno spacecraft at Jupiter in July began a phase of unprecedented observations of the jovian environment.

The meeting started with an invited talk from **Emma Bunce** (University of Leicester), who presented an overview of the key results from the Cassini and Juno missions, and their importance for our understanding of the magnetospheric environments of Saturn and Jupiter. She showed how Cassini magnetometer observations were used to discover the plasma plumes from Enceladus that populate Saturn's magnetosphere, and how the combination of Cassini solar wind measurements with Hubble Space Telescope images allowed for the analysis of saturnian auroral storms. Furthermore, the Cassini mission led to the discovery of a complex and unexpected rotating current system, resulting in a phenomenon termed PPO (planetary period oscillations). The grand finale of the mission has provided a unique data set that promises to significantly advance our understanding of these current systems. Moving to Juno, new results demonstrate that it is possible to test existing magnetospheric theories with the new *in situ* observations. Bunce highlighted the first observations of field-aligned potentials providing evidence for auroral acceleration regions, as well as simultaneous Juno and Hubble observations indicative of large-scale field-aligned currents generating the main auroral oval.

"They presented a new model of Saturn's magnetodisc, based on Cassini observations"

The Cassini theme continued with a talk by **Gabrielle Provan** (University of Leicester), who presented new results on the ubiquitous PPO in Saturn's magnetosphere. An analysis of magnetometer data unveils the seasonal variations in the two rotating current systems, with data from the proximal orbital phase of Cassini promising further insight and understanding of the behaviour of PPO.

Next, **Arianna Sorba** (University College London) presented a new model of Saturn's magnetodisc, based on Cassini observations. A geometric sheet model to account for the disc "flapping" behaviour is combined with a local force-balance magnetodisc model with variable size to represent the "breathing" of the magnetosphere. The results demonstrate a more accurate characterization of the magnetic field perturbations (figure 1).

Moving to the magnetotail, **Ewen Davies** (Imperial College London) discussed features of return flow plasma arising from reconnection in Saturn's magnetosphere.

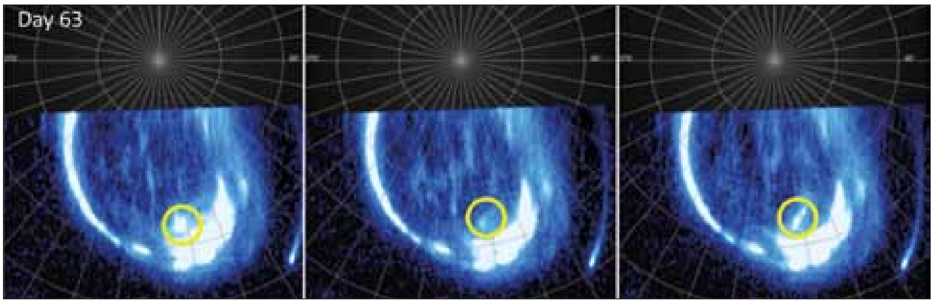
Impulsive changes in the azimuthal magnetic field component were identified from times when Cassini was located in the morning local time sector, and a correlation with high-energy particle flux intensifications was observed. Future work will further analyse the timescales of the magnetic field response to reconnection, as well as investigating a possible link to the current systems of the PPO.

In the penultimate talk of the first session, **Greg Hunt** (Imperial College London) presented an analysis of Cassini magnetometer observations, using the azimuthal magnetic field to explore the modulation of Saturn's large-scale current systems by PPO. Using data obtained during the F-ring orbits, the results showed no clear evidence of the interhemispheric closure of the northern and southern PPO current systems, and the current systems were weaker than observed in 2008.

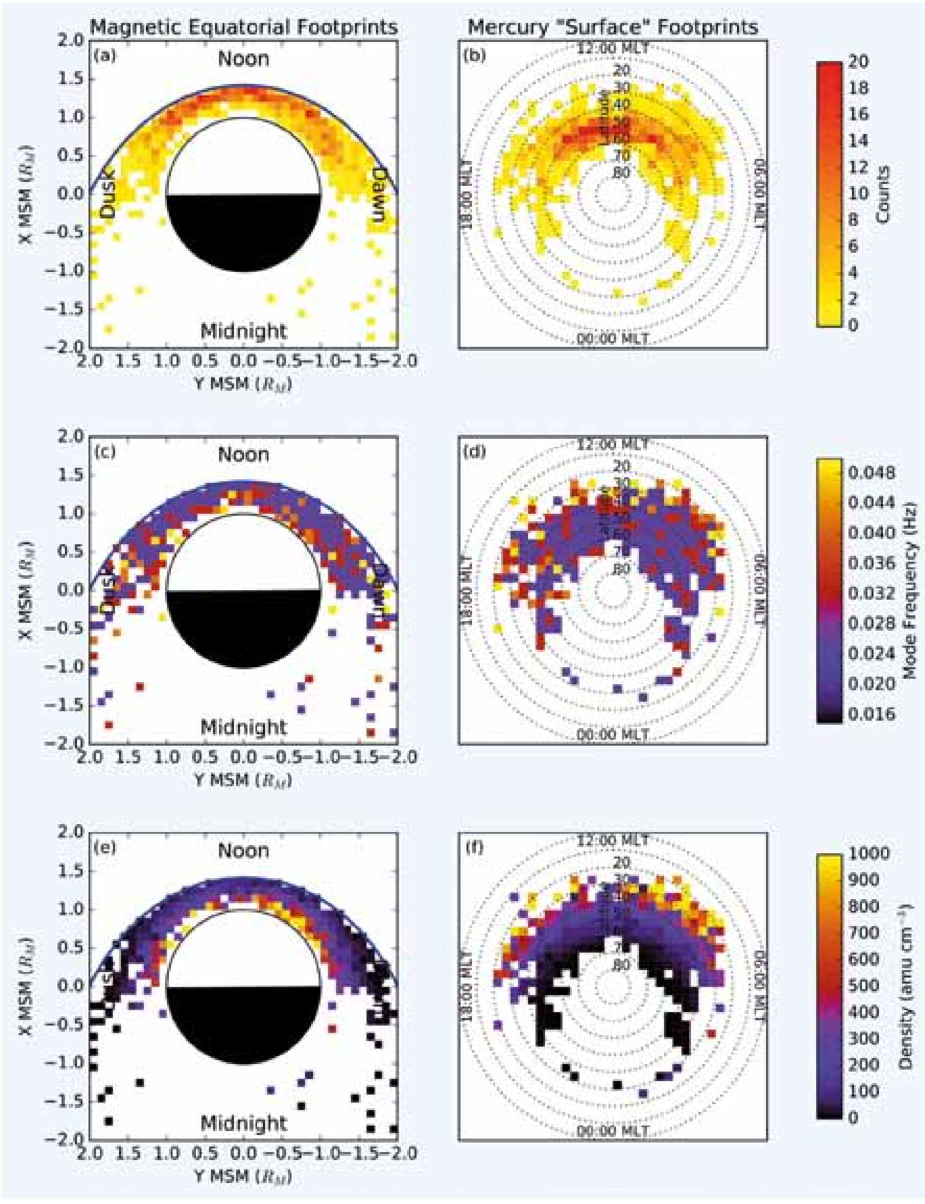
To conclude the morning session, **Emma Woodfield** (British Antarctic Survey) investigated the role of wave–particle interactions as the primary source of a high-energy electron radiation belt within the rings of Saturn. Using Cassini wave data, the capabilities of Z-mode waves in energizing low-energy electrons were assessed and found to be weak, with resonances difficult to achieve. However, whistler mode waves in this region are much more able to resonate with electrons over a wide range of energies and future work will establish the effect of this interaction.

Moving back to PPO, the second session began with a talk by **Thomas Bradley** (University of Leicester). He discussed new measurements of field-aligned current systems based on observations from the Cassini magnetometer in 2012/13, and compared them to previous measurements from 2008. The 2012/13 observations show dual-modulation for both hemispheres, whereas the 2008 observations only showed dual-modulation for the northern hemisphere, suggesting an unclear seasonal dependence. Future work will examine the role of the conductivity and subcorotation rates.

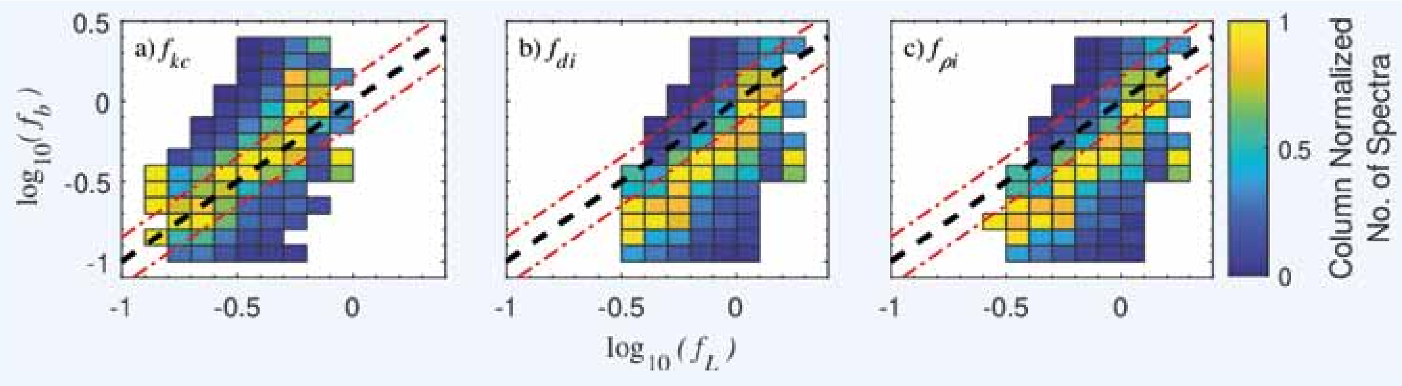
Yutian Cao (Mullard Space Science Laboratory) presented work using Cassini CAPS-ELS data to observe photoelectron



2 HST UV observations of Jupiter's dayside aurora, showing the presence of a pulsating feature. (R Gray)



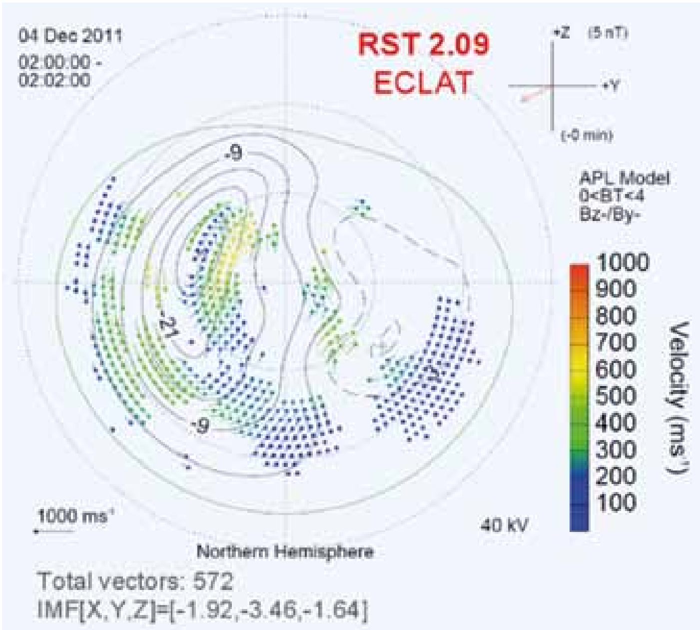
3 Transverse magnetic field perturbations identified from MESSENGER magnetometer observations. The number of identifications (a,b), frequency of perturbations (c,d), and inferred equatorial plasma mass density (e,f) are shown. (Matt James)



4 The observed break frequency measured from WIND observations for different characteristic ion scales. The best agreement is seen for the proton cyclotron resonance scale (a). (Lloyd Woodham)

peaks near Titan coming from the ionization of nitrogen molecules. A statistical analysis of the location of the photoelectron peaks, identified using an automatic finite impulse response algorithm, showed a clear spatial dependence. The presence of peaks in the nightside and at high altitude suggests transport of the electrons from the dayside along magnetic field lines, and provides insight into the magnetic field geometry.

5 An example of a SuperDARN convection map from the map potential solution, as analysed in a case study. (Alexandra Fogg)



Exploring Jupiter's environment

Rebecca Gray (Lancaster University) turned to Jupiter, presenting an analysis of the response of the jovian dayside aurora to solar disturbances. Using HST UV observations and Chandra X-ray observations, in conjunction with upstream solar wind data from New Horizons, the features of the dayside aurora were examined in two case studies. The results indicated the presence of a dynamic and expanding magnetopause signature, that maps to open field lines and pulsates with a 3–4 minute periodicity (figure 2). Gray proposed the addition of open flux at the dayside and velocity shears to address the observed auroral features.

Rosie Johnson (University of Leicester) showed how ground-based observations of H_3^+ emissions were used to examine changes in temperature in Jupiter's upper atmosphere. The capabilities of H_3^+ as an atmospheric thermostat were demonstrated using CRIRES data, and possible heating processes of the atmosphere discussed. Variations in derived temperature were found during an observation period of about 1 h 20 min; they are thought to arise from either altitudinal dependences in the sampling or a thermospheric response to a transient solar wind compression.

Moving to Jupiter's largest moon, **Gianluca Carnielli** (Imperial College London) presented results on the first 3D test particle model of Ganymede's ionosphere. 2D maps of O^{2+} density and velocity indicated several features, including slow moving, high-density ions in the Alfven wings. Furthermore, the model was used to estimate for the first time the contribution from ionospheric ions to surface sputtering, which was found to be important and comparable to that from jovian magnetospheric ions. The model was also compared to Galileo data, with generally good agreement.

Robert Burston (University of Bath) then presented an examination of planetary magnetotail dynamics. Based on the Shaw nonlinear oscillator model of plasmoid formation, the model was extended to include both Dungey cycle and Vasyliunas cycle contributions. The results exhibit both periodic and chaotic behaviour. By considering different planetary conditions at Mercury, Earth, Jupiter and Saturn, a switch in behaviour from limit cycle to deterministic chaotic was observed.

The inner solar system

Matt James (University of Leicester) shifted the focus to Mercury in his talk, in which he used MESSENGER magnetometer observations to identify ~500 cases of field line resonances. Using a realistic magnetic field model, the equatorial plasma mass density was estimated for each event (figure 3). Although the values were in good agreement with plasma models, the estimated mass density appears to be higher than *in situ* observations. However, a direct comparison to MESSENGER FIPS plasma moments is needed to elucidate the validity of the mass density estimates.

In the final talk of the session, **Lloyd Woodham** (Mullard Space Science Laboratory) examined the spectral properties of the solar wind turbulent magnetic field fluctuations. Using WIND magnetic field and particle moment observations at L1, the location of the spectral break and the onset of a coherent helicity signature were measured, and tested against possible dissipation mechanisms. Woodham found that the proton cyclotron resonance presents the most viable candidate for energy dissipation at ion-kinetic scales (figure 4).

The terrestrial environment

To begin the final session of the meeting, **Imogen Gingell** (Imperial College London) presented MMS observations of surface ripples on the Earth's bow shock. The results were compared to hybrid simulations to examine differences between quasi-parallel and quasi-perpendicular shocks, finding

Breadth and depth in MIST posters

In keeping with the theme of the meeting, posters included presentations on jovian X-ray emissions (**Caitriona Jackman**, University of Southampton) and Cassini observations of nongyrotopic pickup ions at Rhea (**Ravi Desai**, Imperial College London). The martian environment was also explored, with posters presented on global ionospheric conductivities (**Ben Hall**, Lancaster University) and the seasonal variability of the total electron content (**Beatriz Sanchez-Cano**, University of Leicester). The breadth of work extended to bodies outside our solar system, with a poster presentation on exoplanet-induced radio emission from M-dwarfs (**Sam Turnpenney**, University of Leicester).

The meeting exhibited a range of work analysing the solar wind in anticipation of the Solar Orbiter mission. Presentations explored strahl beam width broadening (**Georgina Graham**, MSSL), coronal electron temperature signatures (**Allan Ross Macneil**, MSSL), number density structures in the slow solar wind (**David Stansby**, ICL), turbulent fluctuations (**Liz Tindale**, University of Warwick), large-scale compressive fluctuations (**Daniel Verscharen**, MSSL), and kinetic Alfvén waves (**Honghong Wu**, MSSL).

Moving to Earth, presentations discussed various aspects of magnetic reconnection, including filamentary currents observed by MMS (**John Coxon**, University of Southampton), flux transfer events near the magnetic reconnection dissipation region (**Xiangcheng Dong**, Beihang University, RAL Space), global MHD simulations of flux ropes on the dayside magnetopause (**Lars Mejnertsen**, ICL), and reconnection in planetary magnetotails (**Andrew Smith**, University of Southampton).

Recent results on the terrestrial magnetosphere were reported, exploring the parameterization of ULF waves using solar wind parameters (**Sarah Bentley**, University of Reading), simulations of magnetospheric dynamics under northward IMF (**Robert Fear**, University of Southampton), correlations between geomagnetic disturbances and field-aligned currents during a storm interval (**Rosie Hood**, University College London), plasma wave instabilities associated with auroral substorms (**Nadine Kalmoni**, MSSL), and the properties of field line eigenfrequencies during storms and substorms (**Jasmine Sandhu**, MSSL).

The terrestrial ionosphere was discussed by presentations on high-latitude electron content and velocity fluctuations (**Martin Birch**, University of Central Lancashire), the influence of the neutral atmosphere during polar darkness (**Gareth Dorrian**, Nottingham Trent University), polar ionospheric convection (**Robert Shore**, British Antarctic Survey), and the constraint of ionospheric flow variability by IMF conditions (**Maria-Theresia Walach**, Lancaster University).

that ripples are transient for quasi-parallel shocks. Furthermore, Gingell demonstrated that the growth and properties of the ripples are strongly modulated by the shock reformation cycle.

Moving into the Earth's magnetosphere, **Julia Stawarz** (Imperial College London) discussed MMS observations of ion-scale flux ropes associated with signatures of reconnection in the near-Earth magnetotail. Using a four-spacecraft timing analysis, the thickness, axial direction and substructure of the flux rope were assessed. The results show an intense electric field and small-scale current loop within the flux rope, which can potentially act as a source for inhomogeneous electron heating.

Samuel Wharton (University of Leicester) demonstrated a new technique to estimate magnetospheric field line eigenfrequencies, as well as the harmonic frequencies, from ground magnetometer data. In addition to assessing the local time and latitudinal variations, Wharton showed that clear bands of different frequencies were observed, indicating the presence of different harmonics. Unexpectedly, the higher harmonics were found to include only the odd modes, which is possibly due to the nature of the driving force and is an area of future analysis.

Stephen Browett (University of Southampton) explored how magnetospheric convection timescales control the correlation between the IMF and magnetotail flux rope B_y components. The results appeared to show an independence of the correlation on the time lag; however, this could be caused by important differences between Earthward- and tailward-moving flux ropes. Browett aims to incorporate additional flux rope observations to extend the study and provide more information on the features identified here.

> **"The results demonstrated a global network response to substorm onset"**

Moving closer to the Earth, **Alexandra Fogg** (University of Leicester) presented an analysis of SuperDARN convection maps (figure 5), examining the differences between software versions in generating the output map potential solutions and the gridded line-of-sight velocities. The results showed subtle differences between the velocities, leading to differences in magnitude and azimuth, whereas the map potential solutions were relatively similar.

The terrestrial aurora was targeted next, with a talk from **Jade Reidy** (University of Southampton). Using SSUSI data from the DMSP spacecraft, interhemispheric observations of the polar cap were used to identify polar cap arcs. Reidy found instances of polar cap arcs associated with both closed field lines and open field lines, as well as cases of non-conjugate theta aurora where the polar cap arcs were not consistent with either open or closed field lines. In addition, the seasonal variations in polar cap arc occurrence were assessed, with results showing effects of dayglow and orbital bias.

Daniel Billett (Lancaster University) then discussed the importance of the neutral wind properties in determining the Joule heating morphology in the ionosphere. SuperDARN data were used to show that the neutral wind contribution to Joule heating varies diurnally. Furthermore, the neutral wind contribution became increasingly significant during higher levels of geomagnetic activity, as well as during dark seasons where the conductivity is reduced.

Space weather

To conclude the meeting, **Lauren Orr** (University of Warwick) presented a talk on the dynamical network characterization of space weather events. A canonical cross-correlation of SuperMAG ground magnetometer field vectors was used to obtain the dynamical network, and the station responses with the inclusion of a time lag were then assessed. The results demonstrated a global network response to substorm onset with the activity observed to extend to lower latitudes as the substorm develops. Future work will utilize the capabilities of the network to compare quantifiable properties of space weather events.

The meeting represented the diverse range of interests within the MIST community, which was also reflected in the 24 posters (see box "Breadth and depth in MIST posters"). MIST council would like to thank the RAS for hosting the meeting and for their continuing support of the MIST community. Furthermore, we thank all attendees and presenters for contributing to an engaging and fruitful meeting. ●

AUTHORS

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