into this downstream shadow region since to get there they must pass close by the Sun where they have a high probability of being ionized and swept out with the solar wind.

SH22C-04 1655h

Interstellar Magnetic Field and its Influence on the Heliospheric Interface.

Nikolai V. Pogorelov[1,2] (nikolaip@citrus.ucr.edu)

Vladimir Florinski[1] (vflorins@citrus.ucr.edu)

Gary P. Zank[1] (zank@ucrac1.ucr.edu)

[1]Institute of Geophysics and Planetary Physics, Univeristy of California, Riverside, 900 University Avenue, Riverside, CA 92521, United States

[2]Institute for Problems in Mechanics, Russian Academy of Sciences, 101-1 Vernadskii Avenue, Moscow 119526, Russian Federation

The strength and direction of the interstellar magnetic field (ISMF) in the Local Interstellar Cloud (LIC) have not been directly measured and remain the less known parameters affecting the interaction of the solar wind (SW) with the local interstellar medium (LISM). The values as small as $\sim 1.5\,\mu$G are consistent with the observations of the pulsar dispersion and rotation measures, whereas the estimates of the heliospheric confinement pressure yield the upper limit of $\mathbf{B}_\infty \sim 3-4\,\mu$G. The latter values are derived assuming that ISMF is directed perpendicular to the LISM velocity vector $\mathbf{V}_\infty$ with respect to the Sun. We analyze the consequences of the SW encounter with LISM possessing magnetic fields in a wide range of strengths and directions. Both axisymmetric ($\mathbf{B}_\infty \parallel \mathbf{V}_\infty$) and 3D configurations are considered. It is shown that the topology of the bow shock strongly depends on its being fast or slow. Special attention is given to slow bow shocks in the quasi-field-aligned cases, where their existence is stipulated by charge exchange processes in the upstream region. The comparison of theoretical results predicted in this case by our model with the Hubble Space Telescope measurements showed very good agreement. Thus, stronger magnetic fields, which are necessary to satisfy the general equilibrium between the Local Bubble and LIC gases, cannot be excluded from consideration. Fields of such strengths are involved in the model of the LIC origin due to Cox & Helenius (2003). We also analyze various superfast cases, including those where fast parallel shocks cannot exist, while switch-on shocks should be excluded in the presence of certain symmetry restrictions. This usually results in the appearance of additional discontinuities between the bow shock and the heliopause. We show that this scenario is not necessarily valid if the interplanetary magnetic field is taken into account. In this case the ISMF lines exhibit complex three-dimensional topology, which may influence the general picture of the cosmic ray diffusion into the heliosphere. Regimes are also investigated, where $\mathbf{B}_\infty$ is nearly perpendicular to V_∞. They are accompanied by the reconnection of the interplanetary and interstellar magnetic field lines and reveal stronger dependence on the ISMF strength than in field-aligned cases.

SH22C-05 1710h

Are Solar Electron Burst Acceleration Sites Highly Localized?

John T Gosling[1] (505-667-5389; jgosling@lanl.gov)

Ruth M Skoug[1] (505-667-6594; rskoug@lanl.gov)

John T Steinberg[1] (505-667-5308; jsteinberg@lanl.gov)

David J McComas[2] (210-522-5983; DMcComas@swri.edu)

[1]Los Alamos National Laboratory, MS D466, Los Alamos, NM 87545, United States

[2]Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX 78228-0510, United States

More than 300 solar electron bursts have been observed at energies below 1.4 keV by the SWEPAM experiment on ACE. All of these bursts are strongly beamed outward along the heliospheric magnetic field. In addition, a backscattered component is also commonly present. A large fraction of these bursts are closely associated with type III radio bursts that extend down in frequency close to the local plasma frequency. Electron burst durations range from about 1 to greater than 30 hrs. Burst beam intensity-time profiles below 1.4 keV usually are relatively smooth and structureless at all energies, although notable exceptions to this rule occur. In contrast, impulsive solar energetic ion events commonly contain significant dispersionless (in energy) temporal structure. That structure has been interpreted as evidence that heliospheric field lines are commonly braided and that the ion acceleration site at the Sun is spatially localized. One possible interpretation of the SWEPAM electron measurements is that the electron burst acceleration sites typically are considerably less spatially localized than are the impulsive ion acceleration sites.

SH22C-06 1725h

Electron Dynamics in Perpendicular Shocks

Laurent Muschietti[1] (1-510-643-9125; laurent@ssl.berkeley.edu)

Ilan Roth[1] (1-510-643-1837; ilan@ssl.berkeley.edu)

[1]Space Sciences Laboratory UC Berkeley, 7 Gauss Way, Berkeley, CA 94720-7450, United States

A full particle electromagnetic code in the Darwin approximation is used to investigate the dynamics of the electrons in a fast magnetosonic shock. We assume a perpendicular geometry where x points into the shock and the electromagnetic field structure is $\mathbf{E} = (E_x, E_y, 0)$ and $\mathbf{B} = (0, 0, B_z)$. The 1D3V code has open boundaries with upstream and downstream particles traversing the left and right boundaries, respectively, while the shock structure remains in the simulation box. Two shock strengths are considered, including a near critical shock with alfvenic Mach number $M_a \sim 2$ and a supercritical shock with $M_a \sim 3$–4. The simulation is initiated by loading the particles according to profiles modeled from conservation laws (Rankine-Hugoniot). Particles and fields are then left to evolve and, once the ion dynamics develops, a self-consistent shock structure forms. Importantly, due to the partial decoupling of ions and electrons which occurs in the magnetic ramp, the electrostatic field E_x builds up a large spike whose role is to slow down the ions. In the supercritical case a significant fraction of ions are reflected and accumulate in the foot, which leads to the process of cyclical shock reformation. We record the trajectories of selected electrons in order to analyse their behavior in the cross field structure of the ramp. We specially look for a possible "superadiabatic heating", a process described by previous authors [Balikhin and Gedalin (1994); Ball and Galloway (1998)]. The latter is expected to occur for extreme cases where the gradient of the electrostatic potential, which reflects the ions, is so strong that the electrons are accelerated across a large fraction of the ramp during one cyclotron gyration. The required potential difference across the ramp $\delta\phi^*$ depends upon its half width Δ, namely $e\delta\phi^*/mv_e^2 \approx (0.2/\beta_e)\,(\Delta/\lambda_e)^2(r+1)^2$. Here, λ_e is the electron inertia length c/ω_{pe} and r is the compression ratio. Our study improves upon the above mentioned works in the sense that we use profiles of the electromagnetic fields that are self-consistently built instead of just adhoc profiles.

SH22C-07 1740h

Quasi-Perpendicular Shocks: Full Particle Simulations With Realistic Ion to Electron Mass Ratio

Irina Sidorenko[1] (irina.sidorenko@ipp.mpg.de)

Manfred Scholer[1] (mbs@mpe.mpg.de)

Shuichi Matsukiyo[1] (matsu@ipp.mpg.de)

[1]Max-Planck-Institut f. extraterr. Physik, P.O. Box 1312, Garching 85741, Germany

In quasi-perpendicular shocks with a Mach number below the whistler critical Mach number M_w the whistler precursor wave train is an essential part of the shock. M_w depends on the magnetic field - shock normal angle Θ_{Bn} and on the ion to electron mass ratio. It has been proposed that above M_w nonlinear wave steepening of the upstream whistler cannot be balanced anymore by dispersion and dissipation, and that this leads to shock nonstationarity. Full particle (PIC) simulations of shocks above the whistler critical Mach number with a reduced ion to electron mass ratio have indeed resulted in shock nonstationarity. We present PIC simulations of collisionless shocks over a wide range of Θ_{Bn} and Mach number with the realstic ion to electron mass ratio. It will be shown that the modified two-stream instability (MTSI) between incident solar wind electrons and incident and reflected solar wind ions occurs in the foot of the shock and leads to a considerable modification of the shock structure. This has consequences for the nonstationarity, for the various lenghth scales, and for the reflection rate of the specularly reflected ions. Simulations with an ion to electron mass ratio of about 400 or less cannot show these processes, since the growth rate of the MTSI depends strongly on mass ratio.

SH31A MCC: Level 2 Wednesday 0830h

Roles of Electromagnetic Waves in Reconnecting Space and Laboratory Plasmas I Posters *(joint with SM)*

Presiding: **H Ji,** Princeton Plasma Physics Laboratory, Princeton University**; W Daughton,** Los Alamos National Laboratory

SH31A-1076 0830h POSTER

3D Kinetic Simulations of the Onset of Collisionless Magnetic Reconnection

Paolo Ricci[1] (ricci@lanl.gov)

Jeremiah U Brackbill[2] (brackbill@cybermesa.com)

William S Daughton[3] (daughton@lanl.gov)

Giovanni Lapenta[4] (lapenta@lanl.gov)

[1]INFM and Dipartimento di Energetica, Politecnico di Torino Corso Duca degli Abruzzi 24, Torino 10129, Italy

[2]Mathematics and Statistics, University of New Mexico, MSC03 2150, Albuquerque, NM 87131, United States

[3]LANL, MS B219, Los Alamos, NM 87545, United States

[4]LANL, MS K717, Los Alamos, NM 87544, United States

We study the onset of collisionless magnetic reconnection by performing kinetic simulations of Harris current sheets. Simulations of two-dimensional systems show that the saturation level of the tearing mode is very low if no initial perturbation is added. Two-dimensional simulations in the current aligned plane show the development of the fastest lower-hybrid drift instabilities on the electron gyroscale, followed by electromagnetic modes with wavelengths intermediate between the ion and the electron gyroscale and, finally, the velocity shear (non-linear consequence of the lower-hybrid modes) triggers a flapping mode that kinks the current sheet. Finally, we perform three-dimensional simulations to investigate the effect of the current aligned modes on the onset of the reconnection process. The simulations are performed with CELESTE3D, an implicit PIC suitable for large scale and high mass ratio simulations, and with a massively parallel explicit PIC code able to study in more detail the microphysical processes.

SH31A-1077 0830h POSTER

Kinetic Simulations of Magnetic Reconnection in Plasma With Different β Values

Jeremiah U. Brackbill[1] (brackbill@cybermesa.com)

Paolo Ricci[2] (ricci@lanl.gov)

Giovanni Lapenta[3] (lapenta@lanl.gov)

William S Daughton[4] (daughton@lanl.gov)

[1]Mathematics and Statistics, University of New Mexico, MSC03 2150, Albuquerque, NM 87131, United States

[2]INFM and Dipartimento di Energetica, Politecnico di Torino Corso Duca degli Abruzzi 24, Torino 10129, Italy

[3]LANL, MS K717, Los Alamos, NM 87545, United States

[4]LANL, MS B259, Los Alamos, NM 87545, United States

We present kinetic simulations of collisionless magnetic reconnection in Harris current sheets. We simulate plasmas with different β values by varying the guide fields: high guide field correspond to low β. For all values of $\beta > m_e/m_i$, fast reconnection is made possible by the separation of the electron and ion dynamics in the reconnection region. The primary mechanism that relaxes the frozen-in conditions is given by the non-gyrotropic electron pressure terms for all the guide fields considered. The reconnection rate is then enhanced by the Whistler dynamics in high β plasmas and by the Kinetic Alfvén Waves dynamics in lower β plasmas. In the latter case, the ion sound radius takes the place of the ion inertial length as the length scale of interest. The guide field diminishes the reconnection rate and decreases the reconnection saturation level. The ion and electron flow pattern, acceleration, and heating are strongly influenced by the guide field. The

simulations are also preliminary to a closer comparison with the results of the Reconnection Scaling eXperiment (RSX) at Los Alamos National Laboratory, which allows one to study plasmas with different β values.

SH31A-1078 0830h POSTER

Component versus Anti-parallel Merging at the Magnetopause: Nonlinear Theory and Particle Simulations

Kevin Quest[1] (quest@ece.ucsd.edu)

Homa Karimabadi[1] (homa@ece.ucsd.edu)

William Daughton[2] (daughton@lanl.gov)

[1]UCSD, Dept. of ECE, MC 0407, La Jolla, CA 92093-0407, United States

[2]Los Alamos National Laboratory, MS B259, Los Alamos, NM 87544, United States

One of the controversial issues regarding magnetic reconnection at the dayside magnetopause is the location where reconnection first occurs during periods of a large interplanetary magnetic field By. The question is whether magnetic reconnection can occur in locations where the field is not exactly anti-parallel. Nonlinear theory of the collisionless tearing mode predicts that in the presence of a guide field the instability saturates at too small amplitudes to be of any relevance at the magnetopause. Our recent linear theory analysis shows that the growth rate of the collisionless tearing mode remains significant even in the presence of a large guide field. This would indicate the possibility of both component and anti-parallel merging. However, aside from sizeable linear growth, the tearing mode must saturate at sufficiently large amplitude if it is to be a viable mechanism for reconnection at the magnetopause. To this end, we have performed a series of full particle simulations to address the nonlinear saturation of the tearing instability both in the presence and in the absence of the guide field. These simulations are the first of their kind and were performed for large mass ratios and with very high resolution in order to address the saturation problem. Our results show major deviations from previous studies of both anti-parallel and component merging scenarios. The results of these simulations and their implications for the magnetopause will be presented.

SH31A-1079 0830h POSTER

Linear Theory of Drift Tearing Modes at the Magnetopause

William S Daughton[1] (505-665-4111; daughton@lanl.gov)

Homa Karimabadi[2] (858-793-7063; homa@san.rr.com)

[1]LANL, MS B259, Los Alamos, NM 87545

[2]Dept of ECE, UCSD, 9500 Gilman Drive, La Jolla, CA 92093-0407

Although the tearing instability has been the subject of extensive research, the approximations typically employed are less accurate for current sheets with thickness comparable to a thermal ion gyroradius. In this work, the linear Vlasov stability of a Harris sheet with an arbitrary guide field is calculated using a formally exact approach in which the orbit integrals are computed numerically[1]. Both electromagnetic and electrostatic contributions to the field perturbation are included and the eigenvalue problem for the resulting system of integro-differential equations is solved using a finite element representation of the eigenfunction. In addition, the calculation includes a finite wavevector in the direction of the current to examine the linear properties of the obliquely propagating drift tearing modes. The growth rate and mode structure are computed for a range of interesting parameters and the results are compared with previous linear calculations. Significant differences are found between these new linear results and previous theoretical treatments. For example the resonant ion contribution, which has been neglected in previous calculations, is found to significantly modify the linear properties of the mode in certain regimes. Given that the linear growth rate is critical in the debate over the location of reconnection at the magnetopause, these new findings point to the need to revisit previous studies of the tearing mode at the magnetopause.

[1] W. Daughton, *Physics of Plasmas* **10**, 3103 (2003)

SH31A-1080 0830h POSTER

Magnetic waves help heat the solar atmosphere

E.J. Zita (360-867-6853; zita@evergreen.edu)

The Evergreen State College, Lab II - Physics, Olympia, WA 98505, United States

How does the temperature rise to millions of degrees in the corona from under 6000 K at the photosphere? We investigate the role of magnetohydrodynamic (MHD) waves in heating the solar atmosphere. Evergreen students and faculty work with HAO-NCAR on complementary theoretical calculations and analysis of observational and numerical data. Analysis of UV continuum from the SOHO/SUMER satellite reveals that pressure (p-) modes lose power with altitude. We show how the oscillation frequency spectrum varies with magnetic field strength. Energy flux analysis of 3D MHD data reveals that p-modes excite Alfvenic and magnetosonic waves. These modes can carry energy into the chromosphere, where field line reconnection may drive Joule heating. Analytic solutions of the wave equation in twisted and sheared magnetic field geometries may shed light on mode transformations. Taken together, these analyses may help solve the mystery of anomalous coronal heating.

URL: http://academic.evergreen.edu/z/zita/research.htm

SH31A-1081 0830h POSTER

Gyrokinetic-Electron and Fully-Kinetic Ion Particle Simulation – A Novel Numerical Model

Liu Chen[1] ((949)824-3530; liuchen@uci.edu)

Xueyi Wang[2] (xywang@physics.auburn.edu)

Yu Lin[2] (ylin@physics.auburn.edu)

Zhihong Lin[1] (zhihongl@uci.edu)

[1]University of California, Irvine, Department of Physics and Astronomy, 4129 Physical Sciences 2, Irvine, CA 92697-4575, United States

[2]Auburn University, Physics Department, 206 Allison Laboratory, Auburn, AL 36849-5311, United States

A novel 3-D numerical scheme is developed to investigate nonlinear plasma processes in collisionless plasmas. In this model, electron particle dynamics is handled by the gyrokinetic (GK) equations, and the ions are treated as fully kinetic (FK) particles. The code is designed as a reduced model to the existing full-particle codes. Due to disparate temporal and spatial scales between electrons and ions, full-particle codes have to employ either unrealistically high electron-to-ion mass ratio, m_e/m_i, or length of simulation domain limited to a few ion Larmor radii, or/and time much less than the global Alfven time scale in order to accommodate available computing resources. In our new model, the rapid electron cyclotron motion is removed, while keeping realistic mass ratio m_e/m_i, finite electron Larmor radii, wave-particle interactions, and off-diagonal components of electron pressure tensor. Such a model is particularly adequate to problems in which wave modes ranging from Alfven waves to lower-hybrid/whistler waves need to be handled on equal footing. As an example, the code can be applied to magnetic reconnection with a finite guide magnetic field. The simulation model allows quasi-neutrality assumption, which leads to the suppression of high frequency electron plasma oscillations. The computation power can thus be significantly improved, and both collisionless physics at the reconnection X-line and that in the global scale can be included self-consistently at the same time. As a first step, the numerical calculation is benchmarked by comparison with theoretical analysis based on the linearized GK-electron and FK-ion equations. In this study, we present the fundamental equations of the scheme and the linear mode analysis based on the dispersion relation. Comparison is made between the numerical and analytical solutions, and between the normal mode solutions based on this model with GK-electron and FK-ions and various other known theoretical analyses.

SH31A-1082 0830h POSTER

Simulation of Heavy Ion Dynamics in a Magnetic Reconnection

Hironori Shimazu[1] (shimazu@crl.go.jp)

Robert M. Winglee[2] (winglee@ess.washington.edu)

[1]Communications Research Laboratory, 4-2-1 Nukuikita, Koganei, Tokyo 184-8795, Japan

[2]Dept. Earth and Space Sciences, University of Washington, Box 351310, Seattle, WA 98195-1310, United States

We use a 2-dimensional hybrid code (fluid electrons and particle ions) to simulate a magnetic reconnection and include the effects of heavy ions. The time evolution of the Harris plasma sheet is examined under nearly the same initial conditions as those of the GEM Magnetic Reconnection Challenge project with heavy ions included. We find that distribution of the heavy ions is different from that of protons in both real space and velocity space after the reconnection occurs. In real space, the density ratio of heavy ions to protons is higher in the vicinity of the reconnection region. In velocity space, distribution function of protons has double peak structure. As they are ejected, protons are heated and thermalized. It is found that minority heavy ions gain kinetic energy in the direction perpendicular to the simulation plane in the reconnection region.

SH31A-1083 0830h POSTER

Kink-mode Waves and Bifurcated Current Sheets: CLUSTER Observations and Analysis Techniques

Chris Cully[1,2] (cully@colorado.edu)

Eric Donovan[1] (eric@phys.ucalgary.ca)

Stephan Buchert[3] (scb@irfu.se)

Elizabeth Lucek[4] (e.lucek@imperial.ac.uk)

[1]Department of Physics and Astronomy, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada

[2]LASP, University of Colorado, 1234 Innovation Drive, Boulder, CO 80303-7814, United States

[3]Swedish Institute of Space Physics, Box 537, Uppsala SE-751 21, Sweden

[4]Imperial College London, Prince Consort Road, London SW7 2BW, United Kingdom

Although the magnetic configuration of the tail current sheet in the moments before reconnection is of considerable interest, many fundamental observational questions remain. What does the large-scale structure typically look like? How thick is the sheet? Is it bifurcated? What bulk wavemodes are active, and at what amplitude? Cluster observations, when combined with multipoint analysis techniques, offer the opportunity to observationally resolve some of these questions. We present an analysis technique that we use to first solve for the local normal vector to the current sheet at each data point, and then to identify the presence and wavemode of large-scale bulk wave modes (e.g. kink modes). We then take this motion into account when reconstructing the large-scale structure of the sheet from the measurements. We apply these techniques to Cluster observations of the tail current sheet before a substorm on the 11th of October, 2001. At the Cluster location 19 Re downtail, we find large-amplitude kink-mode waves that are propagating duskward in the minutes before reconnection onset.

SH31A-1084 0830h POSTER

Self-Organization and hysteresis in a simple plasma model

Juan A Valdivia[1] (562-6787279; alejo@fisica.ciencias.uchile.cl)

Luis Gomberoff[1] (562-6787279; alejo@fisica.ciencias.uchile.cl)

Luis Gomberoff[1] (562-6787279; alejo@fisica.ciencias.uchile.cl)

[1]Universidad de Chile, Las Palmeras 3425, Nunoa, Santiago Nunoa, Chile

The study of self-organization (SO) and its relation with turbulence is a subject at the forefront of astrophysics and space research, and in particular, it may have relevance in the behavior of the magnetospheric environment. We will study the intermittent energy dissipation in a simple plasma models of a current sheet induced by a localized instability with a hysteretic dissipation loop. The multi-state behavior present in this model seems to occur naturally in complex systems, and is of particular relevance for the existence of a out-of-equilibrium globally stable state with underlying turbulent behavior. The complex behavior of this system will be studied using the techniques that are being developed for spatio-temporal chaotic dynamics. In the case of the magnetotail, this self-organized state [Chang 1998] is necessary to bridge the two seemingly contradicting observations. While the magnetotail plasma sheet appears to be a dynamic and turbulent region [Borovsky et al., 1997], the magnetotail activity seems to be predictable [Vassiliadis et al., 1995], repeatable and globally coherent [Baker et al., 1998] as characterized by its different phases.

SH31A-1085 0830h POSTER

Anomalous resistivity in non-Maxwellian plasmas

Panagiota Petkaki[1] (+44 1223 221 536; ppe@bas.ac.uk)

Clare EJ Watt[2] ((001) 780 492 6568; cwatt@Space.UAlberta.CA)

Richard B Horne[1] (+44 1223 221 542; rh@bas.ac.uk)

Mervyn P Freeman[1] (+44 1223 221 543; mpf@bas.ac.uk)

[1]British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom

[2]University of Alberta, Department of Physics, Edmonton T6G 2J1, Canada

Vlasov simulations of the current-driven ion-acoustic instability produced in Maxwellian and non-Maxwellian (Lorentzian, $\kappa = 2$) electron-ion plasma with number density $7 \times 10^6\ cm^{-3}$, reduced mass ratio $m_i/m_e = 25$ and electron to ion temperature ratio $T_e/T_i = 1$ are presented and compared. A concise stability analysis of current-driven ion-acoustic waves in Maxwellian and non-Maxwellian plasmas modeled by generalized Lorentzian distribution function with index $2 \leq \kappa \leq 7$ and electron to ion temperature ratio, $1 \leq T_e/T_i \leq 100$ is also presented. The ion-acoustic instability is excited in low temperature ratio Lorentzian ($\kappa = 2$) plasma for lower absolute electron drift velocity (up to half the critical electron drift velocity of a Maxwellian). The anomalous resistivity resulting from ion acoustic waves in a Lorentzian plasma is a strong function of the electron drift velocity, and in the work presented here varies by a factor of ~ 100 for a 1.5 increase in the electron drift velocity. Furthermore, ion-acoustic anomalous resistivity is excited for electron drift velocities that would be stable for Maxwellian plasmas. The magnitude of resistivity which can be generated by unstable ion-acoustic waves maybe important for magnetic reconnection at the magnetopause.

SH31A-1086 0830h POSTER

Three-Dimensional Alfvenic Reconnection

Yan Song[1] (612-624-4053; yan@fields.space.umn.edu)

Robert L Lysak[1] (612-625-1323; bob@belka.space.umn.edu)

[1]University of Minnesota, School of Physics and Astronomy, 116 Church Street, S.E., Minneapolis, MN 55455, United States

Observations in space plasmas and laboratory plasmas show reconnection is a three-dimensional dynamical process occurring often in a patchy and sporadic manner involving the energization of charged particles and fluctuations of magnetic and velocity fields. However most traditional reconnection models describe large scale, quasi-steady processes occurring in a specific, two-dimensional configuration. In active cosmic plasma regions, the nonlinear conversion of fast mode waves to shear Alfven waves is an important physical process. For example, during the impinging of fast mode wave packets on a current sheet at the magnetopause or in the magnetotail, the fast mode wave packets can be nonlinearly converted into shear Alfvén wave packets. In this process, the localized breakdown of the frozen-in condition is a consequence of the interaction between the fast mode wave packets and the current sheet. It is also a necessary condition for further irreversible nonlinear evolution of the MHD wave packets. Nonlinear MHD wave mode conversion can be considered to be a three-dimensional Alfvenic reconnection process, where the generated shear Alfven wave packets carry energy, momentum, magnetic twist and angular momentum away from the reconnection site. This process corresponds to a reactive, rather than a resistive, transport process, where the parallel electric field has an inductive nature. The radiation of shear Alfven waves, accompanied by fluctuations of magnetic and velocity fields, provides the impedance causing fast reconnection. The Poynting flux of electromagnetic energy flowing into the reconnection region is converted not only into Joule heating, the kinetic energy of plasma flows and accelerated particles, but also into electromagnetic energy associated with the Alfvén wave packet. Approximate conservation of magnetic helicity and cross helicity leads to the energization of charged particles on current sheets. In space plasmas and laboratory plasmas, the three-dimensional fast reconnection process has a reactive nature. However, due to the limitations of laboratory experiments, some physical processes occurring in space plasmas may not occur in laboratory plasmas.

SH31A-1087 0830h POSTER

Heating and Acceleration due to Lower Hybrid Waves in Magnetic Reconnection Regions

Iver H. Cairns (+61-2-9351-3961; cairns@physics.usyd.edu.au)

University of Sydney, School of Physics, Sydney, NSW 2006, Australia

Magnetic reconnection is widely believed to produce significant plasma heating and acceleration of particles to high energies. Little agreement exists as to how this is done. Here it is shown that a critical theoretical difficulty is posed by the following: (1) Observations of solar flares suggest that $\approx 10 - 50\%$ of the available magnetic energy is channelled into semi-relativistic electrons and protons, plus plasma heating to over 10^6 K. (2) Wind spacecraft observations of reconnection in Earth's magnetotail show that electrons are accelerated to speeds $\approx c/2$, but contain less than $10^{-10}\%$ of the total electron energy. (3) Why are the acceleration efficiencies many orders of magnitude different when the Alfven speeds and plasma temperatures are similar? Lower hybrid waves are common in Hall-MHD simulations and Wind observations of reconnection. It is suggested here that lower hybrid waves are important in producing electron acceleration and ion heating in reconnection regions, via so-called "lower hybrid drive". Analytic theory is used to support this suggestion and to argue that lower hybrid drive should be much more efficient under solar conditions.

SH31A-1088 0830h POSTER

Quick reconnection triggering mediated by the lower-hybrid-drift instability

Iku Shinohara[1] (+81-42-759-8404; iku@stp.isas.ac.jp)

Masaki Fujimoto[2] (+81-3-5734-3535; fujimoto@geo.titech.ac.jp)

[1]Institute of Space and Astronautical Science, 3-1-1 Yoshinodai, Sagamihara 229-8510, Japan

[2]Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8551, Japan

Recently, we have shown that the effects of lower-hybrid waves at the edges of the current sheet provide a quick triggering of magnetic reconnection even in ion-scale current sheets. However, there is an upper-limit to the current sheet thickness for this type of quick triggering via the lower-hybrid-drift instability alone because the lower-hybrid-drift wave activity becomes weaker in the thicker current sheet. Therefore, we should take account of other effects, like, couplings with other instability modes (CSKI, KHI), or effects of perturbation from the outside of the current sheet, etc. to understand reconnection triggering in thicker current sheets. In order to examine these topics, we have performed a parametric study on the thin electron current layer formation due to the current driven instabilities by 2D full particle simulation runs. In this paper, we evaluate whether the quick triggering mechanism mediated by the lower-hybrid-drift instability is truly realistic or not.

SH31A-1089 0830h POSTER

Current Layer Jump Conditions for the Magnetopause

Loren C. Steinhauer[1] (1-425-483-1682; steinhauer@aa.washington.edu,lstein@u.washington.edu)

Michael P. McCarthy[2] (1-206-685-2543; mccarthy@geophys.washington.edu)

Elden C. Whipple[2] (1-907-745-9081; whipple@geophys.washington.edu)

[1]Redmond Plasma Physics Laboratory, University of Washington, 14700 NE 95th St., Redmond, WA 98052, United States

[2]Earth and Space Sciences Department, University of Washington, PO Box 351310, Seattle, WA 98195, United States

Reconnection theory has focused primarily on the elusive x-point or the structure of the current sheet. However the gross properties of reconnection can be determined without probing the internal details of the current sheet: in particular, the energization of particles, the direction and speed of their ejection, the self-consistent magnetic field angle, and the densities of the incident and ejected plasma streams. This can be done with a technique from fluid mechanics, the use of jump conditions such as the familiar Rankine-Hugoniot equations. The magnetopause departs from a simple fluid boundary in that the interaction of the plasma particles with the current sheet produces a highly anisotropic plasma state: particles drift inward in nearly the normal direction; once ejected they move at relatively high speed in nearly the tangential direction. In contrast to the usual jump conditions across a boundary, our analysis considers changes in macroscopic quantities on one side of the current layer boundary as the incident population becomes the ejected population. By incorporating results from studies of the particle equations of motion into conservation laws and Maxwell's equations, new jump conditions for the tangential component of momentum, the out-of-plane component of current density, and energy (Poynting's theorem) are derived. Modest simplifications on the magnetic and electric field structure are assumed, but the fields are quite general otherwise.

SH31A-1090 0830h POSTER

Thin anisotropic current sheets: Equilibrium theory and simulations of current -driven instabilities

Mikhail I Sitnov[1] ((301) 405 1632; sitnov@glue.umd.edu)

Marc Swisdak[1] (swisdak@glue.umd.edu)

James F Drake[1] (drake@glue.umd.edu)

Parvez N Guzdar[1] (guzdar@glue.umd.edu)

Barrett N Rogers[2] (barrett.rogers@dartmouth.edu)

[1]Institute for Research in Electronics and Applied Physics, University of Maryland, IREAP, UMCP, College Park, MD 20742, United States

[2]Department of Physics and Astronomy, Dartmouth College, HB 6127, Wilder Buiding, Hanover, NH 03755, United States

Concentration of the current in thin sheets forms a free energy source for instabilities of the plasma waves, which do not change the initial magnetic topology as they propagate mainly in the current direction. However, these current-driven instabilities may be an effective mechanism of collisionless dissipation and thus promote the reconnection process. Until recently both the linear stability analysis and simulations of current-driven instabilities were limited to the single class of initial equilibria known as Harris current sheets [Harris, 1962]. This limitation did not allow, in particular, the modeling of the sheets with counter-streaming flows of ions, which are typical for the outflow region of the reconnection pattern in the deHoffman-Teller frame (hereafter outflow sheets) [e.g., Yamada et al., 2000; Hsu et al., 2001], and the thin current sheets with two-humped profile of the current density (bifurcated sheets) found in multi-spacecraft observations of the current sheet of Earth's magnetotail [Nakamura et al., 2002; Runov et al., 2003; Sergeev et al., 2003]. Recently the Harris current sheet model was generalized to account for the aforementioned features of the thin current sheets [Sitnov et al., 2003] and then it was included in the massively parallel particle code P3D [Zeiler et al., 2001]. We report the first results of studies of the current-driven instabilities using that modified particle code. We compare in particular the stability picture in thin Harris sheets and similar pictures in the cases of outflow and bifurcated current sheets.

SH31A-1091 0830h POSTER

Production of Energetic Electrons during Magnetic Reconnection

James F. Drake[1] (301-405-1471; drake@plasma.umd.edu)

Marc Swisdak[1] (swisdak@glue.umd.edu)

Michael A Shay[1] (shay@glue.umd.edu)

[1]University of Maryland, IREAP, College Park, MD 20742, United States

A new mechanism for the production of energetic electrons during magnetic reconnection is being explored to understand spacecraft observations in the Earth's magnetosphere and in astrophysical systems. Energetic electrons with $100's$ of kev have long been observed in the Earth's magnetotail (*e.g.* Baker and Stone 1977) and their presence has been linked to magnetic reconnection. More recent data suggests that the source of these particles is the dissipation region (Oieroset, *et al.*, 2002), which significantly constrains possible acceleration mechanisms. Single x-line encounters can not produce these energetic particles. We suggest that electrons can have multiple interactions with the dissipation region by scattering off of turbulence which develops in the outflow region and then migrating upstream along magnetic field lines adjacent to the separatrix. Particle simulations reveal that this turbulence is driven by the electron pressure anisotropy ($T_\perp \gg T_\parallel$ with $kc/\omega_{pe} \sim 1$ and $\gamma \sim \Omega_{ce}$) (Vedenov, et al 1961). Large $T_\perp$ results from electron compression during merger with the ion outflow downstream from the x-line. Analytic arguments suggest that the resulting energy spectra should take the form of a power law with spectral index $k = \ln(m_i/m_e)/2\ln 2 = 5.4$, which is in the range of observations. The calculations extend the work of Hoshino, *et al.*, 2001.

SH31A-1092 0830h POSTER

Hall Mediated Reconnection in Wide Current Sheets

Michael A Shay[1] (301-405-1495; shay@glue.umd.edu)

Barrett N Rogers[2] (barrett.n.rogers@dartmouth.edu)

James F Drake[1] (drake@glue.umd.edu)

Michael M Swisdak[1] (swisdak@glue.umd.edu)

[1]University of Maryland, IREAP Energy Research Building University of Maryland, College Park, MD 20742

[2]Dartmouth College, Department of Physics and Astronomy Dartmouth College HB 6127, Hanover, NH 03755

We examine the collisionless reconnection process in the double tearing mode system. Previous studies with very thin equilibrium current sheets found that the Hall term played a key role in allowing Alfvenic reconnection to occur, with the reconnection rate being insensitive to the system size length and the wavelength of the initial x-line perturbation. We generalize these results to systems with very wide equilibrium current sheets, examining both the scaling of the reconnection rate versus system size, and the criteria necessary to allow Hall physics to accelerate the reconnection rate. It is necessary to renormalize the reconnection rate to the magnetic field just upstream of the dissipation region in order to compare the relavent reconnection rates, and we have developed a numerical technique to do so. We find that the asymptotic reconnection rate is insensitive to both the system size and the wavelength of the initial x-line perturbation, as long as both of these values are sufficiently larger than c/ω_{pi}.

SH31A-1093 0830h POSTER

Hall and Turbulence Effects on Magnetic Reconnection

Daniel Smith[1] (dcs@ruach.gsfc.nasa.gov)

Sanjoy Ghosh[1] (rghosh@dsdial.net)

Pablo Dmitruk[2] (pablo@bartol.udel.edu)

William Matthaeus[2] (whm@udel.edu)

[1]Bartol Research Institute, University of Delaware, Newark, DE 19716, United States

[2]L3 Communications Analytics, 1801 McCormick Dr. Suite 170, Landover, MD 20774, United States

We reexamine the influence of the Hall effect and the level of background MHD scale turbulence upon the reconnection rate of a large scale periodic sheet pinch in 2.5 dimensional compressible Hall MHD. The simulations indicate that the large scale reconnection rate is enhanced by both increasing Hall parameter and by increasing turbulence level. The reconnection rate is found to scale linearly with turbulence amplitude and as the 3/2 power of the Hall parameter (correlation scale/ion inertial scale). The effect is quantified for a range of parameters, thus helping to clarify and extend the related GEM challenge simulation study of reconnection rates.

SH31A-1094 0830h POSTER

Laboratory Observation of Fast Collisionless Reconnection*

Jan Egedal[1] (jegedal@psfc.mit.edu)

Will Fox[1] (willfox@mit.edu)

Miklos Porkolab[1] (porkolab@psfc.mit.edu)

Ambrogio Fasoli[2] (ambrogio.fasoli@epfl.ch)

[1]MIT,PSFC, 167 Albany St., Cambridge, MA 02139, United States

[2]CRPP, EPFL, Lausanne CH-1015, Switzerland

Magnetic reconnection in the collisionless regime is studied on the Versatile Toroidal Facility (VTF). The detailed evolution of the profiles of plasma density, current density, and electrostatic potential at the onset of driven reconnection is reconstructed experimentally. Despite a constant, externally imposed reconnection drive, we show that the reconnection does not proceed in a steady-state manner. The formation and decay of the current is shown to be related to the evolution of the electrostatic potential and the associated ion polarization currents. The size of the diffusion region is inferred from the detailed knowledge of the electrostatic potential, and is shown to scale with the drift orbit width of the electrons insensitive to the ion mass and plasma density [1]. The accurate characterization of the steady state electric and magnetic field profiles provides an excellent basis for detailed kinetic simulations of the reconnection process. With the known electric and magnetic fields Liouville's equation is readily solved numerically providing the detailed phase space distribution function of the electrons. The current profiles, obtained from the first moment of the theoretical electron distribution function, are consistent with the measured current profile. Also consistent with VTF experiment results, the theoretical current densities are three orders of magnitude below the classical value, E/η_S. The phase space distributions of the electrons reveal non-Maxwellian features, which are fundamental in accounting for the momentum balance of the electrons in the vicinity of the X-line. The strong non-Maxwellian features also represent a source of free energy which can excite electromagnetic instabilities and fluctuations. [1] Egedal J, Fasoli A and Nazemi J, (2003) Phys. Rev. Lett. 90, 135003. * This work is supported by DOE and NSF

SH31A-1095 0830h POSTER

Observation of the lower-hybrid drift instability in a laboratory current sheet

Troy A Carter (tcarter@physics.ucla.edu)

Department of Physics and Astronomy, UCLA, 405 Hilgard Ave, Los Angeles, CA 90095-1547

The exact role of turbulence in collisionless magnetic reconnection has been a controversial theoretical topic, with some theories suggesting it is essential to provide anomalous resistivity, while others present a laminar fast reconnection mechanism based on the Hall term in the generalized Ohm's law. A thorough study of fluctuations in the current sheet of the Magnetic Reconnection Experiment (MRX) was performed in order to aid in resolving this controversy. Using amplified Langmuir and magnetic probes, we have measured broadband fluctuations in the lower hybrid frequency range ($f \sim 10-15$MHz) which arise with the formation of the current sheet in MRX. The frequency spectrum, spatial amplitude profile, and spatial correlations in the measured turbulence were examined carefully, finding consistency with theories of the lower-hybrid drift instability (LHDI). The observation of the LHDI in MRX has provided the first opportunity to experimentally study its role in the process of magnetic reconnection. It was found that: (1) the LHDI amplitude does not correlate well in time or space with the reconnection electric field (which is directly related to the rate of reconnection) and (2) the LHDI amplitude was found to be fairly insensitive to collisionality, unlike the measured resistivity anomaly. These two findings suggest that the LHDI does not play an essential role in determining the reconnection rate in MRX.

SH31A-1096 0830h POSTER

Laboratory Investigation of Boundary Layer Processes Due to Strong Spatial Inhomogeneity*

William E. Amatucci[1] (202-404-1022; amatucci@ccf.nrl.navy.mil)

Gurudas I. Ganguli[1] (202-767-2401; gang@ppd.nrl.navy.mil)

David N. Walker[1] (202-767-2248; dwalker@ccf.nrl.navy.mil)

[1]Plasma Physics Division, Naval Research Laboratory, Washington, DC 20375, United States

Boundary layers are often found in laboratory plasmas, such as at the edges of laser-produced plasmas, and in natural settings, such as the magnetosphere. These are regions in which plasma characteristics undergo rapid transition and are usually the sites of wave activity. An investigation of boundary layer processes has been conducted in the NRL Space Physics Simulation Chamber (SPSC). A method has been developed to create a boundary layer with controllable density gradients and transverse electric fields with arbitrary amplitude and scale length as small as one-fourth of an ion gyroradius. This method involves interpenetrating plasmas with different diameters, whose plasma potentials can be controlled. Under these conditions, waves in the lower hybrid frequency range have been observed and their characteristics documented. Theoretical work indicates that the observed mode characteristics are similar to those expected for the Electron-Ion Hybrid Instability. As an illustration, we apply our results to space plasmas and the dynamics of the plasma sheet boundary layer (PSBL). The PSBL is key in the transfer of solar wind mass, energy, and momentum into the magnetosphere and ultimately into the auroral regions. During times of solar activity, the PSBL can become compressed to widths on the order of an ion gyroradius and can contain localized transverse electric fields similar to those generated in the SPSC experiments. At these times, thin layers of energetic electrons and broadband wave activity have been observed in the PSBL. The details of the response of a plasma to such conditions and the observable signatures are the focus of this study. *Work supported by ONR.

SH31A-1097 0830h POSTER

Microphysics of Magnetic Reconnection: Experiments on RSX and Simulation

Thomas P Intrator[1] (505 665 2927; intrator@lanl.gov)

Ivo G Furno[1] (505 665 2703; furno@lanl.gov)

Scott C Hsu[1] (505 667 3386; scotthsu@lanl.gov)

Giovanni Lapenta[2] (505 667 4394; lapenta@lanl.gov)

Paolo Ricci[2] (505 667 3412; ricci@lanl.gov)

[1]Los Alamos National Laboratory, P-24 Plasma Physics, Los Alamos, NM 87545, United States

[2]Los Alamos National Laboratory, T-15 Plasma Theory, Los Alamos, NM 87545, United States

Using a unique LANL laboratory facility, the Reconnection Scaling Experiment (RSX), and a state-of-the-art LANL numerical code, CELESTE3D, we are beginning an experimental and numerical study of the microphysics of 2D and 3D "fast magnetic reconnection". RSX at Los Alamos National Laboratory is already operational and producing research plasmas. In RSX, the radial boundaries and thus the reconnection geometry are not constrained to two dimensions. It is capable of investigating 3D magnetic reconnection occurring in a free-boundary 3D linear geometry during the coalescence of two parallel current plasma channels, which are produced by using plasma gun technology. RSX can also scale the guide field (ion gyroradius) independently of other reconnection parameters. Frontier reconnection research invokes (1) anomalous' microinstability-induced resistivity, which enhances dissipation rates inside the reconnection layer and (2) terms of the two-fluid generalized Ohm's law which introduce whistler and kinetic Alfvén wave dynamics. The two-fluid approach predicts (a) a two-spatial-scale spatial structure of the reconnection layer, with outer (inner) thickness equal to the ion (electron) skin depth and (b) Hall currents in the reconnection plane and out-of-plane magnetic field on the electron scale. We will show spatially resolved RSX experimental measurements of the dynamics of the reconnection layer, and take advantage of our scaling capabilities to address the applicability of the two-fluid approach.

URL: http://wsx.lanl.gov/

SH31B MCC: 2002-2004 Wednesday 0900h

Van Allen Lecture *(joint with SA, SM)*

Presiding: **D Baker,** Laboratory for Atmospheric and Space Physics, University of Colorado**; R Strangeway,** Institute of Geophysics and Planetary Physics, University of California, Los Angeles

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SH31B-01 0910h INVITED

New Insights Into Magnetospheric Physics From Recent Multi-Spacecraft Observations

Goetz Paschmann[1,2] (gep@mpe.mpg.de)

[1]Max-Planck-Institut fuer extraterrestrische Physik, Giessenbachstr. 1, Garching 85748, Germany

[2]International Space Science Institute, Hallerstr. 6, Bern 3012, Switzerland

Please see abstract paper number SM31D-01 for the complete abstract.